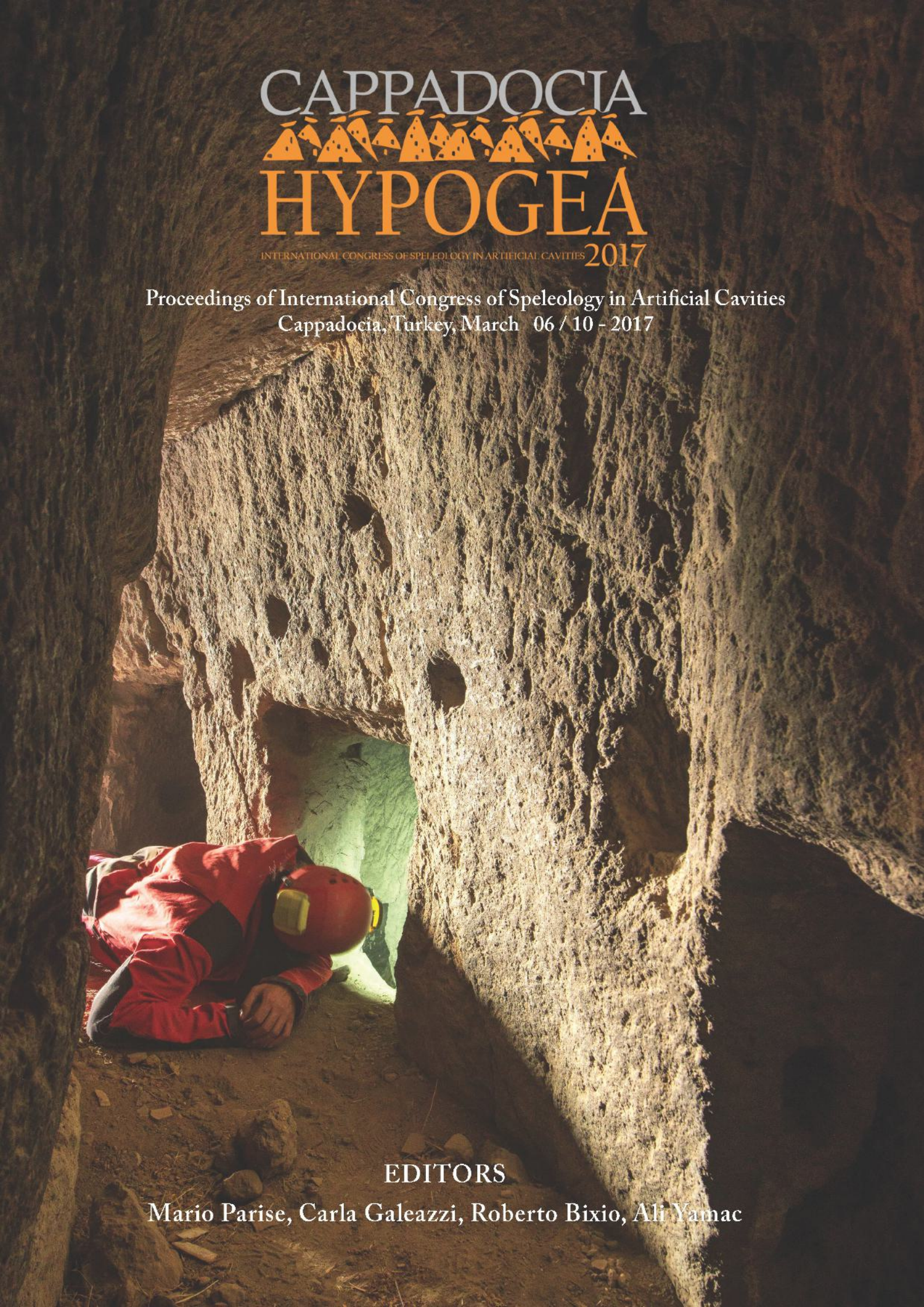
CAPPADOCIA HYPOGEA 2017

INTERNATIONAL CONGRESS OF SPELEOLOGY IN ARTIFICIAL CAVITIES

Proceedings of International Congress of Speleology in Artificial Cavities
Cappadocia, Turkey, March 06 / 10 - 2017



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Mario Parise, Carla Galeazzi, Roberto Bixio, Ali Yamac

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Mario Parise, Carla Galeazzi, Roberto Bixio, Ali Yamac

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"HYPOGEA" The Official Brand of the International Congresses of Speleology in Artificial Cavities

Carla GALEAZZI [*], Mario PARISE [**]

[*] President of HYPOGEA

[**] President of UIS Commission on Artificial Cavities

HYPOGEA, Federation of the Speleological Associations of Latium (Italy) for the research and valorization of artificial cavities, was originally born from the shared desire to bring together the professional experience of three established organizations, each one with more than a decade of experience in the scientific documentation of artificial cavities. ASSO, EGERIA UNDERGROUND RESEARCH CENTER, and ROMA SOTTERRANEA. The three organizations joined together to combine and integrate their respective areas of expertise in the services of knowledge, preservation, management and protection of the Italian underground cultural heritage.

The first International Congress "Hypogea 2015" took place in Rome in March 2015, from the 11th to the 17th. The event was organized by the Federation Hypogea, in collaboration with the Commission on Artificial Cavities of the International Union of Speleology (UIS). One hundred and fifty scholars took part in the event, from Austria, Armenia, Bulgaria, Czech Republic, Croatia, France, Georgia, Germany, Israel, Italy, Russia, Switzerland, Turkey, UK and USA. The congress was the ideal setting to share important multidisciplinary researches, and to discuss and compare different topics dealing with artificial cavities. Hypogea 2015 was actually an important event for sharing, as testified by the proceedings (550 pages), edited by Mario Parise, Carla Galeazzi, Roberto Bixio and Carlo Germani, that were made available both on paper and in electronic format at the opening of the congress.

During this event the candidature of Turkey for the second congress Hypogea 2017 was announced.

This new appointment, too, was organized by HYPOGEA (Italy) with the OBRUK Cave Research Group (Turkey), again in collaboration with the UIS Commission on Artificial Cavities. The main goal of the HYPOGEA 2017 Congress is to continue the exchange of experiences acquired at the international level in the field of artificial cavities, which had begun with the first congress, and, even before, with the other activities of the UIS Commission. Even in a quite complicated moment of history, and of difficult times for travelling, the response has been more than positive, with 67 contributions accepted for publication in the 2017 proceedings (566 pages).

And the story does not stop here… As a matter of fact, there are already several candidates for the next Hypogea, to be held in 2019, which is a very good sign of vitality and interest for the issue of artificial cavities, and the related researches in many fields and disciplines. At the moment we write this preface (December 2016) we do not know which country will host the next congress, but we are already sure about one, very simple but extremely important, thing: it will be called HYPOGEA 2019.

This means that the original name of the Latium Federation has grown a lot, and is now inextricably linked to international caving appointments in artificial cavities. To us, it is an important acknowledgment for the work we have done together so far. At the same time, it represents an incentive to convince us to keep working in the future, hoping to reach an increasing number of people, cavers and scientists, sharing the interest and passion for artificial cavities.

HYPOGEA 2015 First International Congress Rome, Italy, 2015. Photo by Antonio De Paolis (archive Egeria CRS)

OPERA IPOGEA
Journal of Speleology in Artificial Cavities

Andrea DE PASCALE [*], Stefano SAJ [**]

[*] Editorial Director *Opera Ipogea*

[**] Main Director *Opera Ipogea*

The artificial cavities are often the evidence of pre-existing territorial organizations and of a lifestyle wiped out by the present urban development, owing to new and different needs developed in the course of time. The "phenomenon of artificial cavities" in a given place, both by number and by extension, is in direct and inverse correlation with the hardness of the rock, and, as a consequence, with the easiness of excavation.

Conventionally, artificial cavities are the underground works of historical and anthropological interest, man-made or readjusted by man for his needs. Where climatic conditions or historical events required it, and the morphology and lithology were favourable, techniques of excavation or construction in negative (by subtraction) were developed, and they produced in the course of ages a large part of what we now call artificial cavities. Underground structures are spread all over the world, diversified by age, excavation technique and purpose.

Since 1999, most of the results of research about this topic are published in **Opera Ipogea - Journal of Speleology in Artificial Cavities**, a scientific journal dedicated to the speleology in artificial cavities, with specialized studies, articles and news on the research activities carried out in this context. The Journal born by the activities of the CNCA - *Commissione Nazionale Cavità Artificiali* (National Commission for Artificial Cavities), founded in 1981, a permanent structure of the SSI - *Società Speleologica Italiana* (Italian Speleological Society).

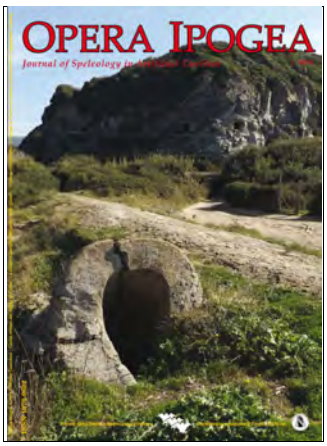
CNCA it is formed by speleologists who document such accessible sites, often unknown or forgotten. Speleologists have real confident with underground environment, because they know the techniques to move around, to topography collect data, images and suggestions. This discipline involves also archaeologists, architects, historians, anthropologists and mines engineers.

Opera Ipogea publishes in Italian and English with large bilingual abstract. Some articles are published entirely in two languages. The Scientific Committee has formed with experienced cavers and archaeologists from Italy, France, England and Turkey.

In 2017 **Opera Ipogea** turns 18 years old! In these years have been published almost 300 articles of more of 280 different authors, divided into 24 miscellaneous, 7 monographs, 3 conference proceedings, a special issue and 2 supplements.

The collaboration between **Opera Ipogea** and **Hypogea**, started in 2015 in the occasion of the first International Congress of Speleology in Artificial Cavities "HYPOGEA2015" (Rome, Italy, March 11th-17th), continues and we are very glad for the great participation of scholars from many countries on Hypogea 2017, in Cappadocia (Turkey), a land that occupy a first special place in the Journal of Speleology in Artificial Cavities as proved by reading the indexes of 18 years of the magazine (www.operaipogea.it).

On the left, the cover of the first number of Opera Ipogea (1/1999); on the right the cover of the number 1/2004 with some articles dedicated to Cappadocia. Below the cover of the number 1/2016.



SESSION 1

ARCHAEOLOGY, ARCHAEOMETRY, ART HISTORY

Signs on the rock. Red paintings in the valleys of Göreme and Kılıçlar (Turkey)

Maria ANDALORO[1], Giulia BORDI[2], Chiara BORDINO[3], Paola POGLIANI[4], Valeria VALENTINI[5]

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Abstract
This paper aims at presenting some preliminary results of the study of red pictorial decorations directly applied on the rock in Cappadocian rupestrian churches and civil monuments, which we have undertaken within the research and conservation project "Rock painting in Cappadocia. For a project of knowledge, conservation and enhancement", carried out by Tuscia University since 2006.
Such pictorial decorations are very popular in the rock hewn churches of the region, but they have scarcely attracted the attention of scholars, who have focused mainly on the paintings realized on plaster and their extraordinarily rich iconographic programs. Once the excavation was finished, the church generally received a very simple pictorial decoration in red, generally applied on the rock with no preparatory layer. Red paintings emphasize the main lines of the architecture and can include crosses and decorative motives, but no human figures. Subsequently, after a short or a long time span the church could get a pictorial decoration on plaster, which partially or totally covered the red signs. In some cases, however, no paintings other than the red decoration were added.
Red pictorial decorations are heterogeneous for several reasons: techniques and materials, forms and meaning. They can be interpreted as an act of consecration, or they can include more articulated patterns. In some cases there is an evident intention to avoid holy figures, and to replace them with aniconic motives. However, these paintings are not connected to Byzantine Iconoclasm. In some monuments we can see figures of animals, probably with an apotropaic function.
We discuss some examples from Göreme and Kılıçlar valleys, aiming at a better understanding of the chronology and function of the red signs, both in religious and in civil monuments.

Keywords
Cappadocia, Göreme Valley, Göreme Open Air Museum, rock-hewn painting, decorative motifs, pictures of animals.

1. INTRODUCTION

The *Cappadocia Rupestrian Art and Habitat Database* (www.museovirtualecappadocia.it) [Andaloro et al. 2016] is originated from the multi-year Italian Mission of the University of Tuscia and is oriented towards integrated knowledge of the paintings of Cappadocia, reconsidered within their rupestrian context and re-read on the basis of art-historic and technical-scientific studies.

As such, it has offered a stimulus to conduct the study of the particular paintings in red applied directly on the rock walls of the spaces, chapels, churches and monasteries. We analyze a sculpted/painted/architecture where the reciprocal connections between these dimensions within the excavated space are fertile, and in some manner intrinsically related.

The paintings in red are a kind of painted skin of the structure, with which they are tightly associated. They can be ephemeral and evanescent or vivid and intense, crude or well made, but they always emphasize the forms of the rock-hewn interiors. Above all they are always present, and at times, when covering all the surfaces, they can be considered as true systems of painted decoration, just as the figurative paintings on plaster, which already boast the attention of a rich historiography.

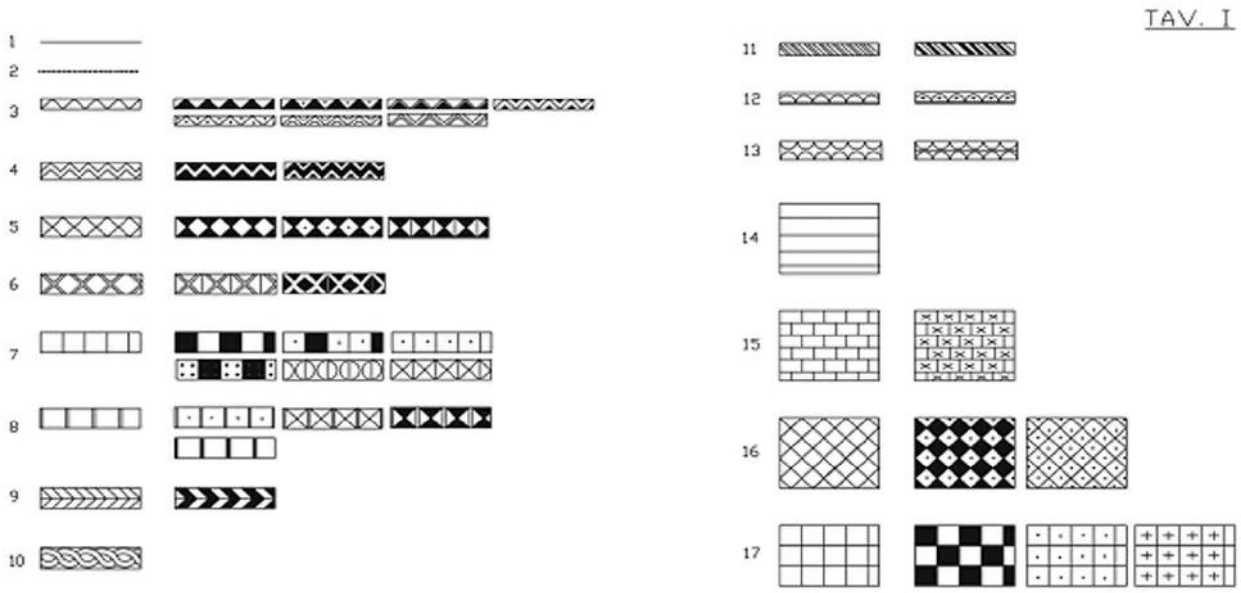

Figure 1: 1 Simple line; 2 Dashed line; 3 Broken line; 4 Delineated broken line; 5. Row of squares on diagonal; 6 Delineated row of squares on diagonal; 7 Row of adjacent squares; 8 Row of non-adjacent squares; 9 Herringbone; 10 Two intertwined lines; 11 Helix; 12 Row of arches; 13 Tow opposing rows of arches; 14 Composition of parallel lines; 15 Isodome structure; 16 Lattice of diagonal lines; 17 Lattice of lines (drawing Valeria Valentini)

Therefore while the painting in red at Cappadocia is extensively diffused, it is at the same time little investigated [Brubaker 2003; Jolivet-Lévy 2015a]. This work, which is presented here in a developmental stage, advances along different directions:

1. The decorative repertory, with particular attention to the geometric patterns and organic figurations;
2. Observations on the methods of execution and the use of tools and materials;
3. Reflections on the possible interpretations of the functions and meanings of these decorations, for those who produced them and those who perceived them.

These directions do not proceed in parallel, however they integrate each other in the attempt to understand the function and value of these paintings; to understand the labour of the workshops and identify the worksites and stages; to retrace the migration of the models, their use and their diffusion through the territory.

Currently, the research is concentrated on a group of churches dispersed through the Göreme Valley and the Open Air Museum.

The cross, a foundational element in the Cappadocian figurative horizon, has been extrapolated from the current context and in future will be the subject of a separate article, as a common denominator of both the red painting on rock and the painting on plaster.

2. FOR A REPERTORY OF DECORATIVE MOTIFS OF THE PAINTING IN RED

Lozenge shapes, geometric lattices, vines, knotted wheels, beaded circles and peacock feathers are only some of the many ornamental motifs that enrich and characterize the Cappadocia painting on plaster, over a time period extending from the 6th to the 13th century. Motifs derived from the classical repertory, pseudo-Kufic elements, re-visitations and true inventions serve as background and framing for the narrative depictions and embellishment to the paintings. An illustrated inventory of the most common ornamental motifs at Cappadocia, still in preparation, is now partially published in the online Cappadocia Rupestrian Art and Habitat Database (http://bancadati.museovirtualecappadocia.it). Following the inventory, the attention of this paper is focused on the decorative elements overlaying the rock, almost in symbiosis with the rock-hewn architecture, and directly applied on it. In the majority of the cases of painting on plaster the repertoire can be considered as the result of a fusion of the truly geometric with organic elements, however in the case of the painting on rock, the geometric element is the unchallenged protagonist. The decorations in red are often hidden by the painting on plaster, and frequently we have no documentation of them except in the losses of the successive plasters, where the stone reappears and the drawing returns to view. Further, by their very nature, the paintings are extremely delicate and easily

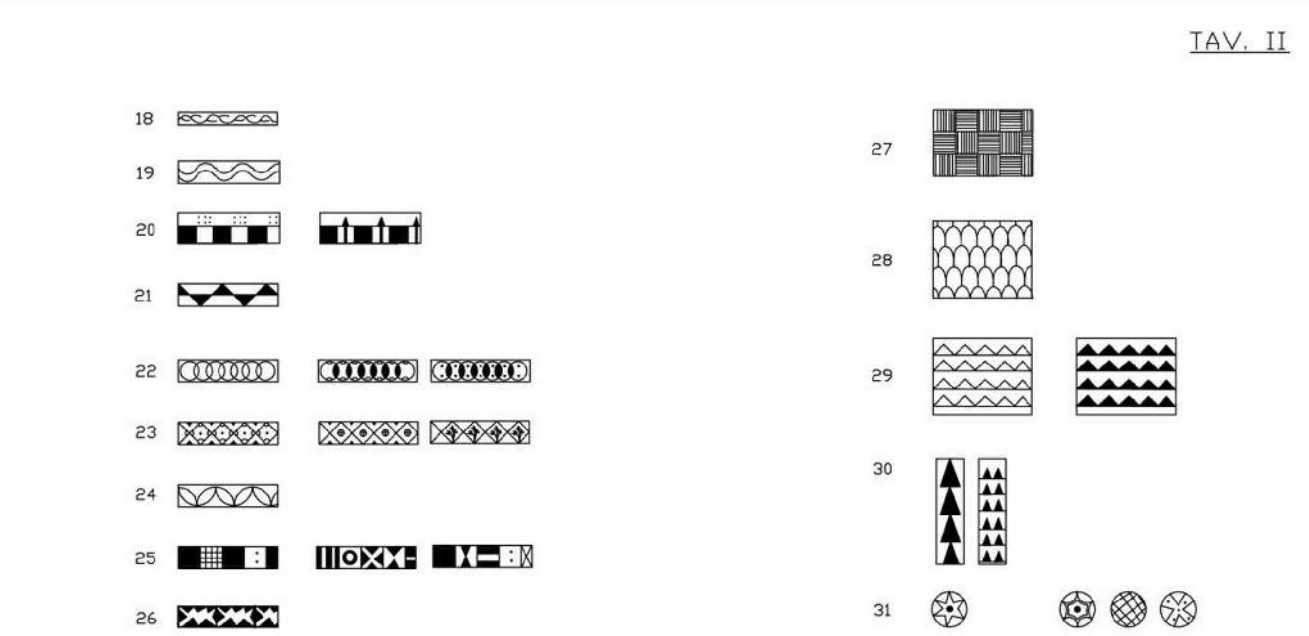

Figure 2: 18 Flower tendril; 19 Wave; 20 Row of adjacent squares (Göreme 21c variant) ; 21 Opposing rows of offset triangles ; 22 Row of intersecting circles; 23 Row of squares on the diagonal (Göreme 12 variant); 24 Row of spindles; 25 Row of adjacent squares (Göreme 14/Göreme 20/Göreme XVII variant); 26 Row of adjacent rectangles containing triangles; 27 Woven bands of lines; 28 Fish-scales; 29 Composition of broken lines; 30 Band composed of linear spines; 31 Fleuron (drawing Valeria Valentini)

subject to degradation. Thus, their presence or absence is very often in doubt, or the motifs are illegible.

Given this, the current study considers only a first nucleus of rock-hewn churches identified in the Göreme Valley and the Open Air Museum: a limited but still representative area. Out of a sample of 45 churches, 31 of these[1] definitely present decorations in red on the rock surfaces. Crosses and decorative friezes derived from a geometric repertory decorate the large part of these, emphasizing the volumes and the architecture and covering the vaults. There are only a few cases of the appearance of different representations: zoomorphic and anthropomorphic figurations (Göreme 10, 12, 14, 20, XXIX, XXXII), or derivations from the plant repertory (Göreme 12), or finally, as in Göreme XXIX and Göreme XVII, the corbels of the vaults host grotesque masks. To give an idea of a general framework, in this sample of churches we note that in eight cases, the red paintings remains in view as the only decoration, while in 11 cases they are completely covered by successive pictorial phases on plaster, and finally in 12 cases the red painting is only partially covered by iconic panels.

Given this first partial repertory from the study (still under way, and excluding the motifs of difficult reading), we will consider both the linear compositions and the compositions of geometric types of surfaces, with the objective of isolating a pattern, while still remaining open to possible variations. We identify the most common ornamental motifs within the defined geographic context, without entering in the specifics of chronological or stylistic data[2]. Figure 1 presents the motifs with the greatest diffusion and longest time span. Among these, the 'broken line' (no. 3), both in simple form and in its many variations, appears in 19 cases. A similar frequency is seen for the 'row of adjacent squares', which we find in 11 churches, especially in its 'checkerboard' variation.

[1] Those with red decoration painted on rock: Göreme 2 Thierry (Göreme 2d - Jolivet-Lévy 2015b), Göreme 4c, Göreme 7, Göreme 9, Göreme 10, Göreme 10a, Göreme 11, Göreme 11a, Göreme 12, Göreme 13, Göreme 14, Göreme 15a, Göreme 17, Göreme 18, Göreme 19, Göreme 20, Göreme 21, Göreme 21c, Göreme 22, Göreme 23, Göreme 23 – Monastery, Göreme 25, Göreme 27, Göreme 28, Göreme 32, Göreme IVb, Göreme IVc (Göreme 4f - Jolivet-Lévy 2015b), Göreme XVII (Göreme 21b -Jolivet-Lévy 2015b), Göreme XXI, Göreme XXIX (Göreme 33a - Jolivet-Lévy 2015b), Göreme XXXII (Göreme 32b - Jolivet-Lévy 2015b).
Churches that have paints in red but have not yet been subject of the Survey of the University of Tuscia:
Göreme 13b, Göreme 13c, Göreme 1 a, Göreme 1b, Göreme 1c, Göreme 2, Göreme 2c, Göreme 2e, Göreme 34, Göreme 14 a, Göreme 14b, Göreme 15c [Jolivet- Lévy 2015b].

[2] The reference lexicon adopted for the geometric motifs is inspired by the widely used scheme proposed in *Le décor géométrique* 1985

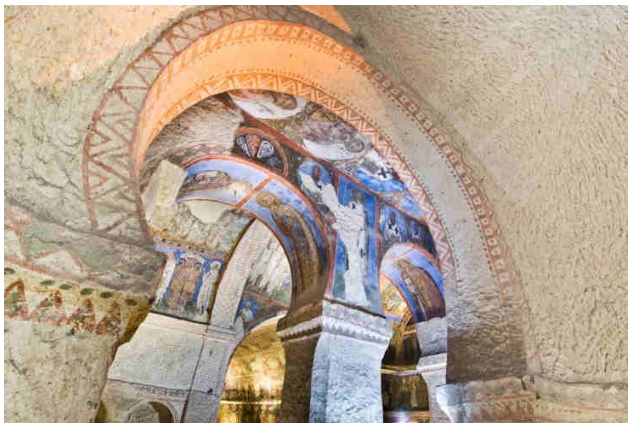

Figure 3: New Tokalı (Göreme 7). Decorative motives in red and green colors (photo Gaetano Alfano)

For the composition of the surfaces, the 'isodome structure' (no. 15) is a common characteristic of eight churches, as is also the 'lattice of lines' in its checkerboard variation. It is interesting to note how the decoration that overlays the rock of New Tokalı (Göreme 7) appears to have drawn on this entire repertory of motifs, except for the 'delineated row of squares on the diagonal' (no.6) and the 'two opposing rows of arches' (no. 13). Other than these more common motifs, the only invention in the Tokalı Church is to have introduced fish-scales (Fig. 2, no. 28) for the composition of surfaces on the naos walls (Fig. 3).

In Figure 2 the attention is concentrated on motifs with little diffusion, and which could be classified as "new". For example, the 'row of intersecting circles' (no. 22) or the variant of the 'row of squares on the diagonal' (no. 23) with a group of three flowers at the centre, are present only in Göreme 12, a church which follows the dictates of painting on plaster rather than those more typical of painting on rock. Again with reference to Figure 2, motif no. 25 is extremely interesting.

The pattern is based on that of motif no. 7, the 'row of adjacent squares', but here, inside every square we find different and varying patterns: delineated parallel lines, hourglass motifs, circles, lattices, etc. This is a singular motif, but not isolated, in that it appears in a group of churches that are very near to one another: Göreme 14 (Aynalı Monastery), Santa Barbara (Göreme 20) (Fig. 4), and Göreme XVII. In these last two churches we see the appearance of another unique and extremely peculiar model: a row of rectangles, with a series of triangles placed on their interior sides (no. 26). Here, the remarkable originality is that the ornament appears to be a stylisation of the cones so characteristic of the Cappadocia landscape [Andaloro 2015] .

3. PAINTING ON ROCK

Together with the elements of formal and iconographic character, the observation of the executive methods and use of materials also results as relevant for the study of the rock-hewn painting at Cappadocia.

In most cases, the red painting thatoverlays the walls of chapels, churches and monasteries appears as a pictorial skin for the architecture, to which it is highly related. This is emphasized by the bearing lines and the forms, but at times it manifests itself as an explosion of motifs that extend to cover all the architectural surfaces, in the manner of a true pictorial system. The technical and formal characteristics are difficult to nucleate in homogeneous groups, and it is also difficult to propose the presence of workshops dedicated to this pictorial phase. In fact often there is the impression of finding oneself confronted by an imprecise, insecure hand, carrying out a duty of completing the architectural plan, without any pictorial intention.

At Cappadocia, rock-hewn painting is a continuous element of long duration. It is primarily red, but it can also be executed with other colours: black, pink, pale red and green. The pigment, diluted in water, sometimes with the addition of an organic binder, adheres to the rock and becomes fixed, thanks to the hardening of the rock itself. This is a simple procedure to painters, but also for artisans of other backgrounds.

The case of the pictorial decoration overlaying the extraordinary rock-hewn architecture of the New Church at Tokalı is entirely exceptional. Here, the architectural surfaces host an ample sampling of decorative motifs executed with paint in red and green colours, flanking each other in an elegant quantitative contrast. Each line is well placed; there are no smears or dribbles; each space is delineated with precision and attention to detail, in a set of motifs traced by brush (Fig. 3). The use of green pigment on rock is also witnessed in churches: Göreme 9, Göreme 14, Göreme 17, Göreme 21c. Instead, the articulated architectural structure of Church no. 17 at Göreme corresponds to a red painting that is only approximate in applying the red lines and in executing the decorative motifs, which are disposed on the walls in inharmonious manner.

For certain churches that share the commonality of the presence of large Maltese crosses inscribed in a *clipeo,* it is possible recognise a sure hand, which masters the tools of work with precision. An example of this would be the Elmalı Church (Göreme 19) in the Göreme Open Air Museum. On the walls of the Elmalı Church, the cross is found within a frame in low arch form, composed of a row of adjacent squares. On the well-smoothed rock surfaces, the arch, the *clypeo* and the cross were drawn using a compass, while the lines of the frame were traced using a snap-line and in freehand, with great accuracy. The coloured fields in the background of the crosses and in the squares are also filled by brush, with expertise, carefully calibrating the quantity of colour necessary to cover the spaces, without going beyond the perimeters or causing dribbles on the walls.

In Church no. 25, although the cross presents variations compared to that painted on the walls of the Elmalı Church, we encounter the same attention in the method of

Figure 4: Church of Santa Barbara (Göreme 20), interior view (photo Gaetano Alfano)

execution. Here the decoration, which is prevalently simple and linear, is organised in the architectural space with a precise rhythm that seems to follow criteria of symmetry. The circumferences are traced with a compass, while a sure hand traces the lines and executes the frames in broken lines (Fig. 1).

In the Church of Santa Barbara (Göreme 20), where we witness a triumph of decorative motifs painted on rock, the execution is entrusted to a lighter hand, engaged primarily in freehand painting of motifs that alternate in homologous, but always diverse decorative sequences (Fig. 4, 5). Here we recognise the strength of the compact, dark red tonality, still well preserved, but the decorative articulation is enriched with elements painted in a lighter red, now weakened and prevalently identifiable in the cupolas. It is again possible to identify the presence of pink or light red pigments in other churches.

In Church 21c, pale red, as well as black in the cross of the counterfacade, is used to emphasise the darker lines that compose the construction of the crosses within ovals of irregular profile. Instead, in the vault of Church IVc (or 32d), the lattice of lines (Fig. 1) alternates in diagonal trend with fields in rock, pink and red colour. In Church IVb, on the other hand, the frame in motif of parallel broken line (Fig. 1) is composed of pink lines with red lines; in addition, in the corbels of the cupola, a pink field fills the circular elements painted in the border.

The execution of the red motifs painted in the Church of San Basilio (Göreme 18) is less certain, with the work overlaying a coarse surface, poorly adapted to accepting the painting.

The execution of the red motifs painted in the Church of San Basilio (Göreme 18) is less certain, with the work overlaying a coarse surface, poorly adapted to accepting the painting. Here there is evident incoherence in the sequence of decorative motifs, executed with rapid freehand stroke, with a brush soaked in liquid colour, inexpertly guided in drawing the frames with rows of arches in the nave, and the lattice of diagonal lines (Fig. 2) of the under-arches.

In spite of the diverse aesthetic results, the execution of this painting on rock requires precise planning and timing of execution, including the use of scaffolding or ladders to reach the greater heights of the cupolas and walls. Overall, it can happen that we find incomplete paintings – such as the cross on the south wall of the Elmalı Church, lacking the red fields; or the pinnacles barely sketched on the counterfacade of the Church of Santa Barbara (Fig. 4) – and also brusk changes in the decorative motifs, such as in the frames of the Church of San Daniele (Göreme 10). This aspect appears in favour of an operational overlap between the artisans involved in the excavation and those who paint on the rock.

At times, the symbiotic relationship between painting and rock even leads to emphasising the defects of an imperfect support, such in the Göreme Church 10a, where the inclusions of harder rock, which are shaped by the action of the excavator, are painted with animal subjects.

A change in approach occurs in those churches where the ornamental decoration is applied on a layer of white preparation which follows the architectural profiles of the excavated spaces. Church no. 12 at Göreme shows an articulated decoration with decorative motifs and crosses painted in red and green on a thin layer of white plaster, applied on the profiles of the cornices, the borders of the niches, and the corbels of the cupolas. This preparation was not necessary to the method of execution, but assumes a chromatic value: the palette is enriched by the white and the rock becomes the singular support hosting the painted decoration (the same procedure is used in the Church n. XXXII). In the spaces of Church VIc, a niche in “cones” form and a rectangular niche are also profiled with white plaster and red painting, while in Church no. 27, the arcosolium of a tomb is outlined with plaster and frame in alternate squares. Where the painting is directly on the rock, the elements added in subsequent stages are less evident. However it is precisely the facility of painting on rock that makes it possible that there would be additions over the course of time, distinguishable on the formal level and for use of different pigments.

4. BETWEEN DEVOTION AND MAGIC. SOME POSSIBLE FUNCTIONS AND MEANINGS OF THE RED PAINTINGS

Among the many motifs included in the red paintings which are the object of the current research we wish to focus here on some pictures of animals (Fig. 6), since they seem to offer particularly interesting insights about the beliefs, attitudes and customs of the faithful who contemplated these paintings in the Byzantine period.

According to Henry Maguire and Eunice Dauterman Maguire, around the 7th and the 8th centuries a fundamental change took place in the Byzantine responses to images of animals and animal violence. The Byzantine beholders considered primarily such pictures not as symbols of Christian concepts, as in the Early Christian

age, but in a magical sense, as talismans embodying unseen powers [Dauterman Maguire & Maguire 2007]. We believe that the animals included in Cappadocian red pictorial decorations should be considered within this horizon. It would be interesting to consider in this perspective also the graffiti included in several Cappadocian churches, although they represent different kinds of animals [Thierry 1994; Xenaki 2015].

First of all, for the connections with the magic-apotropaic sphere, the figure of a ferocious dog, with the open mouth seems particularly relevant. We can see it in the chapel of saint Daniel (Goreme n. 10) [De Jerphanion 1925-42; Jolivet-Lévy 2015b], in the tympanum of the west wall, close to a cross, and in the church n. 33a, where it is flanked by a bird [Jolivet-Lévy 2015b]. Both these churches have been assigned to the 11th century. Catherine Jolivet-Lévy has suggested that this fierce dog can be identified with the λάβραξ κύων mentioned in some magic amulets dating back to the Late Antique or Early Byzantine age [2015b]. In the inscriptions engraved in such gems the dog is attributed the role, together with other figures (Sisinnius, Sisinnia, Salomon or some angels) of keeping away a female demon named Abyzou, on behalf of the sons or daughters of the person who sponsored the amulet. Quite often we can see on similar objects a holy rider saint who is piercing with his spear a female figure lying on the ground [Barb 1972; Robert 1981; Spier 1993; Patera 2006-2007].

The origins of this belief are probably to be found in the Testament of Solomon, an un-canonical writing of the first centuries of Christianity. In this text King Solomon subdues several demons, thanks to a magic seal which he has received from God. Among these demons there is Obyzouth, a female demon defeated by the Archangel Raphael [PG 122, 1333-1336; Mc Cown 1922]. In other versions of the story the punisher-avenger is not Salomon, but saint Sisinnios, whose hagiographic legend was formed since the 4th or the 5th centuries [Thierry 1999; Patera 2006- 2007]. A fresco in the monastery of Bawit, dating back to the 6th or the 7th century, showed him in the act of piercing a female demonic figure named Alabasdria [Clédat 1906].

Despite the different names, the female demon defeated by Sisinnios, Solomon or one of the archangels can be identified with Gylou, a demon who was considered responsible for the death of infants or for damages inflicted to pregnant women [Patera 2006-2007]. In the Byzantine age the belief in Gylou and in the Geludes became very popular. The Geludes were not demons but real women who, as Gylou, were considered capable of passing through walls and closed doors with the aim of harming pregnant women and infants. Evidence about such beliefs is provided by some Byzantine sources, like the Life of Tarasius by Ignatius Deacon (9th century) and Michael Psellos (11th century) [Efthymiadis 1998; O'Meara 1989; Patera 2006-2007].

Figure 5: Church of Santa Barbara (Göreme 20), particular of animals (photo Gaetano Alfano)

As shown by the studies of Maria Patera, such beliefs had a long life also in the post Byzantine age [Patera 2006-2007; Patera 2015].

Coming back to our red pictorial decorations, the connection between the λάβραξ κύων and the necessity to keep away demons who were particularly dangerous for babies seems stimulating, if we consider that in many churches and chapels of Cappadocia, and also in the chapel of saint Daniel, we can find small size tombs, probably to be referred to children.

Jolivet Levy has suggested that the λάβραξ κύων possibly had an apotropaic meaning not only for the living faithful, but also for the dead ones, especially in the church 33a, which hosts a noteworthy tomb [Jolivet-Lévy 2015b].

However this could be true also for the chapel of saint Daniel, which appears characterized by a strong funerary function. In connection with the λάβραξ κύων and the intention to keep away demons it is also interesting to remember that the chapel of saint Daniel hosts two panels with the vision of saint Procopius in the southern and western walls of the naos [De Jerphanion 1925-1942; Jolivet- Lévy 2015b] .

These paintings can be referred to the middle or late 11th century, on the basis of the stylistic affinities with the so called "Ylanlı group" in the Göreme Open Air Museum [Wharton Epstein 1975], and are probably a bit later than the dog and the other red decorations on the rock which we can see inside the chapel.

However, as we have seen before, holy riders were attributed a main role in defeating female demons who harmed children. Therefore it seems likely that contemporary beholders could catch this connection. Furthermore Sisinnios was very popular in Cappadocia, as attested by several pictorial decorations [Jolivet-Lévy 1991; Jolivet-Lévy 2015b]. The proximity between the dog and the cross also strengthens the apotropaic character of the decoration.

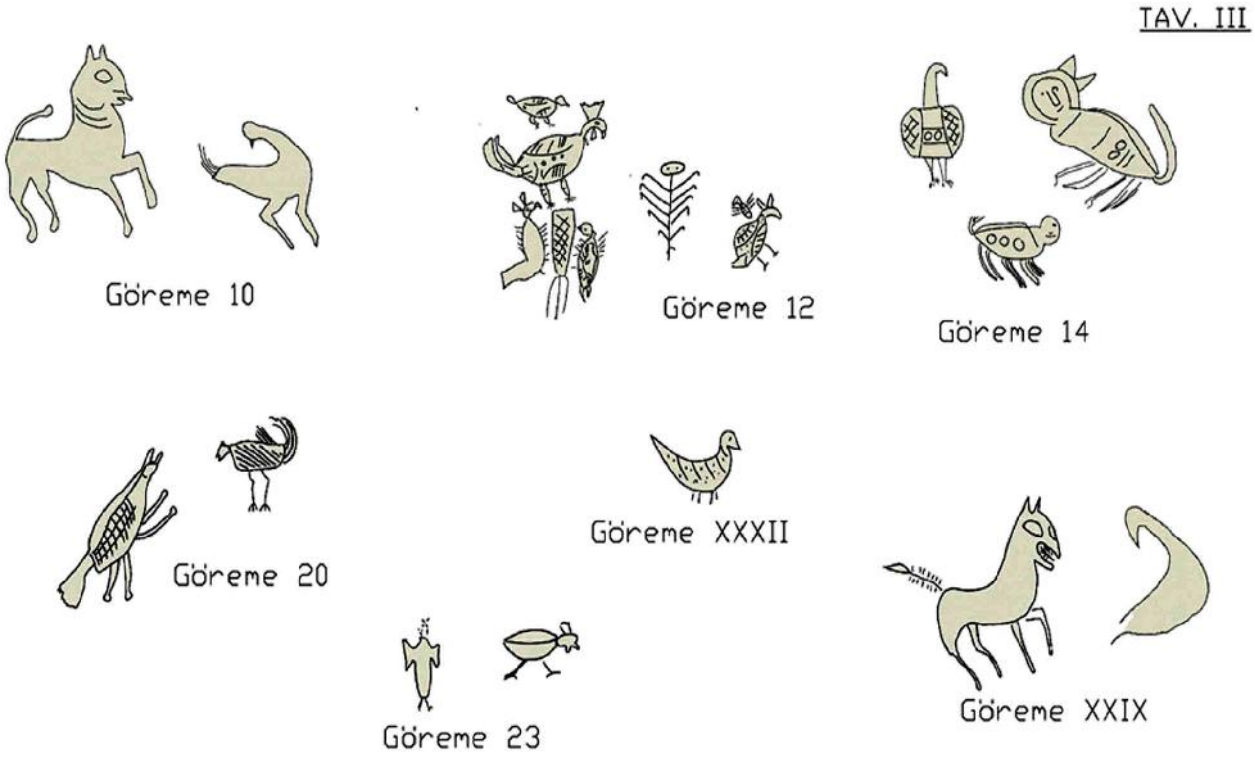

Figure 6: Repertory of animals and insects (drawing Valeria Valentini)

Besides dogs, among the animals that we have met there are noteworthy depictions of insects in some red paintings which plausibly date back to the 11th century.

In most cases it is not possible to identify them with certainty, both because of the extreme schematic nature - sometimes even roughness - of the representation - and because of the combination of elements belonging to different animals or living beings. Quite often what we can see are fantastic creatures, which were probably related to a magic-esoteric or apotropaic dimension.

Emblematic in this regard is the most famous example of Cappadocian red painting, that is, the pictorial decoration of the church of saint Barbara inside the Göreme Open Air Museum (Fig. 4-5). Besides to crosses and decorative motifs, it includes an enigmatic representation with a cock and a fantastic creature - similar to a turtle according to Jolivet Levy - flanking a cross [Jolivet-Lévy 1991; Thierry 2002; Jolivet-Lévy 2015].

However, we could also mention other cases. In the church Göreme 12 [Jolivet-Lévy 2015b], in one of the pendentives of the dome, two insects flank a vegetal element, above which there is a rooster. A small bird - probably a chick- is depicted close to the cock. It could be assumed that the two insects are trying to climb on the plant in order to reach the cock and the chick and attack them. It is not possible to identify the bugs in a more accurate way; however the many small legs of both and the ears of the one on the left side suggest that they are insects. A worm is visible on the same pendentive, a schematic millipede in another one. In Göreme 12 we can also recognize another insect, accompanied by a smaller and flying one, perhaps a bee.

In the complex of Aynali (Goreme 14) [Rodley 1985; Wallace 1991, II.3; Jolivet-Lévy 2015b] an insect similar to a ladybug and another one with ears and a long tail are visible. The last one could be a beetle, but a certain identification is not possible. However, its human head makes us think of a fantastic animal rather than of an accurate reproduction of a specific species.

Insects are not very common among the animals depicted - generally with a symbolic meaning - since the first centuries of Christianity. However, Church Fathers and later Christian authors did not miss to pay attention to them. In the Early Christian Age and up to the Iconoclastic era the natural world was celebrated in many sermons and commentaries devoted to *Hexaemeron*, the six days during which God created the world. A common assumption in such works is that the beauty and marvels of the created world reflects by analogy the greatness of God the Creator [Maguire 1987b; Maguire 2002; Maguire 2012].

Within this context a noteworthy although not preponderant place is given to the insects.

Basil of Caesarea, in the first sermon on the *Hexameron*, observes that "Compared to their maker, the sun and the moon are like an insect and an ant" [Giet 1949; Maguire 1987b]. In the eighth homily of the same commentary, devoted to terrestrial life, he provides a description of birds and insects [Giet 1949; Maguire 1987]. Gregory of Nazianzus, in his Second Theological Oration, provides a celebration of the creation which sounds similar to the commentaries on the *Hexaemeron*. The sermon includes a famous *ekphrasis* of the peacock, but at the same time pays attention also to the insects, like bees, spiders and ants [Gallay, Jourion 1978; Maguire 1987b; Maguire 2012]. Some centuries later George of Pisidia offers in his poem on the *Hexaemeron* a similar *ekphrasis* of the splendors of the peacock, but he also describes the locust and its destructive swarms [PG 92; Maguire 1987b; Maguire 2012].

Besides textual mentions and *ekphraseis*, we should also remember visual evidence. In a famous ivory diptych preserved in Florence and depicting Adam giving names to the animals while he is in Paradise we can see a locust just above the source of the four rivers at the bottom of the panel. In a marble relief from the church of the Acheiropoietos in Thessaloniki, dating back to the 5th or the 6th century, a vine scroll hosts several bees, birds and a snail [Maguire 1987a; Maguire 2012].

However, as highlighted by Maguire, after Iconoclasm there was a considerable decrease of interest in the tradition of the *Hexaemeron* [Maguire 2012]. Furthermore, our red representations seem too schematic to suit the intent of celebrating the beauty of creation. In most cases they do not even allow to identify the species with certainty, although we must remember that this identification was sometimes not possible in the scientific manuscripts either, as observed by Leslie Brubaker about the images of animals that illustrate Nicander's *Theriaca* in the Dioscorides of Vienna [Brubaker 2002]. A later and famous version of the *Theriaca* of Nicander produced in Constantinople in the Macedonian age also includes pictures of scorpions, animals and plants [Kádár 1978; Touwaide 1998].

Coming back to our red paintings, it is more likely that they are to be connected to a magic-apotropaic function. We could suggest the necessity to protect fields and agricultural activities. It is worthy to remember that the *Geoponika*, a compendium on agriculture compiled from ancient writings, assembled in the 10th century under the auspices of Constantine VII, included chapters on the following topics: "To avoid insects and birds"; "To avoid worms" [Rodgers 2002]. We can also notice that in the Cappadocian red paintings insects are often accompanied by flying animals, especially poultry, as in the church Göreme 12 [Jolivet-Lévy 2015b]. Such an element gives credit to the idea that these signs are related to the every day life of a rural area. Furthermore, the Byzantine *Euchologion* includes many prayers for problems concerning fields, gardens, vineyards, animal health and fecundity [De Meester 1930; Safran 2005]. A special role in protecting fields and vineyards from the damages produced by animals was attributed to saint Tryphon, who was very popular in Cappadocia, as attested by several pictorial representations [Jolivet-Lévy 1991; Jolivet-Lévy 2015b]. According to the hagiographic narrative, Tryphon was a guardian of geese who was given the power to cast out demons and cure diseases. For this reason he is associated to the Anargyroi in some paintings [[Jolivet-Lévy 1991; Safran 2005]. The *Euchologion* contains a text exceptional for its length and content, "The exorcism of saint Tryphon". It includes some prayers in which the wonderworker Tryphon speaks in the first person about the destruction of plants and crops in his neighborhood and an exorcism which mentions seventeen reptiles and other animals which used to damage plants, gardens and vineyards [De Meester 1930; Safran 2005].

We intend to further investigate these and other elements of the red paintings on the rock in future research.

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Hypogea with niches of southern Apulia
Examples of rural economy in medieval cave settlements of Salento

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Abstract
The remarkable phenomenon of cave living represents a housing trend found in many regions of southern Italy, with significant cultural links with other countries of the Mediterranean basin. In Salento (southern Apulia) there are cave settlements of different types, ranging from simple and limited settlements composed of few small caves, to churches-crypts or even wide cave villages characterized by some elements related to *sub-divo* settlements. Cave settlements of Salento developed with significant cultural expressions that can be seen both in the area of Serre Salentine (the western part of Salento) and in eastern areas. Some of these artificial undergrounds and cavities are characterized by a specific shape, while the presence of elements, such as cells and niches, allows to exclude a strictly residential use and to recognize productive or cultural purposes. A campaign of exploratory survey for the study of several cave settlements of southern Apulia has allowed us to deepen the knowledge on underground productive sites, such as dovecotes (*colombai*), exploited for doves breeding, an activity frequently practiced in medieval Apulia.

Keywords
Cave settlements, rock settlements, rupestrian settlements, hypogea with niches, dovecote, *columbarium*, Apulia, Salento.

1. INTRODUCTION
Cave settlements phenomenon is well attested in Apulia region (Fiore et al., 2012) and throughout southern Italy, with significant cultural connection with different areas of the Mediterranean basin also.

This topic is studied since the seventies, and the context of medieval rock settlements of southern Salento (southern Apulia) is known mainly thanks to the work by Cosimo Damiano Fonseca.

He was one of the first to set his research on the recognition of villages and cave settlement systems, before that time the scientific interest on this topic was focused on the analysis of the cave churches, considered substantial in terms of art and architecture, that were the subject of studies based on an extremely generic academic orientation that, starting from the end of the nineteenth century, saw the spread of "*panmonastica*" vision.

According to this view, all Byzantine art manifestations in rock environment were nothing more than the cultural expression of Italian-Greek monks, arrived in Italy during the iconoclastic persecution. Therefore, all the caves and hypogea found were considered uniquely as hermit crypts and monastic settlements, starting calling them with the wrong definition "Basilian" [Gabrieli, 1936; Medea, 1939].

In the 1960s and 1970s studies the attention moved from the religious to the civilian sphere, starting to talk about civil rock-cut settlements, demonstrating how these were the expression of a population trend, not only linked to the monastic phenomenon (Fonseca, 1970, 1975). Despite the significant achievements, the studies on these rock-cut settlements are not yet supported by systematic topographical and archaeological investigations. For this reason it has started an analytical study that allowed to analyze some hypogeum and artificial cavities forming part of rupestrian living systems scattered throughout the southern Salento [Fonseca et al., 1979; Sammarco & Parise, 2011; Calò, 2015a, b]. The analysis relates to hypogea with niches whose use has had different meanings; in the examples treated it refers primarily to the use of these sites as places for breeding of pigeons, a rural activity widely practiced in southern Apulia during the Middle Ages, characterized by distinctive architectural elements including small cells or niches. What has been done is a comparative analysis between the different case studies, with the intention, on the basis of the obtained data, to clarify the interpretation and intended use of unpublished and published undergrounds so far misunderstood and not properly contextualized.

2. *COLUMBARIA*: AMBIGUITY OF MEANING
For a long time it was considered that the presence of cells in undergrounds was a prerogative of the funeral sphere. The presence of niches or cells within funerary undergrounds, the so-called *columbaria*, was a peculiarity that characterized the culture of ancient Rome, where there was the habit to put cinerary urns inside small dedicated niches.

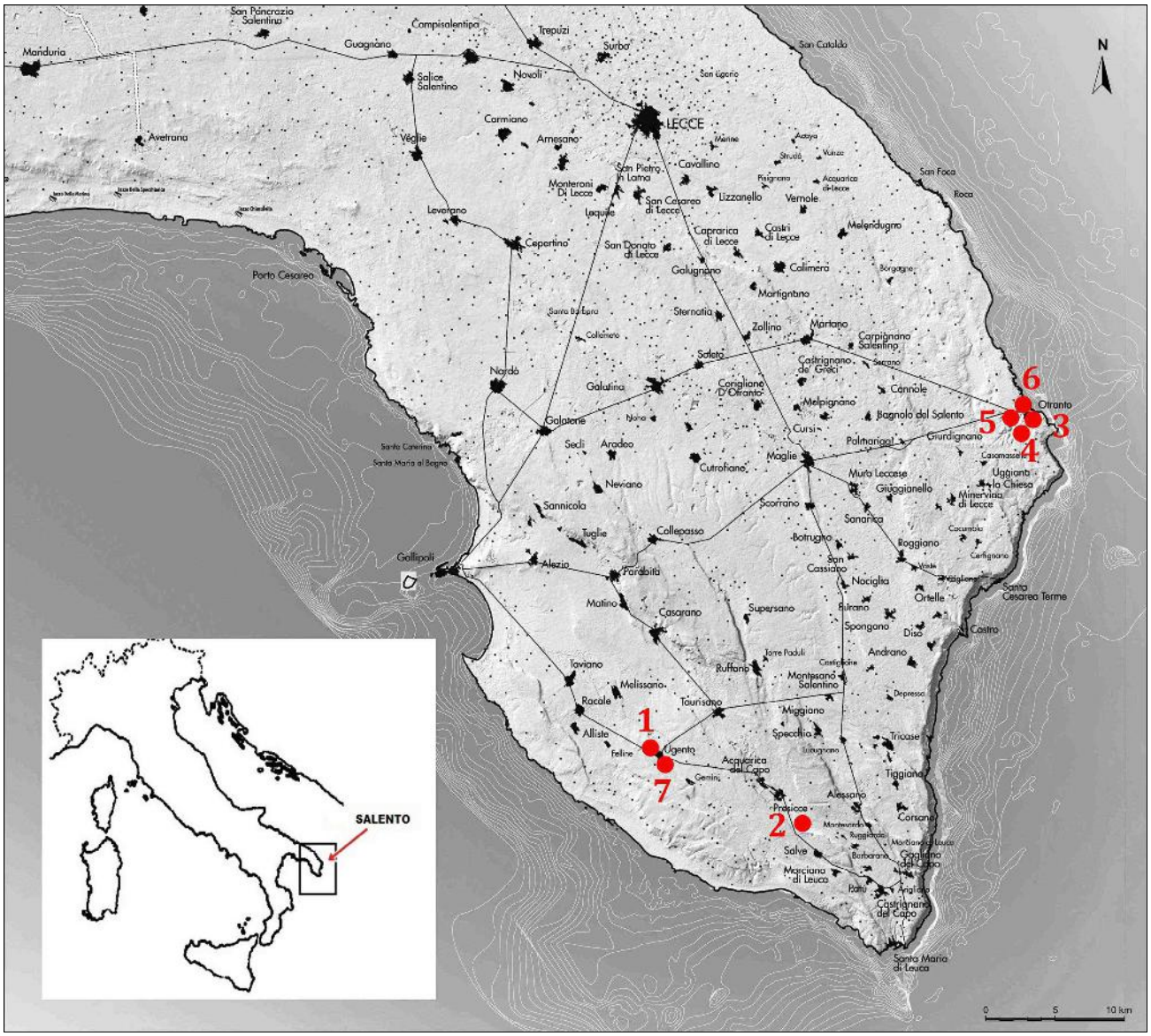

Figure 1: Salento, distribution map of underground sites studied

The first *columbarium* dates back to the Augustan and Tiberian age. This type of tombs, located outside the *pomerium* along the consular roads, were built using the opus *reticulatum* masonry technique and embellished with stucco, columns, slabs of marble or niches. Generally they were associated with a funeral guild or representatives of important families.

The term *columbarium*, from Latin [De Ruggero, 1985; Pastura, 2013], indicates the cell or niche that, from the second century B.C. until the Christian period, it was created specifically to contain one or more cinerary urns; this definition, with time, began to be used to indicate the entire monument. The Italian term *colombaio* or *colombaia* (dovecote) is instead used to define a place, characterized by small cells as well, used for the breeding of pigeons. The typological affinity of these structures has justified the use of the Latin term for the definition of the underground funerary buildings also. This is the reason why often dovecotes, whose purpose was the breeding of pigeons, were confused with funerary columbaria, not considering the fact that despite their conformation is quite similar, their use corresponded to completely different scopes.

3. DOVECOTES AND BREEDING OF DOVES

In Italy the practice of breeding pigeons is well-attested since ancient classical times [Pastura, 2013]. We do not know the time when this practice began to spread, some Mycenaean evidences suggest their existence even in previous eras [Rossi, 2012].

Dovecotes are mentioned in the treaties on agriculture by Columella and Pliny (Columella, 1997; Varro) , where both authors emphasize the breeding of pigeons not only for feed purpose, but also for the production of "*palombino*", an extraordinary fertilizer product, get from excreta of these birds.

The meat of pigeons, popular for its high nutritional value, was available throughout the year (the mating period of the pigeons is three to six times a year), and the material obtained was often the only fertilizer available to increase agricultural production. For these reasons, this type of farming lasted from antiquity until modern times.

During the medieval period, in Italy, the phenomenon of the construction of dovecotes came primarily concerning the built structures, named *sub divo*, than those excavated, and in the seventeenth century they reached the maximum level.

The Middle Ages was also the period in which the rupestrian living phenomenon grew strongly, and the spread of rock-cut settlements made these structures, essential elements of the rural economy of the time, carved into the rock also.

Rock-cut dovecotes are well attested in the whole central Italy; in Lazio region, for example, are preserved underground structures with a complex articulation [Desiderio, 2008; Pastura, 2013].

In southern Apulia, and more specifically in Salento, breeding pigeons activity in cave settlement contexts is well represented. But it is necessary to make an historical clarification.

During the transition from Early to Late Middle Ages, in this area grew a lot of noble and ecclesiastic rights on uncultivated land and forests, due to increasing economic growth and a significant population increase.
This restricted the hunting and fishing activities of the local population, that started breeding pigeons in order to be able to eat meat.

From the studies carried out so far, rock dovecotes have been found in several cave settlements, especially in the northern part of Salento, for example in the area of Taranto, in the *gravine*, where there are very articulated underground complexes, and rock villages of Laterza, Castellaneta, Crispiano, Grottaglie and Massafra [Caprara, 2001; Fornaro et al., 2008], where can be found many dovecotes of considerable size.

In southern Salento and Lecce area, there are few known examples of rock or underground dovecotes, since the phenomenon seems to affect mainly those built.

These buildings are characterized by a tower structure and are scattered in various rural settings [Rossi, 2012].

Figure 2: Cave of Polyphemus, Ugento. View of the main room

4. CASES STUDIES

The survey was focused on the analysis of seven undergrounds with niches (Fig. 1) of southern Salento. These hypogea have different characteristics, and six different types of dovecotes and an apiary can be identified. The analysis of the context in which these structures are located and the study of their characteristics have allowed, in some cases, to propose tentative dating.

4.1 Case study no. 1 - "Cave of Polyphemus" in the rock village of Ugento

The cave is located in the medieval rock village of the city of Ugento [Fonseca et al., 1979; Calò, 2015a]. It was carved into the rock to host a dovecote. The entire complex currently consists of sixteen rock units, divided into two main parts; the Cave of Polyphemus is the characterizing element of one of them. The hypogeum is located within a huge rocky ridge, characterized by the presence of six more cavities used for residential purposes.

The underground structure has two rooms, the larger one being characterized by an elongated oval about 10 meters long and 4 meters wide. It has a vaulted ceiling with a large opening that inspired the name of the cavity [Calò, 2015a]. The walls are characterized by a series of small cells - they abundantly exceed one hundred elements - of quadrangular or circular shape, used as nests. The niches occupy almost all the space available on the walls, and in some points they come to lap the ceiling (Figs. 2, 3, 4).

The present floor, filled with terrain and debris, does not correspond to the original. In some points, at the actual floor level, it can be noticed the presence on the rock walls of traces of a whitish coating similar to plaster; in addition, the terrain that covers some lower niches hints at the continuation of the walls. In correspondence of the innermost long wall, at the base of the walls, two openings that appear to be excavated deposits, can be observed. On the same wall a rectangular entrance opens, leading into a very short corridor, connected to a small chamber with vaulted ceiling. At the end of the corridor there is a second entrance, probably the secondary one, which allows to reach the opposite side of the rocky ridge. The whole cave settlement is dated to the Middle Ages by the studies conducted to date, but it is believed that it will also have been used in the late Roman period [Lavermicocca, 1972; Fonseca et al., 1979].

4.2 Case study no. 2 - The Hypogeum of Spiggiano, Presicce

In the heart of southern *Salento* there is a type of underground dovecote whose particularity (one of the few known cases in which the dug part of the structure is directly linked to the dovecote tower) is found only in a second case, the hypogeum Torre Pinta in Otranto, described below. The hypogeum of Spiggiano (Presicce), whose name comes from the farm nearby, arose in an archaeological context dating from Roman times to the modern age.

Figure 3: Cave of Polyphemus, Ugento. View of the main room

Figure 4: Cave of Polyphemus, Ugento. Cave sections, graphic restitution of ortho (photo E. Santucci)

The structure is divided into two parts, the first one is underground and the second one was build up as a circular tower; the two portions were built in different times. The hypogeum is characterized by a trapezoidal shape, of about 5 to 4.30 meters, with entrance carved in the rock, consisting of a few steps. The recesses on the walls are made of parallel rows and appear to occupy all the available space; even though they have almost the same size (the average is 25 cm wide, 30 to 50 cm high and 25 cm deep) their shape is not always regular: there are niches of quadrangular, circular and arched shape, some of them have a trapezoidal section, others have a quadrangular or circular section (Fig. 5).

Some of these niches seem made at different times than the original excavation, a sign that this structure probably had a very prolonged use in time. On most of the walls surface there is the presence of what appears as a layer of plaster, used as a coating (now preserved only outside the cells).

Figure 5: Dovecote of Spiggiano, Presicce. Detail of niches of the underground room

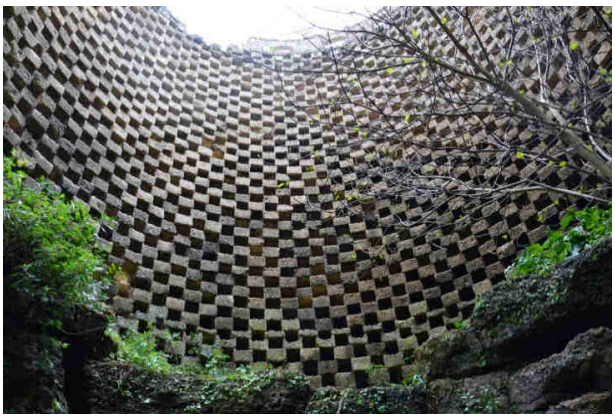

Figure 6: Dovecote of Spiggiano, Presicce. Sixteenth-century *sub-divo* tower

The current appearance of the hypogeum is not the original; the North side of the rock is completely covered with cells made of tuff blocks. The collapse of a part of them has revealed the presence of a large recess in the rock, which was closed and hidden by the construction of the wall; today it is hard to define if this cavity had a practical purpose. The wall with the cells made of blocks is certainly contemporary to the circular tower dating from the late sixteenth century, made with the same technique and placed above the underground part (Fig. 6). The only decorative element of this *sub-divo* tower is the upper crowning, preserved in part, characterized by brackets, arches and a cornice. The only access, which connects the interior of the tower with the outside, consists of an opening located at a height of more than four meters from the floor level [Rossi, 2012]; on the inner side of this opening there is a spiral staircase system that, following the circular movement of the tower, goes to join to the entrance steps of the hypogeum.

In addition to the morphological and architectural features of the structure, another characteristic is the context in which it was built. Some investigations made by the authors in the area show the presence of rural settlements, probably dating back to Roman times, in fact, near the dovecote, some burials with rectangular pit, traces of ruts and silos, and a wide area with ceramic fragments were found.

Probably the agricultural purposes of the area were maintained both in the Middle Ages and in the modern age, period in which the construction of the dovecote tower could had been realized.

The underground structure, which surely was used during the Middle Ages, may be older, and represent a part of the Roman phase of the settlement; in support of this hypothesis is the presence of the plaster coating on the walls (element described by Columella, who says that it was used to make the dovecotes walls slippery and less attractive to predators), and some *sigillata* ceramic fragments identified inside the hypogeum. It is uncertain if the underground dovecote was frequented continuously from Roman times to the Middle Ages, certainly in the modern age the structure exploitation has intensified, thanks to the construction of the circular tower. This structure is part of the architectural types that can be found in Salento, that are dated between the fourteenth and eighteenth centuries [Rossi, 2012].

4.3 Case study no. 3 - The hypogeum of Torre Pinta in 'Valle delle Memorie', Otranto

Before describing this type of underground dovecote is useful to specify that it is located in a complex and detailed cave settlement system, a rupestrian village characterized by various artificial cavities used not only for residential purpose, but also used as locations for rural and worship activities.

The cave village of Otranto is one of the largest in southern Salento; it was inhabited in the Middle Ages and even in later stages, and includes two valleys, the 'Valle delle Memorie' (Valley of Memories) and the Idro Valley, which characterize the territories in the south of the city [Calò, 2015a]. The underground dovecote is located in the heart of the 'Valle delle Memorie'. It appears to be unique among those investigated, and its plan and characteristics have generated numerous interpretations. The hypogeum, which probably has been used for more purposes across decades, is composed of a long corridor with vaulted ceiling, often referred as *dromos*, about 30 m long. It leads into a circular room connected to three barrel-vaulted rooms equipped with a short staircase at the entrance (Fig. 7).

Along the perimeter of the circular room and along the corridor there is a continuous step used as a seat; the walls of all the rooms and the *dromos* are characterized by quadrangular niches (probably already existing at the time when the original structure was built), that were used as niches for the breeding of pigeons (Fig. 8).

The hypogeum shows many traces of excavation and restoration works at the time of construction of the tower, made of masonry with triangular battlements, dating back approximately to the Modern Age [Fonseca et al., 1979].

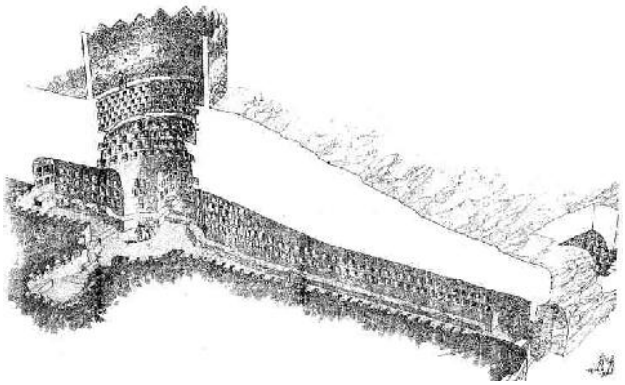

Figure 7: Hypogeum of Torre Pinta, Otranto. Isometric split (after Cazzato et al., 2007)

Figure 8: Torre Pinta, Otranto. *Dromos*

Figure 9: Torre Pinta, Otranto. Circular tower

The tower was implanted on the roof of the structure - now absent, probably it was a barrel vault - on the central room (Fig. 9). The small niches on the walls, more than six-hundred, are holes measuring roughly 35 x 60 x 25 cm each, some of them being arch-shaped. Inside, there is evidence of further modifications which allow to distinguish the room walls from the corridor walls. The overall shape of the structure is obviously linked to its original function which, according to different hypotheses, could have been either funerary or cultural. The latter is supported by those experts who considered this hypogeum as "a pre-Christian structure initially used as a funerary area and then transformed into a religious one during the Constantine Age by the first Christian communities" [Antonaci, 1974, p. 124]. However, no evidence inside the building confirms this hypothesis and it is even likely that it was built at a later stage.

The presence of other structures, some of them underground, could be the evidence of a change of function of the hypogeum and its surrounding area (it is difficult to define whether these elements date back to the same period). A first ruined structure seem to testify the presence of another rounded columbarium, perhaps incomplete, which is horizontally truncated at one meter from the ground, has a 4 m diameter, and is enriched with some rectangular niches on the internal walls [Bernardini, 1957; Fonseca et al., 1979]. The second building, located west of the hypogeum, is a one-room cave with vaulted walls and blocks of stone placed near the entrance and on top of it, which is almost impossible to access. It was probably used to store snow underground [Calò, 2015a].

4.4 Case study no. 4 - Another underground dovecote in the 'Valle delle Memorie', Otranto

Along the western side of the rock-cut settlement of the 'Valle delle Memorie', not far from Torre Pinta, is it visible another underground structure with cells. It is dug along the rocky ridge of a terrace and is characterized by a single, small rectangular entrance (about 1.50 m high). Inside there are many niches, extremely worn and damaged but still recognizable, arranged in four parallel rows on both sides (Fig. 10). The hypogeum is in a state of degradation: on the bottom and side walls heavy tampering actions appear, they caused the destruction of many of the present cells (those on the left wall have been almost totally deleted). These interventions deeply altered the original appearance and shape of the hypogeum. In this structure we find the typical elements of a dovecote: in addition to the cells of fairly regular shape, there is a deep horizontal cut in the rock, placed between the floor and the bottom of the first row of niches. This element is frequently found in underground dovecotes and its purpose was to make inaccessible the nests to predators. This solution, in most cases, was characterized by a smoothing of the walls' surface. The hypogeum is part of one of the largest rock settlements of southern Salento, which includes 46 unities of different functions (residential, warehouses, service areas, etc.). It is traditionally dated to the Middle Ages, however in this area numerous pottery fragments were found, with high concentration of African *sigillata* pottery, and fragments of amphora of *Late Roman 1* type, dating back to the IV-V century A.D. It cannot be excluded that some hypogea have already been used in Late Roman time such as ceramics findings seem to demonstrate. Unfortunately, the information available, in the absence of a systematic excavation, do not allow to clarify this aspect.

Figure 10: Dovecote in the 'Valle delle Memorie', Otranto

Figure 11: Wall dovecote in the Idro Valley, Otranto

4.5 Case study no. 5 - A wall dovecote in the Idro Valley, Otranto

This dovecote, located in the Idro Valley, is part of the rock-cut village of Otranto. According to its characteristics it is possible to introduce a specific type of dovecote, defined 'wall dovecote'. The structure is a vertical rock wall of about 5 meters height, with six parallel rows of niches dug on its surface (Fig. 11). On the right side of the wall there is the entrance of the cave settlement to which the dovecote belongs. The interior space consists of two rooms, which probably could accommodate a single family unit; the presence of the dovecote was probably designed to meet the needs of the occupants.

The niches, whose dimensions are 13-14 cm long, 18-20 cm height and 20 cm deep, are characterized by a triangular cross section with inclined base inwards. This solution had the function of preventing the eggs from falling accidentally from the niches. In this case also (see case study no. 4) the cells were made at a certain distance from the floor to protect pigeons against the attacks of predators [Pastura, 2013].

4.6 Case study no. 6 - Hypogeum of Masseria Santa Barbara, Otranto

The underground dovecote of 'Masseria Santa Barbara', located in the Idro Valley, is comparable with the hypogea of Torre Pinta and Spiggiano (case studies no. 2 and no. 3). The hypogeum is characterized by two adjoining circular rooms (Fig. 12), and an access corridor formed by squared juxtaposed lithic blocks, covered by a gabled vault (Fig. 13). On some of these blocks can be observed recently made graffiti among which is the date '1945'. On the surface of all the internal walls there are niches of about 20-30 cm long, 15-20 cm height and 15-20 cm deep. The first room seems to be characterized by some tampering, on the side of the NW wall there is a large rectangular recess on the bedrock, now filled with earth (Fig. 14).

The second room is characterized by a large niche in the NW wall, on the opposite side there is an opening towards the outside, currently blocked by the filling material which has altered the original floor level.

The observation of the cells in the two rooms made it possible to identify some differences. The niches of the first room have a regular pattern, have similar size and are placed along parallel rows.

In the second room, the provision of the niches appears less regular, and some of them have an arc shape, but the excavation technique of this portion seems more accurate. Probably the second room is the result of a subsequent expansion, as well as the rectangular recess located in the NW wall of the first room, which is a later work. This confirms the re-use of the hypogeum over time: probably, first as a dovecote, then as a deposit.

5. APIARY AND BREEDING OF BEES

The cases presented so far concern hypogea with niches related to rural activities, destined specifically to the breeding of pigeons. The last case presented introduces a new type of hypogeum, which has similar characteristics to those described above but whose purpose was the breeding of bees. Beekeeping is an activity known since ancient times for the production of honey and natural wax [Lionetti et al., 2015]. Initially it is likely that for this purpose were used hollow logs placed in niches carved into the rock, and only later baskets or wooden boxes. The beekeeping featured many rock settlements of Apulia and often the size of certain complexes, such as the 'Grotta del Miele' or the 'Grotta delle Navi' in Massafra (Taranto province), shows that the production of honey and wax was linked to a significant business activity [Caprara 2001; Fornaro et al., 2008]. From a morphological point of view the niches of dovecotes and those of rock hives have many similarities.

5.1 Case study no. 7 - An apiary in the rock village of Ugento

The last case study is in the rock village of Ugento. It is located at the base of a rocky ridge and it is characterized by a narrow rectangular plan of approximately 1.40 x 5.00 meters, with a slightly pitched roof made of blocks. Inside, along the SW wall there are 60 niches arranged in five horizontal rows, then coated with plaster. On the same wall above the niches and in correspondence of the entrance wall there are two small openings for the lighting and

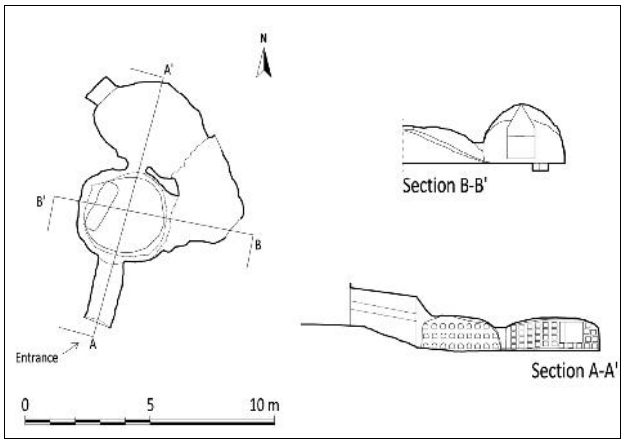

Figure 12: Hypogeum of Santa Barbara, Otranto. Survey by M. Martellotta, Speleological Group 'Ndronico, Lecce

Figure 13: Hypogeum of Santa Barbara, Otranto. Access corridor

Figure 14: Hypogeum of Santa Barbara, Otranto. First room

ventilation of the place (Figs. 15, 16). The niches square-shaped have fairly regular size, 25 cm high and wide, but a particular detail is their depth, which reaches 50 cm, and a small hole of few centimeters on the bottom of the niches. Along the western wall is a rock seat that extends in the second half of the room. Until recent times this structure

Figure 15: Apiary of Ugento, external view

Figure 16: Apiary of Ugento, internal view

has been interpreted as a funerary *columbarium* [Lavermicocca 1972; Fonseca et al., 1979]. As a result of a recent study and survey activity, and making some comparisons, it is now possible to interpret the structure in a new way. Some evident features, such as the good building orientation, the plaster coating inside the cells and especially the holes of about 2-4 cm in diameter places on the bottom of each of them, allow us to hypothesize a purpose related to beekeeping. Rock structures with the same characteristics, that have been identified as apiaries, can be found in medieval rock villages of Apulia, the nearby Basilicata, and Cappadocia [Caprara 2001; Bixio et al., 2002; Lionetti et al., 2015].

The holes, defined *flight holes*, allow the bees to move from the hive, housed in the niches, to the outside environment. Moreover, the exposure to south-west sun, the location protected from the winds and the two windows placed above the entrance and on the niches favored a natural temperature regulation, protecting the environment from thermal excursions and creating optimal conditions for the management of the hives and the production of honey and wax [Bixio et al., 2002]. As a result of the study on this and other cases (case study no. 1) it can be said that the rock settlement of Ugento was characterized by rural activities aimed at production and breeding (for other rock structures in the area see Calò 2015 b).

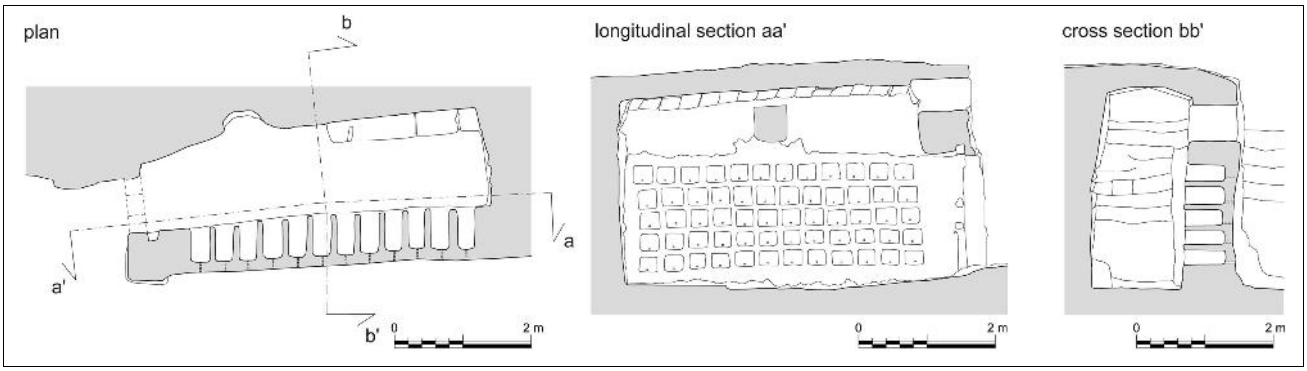

Figure 17: Apiary of Ugento. Survey and graphic restitution of ortho-photo by E. Santucci

Currently there are not certain elements that allow to define whether the structure was originally created as an apiary or whether it was modified for this purpose only in a second phase, as well there are no elements for its dating. Some authors [see Lavermicocca 1972; Fonseca et al., 1979] made the hypothesis that the rock-cut village was already known in the late Roman era.

6. CONCLUSION

The study on the presented hypogea was performed through surface investigations and surveys, that allowed to clarify some issues and provide relevant data on the contextualization of the structures. Regarding the chronology of the sites, it can only be determined after specific archaeological excavations that have never been conducted in the studied hypogeal (the absence of archaeological excavations is a common problem for the majority of the rock settlements of Apulia). The data collected in this survey represent a preliminary analysis and a typological study to understand the context and the structures investigated.

The exploration, the direct observation of the hypogea and the comparison with other similar structures in the Italian territory [see Quilici Gigli 1981; Desire 2008; Pastura 2013; Lionetti et al., 2015] made it possible to clarify the actual rural function of many of them, helping to see their productive purpose and refuting some interpretations that associate the dovecote with niches of Salento exclusively to the funeral field. In detail, hypogea no. 1, 4 and 6 have structural similarities with several cases found in Taranto area and in the Lazio region [see Caprara 2001; Fornaro et al., 2008; Pastura 2013].

Morphological analysis of the underground structures made possible to identify the common characteristics, such as the type of cells and their size. The niches of the case study no. 7 differ from the previous type, they are square in shape and characterized by a considerable depth of over 60 cm (Fig. 17).

This particular feature highlights their different use, certainly not suitable for pigeons breeding and probably destined, as previously explained, for beekeeping.

The investigations carried out so far represent only a starting point in the study of the rock-cut settlements of Salento, to understand the development of this complex phenomenon there is a need for further, detailed studies.

The contribution here presented aims also to rekindle interest in a territory, Salento, rich in history, whose historical and cultural heritage is too often not adequately protected and enhanced.

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8. ACKNOWLEDGMENTS

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Model and experience. Measuring deformations of rupestrian architectures in the area of Goreme

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Abstract
The tufa limestone that characterizes much of Cappadocia is a sensitive material to be shaped both by wind erosion and by man's tools. For centuries these parallel actions have been producing a highly dynamic landscape, which changes in real time and in which what is artificial is hardly distinguishable from what is properly natural. Rock-cut settlements often demonstrate precise spatial and stylistic intentions. Obviously, the constructive precision of these architectures is a function of both specific historical events and inconstant technical skills of the builders. Nevertheless, most of these "full-scale models" referencing to traditional Byzantine architectures in XX century were usually perceived and represented as regular structures by scholars such as Jerphanion, Thierry, and Rodley. The surveys conducted with automatic photogrammetry in recent years have revealed that the most of these rock-cut environments are very irregular shaped. As part of a national research, the authors have participated in the survey and the digital documentation of some monumental sites in Goreme, using primarily laser-scanner and numeric models to produce faithful and incorruptible models of the sites. A further possible application of these models is to relate the true form of rooms with the way people perceive and experience them. This paper presents the results of a geometric study in order to define the range of such deformations compared to supposed regular models behind them and measure the "threshold" of their perception. Even if the sensitiveness to space is largely a cultural inconstant phenomenon, as a corollary, this paper aims at contributing to understanding some of the possible original intents of their builders.

Keywords
Cappadocia, Rock-cut architecture, Digital photogrammetry, Architecture survey, Deformations measure.

1. INTRODUCTION

The territory of central Turkey is the result of volcanic upheaval and subsequent aggression of the weather that gave rise to the formation of a complex and dense network of ravines and debris valleys with specific erosive forms represented by depressions, cavities, towers and pinnacles. Climatic, lithologic, and structural factors perpetuate today such wind, fluvial-atmospheric and thermo-clastic phenomena shaping from outside the malleable calcareous tufa that characterizes much of Cappadocia. Further, the territory has been shaped from the action of excavation and construction accomplished by different human communities that have lived for centuries. These two parallel actions still produce a highly dynamic and changing landscape, in which what is artificial can be hardly distinguished from what is natural.

The Open Air Museum (OAM) in Goreme contains a considerable number of religious settlements, excavated both in the famous cones and within a large steep wall that connects the upper plateau to the lower valley, forming a sort of semi-circular exedra.

This articulated rocky habitat has often developed from pre-existing natural caves, but some architectures prove the existence of precise spatial and stylistic intentions, which over the centuries have suggested typological and stylistic comparisons with the contemporary Byzantine architecture built in the urban centers.

2. SURVEY AND REPRESENTATION OF RUPESTRIAN ARCHITECTURE

As partners in a national research [Andaloro et al., 2015; Bordi et al., 2015], the authors have participated in a major multi-annual program of survey and documentation of OAM's exedra and other rupestrian sites near Goreme. This experience has stimulated a series of reflections in relation to both the survey concept and its application to a specific topic such as rock-cut architecture.

The graphic description of built architecture is processed by means of projections and sections. In the first place, a section plane (horizontal for a plan or vertical for other representations) is placed in order to best describe the elements which are "orthogonal" to it. Then, a selection and

tracing of edges and apparent contours operate a discretization of the objective continuum. This procedure allows to define homogeneous areas ascribable to simple geometrical elements such as planes, ruled surfaces (cylinder, cone) or rotation surfaces (sphere, ellipsoid, etc.); more rarely even complex surfaces, not amenable to Euclidean solid, whose representation has other methodological approaches.

These fundamental semiotics concepts base not only the traditional practice of the survey and representation of architecture, but also a reader's architectural interpretation of the graphic signs. Thus, a thick solid line borders the sectioned part, describing a "physical" boundary between inside and outside (between full and empty), while continuous thin lines display edges and contours of not sectioned elements that are visible in the represented space. This graphical distinction is not sufficient to avoid possible misunderstandings. For example, in some cases the sectioned shape suggests that what is sectioned is also orthogonal to the section plane, like vertical structures in a plan or horizontal floors in a vertical section. In order to avoid these misunderstandings, the oblique elements are used to be either not sectioned or interrupted before being sectioned, as in the case of the stairs in a plan.

The representation of rock-cut architecture addresses at least two specific issues: a structural one; and a formal one.

- From a structural point of view, the caves have no corresponding extrados. The extrados is the natural morphology of the rocky site they are excavated in, whose raw material is almost constant and uniform.

- From the formal standpoint, only the interiors can be perceived. Unlike for traditional built architecture, the surveyor is therefore precluded from any "bird's eye view." The cognitive approach at the architecture is strictly a function of the surveyors' experience by looking at, interpreting and discretizing parts from the whole to know them better and better. The impossibility of looking at it from outside can distort the interpretation flattening it in the overlap between what is known and what can be seen.

These two aspects, the former tied to the representation, and the latter to the form knowledge, make the rock-cut architecture a challenging field to activities such as survey and representation, as testified by the iconography produced by the past scholars.

3. HISTORICAL SURVEYS OF RUPESTRIAN SITES OF CAPPADOCIA

Many of the interpretations of Cappadocian rock sites are based on evidences collected from a limited number of scholars in the last century. Scholars like Guillaume de Jerphanion [1925-1942], Nicole Thierry [1963] or Lyn Rodley [1985] have provided invaluable descriptions, illustrations and interpretations in their reports. They seem to have generally perceived and represented many of these sites as rather regular settlements. The plan and sections they inserted in their publications are derived from pictures, sketches and metrics information collected with traditional procedures and tools, often between huge difficulties. Their illustrations generally show symmetrical architectural settlements with rectangular rooms that are the result of an intense process of regularization, often arbitrary if not totally invented. In their plans, walls appear as if they were built in masonry, with a constant thickness and orthogonal intersections. The same could be said of doors and windows. If considered alien to the central settlement, nearby rooms are generally ignored or censored. The settlements are conceptually "removed" from their physical environment. Thus, the general plans can be hardly referred to the outer natural morphology. Vertical sections are partial or missing and generally no altitude information is shown in the drawings.

These last choices are quite arguable, especially considering the specific morphological conditions that favored the development of Cappadocian rock-cut architecture. This is an architecture achieved directly *in* and *by* the territory, by subtraction and displacement of rocky materials. Having regard to its origin as a hollowed space, the rock-cut architecture is a borderline case between sculpture and landscape. No "wall" can be considered as a vertical surface, as well no "floor" can be assumed as a perfect horizontal surface. These and other physical characteristics profoundly mark the perception and exploration of this hypogeal environment. The soil makes the step uncertain; the hand verifies the roughness of the rock wall; the body twists to respond to the narrowness of the tunnels and to judge the position of niches and holes; the eye probes the dense dusty atmosphere; the mind measures the weight of the rock ceiling suspended on the head; etc.

Yet, all these sensitive aspects have long been banned from representations. It is certainly difficult to give an account of them in an architectural drawing. However, a plan should record physical and topological properties of a place, especially if it is supposed to be widely used by historians and archaeologists to speculate on building procedures and manufacturers' targets. Instead, authors such as Jerphanion, Thierry, and Rodley seem to have designed plans and sections to set up a fiction, bringing those rock-cut architectures into the traditional architectural iconography, as if they were built by "addition" of materials in an ideal site. Such authors decided to ignore that they are actual "living sculptures" in continuity with the landscape, choosing instead to convey the "idea" that lies behind their uncertain and irregular configurations.

3.1 Ideal Form, regularized form, actual form

The architectural representations of Cappadocian rock-cut habitat seem to have been generally influenced by the search for the idea (aesthetic, typological, stylistic, etc.) lying behind the tangible and effectual form. This approach is implicitly based on the hypothesis that mistakes and

distortions always resulted from constructive inaccuracy and technique incompetence of the manufacturers as well as subsequent interventions (and, as such, are graphically negligible). Such an idealistic approach has been shared for centuries. In the XIX century context, for example, the French architect Paul-Marie Letarouilly [1992] produced idealized surveys of the *Edifices de Rome Moderne*. They result of the attempt to correct and translate the most famous Renaissance palaces into attractive and rational drawings, according to his idea of Renaissance, of course. While the surveyed measures are mostly faithful to buildings form, their representations are symmetrized and regularized to respond to the expectations of a public of scholars and designers. And certainly, the education of de Jerphanion and the others was also influenced by the work of Letarouilly.

It is difficult to say to what extent scholars have deliberately ignored the effectual form of the space. A number of causes can be identified to be referred to the specific type of analytical and critical action conducted by the scholar as well as to the specific features of the site. To the formal group of causes belong:

1. the method of study, suggesting an approach to architecture through mental models and elementary geometries, as indeed a surveyor used to do according to the traditional procedure, which can turn into a sort of prison for the scholar;

2. the purposes of study, involving an prominent interest in the plastic and visual arts. Sometimes, the architecture seems to be conceived as just a physical support for artworks and its representation as a simple diagram to illustrate size and position of decorations and reliefs;

3. psycho-cognitive aspects related to a perception targeted to specific contingent interests and conditioned by the so-called "professional deformation";

4. the quality and quantity of staff and equipment used, often limited to tapes, graduated rods and torches.

To the latter group of causes belong:

1. the intrinsic formal characteristics of the space that, as a function of inputs, steps and illumination sources, affect the overall perception of site;

2. the "optical" features of surfaces, as dematerializing decorations and paintings can alter the perception of the space, especially in the light of torches and lamps;

3. the "intertextuality" of the interiors can affect the investigator as they can be interpreted as scale of full-size models of actual Byzantine buildings [Carpiceci et al., 2016];

4. the state of the sites at the time of the survey, certainly much rougher than a tourist can find today.

However, in the afore recalled representations of rock-cut settlements by de Jerphanion, Thierry or Rodley, not everything has been regularized. There are irregularities that have been recorded and impressed in the illustrations. Some caves are simplified into a rectangle in plan; others into a trapeze; others are just systematized in irregular quadrilateral shape. It therefore seems to exist a perceptual and / or metric threshold to be adopted when drawing plans and sections. Before this threshold, an irregularity is considered as a deformation – a certain distance from the ideal form as conceived by the scholar – to be ignored. After this threshold, an irregularity deserves to be recorded or even emphasized, albeit partially.

It is hard to trace the line separating the effects of the mentioned psycho-perceptual effects and the aware methodological intervention by the scholars. However, the possibilities offered by new survey technologies allow today to measure the size of their corrections and to put it in relationship with the perception of those environments.

4. LASER SCANNER AND THE REAL FORM

In the large and multidisciplinary survey process and interpretation of a rock-cut habitat, innovative land and architecture survey techniques offered by digital photogrammetry and photo-modeling allow the surveyors to reveal the "real form" of interiors. In particular, some morphological features of the Cappadocian sites, which have been either previously ignored or deliberately neglected, have surfaced. The laser scanner provided a kind of hermeneutic experience. By detecting, the instrument reveals and envisions both the cryptic aspects due to its underground and sculptural quality. First of all, the numerical model, which is formed by the assembly of the partial clouds of points obtained outside and inside, provides a measured image of the relationship between natural extrados and artificial intrados. Secondly, it allows to view the whole structure of inner volumes, providing a surrogate for the desired "bird's eye view". All this takes place after the field survey, offering an integrative experience that, through the mediation of the model, provides with a specific cognitive contributions that enable the scholar to conduct analyses before impossible.

To this result, which is somehow "congenital" to the use of the laser scanner, is added the specific contribution of the authors in the field of visual processing in order to produce architectural representations that are traditional and innovative at the same time [Crescenzi & Verdiani, 2013]. For example, this research unit has defined methods and procedures to represent rock-cut architecture in a complete form by introducing the third dimension information given by equidistant contour lines and chromatic codes [Colonnese et al., 2016].

This new generation of territorial and architectural iconographies, which is gradually being adopted by a few scholars [Ousterhout 2005; Kalas, 2007; 2009], offers a new vision on morphological contents of the rock sites as well as alters the way to look at the historical surveys.

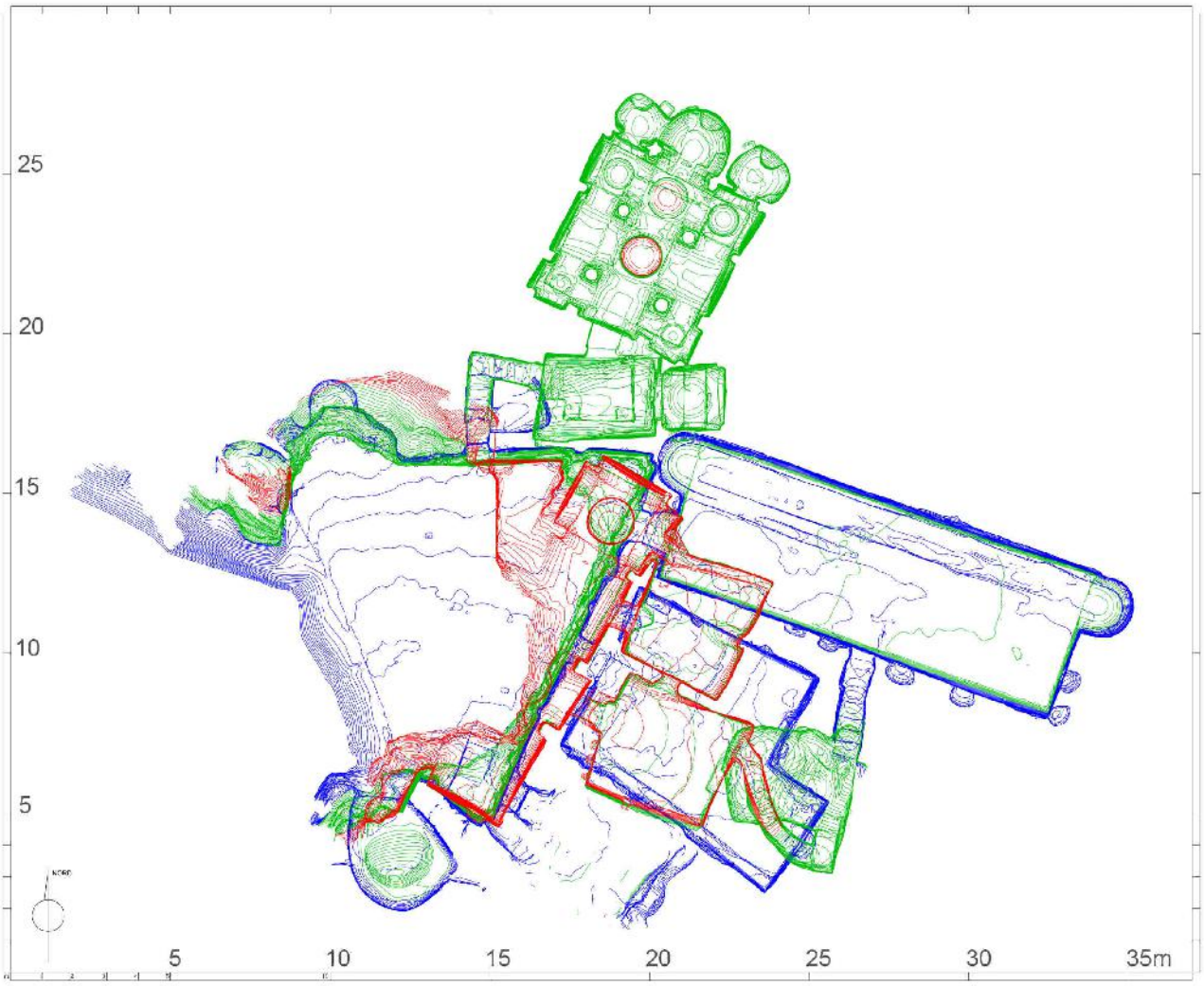

Figure 1: Karanlik Kilise Monastery. General plan by contour lines after mesh model. Colors identify: ground floor (blue); first floor (green); and second floor (red) (drawing by M. Carpiceci)

For example, it reveals that most of the rock-cut rooms have a much more irregular shape than both it is represented in the historical plans and sections and to what is commonly perceived.

By comparison with the historical iconography and the identification of what could be called the "deformation tolerance threshold," it is therefore possible to investigate the way some rock-cut environments are perceived and try to understand to what extent these formal results are part of the design of the ancient builders luggage and adopted by them with static and aesthetic intent.

5. DESIGNING THE EXCAVATION

The expertise of a linear and plane progression of an excavation operation was definitely known by local workers, and this is demonstrated by numerous examples where facades, interior surfaces, liturgical furnishings and refectory facilities are undoubtedly executed with great skill. The grinding wheels, which were strictly carved in place, constitute an even virtuosic example of this technological achievements.

The excavation is a practice that needs to be planned. Not all settlements surveyed by the authors have been completely planned in one time and by one mind: many of them are the result of different projects and generations and show signs of expansions and reconsiderations. Nevertheless, their rich and articulated spatial organizations suggest the builders possessed considerable expertise and planning skills.

Especially the initial structure – usually the part of higher artistic value – is a product of neither chance nor some practices of pseudo-automatic excavation. Indeed, the excavation accuracy and achieved results indicate a remarkable specialization of local labor. In this scenario, how the widespread irregularities, which are present both in the monumental rooms and in the service ones, are to be

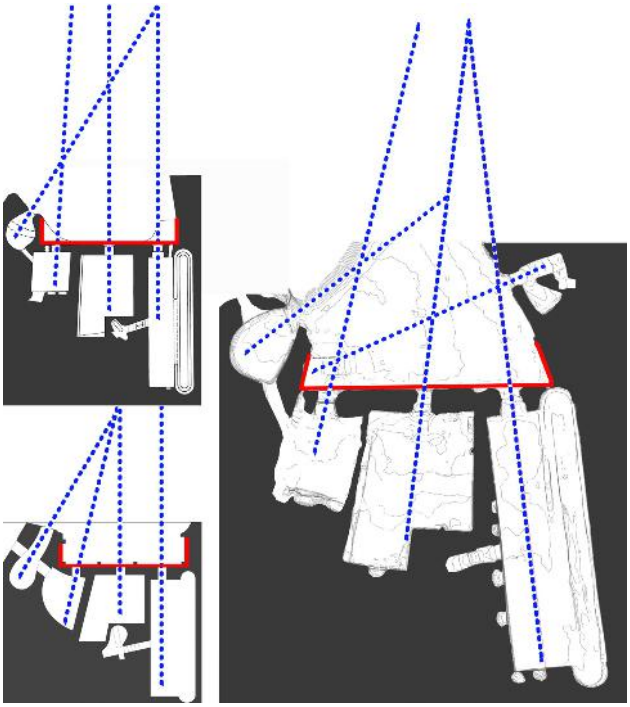

Figure 2: Karanlik Kilise Monastery. Geometric analysis of ground floor plan. The courtyard angles (red) and rooms' axes (blue) in authors' survey plan (right) compared to Rodley's plan (above) and Jerphanion's plan (below) (drawing by F. Colonnese)

considered? Are they just a consequence of constructors' ineptitude or the result of a precise calculation?

Before attempting any answer, the irregularities are to be measured both in plan and section. This is allowed by the model after authors' survey. Then, the results can be compared with the previous iconography of de Jerphanion and Rodley, which result from a different perceptual and measurement activity. This can highlight both their different approaches to regularizations and a general consideration on the geometric features of some of these rock-cut architectures.

For this purpose, three different sites are analyzed here:

- the ground floor of the monastery Karanlik Kilise, the Dark Church at the OAP, relative to the general plan and shape of individual rooms, which allude to but rectangles are quadrilaterals mixtilinear;

- the ground floor of the so-called Monastery of Aynalı, relative to the individual rooms, which are generally represented as rectangles but actually allude to circular sectors;

- the vertical section of the Forty Martyrs church in Sahinefendi, relatively to the ceiling: this is generally considered plan but is actually configured according to a "hanging rope" line.

5.1 Karanlik Kilise

At the ground floor of the Karanlik Kilise monastery, [Carpiceci et al., 2015a; Carpiceci et al., 2016] the rooms are disposed around a courtyard which is accessed by a staircase carved into a curved tunnel. Apart a cave now occupied by the guardians and the entrance to upper church, the openings are concentrated on the southern face of the court. They lead to two service rooms and one of the longest double-apse refectories of all Goreme, with a flat ceiling, a long table with carved sitting partially demolished (Fig. 1).

The existence of a general plan of the two-level settlement would be testified by many precise alignments like, for example, that between the upper church and the courtyard wall. In both de Jerphanion and Rodley's previous surveys, this complex has been regularized in a strictly orthogonal structure around a rectangular courtyard. Yet the courtyard is certainly not rectangular. Angles of ca. 77 degrees and 69 degrees can be easily measured at the ends of the southern face. It must rather be assumed as trapezoidal or even triangular (Fig. 2).

It is interesting to confirm that the refectory actually has a rectangular shape, with all of internal angles of ca. 90 degrees. This seems an exemplar confirm of the planning and execution capabilities of the ancient builders of this site. On the contrary, its axe is ca. 6 degrees inclined with respect to the orthogonal. Also the adjacent rooms show axes that are converging to the opposite corner of the courtyard. Thus, the geometry of the whole ground floor can be assumed as radial, as perhaps partially intuited by de Jerphanion. In this scheme, a vital role is played by the inclined "wall" dividing the two service rooms. The survey has revealed that it forms a ca. 100 degrees angle with the inlet wall. De Jerphanion and Rodley had two opposite approaches to it. Rodley regularized it to a right angle, while de Jerphanion extended its up to ca. 104 degrees, emphasizing its role in the overall composition. This choice causes an alteration of the central room shape. De Jerphanion imposed a trapezoidal shape with parallel opposite sides to it, while Rodley kept it basically rectangular, but it follows a sort of conical scheme, indeed (Fig. 3).

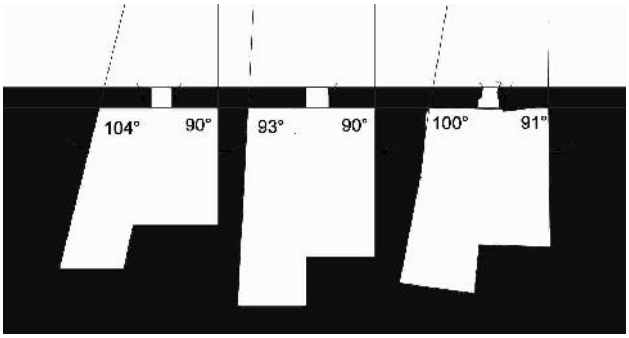

Figure 3: Karanlik Kilise Monastery. Angles analysis of central room at ground floor comparing de Jerphanion's plan (left), Rodley's plan (middle) and authors' plan (right) (drawing by F. Colonnese)

Figure 4: Aynalı Kilise Monastery. General plan by contour lines after mesh model. Colors identify ground floor and lower parts (blue); first floor (green); and second floor (red) (drawing by M. Carpiceci)

5. 2 The Church and the Sala Maior of Aynalı

The church and the rooms of the monastery of Aynalı [Carpiceci et al., 2015b] are on two main levels around a pseudo-rectangular courtyard (Fig. 4). Two of the three doors in the exterior face open into the largest room of the complex, the Sala Maior: its walls are articulated by pilasters, support a barrel vault with arches and are barely decorated with red geometric patterns. The third opening is the main entrance to the Firkatan Kilise through a small square narthex with cross-arms covered by a dome covers it.

Four large columns (with one partially collapsed) divide the approximately square church into three naves covered by barrel vaults and decorated with red symbols: a large central horseshoe-shaped apse and two smaller ones at its sides opens in the east wall with their floor as high as the continuous bench running at the base of walls.

As before, this complex appears largely regularized both in de Jerphanion and Rodley's plan (Fig. 5). Apart the Sala Maior de Jerphanion drew slightly trapezoidal, all the rooms at the ground floor are reduced to rectangles. Instead, authors' survey has shown that the longer walls of rooms show congruent curvatures. This phenomenon is particularly evident in the space sequence formed by Sala Maior and church.

In both rooms, the primitive rectangular shape is arched longitudinally in a manner that the plan seems to aspire to

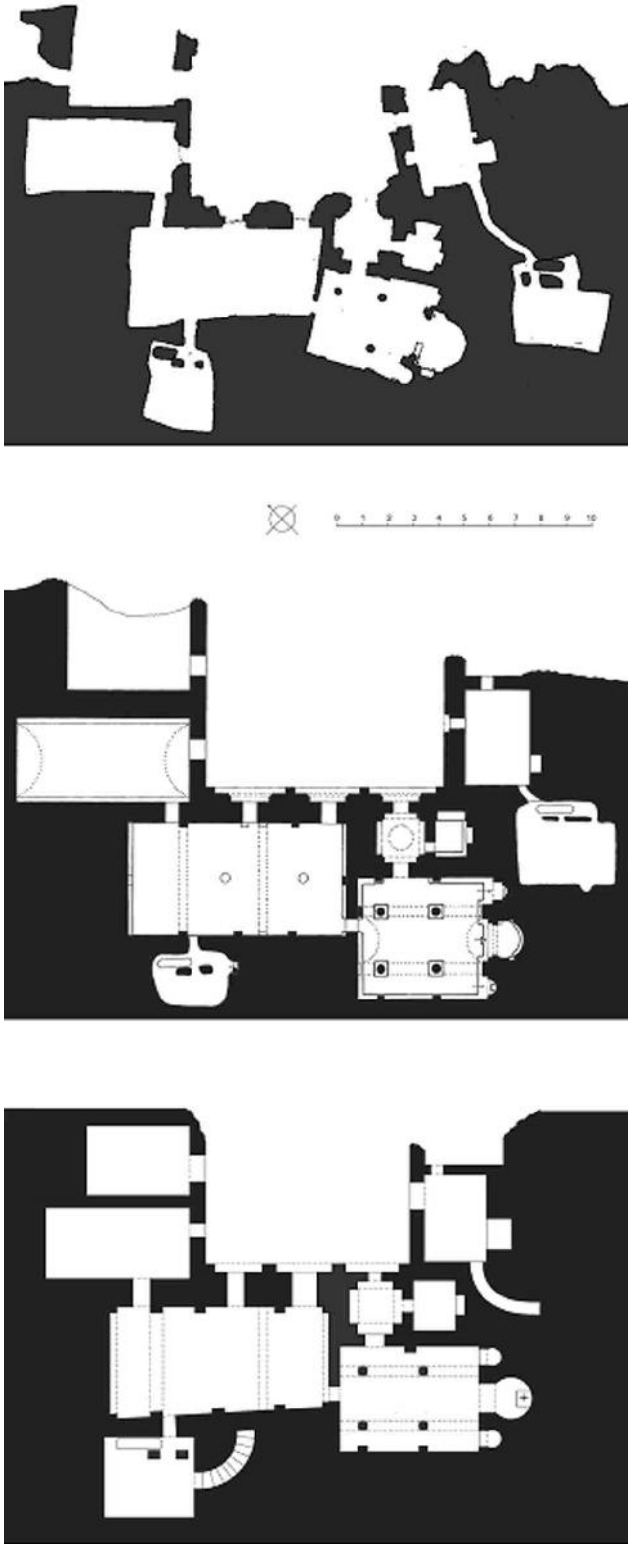

Figure 5: Aynalı Kilise Monastery. Comparison between the ground floor plans by the authors (above), by Rodley (middle) and by de Jerphanion (below) (drawing by F. Colonnese)

the shape of a circular crown sector. Actually, the walls do not even follow concentric arcs, with the result that they are rather spiral sectors. By taking in account the curved line formed by the curved axes passing through the opening, a part of this hidden geometry can be measured. The arrow of the whole curve, i.e. the distance between curved configuration and the associated rope, is the 15% of the overall length. The curved axes of Sala Maior and church can be considered as parts of different circles but according to angles of both 17 degrees angles. Although this can be a mere coincidence, one cannot ignore that the type of curvature of the walls appears rather uniform, clearly guided by a specific sensitivity to the interior space of the ancient manufacturers (Figs. 6, 7).

The most amazing thing is that standing by the bottom of the Sala Maior and pointing to the apse of the church through the opening, it is clear not only that the walls are not straight but also that it is impossible to see the apse except by an visual axis that is oblique to the structures. While de Jerphanion and Rodley's regularized plans convey the idea of a system of spaces linked by distances and visual axes, the built environment expresses the desire to hide the goal and accentuate the sense of progressive discovery related to human movement.

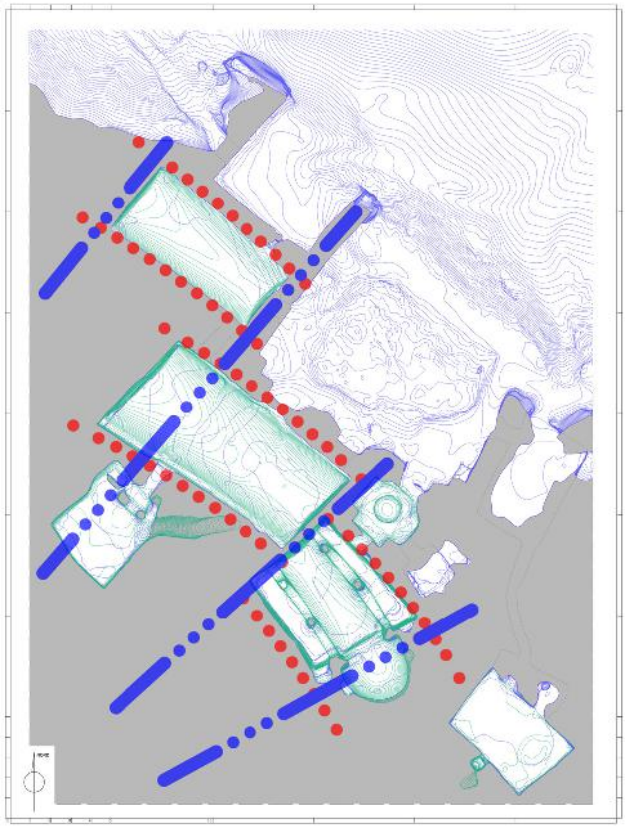

Figure 6: Aynalı Kilise Monastery. Geometric analysis of axes and twisting effects of main rooms (drawing by M. Carpiceci)

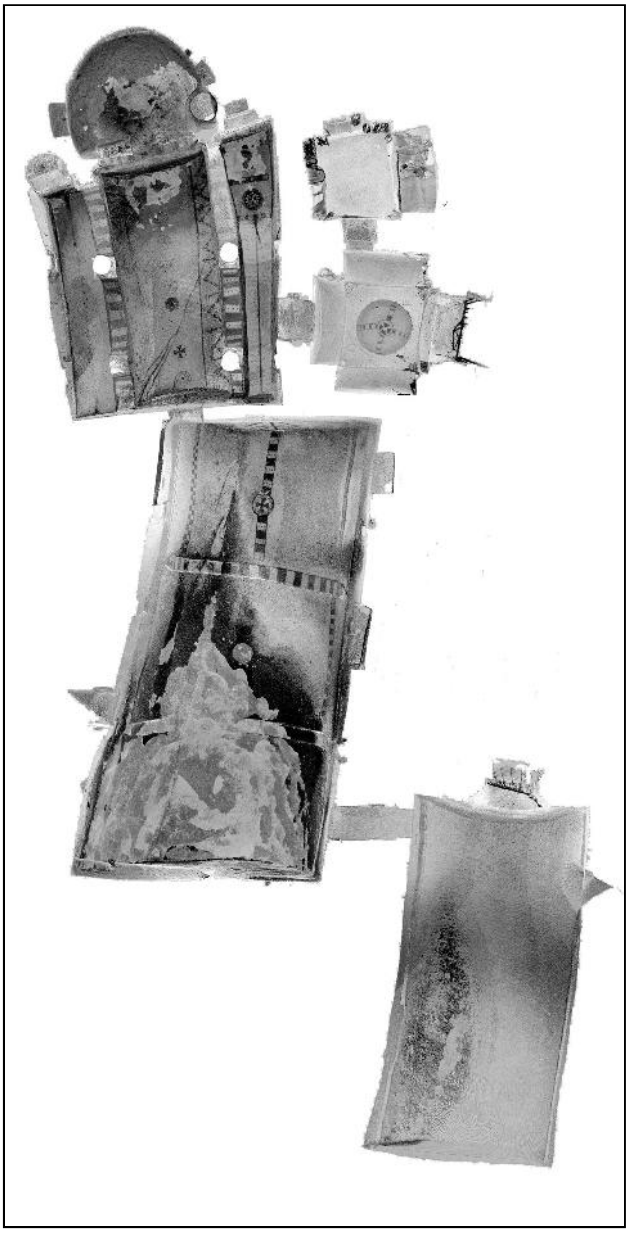

Figure 7: Aynalı Kilise Monastery. Photographic mapped *ipografia* of the main sequence of curved rooms. Above, the Firkatan Kilise with the narthex; in the middle, the Sala Maior; below, a room open to the courtyard (drawing by M. Carpiceci)

5.3 The Church of Forty Martyrs at Sahinefendi

The section of Forty Martyrs Church at Sahinefendi produced to guide its restoring [Andaloro, 2012], reveals one of the most widespread irregularities. The coverage of both the church and the service areas seem to have been hewn to show a marked dip in the center. It results in a curvature normally called "hanging rope" or more properly "catenary," that is opposite then a lowered arc.

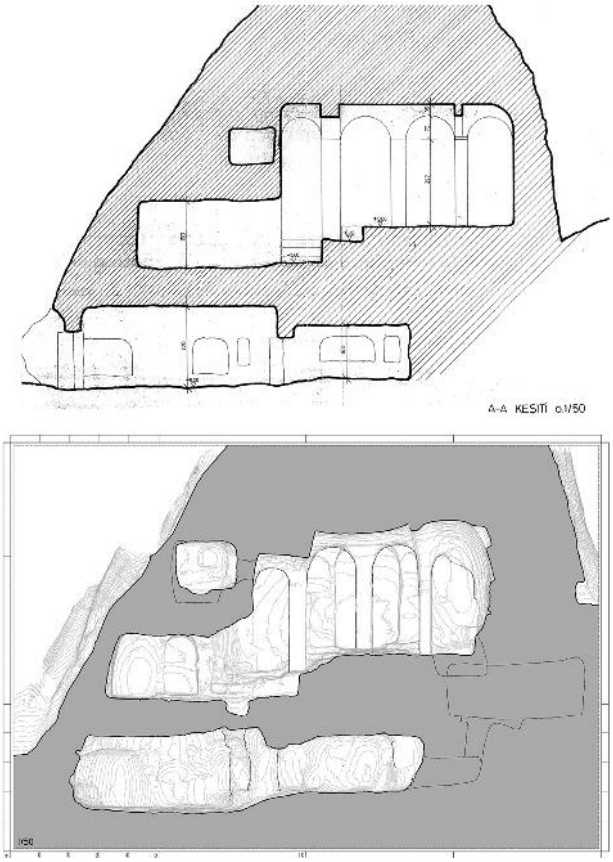

Figure 8: Forty Martyrs' Church at Sahinefendi. Comparison between longitudinal sections after a traditional survey used by archeologists (above) and authors' survey by contour lines after mesh model (below) (drawing by M. Carpiceci)

Of course, even when it has been perceived, it has always been labeled as a constructive imprecision and consequently flattened, even in the remark of the Superintendent. A possible justification for such a form is located in the intuition that this upside down arc is a configuration that is similar to a buckling beam diagram. In fact, under the stress of a uniformly distributed load, an elastic flat structure, such as a wooden floor, deforms up to assume a similar shape. This means that the church ceiling not only constitutes the image of a deformed ceiling but it is also more resistant than a flat shape. This type of deformation is also applied in some barrel vaults in which the ridge generatrix has the form of a pseudo-catenary and all of other generatrices are consequently deformed (Fig.8).

6. CONCLUSION

The criterion of "inclusiveness" that distinguishes the recent addresses of the cultural heritage requires that the interpretations of historic sites take into account all of its aspects (historical, political, spiritual, artistic, etc.), also of historical interpretations that have occurred over time. The interpretation of a complex region like Cappadocia as well

as an ambiguous phenomenon as the rock-cut architecture, is necessarily based on a multidisciplinary study based on data collected from oral and written information, material evidence, traditions and meanings attributed by following methods scientific research.

In the light of recent geometric investigations carried out on the rupestrian sites in the territory of Goreme by authors, one can critically review the historical reception of plastic and geometric values of some complex, as is clear, for example, in the works of de Jerphanion and Rodley. In the ground floor of Karanlik, both de Jerphanion (less) and Rodley (more) bring back the rotation axis of the rooms, between 5 and 15 degrees with respect to the orthogonal, at right angles and ignore the convergence of opposite walls in the rooms. In the ground floor of Aynalı, both of them ignore obvious curvature of the walls with arrows up to 15%. In the few sections made, they never record the phenomenon of the "hanging rope" ceilings. It is clear that these data are still insufficient to establish a "tolerance to deformation threshold." However, they constitute evidences of a diffused phenomenon and a starting point to open an unedited debate not only on the way historians and archeologists such as Jerphanion and Rodley perceived and interpreted graphically those sites, but mainly on construction techniques and design intents adopted and mastered by the ancient builders.

The settlements here analyzed show a clear "design" intent to deform the primitive solids and to mold them into novel spatial designs, which seem to use the way of perceiving space as a design instrument in itself. On the one hand, in the context of single environments, minor irregularities seem to be admitted as the human perception tends to ignore them and instinctively correct them. On the other hand, the presence of intentional deformation matrices testifies the aspiration to specific aesthetic results from excavated architecture, which seem to be very distant, if not antithetical, to traditional architecture.

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Rock Cut Façades from Byzantine Cappadocia

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Abstract
At the Peristrema Valley, in and around the modern Turkish villages of Selime and Yaprakhisar, fifteen newly discovered, rock-cut courtyard units preserve a variety of façades that are instrumental for our understanding of Middle Byzantine houses and their outward appearances. They demonstrate how architecture was used to display social status, power, and wealth for a rural, frontier society bordering the medieval Byzantine, Arab, and Transcaucasian cultural realms.

Keywords
Architecture, façade, dwelling, settlement, courtyard complexes, Ihlara, Peristrema, Selime, Yaprakhisar.

Cappadocia in central Turkey constitutes one of the most fascinating natural and human landscapes ever seen. It is well known for its many colorful valleys of volcanic rock formations in which hundreds of churches were carved in the early medieval period. These accompany dozens of multi-story dwellings that could sustain entire troglodyte villages. Although Cappadocia's unusual rock-cut environment is generally regarded as an architecture of interiors, during a time of security and prosperity for the region under Byzantine control, from the tenth to eleventh centuries [Kaplan, 1981; Cheynet, 1990; Whittow, 1996; Cooper & Decker, 2012], Cappadocians began to carve the outside face of the soft volcanic rock cliffs.

Cappadocia's carved façades are rather unique within the tradition of rock-cut architecture in that they are neither funerary nor religious-- most rock-cut façades in the history of world architecture of the pre-modern era either front tombs or places of worship. Some examples include the rock cut tomb façades of Lycia and Caria in Turkey, Petra in Jordan, and the rock carved temple architecture of India and other traditions from the Far East. By contrast, the carved façades of Cappadocia occasionally designate churches, but usually they mark places of dwelling. They ornament the walls of courtyards located at the entrances to complexes of rooms that have been identified as the residences of the local, landed aristocracy of the tenth to eleventh centuries AD.

They are immensely important for the history of Byzantine architecture because very few residential buildings remain from the Middle Byzantine period elsewhere in the former territories of the Byzantine Empire. Especially lacking at Byzantine sites outside of Cappadocia is any evidence of the elevation of any kind of Byzantine domestic structure. The examples from Cappadocia fill a tremendous gap in our understanding of the design, structure, layout, elevation and outward appearance of houses in Byzantium [Mathews & Mathews, 1997; Ousterhout, 1997, 2005].

These complexes are scattered throughout the region, as almost every volcanic rock outcropping was used for dwelling. In most cases however, the walls of the courtyards have collapsed, leaving very little evidence of the original façade. Most examples are grouped at the sites of Çanlı Kilise, Açık Saray, and the Peristrema Valley.

Of the twenty-three complexes examined by Robert Ousterhout at Çanlı Kilise, only one (Area 16) preserves enough of the principal wall of the courtyard with a sculpted façade in order to reconstruct its original appearance [Ousterhout, 2005]. Lyn Rodley has published four courtyard façades at Açık Saray, which are better preserved than those of Çanlı Kilise, though none have their full lengths and heights [Rodley, 1985; Verzone, 1962; Öztürk, 2014].

Other well-preserved façades are scattered throughout the region, and elaborate, single examples can be found at Eski Gümüşler [Rodley, 1985; Gough, 1965], Şahınefendi [Rodley, 1985], and Erdemli [Thierry, 2003].

At the Peristrema Valley, in and around the modern Turkish villages of Selime and Yaprakhisar, a newly-recorded settlement comprising fifteen rock-cut courtyard units presents some of the largest and best-preserved façades of the region, which are instrumental for our understanding of Middle Byzantine houses. They also demonstrate how architecture was used to display social status, power, and wealth for a rural, aristocratic, frontier society bordering the Byzantine, Arab, and Transcaucasian cultural realms [Kalas, 2000, 2004, 2006, 2007, 2009].

Selime and Yaprakhisar are located at the northern opening of the Peristrema Valley, also known as Ihlara Vadisi, which is actually a steep canyon with vertical rock cliffs several kilometers long that cuts through the northern foothills of Hasan Dağı. The steep gorge opens onto a wide river valley surrounded by volcanic outcrops in which churches and multistory dwellings were carved (Fig. 1).

Figure 1: View facing north of Selime (Kalas)

Figure 2: View of eroded rock face at Selime (Kalas)

At both Selime and Yaprakhisar the ignimbrite rock cliffs (solidified volcanic ash) are massive, and in several areas the rock face has collapsed or eroded to show the spaces of dwelling inside, offering a kind of section-drawing ready made by the forces of nature (Fig. 2).

It is impossible to assess the actual number of dwellings that may have existed inside these rock cliffs, however in certain places it is possible to define complexes of rooms arranged around courtyards that are compatible with one another because of their scale, proximity, and similarity in design and decoration. The various features of these complexes are laid out in relationship to each other in a logical fashion. Moreover, the individual features themselves, including the façades, are designed in similar ways. Therefore it appears that they form a cohesive group that dates to around the same time period. I assess the date of the settlement to be from around the tenth to eleventh centuries on account of a handful of painted inscriptions as well as the style of the churches associated with almost all of the complexes, which are based on the domed, four support, nine bay plan common for the region in the Middle Byzantine period.

According to the methodology developed for recording this site, a courtyard unit is defined as having two or more of the following features contingent to one another and in the same area: a courtyard, a façade, a church, and one or more utilitarian rooms with identifiable features to show their probable original use as either ceremonial halls, kitchens, or stables (Fig. 3). In discussing the outward appearance of these courtyard units, moreover, several issues must be addressed. Firstly, the manner in which the courtyards are formed falls into two distinct groups. They provide for the working methods of the carvers. Secondly, the architectural design typology of the façades themselves is important.

Courtyards were formed either by arranging various rooms and their façades around cone formations so that the space in front of these features formed a courtyard, or by carving out of the living rock a rectangular space open to the sky enclosed by two, three, or even four walls, which offer the entrances into the various rooms of the complex. In both cases the courtyards were purposely formed, either by the intentional selection of suitable cone formations along the landscape and the arrangement of rooms around them, or by the deliberate carving of a rectangular space open to the sky surrounded by walls.

The second courtyard of Area 7, the courtyard of Area 8 (Fig. 4) and the courtyards of Areas 13 and 14 (Fig. 5) clearly show the remains of all four corners of a four-sided rectangular courtyard open to the sky. It appears as if a rectangular area was surveyed at the top of the rock mass, and then the rock was removed from top down as if in a quarry. The selected outcrop provided enough vertical mass to generate four walls of an enclosed space. The main wall of the courtyard faces outward, toward the river and across the valley, and is in direct view of the other courtyard units of the settlement arranged around the riverbed. The main wall was tall enough to generate a façade that could be clearly visible and articulated with multiple registers. Two additional examples of the settlement, at Areas 9 and 15, remained unfinished and thus provide some unique insights into the working method of the carvers, including evidence of this top down working method, although the fourth wall on the downward side of the cliff toward the river either does not survive or was never carved.

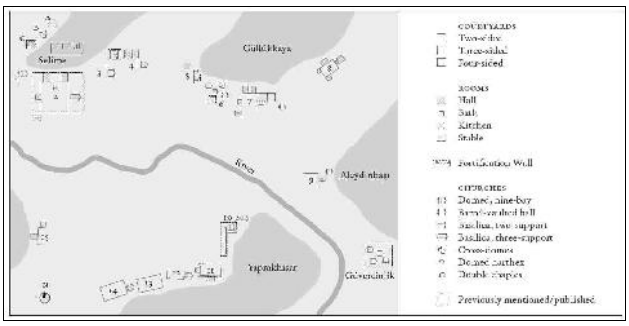

Figure 3: Site Diagram (Kalas)

Figure 4: View from a distance, facing west, of Area 8: the four-sided courtyard open to the sky located at the middle of the photograph (Kalas)

Figure 5: View facing south of the four-sided courtyards of Areas 13 and 14 at Yaprakhisar (Kalas)

At Area 9 (Fig. 6), along the lower part of the courtyard walls, there are the remains of grooves that outline blocks, which were about to be removed from the wall surface, and it appears as if the workers abandoned their project in the middle of the day. The only finished part of the façade is a horizontal molding of shallow horseshoe niches at the very top, a feature that is found in other façades as well. At this unfinished façade of Area 9, it appears that work proceeded, logically, from top down.

At Area 15 (Fig. 7), the courtyard wall was clearly outlined, and along the middle of the wall in a horizontal line, there are remains of putlog holes most probably used to erect scaffolding. The wall is fairly smooth, with no decorative articulations, which most likely indicates it was left unfinished. In both cases, moreover, it is clearly evident that the carvers also worked inside out, finishing the complexes' interiors first, and leaving the full ornamentation of their exteriors for later.

Figure 6: View facing east of Area 9 (Kalas)

A second important aspect of these façades is the typology of their design, which also fall into two distinct groups. One type of façade marks the entrance into churches, and another type marks the entrance into the complexes. They are distinct from one another not only in terms of the kinds of spaces they front and where this space is located in relationship to the other spaces of the complexes, but also in terms of the formal design of the façades themselves, which differ between the two groups. They not only mark two different kinds of spaces, but also are designed on two different principles. The façades that articulate the entrance into churches are blind triple arches with engaged piers set within a rectangular stepped frame. The doorway into the church occupies the central arch. This façade is not on the principal wall of the courtyard but rather relegated to one or another side of the courtyard wall, expressing the notion that the church was not the main room of the courtyard complexes but only one of many of its components, off to one side of the unit. The church façade located along one side of the first courtyard of Area 7 (Fig. 8) provides a good example of this phenomenon.

The triple arch is most likely used to reflect the three-bay division along one side of a nine-bay domed church with piers, located inside. However it is interesting to note that directly behind this façade, and parallel to it, is a long, barrel-vaulted hall that serves as the church narthex and does not host a triple-bay division. The three-arched division of the façade reflects the idea of a nine-bay church inside even if this is not the exact space located directly behind the façade. This kind of layout can be seen at other examples at this settlement as well as in other parts of Cappadocia, especially at the most celebrated Cappadocian site of Göreme, where there is a high concentration of Middle Byzantine rock cut churches of the domed, nine-bay variety.

This kind of inexactitude between the articulations of the façade and the spaces that are found immediately behind constitutes an important aspect of the meaning and purpose

Figure 7: View facing southwest of Area 15 (Kalas)

of these structures. The layout of the courtyard façades that articulate the main wall of the courtyard complexes also exhibits the same kind of contrasting interplay between exterior and interior features. This second type of façade defines the principal wall of the courtyards. They almost always face the farmland surrounding the river, are arranged in a circular pattern along the cliff faces around the riverbed, and are inter-visible. This inter-visibility among the units and their accompanying façades is striking, and offers further support for the conclusion that all fifteen units identified in this study belong with one another and are from the same time period.

The unusually well preserved façades, located at the rock outcropping at Yaprakhisar, present the most impressive examples of the entire settlement. They preserve the full extent of their original lengths and heights-- and are monumental in scale, ranging from 12 to 20 meters in length, and 10 to 15 meters in height. At Yaprakhisar local villagers use the complexes for dwelling and storage, so that the façades suffer not only from natural erosion but also from re-carving and reuse. The interiors, moreover, are almost entirely destroyed or impossible to reach because of continuous reuse over time. In other words, there exists here an entirely reverse situation from other sites in Cappadocia, where interiors are usually better preserved than the exteriors. Nonetheless, whatever is still accessible on the inside of these complexes consistently shows that internal spatial divisions do not correspond to the design of the façades. This peculiarity among the façades can be seen throughout Cappadocia where the articulations of the façades do not reflect interior spatial divisions. Because these are carved rather than built spaces, interiors and exteriors did not have to correspond structurally. They could be worked on separately, and this partly explains why Cappadocia's façades rarely reflect the divisions of spaces that lie within. Some of the more elaborate examples, in fact, seem to have had no function other than ornamentation. They may be considered as status markers for individual household owners. Display itself was the ultimate utility of the façades.

Superimposed registers that vary in number and height divide each façade vertically. The façades of Areas 11 and 14 preserve enough of their lengths and heights to reconstruct their original appearances. One type of courtyard façade uses pilasters to divide each register into bays, as at Area 11 (Fig 9). The other type features an uninterrupted blind arcade on each register, as at Area 14 (Fig. 10).

Other examples throughout the region that are not as well preserved seem to represent this typology nicely. Every register includes an odd number of bays or arches, either five, seven, or nine. The main doorway on the lowest register is always placed in the central bay or arch to produce lateral symmetry. Shallow, blind arches and niches of varying shapes and sizes further decorate the walls in rhythmic, symmetrical patterns. The design repertoire consists of blind niches and arcades, engaged piers and pilasters, stepped moldings and cornices, and doorways and windows that are usually arched or keyhole-shaped. These features are always symmetrically arranged and many details are repeated throughout. Though all the façades appear to be based on similar design patterns, no two are ever the same. This testifies to a remarkable virtuosity among the Cappadocian carvers, who commanded a diverse repertoire of designs, which they could manipulate and change with great flexibility as they sculpted the landscape.

At Area 11 pilasters divide four registers of different heights into five bays. One horseshoe shaped blind niche decorates each bay. The four-story façade, however, corresponds to only two levels inside. At ground level, a tall, barrel-vaulted hall parallel to the courtyard is equal in length and height to the first two registers of the façade. Another similarly oriented hall lies behind the topmost register.

Figure 8: View facing east of the church façade along the first courtyard of Area 7 (Kalas)

Figure 9: View facing south of Area 11 (Kalas)

A tunnel toward the back of the complex connects these two levels, so that no spaces are carved behind the third register of the façade. A large opening at the center of the upper tier allows access to a wide balcony with spectacular views down toward the river. This is the largest, most elaborate, and best-preserved façade recorded thus far in Cappadocia.

At Area 14 there are two horizontal registers-- a tall one at ground level, and a shorter one above it. A continuous blind arcade of seven arches adorns the ground floor register, and a blind arcade of nine arches adorns the upper tier. One shallow, blind niche appears within each of the arches on the upper tier, again producing a rhythmic, symmetrical pattern. The tall arcade at ground level does not correlate to any interior space, except for three very small square rooms opening off the second, middle, and sixth arches-- an arrangement that maintains lateral symmetry in design. The upper tier appears to have been almost entirely blind, except for a small room on the upper corner to the right as one faces the façade. No doubt these façades were meant to impress any visitor to the site, and to recall built architecture, perhaps a mansion from Constantinople, of which none survive.

For lack of comparative material in secular architecture in Byzantium, parallels may be sought further east, in Sassanian, Umayyad, and Abbasid architecture. The formal relationships are striking. The façade of the sixth century palace of Taq-I Kisra at Ctesiphon near Baghdad shows articulations of the wall surfaces that are especially close to those of the façade at Yaprakhisar 11, which I believe forms one type that can also be seen at Areas 2, 3, 4, 7, and 10 of the settlement. There is a correspondence in both the repertoire of design elements-- blind niches and arcades, bays and pilasters, stepped frame moldings and arched openings-- as well as the symmetrical and rhythmic arrangement of these features. It is well known that Byzantium admired and adopted forms from both Sassanian and early medieval Islamic art throughout the Middle Byzantine period, especially in the secular realm of decorative arts [Grabar, 1987].

For the other type represented at Area 14, which can also be found at the site of Şahınefendi mentioned earlier, there is continuous blind arcading on both lower and upper tiers. A possible parallel can be sought with the main courtyard wall of the Abbasid palace of Ukhaidir, dating to the late eighth century, also in Iraq. Although these parallels are located far afield from Cappadocia, it is not unlikely to see cosmopolitan sources and influences on the design of Cappadocia's architecture, as is demonstrated by Cappadocia's church architecture and their paintings, which seem to recall sources and influences from Constantinople itself. Both Ctesiphon and Ukhaidir are courtyard facades that open onto palatial complexes of residential rooms, and not single, religious buildings. We might seek closer parallels for similar systems of arcading on Byzantine cut-stone masonry buildings in Anatolia, but only churches survive. Medium also matters. The two palace façades are made of brick and the surfaces plastered, a technique that creates greater plasticity on the wall surfaces and allows for more nuanced shapes of blind niches and arcades. Sculpting Cappadocia's soft volcanic rock allowed for similar effects on the wall surfaces, so that the resemblances with brick and plaster surfaces are strong. Moreover, both the Byzantines and the Arabs of the early medieval period inherited a common tradition of Roman architecture, and though no Roman country villa façade survives from the region to make a comparison, it should be no surprise that the Byzantine and early Islamic examples resemble each other because of this common root.

The design patterns represented by both Ctesiphon and Ukhaidir must have been circulating in Cappadocia as it was a region that bordered the Byzantine and Arab worlds for almost two centuries before Byzantium's push east in the ninth and tenth centuries.

Figure 10: View facing south of Area 14 (Kalas)

The evidence is suggestive of a desire to show familiarity with the most current cosmopolitan, and Mediterranean-wide styles of architecture at the time, which also corresponds nicely with the mindset of Byzantium's famous Anatolian warlords. Because the façades do not seem to have any utilitarian function, although they are often monumental in scale and elaborate in design, they can be seen as reflections of status and power, and indications of prestige. Perhaps there is a certain degree of social competition involved as well. The range in scale and elaboration may point to different levels of status in society-- the more prominent the family, the bigger and better the façade to their home. We know from historical sources that Cappadocia's great Anatolian warlords were unruly and competitive, often vying for the imperial throne itself, and we can imagine that demonstrating status in outward expressions of material wealth and power was an integral part of life on the frontier. With these façades we have a rare opportunity to examine how social, cultural, and economic roles played out on the exteriors of architecturally elaborate habitations. Although the appearances of the house façades did not correspond to their function in terms of structure, it definitely did in terms of aesthetics, and it was this aesthetic of prestige that must have given meaning beyond utility to Cappadocia's elite residences as locations for display.

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Graffiti of Boats from the Hellenistic and Early Roman Period in Underground Chambers in the Judean Foothills, Israel

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Abstract

Within the Judean Foothills, a hilly area lying about 30-40 km east of the coastal plain of Judea, thousands of underground artificial cavities and installations were handmade carved in the soft limestone rock. The local inhabitants have used these cavities throughout history for various purposes, such as agricultural installations, rock quarries, water cisterns, stables and underground storage installations for agricultural produce.

During the Hellenistic and Roman Periods, numerous underground installations were hewn and used in the Judean Foothills. Fixing the date of use for these cavities as well as identifying the ethnicity of the hewers is hard, even though sometimes it can be based on the style of quarrying, the integration of architectural, technical, or stylistic elements, the purpose of the spaces, the dated items found inside them, dating the site to which the installations belong to, and graffito and inscriptions found on the walls of the installations. Large numbers of these underground installations were connected to each other by narrow tunnels allowing passage only by crawling and were integrated into underground hiding complexes. These complexes were installed under Jewish settlements that existed in the area until the time of the Bar-Kokhba Revolt (132-136 C.E).

In this paper, four underground installations from the Hellenistic and Early Roman periods with graffiti of boats engraved on their doorpost or lintel will be presented. These installations, located in ancient sites in the vicinity of the Hellenistic city 'Maresha', were later integrated into hiding complex systems that were used during the Bar-Kokhba Revolt. We present a discussion regarding the use of these installations and the dating of the boat graffiti, and rise various proposals about the reason for their appearance and symbolic significance.

Keywords

Boats, Grafitti, Judean Foothills, Maresha, Hellenistic Period, roman Period, Bar-Kokhba Revolt, Hiding Complexes.

1. INTRODUCTION

The Judean Foothills, a hilly area that stretches eastward for some 30–40 km from the Judean coastal plain, contains thousands of artificial cavities and chambers hewn out of the chalk bedrock. Throughout history, these cavities served the local residents in various ways, as it is typical for many types of artificial cavities [see Parise et al., 2013]: agricultural installations, quarries, water cisterns, underground stables, columbaria, and storage facilities for agricultural products.

Many of them were hewn out during the Hellenistic and Roman periods. In many cases it is difficult to identify their exact chronology and the ethnic identity of the people who did so. Attempts to date these systems generally rely on several relevant factors:

1. The inclusion of various architectonic, technological, or stylistic elements in the structure.

2. The typology of the rooms and chambers.

3. Carvings and inscriptions found on the walls.

4. The relative stratigraphy of adjacent underground chambers.

5. Datable finds inside the chambers.

6. Context: dating of archaeological finds on the surface and their association with the underground chambers.

7. The style of hewing.

Most of the underground facilities in the area of this study that were hewn out during these periods were joined by narrow tunnels or burrows that are passable only on all

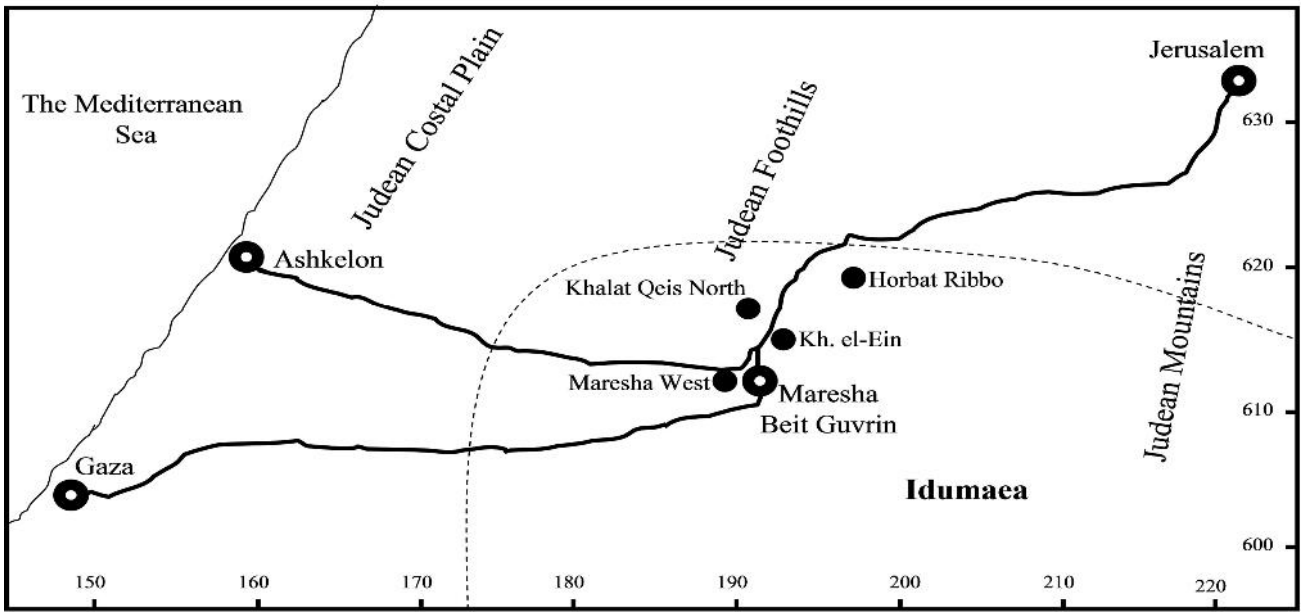

Figure 1: Location Map (drawing E. Klein)

fours and incorporated into the refuge systems that were prepared under residents' homes in the Jewish villages that existed in the region until the Bar-Kokhba Revolt.

In this article, we present four underground facilities from the Hellenistic and Early Roman periods where images of boats were carved into the doorposts or lintel of the entrance. These facilities, located in Second Temple period Jewish villages in the Judean Foothills (Fig. 1), were later incorporated into typical hiding complexes that were in use during the Bar-Kokhba Rebellion. The article will discuss the purpose of these facilities; we will also date the boat graffiti and consider their symbolic significance.

2. DESCRIPTION OF THE CARVING

Horvat Ribbo

Ḥorvat Ribbo is an ancient site that covers an area of some 10 acres at the top of a knoll that rises to 420 m a.s.l. The site is located some 3 km south of the Elah Valley, 2.5 km south of Tel Sokho and 2.5 km northwest of Tel Adullam.

Victor Guérin visited the site in the mid-nineteenth century and focused on a stone lintel decorated with crosses, found on the edge of the site, and the adjacent stone columns. He proposed that a church existed there during the Byzantine period [Guérin 1969]. As a result, most scholars proposed identifying the site with Rebbo (Ροββώ), which Eusebius, in his Onomasticon (early fourth century) locates on the eastern side of the territory of Eleutheropolis (i.e., Beth Guvrin) [Klostermann 1966; see Conder and Kitchener 1883; Thomson 1907; Beyer 1931; Abel 1967; Tsafrir et al. 1994]. The Israel Antiquities Authority conducted a survey under the supervision of Boaz Zissu and Amir Ganor in 2000–2001 (licenses G99/2000 and G35/2001). In the wake of antiquities looting, the IAA conducted additional fieldwork at the site under the supervision of Eitan Klein in 2011–2013 (license A-6979/2013-01). These uncovered the remains of various buildings and facilities in and around the ruin—including columbaria, elements of an oil press, winepresses, quarries, underground storage chambers, cisterns, and several burial caves [Klein, Zissu and Ganor in print]. Among the other ancient elements reported was a rock-cut facility that includes a rectangular corridor descending towards an opening with an arched lintel and then leading to a trapezoidal inner chamber covered in gray plaster. This was identified as a *mikveh* (Ritual Bath), which allows us to assert that Jews lived on the site during the late Second Temple period [Zissu 2001].

The 2000-2001 survey found 23 bronze coins dating from the Hellenistic to Muslim periods; these include Ptolemaic, Hasmonean, and Herodian coins, as well as one coin from Year II of the Jewish War.

An extensive underground system (ICS coordinates 148165/118501), which had previously been penetrated by antiquities thieves, was documented in the northern section of the site, slightly south of the trail that crosses the saddle north of the ruin. The system includes several underground facilities that were linked by narrow tunnels (Fig. 2).

Today it is possible to enter the system through an elliptical shaft that was opened in the *nari* (hard limestone) crust that serves as the roof of Chamber B. Handholds were cut into the sides of the shaft to facilitate climbing in and out of the system. Chamber B is irregularly shaped, due to two large pillars of bedrock that were left in the northern and eastern walls.

The eastern section of the chamber—including the eastern pillar—was covered in the gray plaster that is typical of the

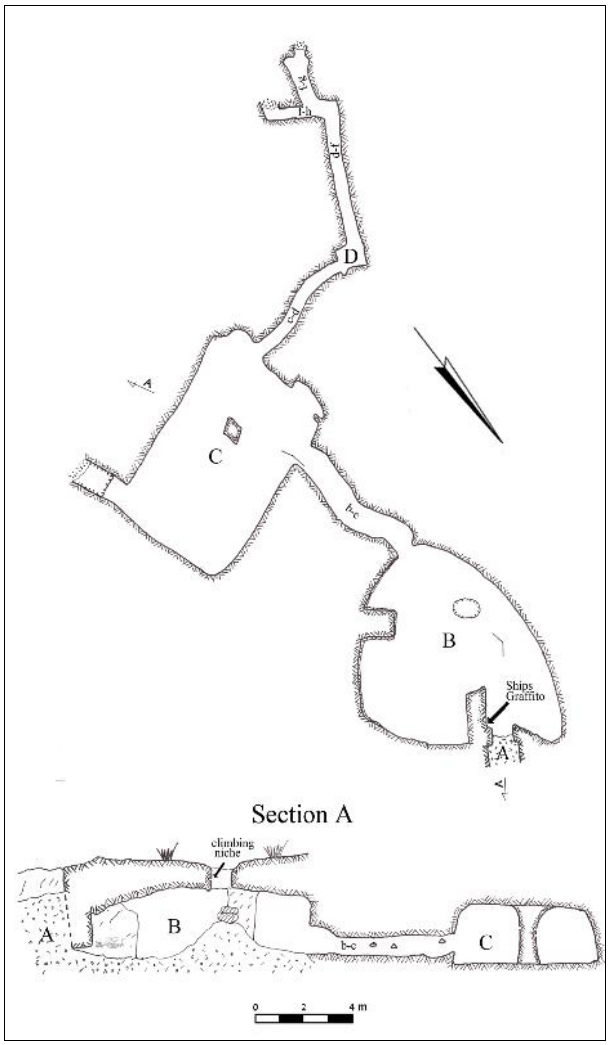

Figure 2: Plan and Section of the Hiding Complex, Horvat Ribbo (drawing E. Klein)

Herodian period; the chamber's western section was not plastered. An opening, 0.85 m wide, which had been sealed, was cut into the western section of the northern wall next to the stretch of bedrock.

A rectangular dromos (Dromos A) discovered at ground level outside the system leads to this opening and at one time afforded easy access to the chamber. It is possible that the pillars were left in Chamber B in order to support its ceiling; it seems more likely, however, that these were originally two or three adjacent chambers that were joined at some stage. The simple architectural plan suggests that the western section of the chamber, which was found without any remnants of plaster and with a dromos leading to it, served as an underground storage during the period before it was joined to the adjacent chambers.

A schematic carving of a maritime scene with two vessels was discovered on the northern pillar in Chamber B, alongside the opening and at the height of the lintel (Figs. 3, 4).

Figure 3: Maritime Scene Graffito on the northern pillar of Chamber B, Horvat Ribbo, Hiding Complex, Looking East (photo E. Klein)

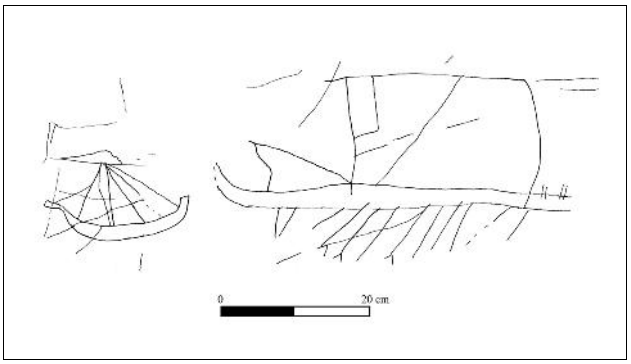

Figure 4: Maritime Scene Graffito on the northern pillar of Chamber B, Horvat Ribbo, Hiding Complex (drawing E. Klein)

The right-hand vessel—a warship with an elongated deck and a bank of oars—is 50 cm long and 28 cm tall. Though not all the details of the boat are clear, the orientation of the oars suggests that the boat is sailing towards the right. A diagonal line that represents a brace runs from the yard supporting a rectangular sail to the deck. Visible on the left side of the carving (the stern of the ship) is the *aphlaston* (ornamental appendage at the ship's stern); two short lines below it apparently depict the steering oar. A large triangle just to the right of the *aphlaston* and above the steering oar may be a tent for the helmsman. The ship's bow is not clearly visible. A similar engraving of a boat is known from the entrance to Jason's Tomb in Jerusalem, which has been dated to the first century BCE [Rahmani 1964]. Left of this boat is another one, a small trading vessel. It too seems to be sailing towards the right; i.e., its bow is on the right and stern on the left. This boat, which has a convex deck, is 17 cm long. A mast, 7 cm tall, stands at the center of the deck and is topped by a 10 cm yard (though its right-hand section has been erased). Two diagonal lines are visible above the yard, one of which stretches to the end of the yard; these may represent triangular topsails or topping lifts. The ship's rectangular mainsail seems to be furled. Six diagonal lines extend from the point where the mast and yard are joined to the deck; these are apparently braces.

Depictions of similar trading vessels are typical of the Roman period in general [Morrison 1980]. A similar

trading vessel is found in the southern panel of the spectacular mosaic floor discovered in Lod and dated to the third or fourth century CE [Avisar 1999; Friedman 2011].

A tunnel carved through the southern wall of Chamber B linked it to adjacent underground chambers, as part of a hiding complex that includes tunnels with a typical cross-section, an entry shaft with handholds for climbing, niches for oil-lamps, blocking stones, and tunnels that bend at right angles. Although it is not certain, the complexity of this system, as well as the fact that the gray-plastered chambers typical of the Herodian period were breached by the diggers, allow us to hypothesize that the system was used for hiding during the Bar-Kokhba period. The schematic depiction of the boats impedes identification of the exact type of vessel and makes it difficult to date them. It does seem, however, that the system was last in use during the Bar-Kokhba Revolt [for details about the characteristics of the Bar-Kokhba hiding complexes, see Zissu and Kloner 2009]. Because the graffito is located next to the original entrance to the chamber, it seems more reasonable to attribute it to the earlier stage, when the chamber was used for storage, before it was linked to the adjacent chambers. Because no other datable finds were discovered in the system, we can date the carvings no more precisely than to the Late Hellenistic–Early Roman period.

Khirbet Khallat Qeis (North)

Khirbet Khallat Qeis (ICS coordinates 1404/1181, also called Trig point 270 and Ḥurbat Qimḥa) is located in the Judean Foothills some 5 km north of Beit Guvrin and 2.5 km northwest of Tel Goded. The ruin, located at the top of a flat ridge, includes the remnants of various ancient structures and underground facilities.

During the various surveys of the site, it became clear that there was a Jewish village here from the Hellenistic and Early Roman periods through the Bar-Kokhba Revolt; a village also existed on the site during the Byzantine period. The finds from the earlier settlement include burial caves with *kokhim* (burial niches) and ossuaries, olive presses, cisterns, storehouses, and well-developed hiding complexes containing artifacts from the first century CE and the first third of the second century CE [Ya'aqoby and Miron 1985; Kloner 1987a, 1987b; Tepper 1992; Zissu 1997, 2001].

Another extensive hiding complex was discovered near the site in February 2012. It is located on the lower third of a ridge that is some 500 m north of Trig point 270 and approximately 40 m west of a large ancient structure that was found nearby on the ridge (ICS coordinates 140463/118484).

The architectural plan of the system is complex (Fig. 5) [for details of the various parts of this system, see Klein & Klein 2014]; it includes a *dromos* (Chamber A; approximately 6 m long and 1.7 m wide) that served as a passage into the system and had three openings in its walls, leading to three ancient chambers (B, C, and D) arranged in a cloverleaf pattern.

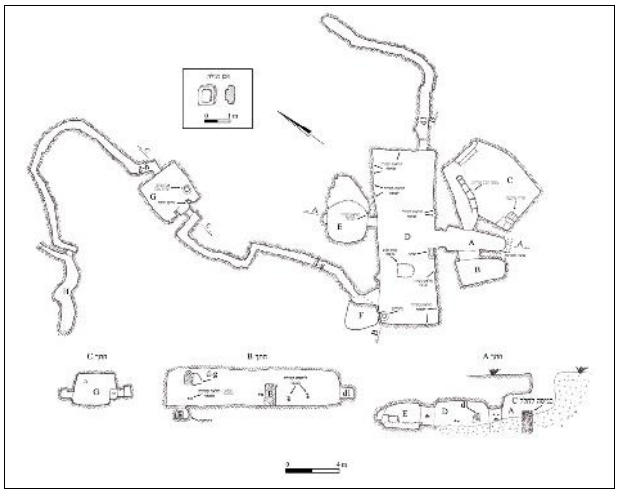

Figure 5: Plan and Sections of the Hiding Complex, Khirbet Khallat Qeis (drawing E. Klein)

Corridors like this, which make optimum use of the underground space, are typical of Maresha and other Hellenistic and Early Roman sites in the Judean Foothills [Kloner and Zissu 2013].

An opening (approximately 2 m high) in the eastern wall leads to a large square chamber (Chamber C; approximately 7 × 7 m) that served as a limestone quarry and whose floor was accessed from the opening by a staircase with a stepped railing.

The second opening, cut opposite the first one, in the wall of the western *dromos*, leads to a rectangular room (Chamber B; 3.8 × 2 m). The room, which is filled with sediment, appears to have been used as a storeroom.

Dromos A was purposely blocked off in antiquity by large fieldstones, but robbers managed to break through the barrier and roll the stones through a wide opening (1.1 m) at the front of the passage to the floor of a broad hall (Chamber D; Fig. 6; 4.4 × 11.5 m and 2.2–3 m high.

Figure 6: Chamber D, Khirbet Khallat Qeis, Looking West (photo B. Zissu)

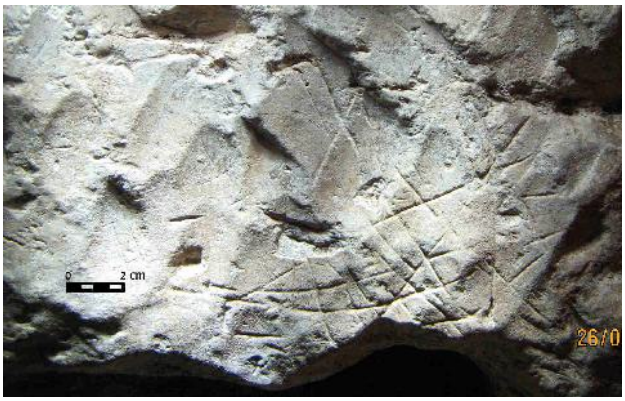

Figure 7: Sailboat Graffito on the Eastern Doorpost of the Entrance to Chamber D, Khirbet Khallat Qeis, Looking North (photo E. Klein)

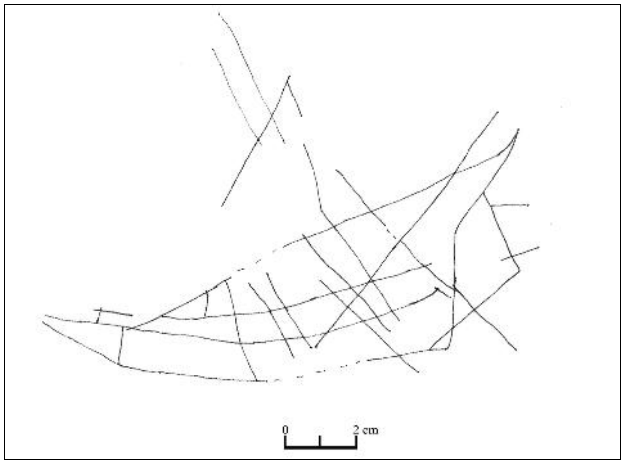

Figure 8: Sailboat Graffito on the Eastern Doorpost of the Entrance to Chamber D, Khirbet Khallat Qeis (drawing E. Klein)

Twelve holes for tying ropes were cut into the lower third of the four walls; a small trough was cut out of the rock near the southern wall of the chamber, west of the door. These features suggest that Chamber D was originally used as a pen for animals. A round opening (0.5 m diameter) was cut into the floor of Chamber D in the northwest corner; a niche around the hole is meant to hold a chalk cover stone.

This opening leads to a small storage area that includes a small bell-shaped rock-cut space from which an opening was hewn to Chamber F, which is oval (c. 3 × 3 m). Branching tunnels were cut into the eastern and northern walls of this space; they lead to interior halls and were part of the preparations to repurpose the system for hiding during the Bar-Kokhba Revolt.

The floor of Chamber D was covered by fragments of more than 100 jars, dated to the period between the last third of the first century CE through the first third of the second century CE, as well as cooking pots, oil-lamps, and glass vessels, all from the same period. The purpose of the room seems to have been modified, apparently before the Bar-Kokhba War, from an animal pen to a storehouse.

A schematic representation of a sailboat (Figs. 7, 8) was discovered on the eastern doorpost of the entrance to this chamber. The carving is 14 cm long and approximately 6 cm high. The boat's bow points to the left and the stern faces right. The deck is long and narrow. A diagonal line extending from the left edge of the deck to the top of the stern is probably a furled sail. There may be an additional triangular sail above the deck, but that is not entirely clear. This image of the ship is similar to other depictions of ships from the Roman period, especially the drawing of the trading ship discovered in the Chapel of St. Vartan in the Church of the Holy Sepulcher in Jerusalem, which is dated to the second–fourth centuries CE [Broshi and Barkai 1985, 125–128].

Khirbet el-ʿAin

Khirbet el-ʿAin (ICS coordinates 141973/11497) lies at the top of a hill 340 m above sea level; it is located some 2.5 km northeast of Beit Guvrin, approximately 1 km southeast of Tel Goded, and next to the Roman road that linked Beit Guvrin and Jerusalem. R.A.S. Macalister documented several refuge systems and underground chambers on the site as part of the PEF excavations in the Judean Foothills, carried out in the late nineteenth century [Bliss and Macalister 1902]. B. Zissu documented a burial system from the late Second Temple period, which features a Greek inscription that has yet to be deciphered [Zissu 1999].

In early May 2012, antiquities thieves broke into a new area in the eastern section of the hiding system, which Macalister had previously documented at the top of the site, through a 2.6 m–high shaft. The opening of the shaft was discovered by Alon Klein from the Unit for the Prevention of Antiquities Looting during the course of his regular inspections in the region.

The shaft (Fig. 9; designated I on the new plan), with a square cross-section, was covered with rectangular slabs that had apparently been incorporated in the floor of a building that previously existed on this site (Fig. 10).

Parallel shelves were cut into the northern and southern sides of the shaft; these were used to support wooden beams or a rock slab that blocked off the upper part of the shaft, while permitting passage on all fours beneath it. There is a low, narrow opening to a tunnel four meters long at the bottom of the northern wall of the shaft. This tunnel cuts through another tunnel, which joins a blocked rectangular shaft (Shaft II) and a rectangular chamber (Chamber III) in which a collection of pottery vessels and fragments of stone vessels, typical of the first and second centuries CE, were found (Fig. 11).

These finds suggest that the hall was used by Jews. It is clear from the layout of the system that Shaft II and Chamber III are part of an earlier storage system that was

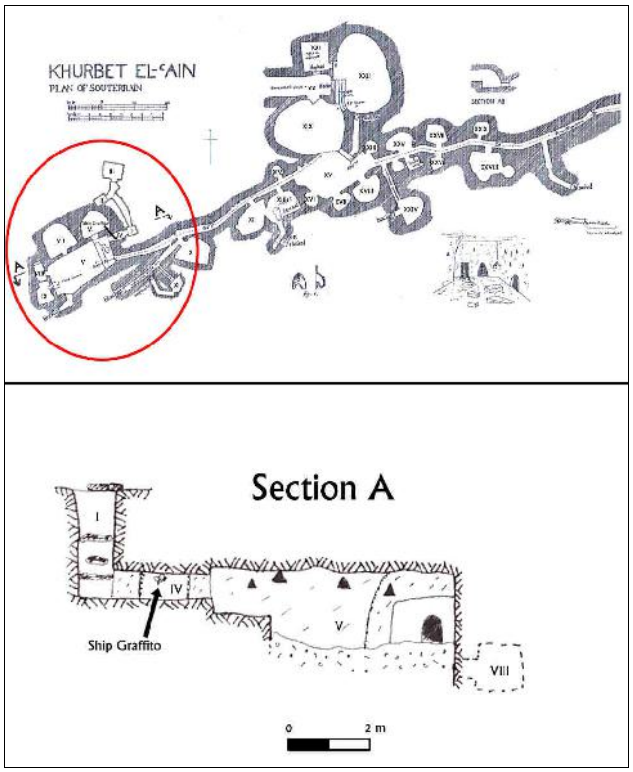

Figure 9: Plan and Section of the Hiding Complex, Khirbet el-ʿAin (drawing R.A.S. Macalister; E. Klein)

Figure 10: The Entrance and the Stone Slabs Covers to the Hiding Complex, Khirbet el-ʿAin, Looking North-West (photo B. Zissu)

subsequently linked to the hiding system via the tunnel from the bottom of the adjacent shaft. Another tunnel, 2.2 m long and 0.6–0.7 m high, opens onto the southeast wall of the bottom of Shaft I. The tunnel, which widens slightly (creating Chamber IV) some 0.4 m from its opening, continues to the upper section of the northwestern wall of a large rectangular hall (Chamber V), whose walls are pierced by openings that give access to smaller rectangular rooms. In the southern part of the northwestern wall of Chamber V, an opening bordered by a carved

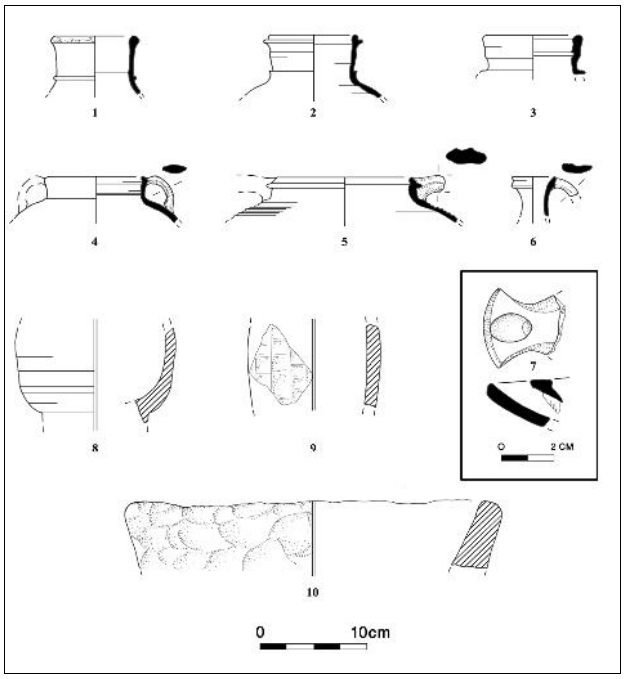

Figure 11: Finds from Chamber III in the Hiding Complex, Khirbet el-ʿAin (drawing J. Rudman)

stepped frame leads to a long tunnel that connects this chamber to the other parts of the system (Fig. 12).

Macalister entered Chamber V from the other part of the system; when he documented the system, tunnel IV was blocked, so that Shaft I does not appear on his plan. Macalister accordingly believed that Chamber V was dug out to serve as a refuge room and was an integral part of the refuge system [Bliss and Macalister 1902]. The discovery of the shaft and the tunnel leading from it to Chamber V made it clear, however, that the shaft, the tunnel, and Chamber V are all part of an earlier underground facility that was linked by tunnels to other, nearby facilities when the system was converted into a hiding complex.

A schematic depiction of a sailing vessel in profile was found on the southern wall of the wider section of Tunnel IV (Figs. 13, 14). The carving is 31 cm long and 20 cm tall. To judge from the deck, the ship is sailing towards the right (i.e., the bow is on the right and the stern is on the left side of the carving). A slightly curved mast, 12 cm tall, rises from the center of the deck. Two diagonal lines extending from the top of the mast to the bow and stern apparently represent braces. Two vertical lines that run from the braces to the bottom of the deck are apparently a schematic representation of a rectangular sail. Another clearly visible line runs down from the stern to below the left side of the deck; it is probably a schematic drawing of the steering oar. An inscription, apparently in "square" Hebrew letters, characteristic of the Second Temple period, can be made out along the length of the bow and the right side of the sail, but we were unable to decipher it.

Figure 12: Chamber V, Hiding Complex, Khirbet el-ʿAin, Looking East (photo B. Zissu)

Ḥorvat Maresha-West

Ḥorvat "Maresha-West" lies approximately 800 m west of Tel Maresha and some 350 m south of Ḥorvat Ada, at the top of a flat hill that rises approximately 300 m a.s.l. Visible on the surface are many openings to bell-shaped cavities and cisterns, some with collapsed roofs, and stone fences that incorporate ashlars. A lime pit at the center of the ruin has been preserved to a height of 3 m. The opening to an underground system was found a few meters east of the lime pit in late February 2012, after antiquities looting at the site.

The system we documented (ICS coordinates 139401 / 111128) comprises ancient underground chambers that were linked by long, narrow tunnels—equipped with oil-lamp niches throughout their length—into a hiding complex, typical of the Bar-Kokhba period (Fig. 15). The system resembles those that have been discovered at many other sites throughout the Judean Foothills. We found pottery and glass shards typical of period from the last third of the first century CE through the Bar-Kokhba Revolt [for details, see Klein and Zissu 2015]. One of the early facilities that was integrated into the refuge system is the bell-shaped cistern E, oval in contour (at the level of the tunnel, it measures 4.5 m long and approximately 3 m wide). A high opening (approximately 0.8 m wide) was created in the northern wall of the cistern, from which spiral stairs descend to the floor. This architectural plan is characteristic of the cisterns that were cut during the Hellenistic period in nearby Maresha [Kloner 2003].

A system of tunnels connects Chamber E and Chamber H. The latter is round (approximately 6 m in diameter and 5–6 m high), with walls that widen slightly towards the floor. An entrance affording easy access (approximately 2.5 m high and approximately 1 m wide) was cut in its northern wall.

This opening was deliberately blocked off by large ashlars, one of which had previously served as the weight of an olive press. At the northwestern corner of Chamber H, near

Figure 13: Schematic Sailboat Graffito on the southern wall of Tunnel IV, Khirbet el-ʿAin, Looking South (photo B. Zissu)

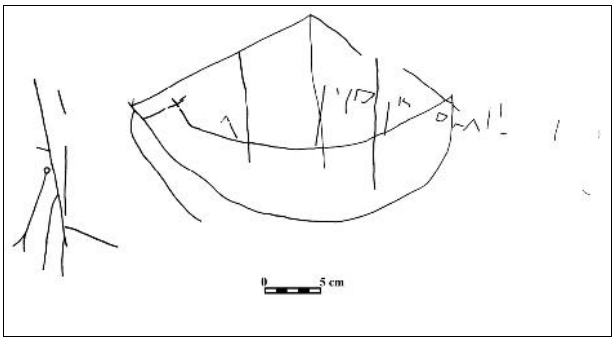

Figure 14: Figure 14: Sailboat Graffito on the southern wall of Tunnel IV, Khirbet el-ʿAin (drawing B. Zissu)

the floor, antiquities looters discovered the opening to a short, 2.5 m–long tunnel (Tunnel h–i) leading to Chamber I. The entrance to this tunnel from Chamber I, which has a shallow frame carved around it, is approximately 1.2 m high.

Chamber I is oval in shape (approx. 9 m long, 5 m wide, and 6 m high above the sediment that has accumulated on its floor). A high, wide entrance in the western wall (2.2 m high and 1 m wide at the narrowest point) once allowed easy access to the chamber. Steps were hewn out from the opening along the western wall of the chamber. This flight of stairs had a low railing cut from the chalk, typical of many underground chambers in Hellenistic Maresha. Tunnel h–i, described above, was cut into the tread of one of the lower stairs (Fig. 16).

The entrance doorposts were shaped like pilasters with Doric capitals that have a triangular diagonal echinus and a short vertical abacus. Above the doorposts, a stepped cornice-like lintel was carved into the rock. The combination of the pilasters and the stepped lintel (a sort of entablature) gives the entrance the look of a classical building, similar to the decoration of the openings to other underground chambers in Hellenistic Maresha [for an example, see Kloner 2003]. The lowest step of the lintel

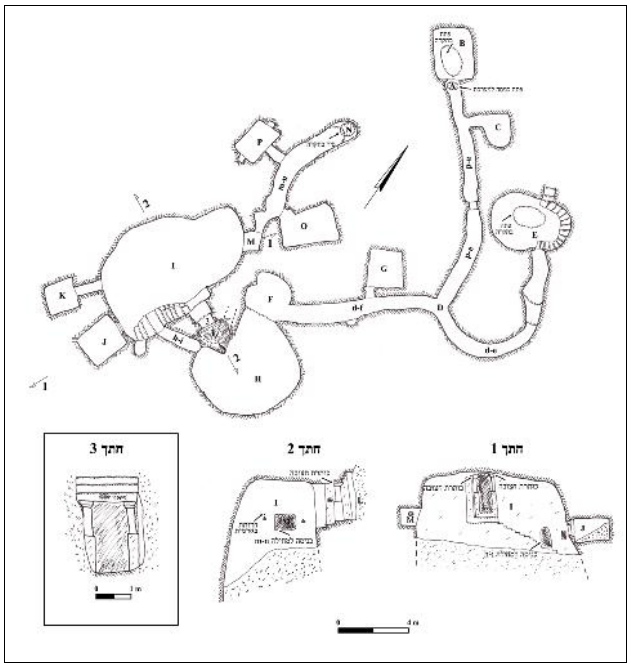

Figure 15: Plan and Sections of the Hiding Complex, Ḥorvat Maresha-West (drawing E. Klein)

contains an inscription in Greek alongside a schematic carving of a sailing vessel (described below). The entrance chamber (Chamber L), which leads to the ornamental opening to Chamber I, was blocked by a layer of dirt and rocks that made it difficult to photograph the opening and the inscription. The fact that the entrance to Chamber I is opposite to that of Chamber H suggests that the two chambers were planned together as a pair of adjacent underground storerooms with a shared *dromos* (Chamber L) that descends from ground level, in the manner typical of Maresha and its environs [Kloner and Zissu 2013]. The *dromos* (Chamber L) affording entry to Chambers H and I seems to have been blocked deliberately, apparently when the refuge system was created and the chambers were linked by Tunnel h–i.

An inscription consisting of eight characters in cursive Aramaic script was found on the northern wall of Chamber I (Fig. 17; average letter width 0.6–0.7 cm, height approximately 1 cm). The letters resemble the Aramaic letters on *ostraca* (potsherds used to write on) that have been found at Maresha and its environs, which have been dated to the fourth–second centuries BCE. Such letters are typically formed with upward strokes [for parallels and a discussion of the letter shapes, see Ephʿal and Naveh 1996]. The inscription was cut into a small area on the chamber wall, which was smoothed for this purpose by a wide chisel.

We propose reading עבדלהי זב(נ) [ʿBDLHY ZB(N)]. ʿBDLHY is a well-known Idumean name that appears on an ostracon from the fourth century BCE [see Ephʿal and Naveh 1996]. The prefix ʿBD was common in Idumean names of this period. If this reading is correct, the carving apparently documents a transaction between ʿBDLHY and someone else. The root Z.B.N. in Aramaic is related to commerce and is found, for example, in the words for "purchase" (*zabun*) and "merchandise" (*zabina*). In talmudic Aramaic, the verb is used for *buy* (in the *qal*) and *sell* (in the *piel*). We can assume that these goods were warehoused in the underground storerooms where the inscription was found; the inscription may attest to the ethnic identity of the people who used it during the Hellenistic period.

The Greek inscription above the lintel at the entrance to the cave (Fig. 18) was engraved in thin lines by an unsure hand. Each letter measures approximately 4 cm in both height and width. We propose the following reading:

Φ (Α/Λ) ΠΑΤΡΙΚΟΣ

The first letter (Φ) may be the abbreviation of a name, perhaps that of the carver. This is followed by Πατρικός, which is apparently the Greek form of the common Latin name Patricius, which means "noble" or "honored" and is related to "patrician." The Greek word *patrikos* means "derived from one's fathers, hereditary; of/belonging to one's father, paternal" [Liddell and Scott 1996]; perhaps the inscription is meant to convey that the owner of the storehouse was named "Abba" ("father" in Aramaic). That said, it seems more likely that the name derives from Latin, which is not common in the Greek from. We believe it was the name of the storehouse owner at some point in the Early Roman period, though we cannot rule out an earlier date, i.e., during the Hellenistic period.

To the left of the Greek inscription is an extremely schematic depiction of a ship (Fig. 19: 26 cm long, total height approximately 12 cm). The ship, with an elongated deck, appears to be sailing towards the left. The mast, 6 cm high, topped by a yard that is 18 cm long, stands mid-deck. A rectangular sail hangs from the yard.

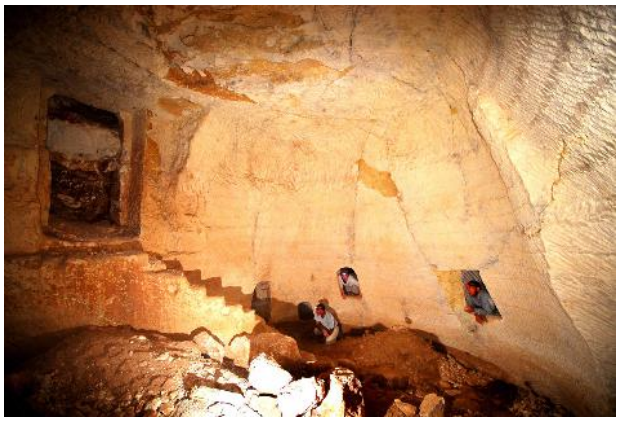

Figure 16: Chamber I, Ḥorvat Maresha-West, Looking East (photo B. Zissu)

Figure 17: Aramaic Inscription the Northern Wall of Chamber I, Ḥorvat Maresha-West (photo B. Zissu)

Two diagonal lines extending from the yardarms to the center of the deck apparently represent braces. Above the bow is a vertical line ending in an oval object. This may be the rounded prow typical of boats from the classical age, as in a fresco from the house of the priest Amandus in Pompeii, dated to the mid-first century CE [Morrison 1980]. Another option is to see it as a schematic representation of an artemon (foresail). A line extends under the stern and ends in something shaped like a backwards L and filled with hatching. This is probably meant to be the steering oar. At least six approximately vertical lines that end in a square run down from the deck—probably the oars.

The schematic nature of the graffito makes it difficult to identify the exact type of vessel and when it was carved. Based on the overall context, we propose dating the Greek inscription and the vessel to the Early Roman period.

3. DISCUSSION

We have presented four graffiti of sailing vessels, incised with a sharp tool on walls, doorposts, lintels, and hewn passages. What all these underground chambers have in common is that they are ancient rock-cut cavities that were apparently used at one stage or another to store agricultural produce and were later integrated into hiding systems that can be dated with a high degree of certainty to the Bar-Kokhba Revolt. Dating the graffiti is extremely difficult, however, because they may have been executed only in the last stage of the systems' use (during the Bar-Kokhba Revolt), but could just as well have originated at some earlier time. Accordingly we have assigned them to the Hellenistic/Early Roman period without further specification.

Judea engaged in extensive maritime trade during the Hellenistic and Roman periods. New harbors were developed along the coast. The surge in seaborne commerce made the coastal plain and major coastal cities

Figure 18: Ship Graffito and Greek Inscription above the Lintel at the entrance to Chamber I, Ḥorvat Maresha-West (drawing E. Klein)

Figure 19: Ship Graffito above the Lintel at the entrance to Chamber I, Ḥorvat Maresha-West, Looking East (photo B. Zissu)

extremely important. From the Jewish point of view, the Hasmonean rulers and Herod and his successors devoted major attention to developing maritime trade [Kashtan 2001]; this is evident from the designs on their coins [Meshorer 1997].

Many depictions of boats, carved in the Hellenistic and Roman periods, have been found in Judea. Most of them are in burials contexts, functioning perhaps as a symbol of the passage of the souls of the deceased to the world to come. This is reminiscent of the myth of Charon, who ferried the souls of the deceased to the other side of the Rover Acheron/Styx in return for payment [Sourvinou-Inwood 2003]. At some point, this symbol seems to have penetrated Jewish rituals, too, albeit without the pagan mythological context [Goodenough 1958]. Noteworthy are the engraving of a boat in a sixth-century BCE burial cave at Ḥorvat Beit Loya [Naveh 1963]; two boats in a burial cave at Maresha dated to the Hellenistic period [Hadad and Artzy 2011]; the schematic depiction of a boat in a Second Temple–era burial cave at Khirbet Haruf in the Judean Lowlands [Batz 2004]; the charcoal drawings of boats in the entryway to Jason's Tomb, which are dated to the Hasmonean or Early Roman period [Rahmani 1964]; a rough image that has been taken for a boat, carved into a third-century BCE arcosolium near Tel ʿItun [Tzaferis 1982]; and on the facades of tombs and sarcophagi in the

Jewish cemetery at Beit She'arim, which dates to the Late Roman period [Mazar 1957]. Two schematic drawings of boats, one with its sail unfurled, were carved on the plaster of the eastern cistern at Herodium, located just underneath the Royal tomb. These carvings could be dated to several periods, including when the cistern was cut, when the tomb was built and walls were constructed inside the cistern to support the ceiling, and even to the Bar-Kokhba Revolt, when the rebels utilized the cistern as part of the system of refuge tunnels. The members of the excavation team assigned the graffiti to the period when the tomb was built on top of the cistern and proposed that they may represent the victory of the deceased over death [Zissu 2015].

Graffiti of sailing vessels from the Hellenistic and Roman periods that do not have a funerary context have been found in the past in the Judean Foothills and elsewhere in Judea. Bliss and Macalister found a chalk tablet with a carving of a boat in Maresha during their excavations in 1900. Gibson dated this carving to the late second century BCE [Gibson 1992; Kloner 2003]. Three depictions of sailing vessels were found in the northern palace on Masada, originally constructed during Herod's reign. One was found on a wall above a bench in the palace guardroom [Aharoni and Rothenberg 1960; Netzer 1991]. Graffiti of three more boats, along with an exercise in writing the Latin and Greek alphabets, were found on the wall of the adjacent Storeroom 120. They seem to have been drawn by soldiers and palace servants who copied what they had seen in the past; alternatively, they may have been documenting ships on the nearby Dead Sea [Cotton and Geiger 1989; Netzer 1991]. From the Second Temple period, we know of the depiction of a sailing vessel anchored in a harbor on a stone tablet claimed to have been found at Turmusʿ Ayyeh in the Shilo Valley [Rahmani 1974]. A graffito of a Roman warship, dated to the second century CE, was found at Ḥurbat Rafiaʿ on a loose building stone [Kloner 1981]. On one of the walls of the Chapel of St. Vartan in the Church of the Holy Sepulcher there is an ink drawing of a typical Roman-period sailing vessel, with a Christian inscription in Latin below it. It has been proposed that this graffito was executed by a pilgrim who came to Jerusalem by sea during the late Roman or Early Byzantine period [Broshi and Barkay 1985].

That said, these boat graffiti have nothing in common that would allow us to draw any conclusions regarding the significance of these images; perhaps each has its own symbolic significance. On the other hand, all of the boats presented here share a date (Hellenistic–early Roman periods), archaeological context (passages, doorposts, or lintels of underground facilities), and geographical provenance (north and east of Maresha in the Judean Foothills). Perhaps a more detailed analysis of these characteristics could help identify the symbolic significance of these inscriptions. Throughout the Hellenistic period this region was inhabited by Idumeans, until they were converted to Judaism, voluntarily or by force, during the reign of Johanan Hyrcanus I [Josephus, *Jewish Antiquities* 13; Shatzman 2005; Rappaport 2009]. From then until the Bar-Kokhba Revolt, the population was Jewish. During the Hellenistic period, Maresha was home to a Phoenician-Sidonian community (though it is not clear whether this group also held estates in the rural district surrounding the city). We are best-informed about the family of Apollophanes, the leader of the Sidonian community, whose burial plot was discovered in the city's eastern cemetery (Peters and Thiersch 1905). It is interesting to note that some members of Apollophanes' family bore Semitic names, while others had Idumean theophorics; this suggests a process of assimilation into the local Idumean society [Kloner 2003]. The Phoenicians were a Semitic group who occupied a narrow strip on the eastern shores of the Mediterranean Sea. Phoenician history is intimately linked to the sea, seamanship, maritime trade, and shipbuilding [Salles 2003]. We can therefore cautiously suggest that the ship graffiti on the doorposts and lintels of the underground chambers could be related to the Sidonians who lived in the region during the Hellenistic period (Recently, during his lecture at a conference in honor of Prof. Amos Kloner, Dr. Ian Stern made a presentation about a large drawing (2 m long) of a sailing vessel. It was discovered in an underground chamber bearing ritual characteristics in the course of the archaeological seminars he runs at Tel Maresha. The graffito may be connected to the Sidonian community that lived there during the Hellenistic period). Self-identified remnants of this group may have survived in the area around Maresha even after Johanan Hyrcanus converted the local population, throughout the Second Temple period, and until the Bar-Kokhba Revolt. It is more likely, however, that most of the Phoenicians refused to accept Judaism and were expelled [see Rappaport 2009].

Another plausible conjecture draws on the fact that the four underground chambers with graffiti at their entrances served, at some time in their history, to store agricultural produce. The ships may have been a way of marking the produce that was meant for export through the ports of Ascalon and Gaza, located some 30–40 km (a day's journey) from the region. It is also possible that the symbols have no practical significance but expresses the storeroom owner's desire to take part in maritime trade, i.e., to succeed and prosper. Finally, images of boats—especially during the Roman period—served an apotropaic function (in other words, they are meant to ward off evil influences) and were meant to protect the produce in the storeroom from harm [Friedman 2011]. If this explanation is correct, perhaps the boat graffiti were meant to protect the refugees hiding there during the Bar-Kokhba Revolt.

We have proposed several theories (a link to the Sidonian community, maritime commerce, an apotropaic symbol) for the boat graffiti found in underground systems in the

Judean Foothills. Whether or not these theories are correct, this is a new, fascinating, and mysterious phenomenon. Scholars who study the riddles of the Judean Foothills should be aware of this phenomenon, because we assume there are other boat graffiti throughout this region that are waiting to be discovered.

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If techniques help to date a monument... three case studies

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Abstract
It is quite complicated to date a carved monument by technology because most of the time, carved technologies seem to be permanent or are adapted to specific geology. With three case studies however, it is possible to propose some hypothesis and to stress how dating from techniques could be used.

The first two are located in Cappadocia, in the central Anatolia. During ten years, we conducted surveys in order to study techniques of carved building site. After observations of tools marks and comparison between tombs and churches, we were able to make a typology of tools. It showed us some evolutions in the tools boxes of stone workers, while some tools specific of one period were identified. These remarks seem not be specific to Cappadocia and monuments carved in soft ignimbrite and, we think that they could be used to date other sites in the Near East.

The third example is located in Tur Adbin, an area in the East of Anatolia, close to Mardin. In the village of Daras that was founded in the 5th century, a necropolis was carved. By literature sources and observations of landscape, it is possible to date this necropolis. Inside the necropolis, a tomb – which is called *Galeri Mezer* by the Province Archeological Museum of Mardin – is realized with different techniques than other tombs. These specific techniques used to carve the *Galeri Mezer* confirm guess work of historians about date of its realization.

Keywords
Cappadocia, Daras, carved techniques, datation.

1. INTRODUCTION

This paper aims at showing how techniques could be used to date rock-cut monuments more precisely. Of course, it is not an absolute dating because most of the tools did not change between the Ancient and Medieval times. It is impossible to find a precise date without crossing archaeological and historical data. But techniques allow us to propose a relative dating; in other words, techniques enable to determine the relative phasing of carved site and understand how a rock-cut monument is made and if this building is completed or not. Studying techniques is also a way to identify workers, their skills and know a bit more about them (if they are left hand or right hand, if they take care of their tools, etc...). More generally, this kind of research is a clue to understand evolution of the local society.

To illustrate this, I selected three case studies located in Turkey. The first two are in Cappadocia in the area of the Nevşehir Plateau. They are carved into a very soft rock, ignimbrite. The last example is located in Daras, a city thirty kilometers from Mardin (south-east Turkey). It is carved in a soft limestone.

2. FIRST CASE STUDY: DATING AN ABANDONMENT

2.1 Description of the church

The first monument is carved in the fairy chimney, located on a crest between the valleys of Göreme and Kılıçlar, close to the open-museum of Göreme. The dating of the church is currently discussed. Recently, C. Jolivet-Lévy and N. Lemaigre Demesnil chose to follow the proposition of M. Xenakis who dates paintings of the northern apse during the 9th century [Xenakis 2012; Jolivet-Lévy & Lemaigre Demesnil 2015]. This hypothesis, however, does not include the date of carving which was logically made before the decoration. N. Lemaigre Demesnil compared this church with another, the church no.3 in Uçhisar, and proposed to place the carved process around the 7th century [Lemaigre, 2010]. This, it can be safely stated that this church was carved between the 7th century and the beginning of the 9th century.

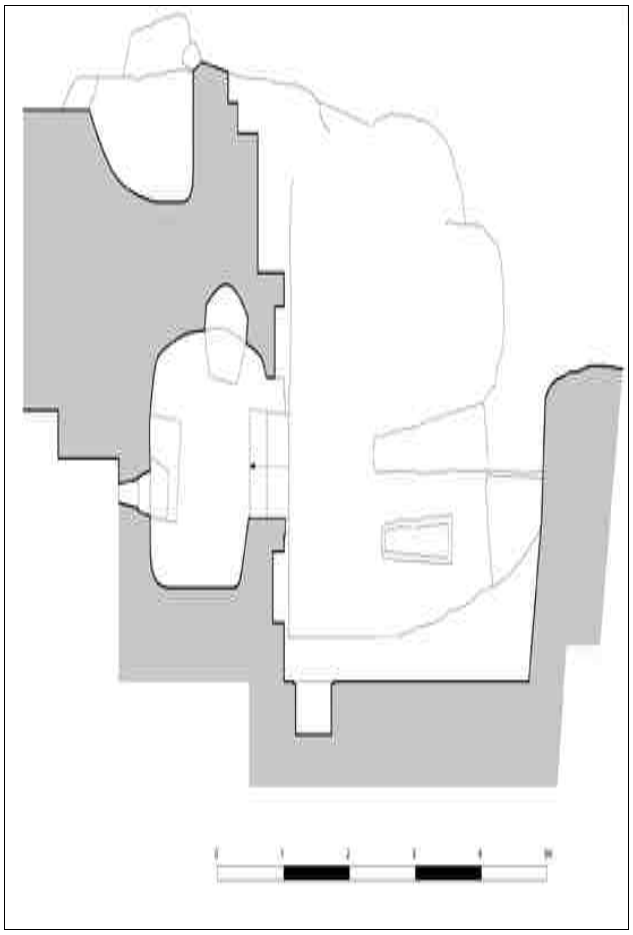

Figure 1: Plan of the church no. 4b in Göreme (drawing A. Lamesa and V. Dubois)

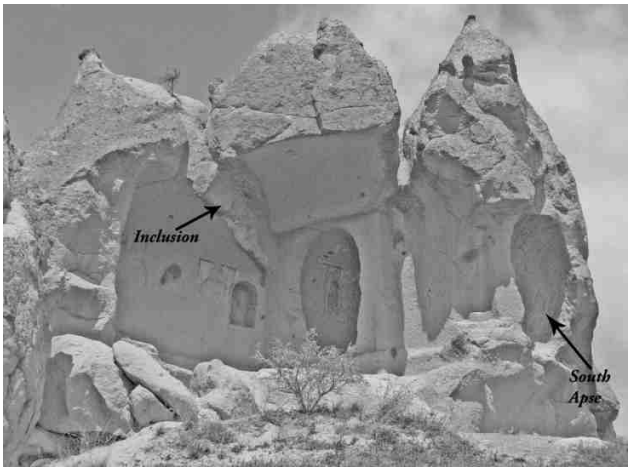

Figure 2: The church no. 4b in Göreme (A. Lamesa)

This monument has an irregular plan and two apses (Fig. 1), this second element was not seen in previous publications [Restle, 1969 ; Jolivet, 1991 ; Wallace, 1991 ; Assutay-Fleissig, 1996 ; Lemaigre, 2010 ; Jolivet-Lévy & Lemaigre Demesnil, 2015].

Figure 3: The unfinished apse and its tools marks (photo A. Lamesa)

Many researchers explained the irregular plan of the church by the change of meaning during the carving process. Indeed, this church should have a transversal plan but stone workers needed to find a new solution to get around a major problem: the presence of one hard stone inclusion, more than one meter in length and width. This hypothesis is most probably the best explanation but the abandonment of the south apse cannot be explained by this big rocky inclusion directly. Therefore in this case study, we want to highlight how phasing of the carving process could help us to better understand the architecture aspect of the monument, and, finally its relative dating.

2.2 Technical aspects

When we are standing in front of the monument, it is clear that the western and southern parts of the nave and the entrance of the church were destroyed, and with them, the most of the ground part (Fig. 2). If we turned around the fairy chimney, a recess is visible on its southern part. Aspect of the wall is completely different than the rest of church. In this recess, morphology of the tool mark is composed by one deep line finished by a round or square hole (which form depends on the tool wear). The organisation of tool marks on the wall formed straight lines almost parallel each other (Fig. 3).

In the nave, morphology of tools marks seems identical but they are less deep than the previous. However, their organisation is completely different. They form semi-circle lines parallel with each other (Fig. 4).

Figure 4: The west wall of the nave and its tools marks (photo A. Lamesa)

Because morphologies of tool marks are identical but not their organisation, it is possible to propose a hypothesis.

We can identify the tool as a pick. The depth of marks shows that it is not the same pick. In the carving process of rock-cut church, stone workers used a quarry-pick to dig the rock and a pick of stone-cutter to regulate the wall [Lamesa, 2011]. The quarry-pick has a very large iron part as well as its point. The iron part of the pick of stone-cutter is thinner [Bessac, 1986] (Fig. 5).

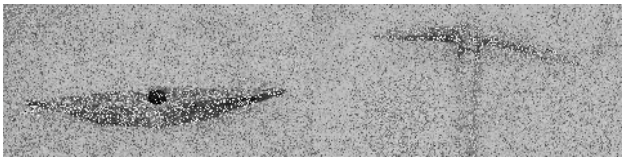

Figure 5: On the left, a quarry-pick, on the right a pick of stone-cutter (photo A. Lamesa)

Because the quarry-pick is used in the southern apse, we can deduce that this apse is unfinished. Indeed, marks of this tool disappear when stone-cutter raises the wall. We can conclude that this apse was abandoned during the carving process, but when?

2.3 Hypotheses for abandonment of apse

Comparisons with other rock-cut churches help us to understand the first idea of workers. Most of the time in Cappadocia, it is the southern apse which is not finished or not carved, and southern apses are forsaken during the phase of completion of structural system and more precisely in the task of regularization of walls [Lamesa, in preparation] as we can see in the church no. 19 in Soğanlı. Around Göreme, the church no. 34 or "church with small refectory" [Jolivet-Lévy & Lemaigre Demesnil, 2015] has its northern apse unfinished and no southern apse. Its northern apse was abandoned during the phase of shaping the structural system like the southern apse of the church no. 4b in Göreme. Because we know that this monument may have a transversal plan in first place, the parallel with the church no. 34 in Göreme leads to conclude that the southern apse of the church no. 4b in Göreme could be the central apse. So its transversal nave should have two or three apses and the unfinished one was started in first.

We can therefore assume that stone workers started excavation in the southern part of the church and continued to the east to end in the actual southern apse. After that they turned on the left to go straight to the northern part as shown by orientations of tool marks. On the preserved south wall of the nave, semi-circles are mainly pointed to the north; on the north wall they are oriented to the west. Furthermore, the vault of the nave is clearly realized from the south. In this context, why did they abandon it?

We can propose some hypotheses:

- In the same time, two quarrymen or stone-cutters carved the church: one of them dug a channel in the nave and the second started to carve the southern apse.

- At first, one diagonal or vertical crack, which now destroyed the southern part of the church, disturbed the worker in the southern apse.

- In a second time, when the second stone-cutter working in the nave found the big stone inclusion, all the team stopped the carving process. The south apse was not realized for the solidity of the monument and because of the change of meaning.

2.4 Some conclusions and hypotheses thanks to observations of tool marks

- The southern apse (or central apse) is unfinished in the first phase of carving process.

- This apse may be abandoned because of a crack. The discovery of the rocky big inclusion changed the carving process schedule and the southern apse was abandoned definitely.

- The church was started by the south and the southern apse was carved first.

- By the help of tool marks it is possible to prove that two stone workers carved at the same time. This peculiarity is a clue to consider this church was thought as a big one and not only a chapel in first place. Indeed, it is more common that one stone-cutter only carved inside the stone during the first phase.

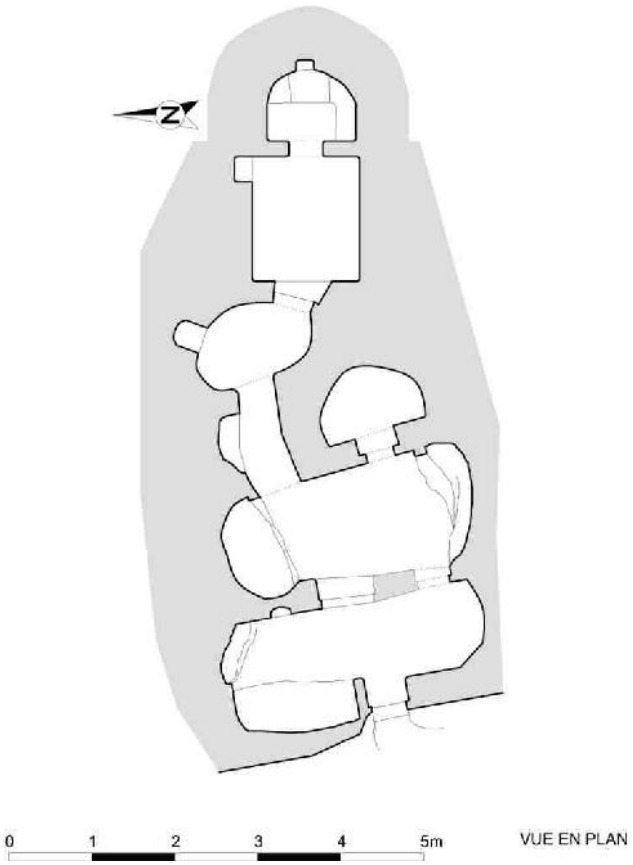

Figure 6: Plan of the church no. 5 DB in Mazıköy (drawing A. Lamesa and V. Dubois)

3. SECOND CASE STUDY: RELATIVE DATING WITH THE HELP OF ONE TOOL

The second Cappadocian church is located in the village of Mazıköy, not far from Kaymaklı köyu and its famous underground settlement. The site is divided in four main valleys, two in the village (named Davutluğu Bucağı and Damlar Önü) and the other two outside the village (called Keşlik dere and Göynuk dere).

3.1 Description of the church

The church no. 5 DB is on the plateau of Davutlu Bucağı, close to an ancient necropolis established above the village. The monument was published by N. Thierry [1977]. This rock-cut church is located in a small complex. The entrance of the complex comes out on a first room almost entirely destroyed. We can discern one *arcosolium* in its northern part. This first room opens to a second, where two *arcosolia* are carved and a unfinished recess which may be a room. The northern *arcosolium* is partly damaged by a channel steered toward the east. Inside this channel a rock wheel, used most probably as a door, is lying on the ground. This short channel ends by an irregular plan room where a chapel opens (Fig. 6).

Thierry identified the church as a refuge-church and proposed to date its excavation during the Arab invasions.

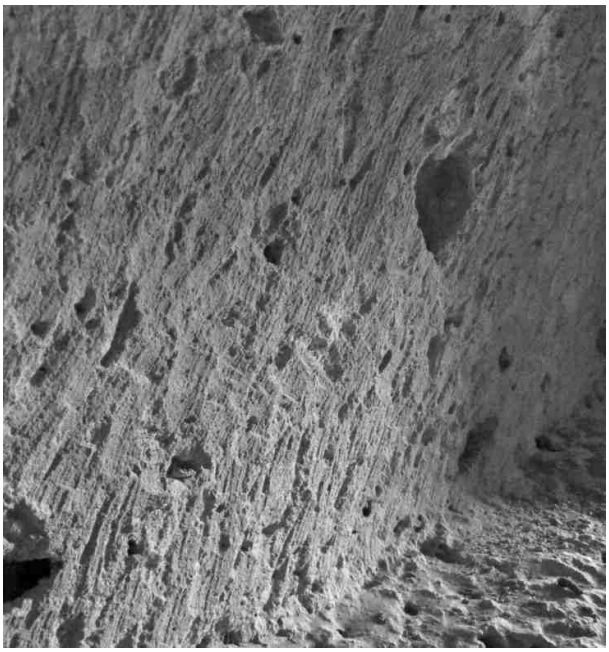

Figure 7: Marks of oriental coarse toothed hammer in the wall of the second room, church no. 5 DB in Mazıköy (photo A. Lamesa)

This hypothesis may be qualified by the observation of tool marks.

3.2 Technical special features observed in Mazıköy

Presence of multiple rock-cut monuments in the site helps to understand evolutions of techniques between the Roman and Byzantine periods. It emerges that some tools disappeared during the Byzantine time. During the task "the regularization of walls", ancient stonecutters used an oriental coarse toothed hammer to carve monumental tombs [Bessac, 2007; Lamesa, 2016]. This oriental coarse toothed hammer (nowadays in Syria, this hammer is called *tchâûtâ*) has horizontal cutting edges instead of european type which has vertical cutting edges.

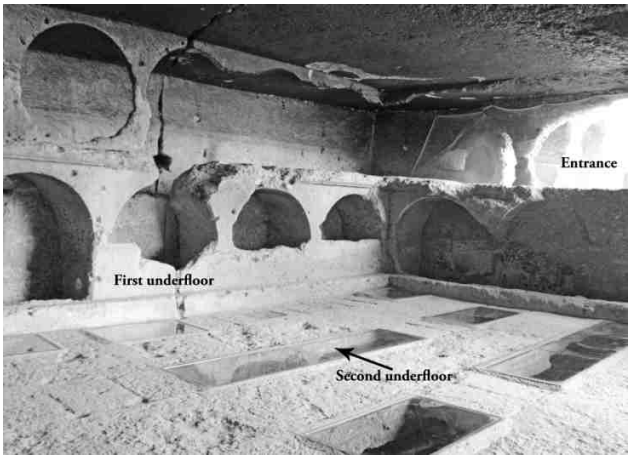

Figure 8: Interior of *Galeri Mezer* (photo A. Lamesa)

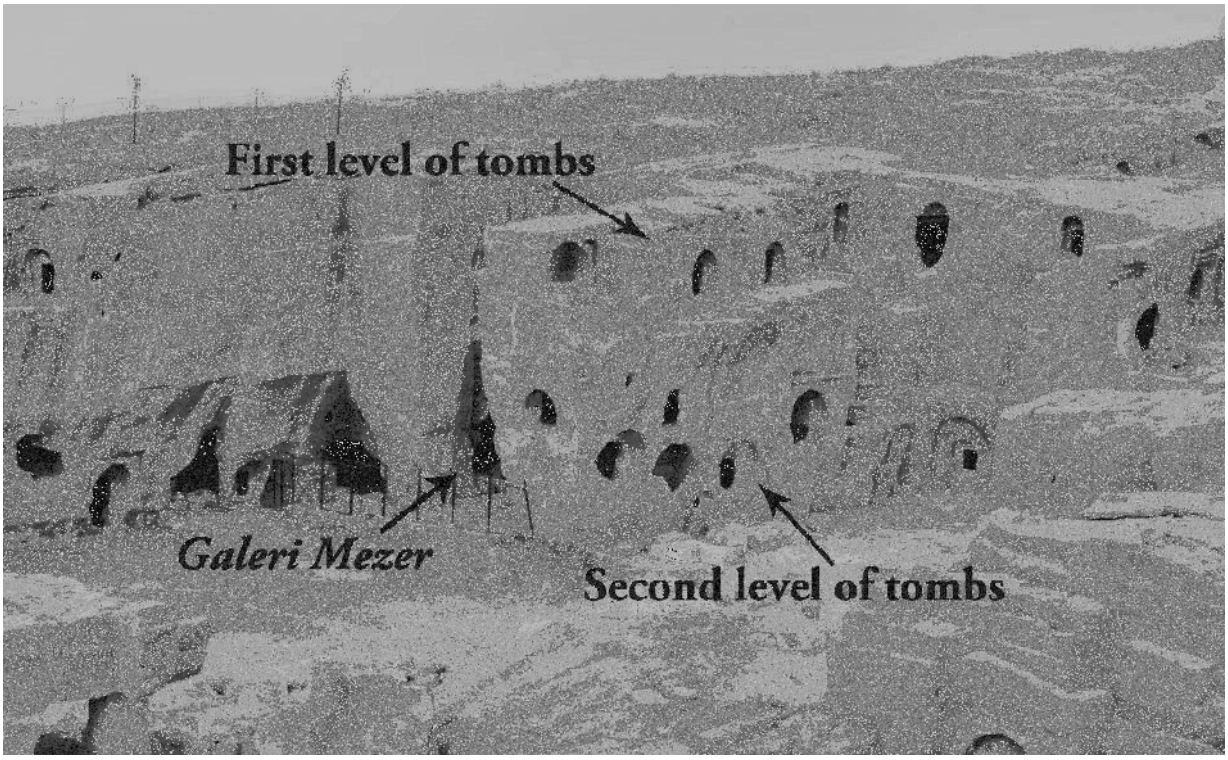

Figure 9: Necropolis A and its phases of realization (from Mardin Museum Archives).

During the medieval period, this tool seems disappear and stone workers used *polka* (a tool with two axes which one is vertical and the other is horizontal) or facing hammer to realize the same task. Abandonment of the oriental coarse toothed hammer could be explained because all of toothed tools used to regulate walls are no longer employed by Byzantine stone-cutters.

If we go back to the church no. 5 DB, marks of oriental coarse toothed hammer are visible in the second room (fig. 7). This indicates that this room was carved during Antiquity.

Observation of plan confirmed this hypothesis. The two first rooms have the same orientation. They are parallel with the natural rock face. On contrary, a *polka* was used to regulate the walls of the chapel and this monument is oriented differently.

3.3 Some final hypotheses

We think that the complex was made in several times. Because of a technical need, the position of the church no. 5 DB in the complex is not in the place where it ought to be. According to geological examination, the church is carved inside another ignimbrite as testifying a vertical crock located just before the entrance of the chapel.

This hypothesis could explain the unfinished recess opened in the second room. It might be a first attempt to carve the church but this ignimbrite has too many inclusions.Workers may decide to search another layer, more homogeneous.

In any case it is obvious, thanks to observation of tool marks, that the complex of the church no. 5 DB in Mazıköy was not carved only during the Arab invasions.

4. THIRD CASE STUDY: CONFIRMATION OF OLD HYPOTHESIS BY OBSERVATION OF TECHNIQUES

Daras is a village not far from Mardin. It is exceptional for its preservation. Daras is fortified and surrounded by quarries some of which have become necropolises.

4.1 Description of *Galeri Mezer*

The third monument, named *Galeri Mezer* in turkish, is exceptional by its size, plan and decoration. It is carved inside a necropolis, called Necropolis A by the museum. It has three floors formed by two galleries and a basement. The entrance of this monument is opened onto the highest gallery. Its monumental façade is decorated by two panels of sculptures: on the left, the first panel is a representation of “Ezekiel in the Valley of Dry Bones” and the representation of the right panel cannot be identified [Mudell, 1975].

Inside, the highest gallery is decorated by a colonnade sculpted on its perimeter. The first underfloor gallery is carved by eighteen *arcosolia*, most of them destroyed. We access to this first underfloor gallery by a spiral scale located in the south-west. The basement or the second underfloor gallery is supported by nine columns. Its ground is covered by abundant bones and its access is a straight scale placed on the south-west too (Fig. 8).

4.2 Datation of necropolis A and *Galeri Mezer*

Before explaining why carving process confirmed hypotheses by M. Mudell and O. Nicholson, it is necessary to expose the date of Necropolis A. Indeed, no one studied this aspect even though it is important to understand implementations of *Galeri Mezer*.

Necropolis A has two levels of tombs, separated by a line made in the rock. This demarcation comes from function of the site as a quarry. It underlines two phases of extraction and proves that Necropolis A was made in two times, between the 509 and 573 (Fig. 9). History of Daras is well known and two phases of its construction is attested during the VIth century (most probably in 507-518 and in 527-530) [Whitbyn 1986; Gregory, 1996]. Reusing quarry as a necropolis was possible in the first phase in 518-527 and in the second phase 531-573.

Mudell proposed to date *Galeri Mezer* between the 591 and 604 [Mudell, 1975]. This hypothesis was followed by O. Nicholson who identified the monument as a *dakhma* [Nicholson, 1985]. As we can see (Fig. 9), the entrance of *Galeri Mezer* is carved in the second level, so during or after the last phase of necropolis' occupation.

With the observation of carving technique, we can go further and agree wholeheartedly with the hypothesis of O. Nicholson.

4.3 Carving process in Daras: two techiques

The first carving technique observed in Necropolis A is common. Tombs have been dug inside the rock by a destructive cut performed by a quarry-pick.

The second carving technique, only used in *Galeri Mezer*, could be compared with the techniques employed for monumental tomb in Qadamgah, Iran [Bessac, 2007]. A terrace was carved above the entrance of the monument (Fig. 10). Its presence may highlight using of stone extractions to raise the facade.

Furthermore, this facade was realized at one time as testified by the presence of scaffolding carved directly in the limestone. It comes from the top of the plateau and goes down close to the old terrace.

The size of the monument and techniques of carving could be a clue to confirm the hypothesis of O. Nicholson: stone workers, who carved this monument, might have used Iranian carving techniques.

5. CONCLUSION

This article aims at demonstrating how study of carving techniques improves dating of a site or a monument as determining phases of monuments' realization, knowing if complex was made in ancient or medieval period, confirming the dates' hypothesis formulated with the help of Art.

More than that, techniques helps to understand how stone workers were organized and their origin in some cases.

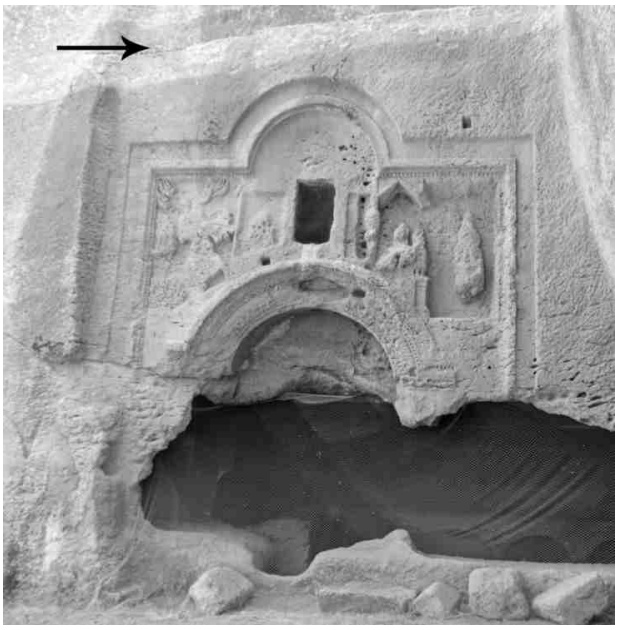

Figure 10: Remain of terrace above the entrance of *Galeri Mezer* (photo A. Lamesa).

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A link between "ancient words" and the "underground world": Cappadocian landscape, rock-cut structures and textual evidence from Hittite documentation

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Abstract

Springs, sinkholes, cave mouths, crevasses and mountain passes characterize the geological landscape of Cappadocia. In the 2nd millennium B.C., i.e. the period of Hittite civilization, these natural features were surrounded by a sacred aura, and often seen as favorite seats of the gods. They were also considered as accesses to the Underworld, as passages connecting the world of the living with the world beyond.

In Hittite cuneiform texts, some terms seem to refer to these peculiarities of the land. The first term worthy of consideration is the cuneiform compound form ^{D}KASKAL.KUR (often translated as "underground water course"), probably corresponding to hieroglyphic (DEUS)VIA+TERRA ("divine earth-road") which occurs in the Luwian-hieroglyphic texts. This definition may specifically refer to a type of cavity in the ground connected to monuments or structures and to the performance of cult activities. Another interesting term is ^{NA4}*hekur*, which most likely refers to a monument on a mountain/rock. The ^{NA4}*hekur* could have various rooms, was very durable and resistant and sometimes served as a shelter for the population and the army. Other terms worthy of note are ^{NA4}*huwaši*, a sort of stele or boundary marker, É.NA$_4$, literally 'Stone House', and *hesta* (often written with the determinative É = house).

In the paper, this type of textual evidence will be examined in detail. Furthermore, by means of a multidisciplinary approach taking into account the various instruments used in speleology, geology, archaeology and history, we will seek to establish a link between some landscape features of contemporary Cappadocia which show traces of past anthropic activity - especially sinkholes and other types of underground cavities or rock-cut structures - and the information provided by Hittite (and post-Hittite) documentation.

Keywords

Cappadocia, underground structures, rock-cut structures, Hittite documentation, Neo-Hittite monuments.

1. INTRODUCTION

As experts know, the topic of the origin and dating of the underground and rock-cut structures of Cappadocia (Fig.1) is much debated.

One of the authors who particularly studied this issue is M. Urban [Urban, 1973/6; Urban, 1973/7; Urban, 1973/8; Urban, 1986]: in some of his works he suggests that Christian (Byzantine) populations, to which underground structures are generally ascribed, have often reused preexisting spaces.

Although in some contributions Urban speaks of links between Hittite (2nd millennium B.C.) or Neo-Hittite (1st millennium B.C.) artifacts and underground structures, after further consideration, he attributes a Phrygian origin to the shelters dug in the ground. Urban stresses, however, that no definitive archaeological and textual evidence has been found, and hopes for further research on the subject.

The research conducted by the 'Centro Studi Sotterranei' (of which R. Bixio and A. De Pascale are members) suggests that the underground structures were most likely to have been used by local people during the period between the 7th and 11th centuries A.D.

However, given the morphological, lithological and climatic characteristics of the region, Urban's suggestions seem to be fairly plausible. Indeed, it would be surprising if ancient people who lived there for several centuries had not taken advantage of the shape of the landscape and the nature of the rocks to start digging the first underground buildings, even if it were only for the sake of creating comfortable environments.

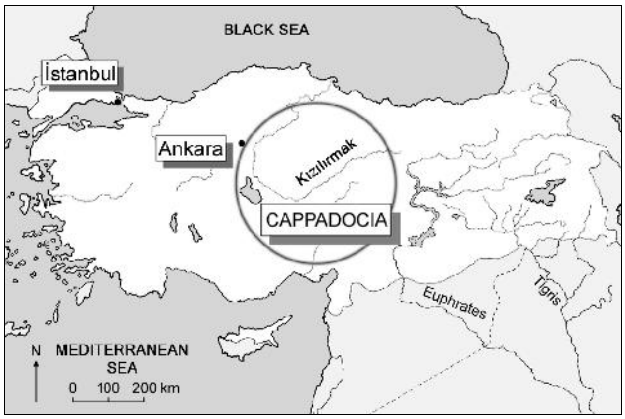

Figure 1: Area of Central Turkey where Hittite and Neo-Hittite kingdoms were located (drawing R. Bixio)

This topic is undoubtedly attractive, albeit difficult to resolve in the current state of knowledge and research. Frequent visits to places in Cappadocia that preserve evidence of 2nd and 1st millennium B.C. civilizations (urban settlements, monuments, steles and rock reliefs or inscriptions, dating back to the Hittite and the Neo-Hittite periods), as well as to underground structures, which are generally attributed to more recent times, as we said above, have helped us to deepen our knowledge and look for any connections.

The aim of this paper is not to propose new hypotheses on the dating of underground sites and rock-cut structures, which are not possible considering the current available data, but rather to offer food for thought on the subject. It will highlight some recurring terms in written texts, descriptions of activities and spatial connections that may be to some extent related to rock or underground structures.

The first part of the paper (section 2) will examine some interesting terms that occur in Hittite cuneiform texts, whereas the second part (section 3) will highlight cases of proximity between monumental evidence of Hittite/Neo-Hittite age and rock or underground structures with the help of some topographic maps.

2. EVIDENCE FROM WRITTEN SOURCES

Some terms in Hittite cuneiform texts seem to refer to peculiarities of the Anatolian geological landscape, such as sinkholes, cave mouths, crevasses, swallow holes, both natural and artificial.

These natural features were often surrounded by a sacred aura, and sometimes seen as favorite seats of the gods; they were also considered as accesses to the Underworld, as passages connecting the world of the living with the world beyond, and therefore were considered privileged places for worship activities. Some texts, especially related to mythology and religion, mention supernatural beings connected to openings in the earth.

The myth of the serpentine dragon Illuyanka says that the goddess Inara "called the serpent up from its hole (Hittite *hatteššar*), (saying) 'I'm preparing a feast. Come eat and drink'. The serpent and [his offspring] came up, and they ate and drunk. Now they do not want to go back down into their hole (Hittite *hatteššar*) again" [Hoffner, 1998, p. 12 (text no 1)]. In another mythological text that narrates the disappearance of the Storm God of Nerik, the story begins with the Storm God who gets angry and retires into a cavity, or pit, referred to as a *hatteššar* [Hoffner, 1998, p. 22 ff., esp. p. 23 (text no 4)]. In a similar way, in a fragmentary text describing a festival in honor of chthonic deities (CTH 645), a *hatteššar* is the ground cavity through which the connection with these deities is established.

In all these instances the word used to denote a special cavity in the ground is *hatteššar*. This term has usually been identified as a sort of hole or pit in the ground in which offerings could be thrown and gods could disappear [Green, 2003, p. 140 with references therein].

In addition to *hatteššar*, another term that seems to refer to a cavity in the ground, or a pit, is *abi-*/*api-*, sometimes personified as ^{D}*Api*. The word, probably from the Hurrian language, is documented in Hittite cuneiform sources and seems to indicate an artificial entry to the Netherworld, a necromantic sacrificial pit for summoning up infernal deities or revenants [HED 1, s.v. *api-*; Hawkins, 1995, p. 45, with references; Taracha, 2009, p. 155].

In the following sections, some other interesting terms will be analyzed.

2.1. ^{D}KASKAL.KUR

This term, which seems to indicate a sacral / divine opening in the earth, occurs in different contexts: in Hittite treaties, as a landmark in boundary descriptions; in treaties and prayers, within lists of deities or topographical features; in some rituals, as a recipient of offerings [Gordon, 1967; Otten, 1980; Otten, 1988, p. 33 f.; Hawkins, 1995, p. 44 f.]. In all these occurrences, the term is marked by the determinative 'god'. The link between the two ideograms can lead to different interpretations (and meanings)[1]; the most common translation is 'underground watercourse'[2], with possible reference to the seat of chthonic deities [Archi, 2007, p. 186-187; Harmanşah, 2015, p. 45]. Hawkins [Hawkins, 1995, p. 44 f.] noted a correspondence ("one-for-one") between the ^{D}KASKAL.KUR in the cuneiform documents and the Hieroglyphic (DEUS) VIA+TERRA (translated 'divine earth-road') in the SÜDBURG inscription (Hittite period, end of the 2nd millennium B.C.). The same hieroglyphic sign also appears

[1] Cf. Gordon, 1967, p. 75 ff., on the different meanings of the two separated signs.

[2] Cf. the authors quoted above. See also the translation proposed by Hawkins, 2000, p. 293: "'karstic slot, pot-hole', conceived also as an entrance to the underworld". About the term, see recently Ullmann, 2010, p. 235-136, who also refers to Korfman, 2001 for the discovery of an underground spring cave at Troy, identified with a ^{D}KASKAL.KUR.

in the post-Hittite inscriptions KARAHÖYÜK and İSPEKÇÜR (12th-11th centuries B.C.), but in very difficult contexts, that do not corroborate the interpretation[3].

Other interesting terms for the issue we are dealing with are characterized by the determinative (or the word) 'stone'/NA_4 (see the following sections). These terms refer to particular structures composed of several rooms that could accommodate people and animals and be used as a refuge in case of danger. They are also often connected with gods, worship activities and cult of the dead.

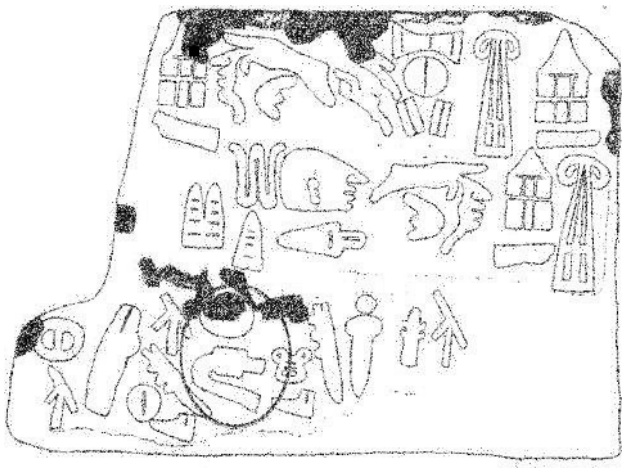

Figure 2: The hieroglyphic sign (DEUS) VIA+TERRA in the SÜDBURG inscription [Hawkins, 1995, fig. 35]

2.2. ^{NA4}*hekur*

The term ^{NA4}*hekur* is sometimes accompanied by toponyms or other geographical references and divine names. According to van den Hout [van den Hout, 2002, p. 74-75], it designates "a rocky outcrop, a mountain peak, profane in origin that often, however, acquired divine proportions and could become a sanctuary" and that "could have more than one function (mountain sanctuary, place of refuge, palatial building, but also tomb)" [van den Hout, 2002, p. 87].

These structures were a kind of institution which had workers, cattle and properties, and were exempt from taxes and duties (cf. for example the exemption from providing horses in CTH 88); they could also have been places of refuge for the local population and troops: it seems therefore possible to assume that the ^{NA4}*hekur* was built on a defendable location[4]. In some occurrences ^{NA4}*hekur* is characterized by the term SAG.UŠ ('eternal, solid, stable, everlasting') and has been interpreted as a 'memorial monument'.

Ullmann [Ullmann, 2010, p. 160 fn. 352] points out that "a ^{NA4}*hekur* or the (Divine) Stone-House was a building or structure, but it could also be interpreted as a naturally occurring structure made out of the natural rock, such as a cave, that one can enter into." In an article published in 2011, Balza and Mora [Balza & Mora, 2011] proposed that some monuments displaying reliefs (in particular SİRKELİ and FRAKTIN) might have been ^{NA4}*hekur*, for the traces of large architectonic structures, for the presence of cup-marks[5] and for specific references and clues in cuneiform texts.

Based on these data, and given especially the mountainous location and the apparently large size of the ^{NA4}*hekur* structures mentioned in the Hittite sources, we wonder whether they may have been some kind of rock-cut houses (cf. the "wall" rock-cut settlements of the Byzantine and Medieval periods, for instance the one in Fig. 3). In this respect, consider that, in a Hittite birth ritual (KBo 17.62 + 63 IV 7' ff.) "the resistance of the ^{NA4}*hekur* to natural forces is stressed" ("and come! as the rock sanctuary the wind and rain cannot [lift from] its place …") [Beckman, 1983, p. 32 ff.].

The etymology of the form ^{NA4}*hekur*, too, would seem to support this kind of hypothesis. In fact, Puhvel [HED 3, p. 287-289], later followed by Kloeckhorst [EDHIL, p. 339], has suggested that the almost complete absence of declension in the occurrences of the word points decisively to a loanword, the base meaning of which may not be "rock" (that is *peruna-*, *pirwa-*); the word most probably derives from the Sumerian form É.KUR, "mountain house", and has been incorporated into Hittite as *hé-kur, hé-gur*, possibly through the mediation of Hurrian [see also HEG, p. 235-237; HW2, p. 556-557].

We have little information about the geographical location of these structures: the Annals of Mursili or the so-called cult inventories provide some isolated references, but they do not seem to relate to a precise region or area. An intriguing hint concerning the likely presence of at least one ^{NA4}*hekur* in Cappadocia is contained in an exemption

[3] On this subject, see also Erbil & Mouton [2012, p. 57 ff.], who discuss the equivalence between the hieroglyphic and the cuneiform term and suggest that possibly "the Südburg complex would symbolize a natural underground watercourse". In more detail, the two scholars suggest that the shape of the sign (DEUS) VIA+TERRA might evoke the idea of a tunnel leading to a cave where an underground watercourse could flow (see Fig. 2). In our opinion, also the previous proposal by Meriggi [Meriggi, 1975, p. 45, p. 319: 'ponte', i.e. bridge], is quite interesting and worthy of further investigation.

[4] In Mursili's Annals (KBo 2.5 Vs I 14) it is said that the commander of the border district of Istahara conquered the ^{NA4}*hekur* of Pitalahsa, which was held by the enemy's army, and captured the people and cattle that were in it [cf. Del Monte, 1993, p. 125, where the term is translated 'rocca'; Goetze, 1933, p. 181, who translates 'Fluchtburg'].

[5] Artificially made depressions often associated with Hittite rock reliefs (see, for an example, Fig. 4): for detailed studies, cf. Ussishkin, 1975; Neve, 1977-1978. Cf. van den Hout, 2002, fn. 36 and § 5, with previous references. See also below, section 3, for the rock of Suvasa, on which there are also cup-marks (Fig. 18).

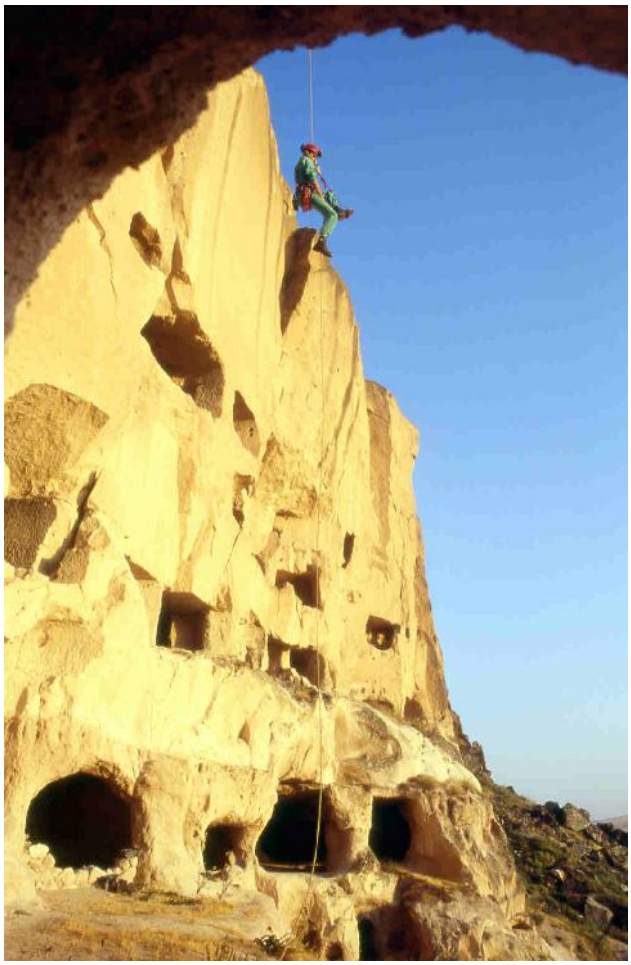

Figure 3: The Byzantine "wall" rock-cut settlement of Tatlarin (Ne 27), sectioned by the collapse of the face, not very far from Ovaören (photo G. Bologna)

decree on behalf of an institution called ^{NA4}*hekur* p/Pirwa (CTH 88). In this particular context, the term p/Pirwa could refer to a god related to horses. Based on the fact that the cult of Pirwa was diffused in an area embracing Cappadocia up to the valley of the Afrin river [Haas, 1994, p. 412-413], it could be assumed that the structure called ^{NA4}*hekur* p/Pirwa could be located in the area where the god was worshipped, that is Cappadocia [Balza, 2013, p. 12 ff.].

2.3. ^{NA4}*huwaši*

The ^{NA4}*huwaši* is usually interpreted as a cult stele, or a boundary marker [HEG, p. 333; Cammarosano, 2015]. ^{NA4}*huwaši* could have been placed in a temple, but they were also located outdoors. Among the activities performed during the KI.LAM festival, the king is said to 'enter' the *huwaši* of the Storm God [cf. Singer, 1983, p. 79, KUB 2.3 II 32-35].

It is common also to identify *huwaši* stones with rock reliefs. Stokkel [Stokkel, 2005, p. 180] distinguishes between ceremonial *huwaši* rocks and land marking *huwaši* rocks (corresponding to two typologies of Hittite rock reliefs). As we said above, 'cup-marks' were found on the top of some of the rock reliefs, probably with a cult function (see footnote 5 and Fig. 4).

2.4 É.NA$_4$

In the Hittite written documentation, the expression É.NA$_4$ ('Stone House') seems primarily to refer to a tomb, "the last resting place of the bodily remains of members of the Hittite royal dynasty" [van den Hout, 2002, p. 86; cf. also Singer, 2009, p. 169]. In more detail, the Stone House seems to have been the place in which, according to the royal funerary ritual, the remains of Hittite kings and queens were disposed after the conclusion of the cremation ritual [van den Hout, 1994, p. 54 ff.; Kassian, Korolëv & Sidel'tsev, 2002]. A donation deed promulgated by the queen Asmunikal [del Monte, 1975; Klinger, 2001] describes the functioning of a Stone House. According to this document, the term also seems to refer to an economical institution owning properties with its own personnel, and benefiting from special privileges, such as the exemption from paying taxes due to the central administration. In fact, this important document tells us that the Stone cult House "was a whole temple-like complex of the ancestor's cult with fields, orchards, vineyards, cattle and sheep, and numerous personnel. (…). The estate of the Stone House, as belonging to the deceased could not be put on sale, and, similarly, people working there and their descendants could not marry outside" [Taracha, 2009, p. 165].

With regard to the architectonic structure of the Stone House, the available documentation seems to suggest that a Stone House should have a *hilammar*, a 'portico(?)', as well as a É.ŠÀ, a 'inner chamber'[6].

2.5 (É) *hesta*

(É) *hesta* (the '*hesta* house') is another interesting term sometimes associated, in the sources, with the ones that were previously mentioned, but not characterized by the 'stone' determinative. We can obtain some significant information about this structure and its functions from the cuneiform texts [Haas & Wäfler, 1976 and 1977, with a thorough analysis of the sources]: it was a building with interior rooms, at least one gatehouse and a spring or basin at the gate [Singer, 1983, p. 106, 108, 113]. The '*hesta* house' was also seat of frequent festivals or cult activities [Torri, 1999, p. 6 ff., 17 ff. with references; HW2, p. 573 ff.], often with the involvement of the king, and is also quoted as being a recipient of goods/supplies [cf., e.g., Singer, 1983, p. 114; DBH 15, p. 19]; various kinds of

[6] See the texts KBo 17.15 rev. 12': NA$_4$-*an pár-na-aš hi-lam-ni*, "in the portico(?) of the Stone House"; see also, for the É.ŠÀ, "inner chamber", KUB 39.12 rev. 14', and probably KUB 39.11 obv. 47' [cf. van den Hout, 2002].

Figure 4: Cup marks at Ambarderesi [photo from Demanuelli, 2015]

workers and priests were employed there [Haas & Wäfler, 1977, p. 92]. In HW2 [HW2, p. 572 ff.], the '*hesta* house' is described as a "Kultbau, meistens chtonischen Gottheiten gewidmet", but, again according to HW2 [HW2, p. 576], there is no definitive reference to the 'Mausoleum /Totentempel' function.

In a royal decree of Hattusili III quoted above (CTH 88, 13th century B.C.), we can read the following passage (obv. 14-15): "the city of Hattusa had been burned down, but […] and the *hesta*-house had escaped", which seems to highlight that at least one of these structures was located close to the capital[7]. Some scholars have suggested that the terms *hesta* house and É.NA$_4$ could refer to the same type of building, but this hypothesis is not generally accepted [Haas & Wäfler, 1977, p. 118; Torri, 1999, p. 31; Groddek, 2001].

To sum up, some data seem particularly interesting. The first point we want to refer to is the fact that most of the analyzed terms are connected with cult activities and can refer to structures, or buildings, composed by several rooms, as in the case of the 'Stone House' (É.NA$_4$), or the ^{NA4}*hekur*. In some cases, such structures look and behave like actual centers of power.

Another hints worth of note is that one of these 'buildings', the *hesta* house, is said not to have been damaged by the fire that destroyed a large part of the Hittite capital during an enemy attack. Although there is no conclusive evidence in this respect, we could infer from this reference that the structure in question was particularly resistant.

The same sense of resistance is also connected to the ^{NA4}*hekur*: in a ritual text, this structure is mentioned as an example of resistance to natural forces. As far as the ^{NA4}*hekur*-structures are concerned, it is also important to stress the fact that, according to at least one text, these structures could serve as shelters for both people and cattle in case of danger for the local population[8]. This specific issue, combined with the word etymology, might suggest a comparison between the ^{NA4}*hekur*-structures and the rock-cut settlements dating to later periods that are still visible in the landscape of Cappadocia.

Finally, the extension and complexity of the famous Kestel Mine, in the Taurus Mountains, which was dug in the Early Bronze Age (from about 3240 to 2200 B.C., according to radiocarbon readings), can testify to the ability of local population to dig galleries and work in the underground starting from very ancient times, and could represent an additional clue to support our hypothesis [Sagona & Zimansky, 2009, p. 200-203; cf. also Yener, 2000 and 2008].

3. BYZANTINE CAVITIES AND NEO-HITTITE VESTIGES

As argued in the introduction, so far there are no literary references or archaeological evidence which directly relate the numerous man-made cavities in the soft tuff rocks of the ancient Cappadocia territory with the Hittite and Neo-Hittite vestiges located in the same area (Fig. 5).

Nonetheless, considering that both are widely present in the territory, it is not surprising to note that some of them have a close proximity.

We think it is now appropriate to provide a short description of five underground structures surveyed during explorations between 1991 and 2000 [Bertucci et al., 1995; Bixio et al., 2002; Bixio et al., 2012], corresponding to sites where inscriptions and other Hittite and Neo-Hittite remains are present. These places are all located in the wide plain which extends to the west of Nevşehir, the Regional Capital. The cavities described here contributed to defining the "horizontal underground refuges". Such a type characterizes the plateaux, while the "vertical rock-cut refuges", carved in pinnacles or high cliffs, are most common in mountains areas. Both constituted a clearly efficient defensive system from the conflicts which, often, over the centuries, affected Cappadocia.

"These structures were destined to house, for short times and in the case of emergency, small groups or whole communities and to protect them from temporary threatening events" [Bixio & De Pascale, 2015, p. 462].

[7] Some hypotheses have been proposed about the identification of the *hesta* house with known monuments, but none of these identifications have been confirmed; for a discussion on the localization, cf. Haas & Wäfler, 1977, p. 119 f. For the possibility that the *hesta* house was only in the Hittite capital cf., Torri, 1999, p. 14. Cf. also Singer, 2009, p. 170 with fn. 6, for additional references.

[8] As mentioned above, some authors have sought to identify a number of Hittite archaeological remains and landscape monuments (among them, e.g., the rock sanctuary of Yazılıkaya) with the *hesta*-house or the ^{NA4}*hekur*-structures mentioned in cuneiform sources. However, to date, no conclusive evidence has been provided to support such identifications.

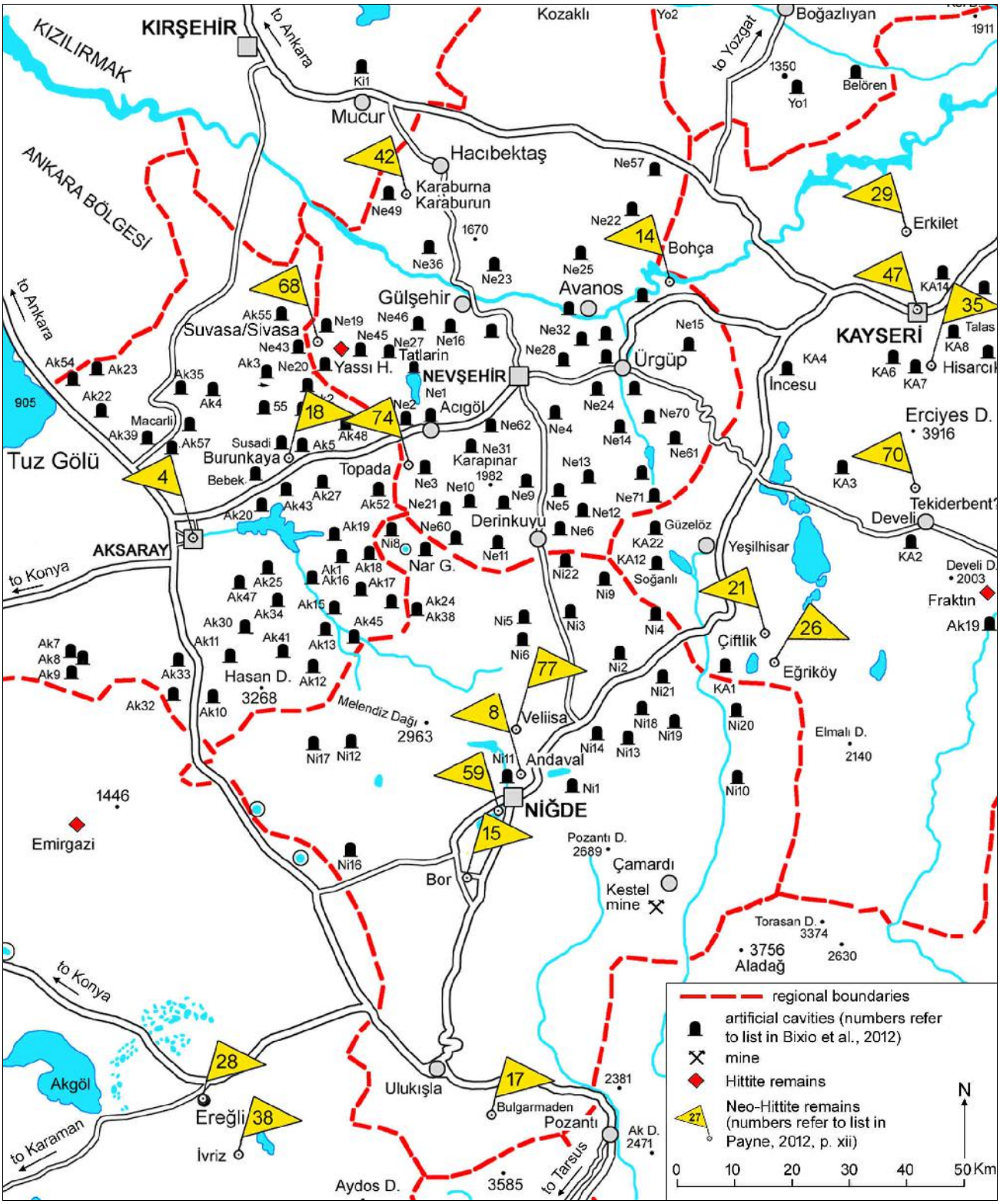

Figure 5: Territory of ancient Cappadocia: Hittite and Neo-Hittite remains and artificial cavities (drawing R. Bixio)

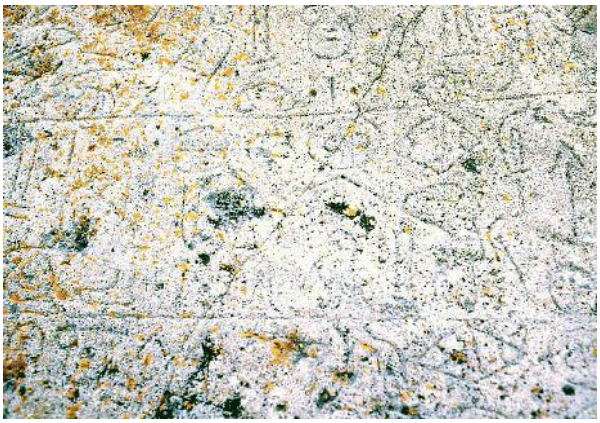

Figure 6: Karaburna village. Inscription of KARABURUN, detail [photo R. Bixio]

The connection with rock-cut churches and Christian symbols, which are quite often closely related, and the guerrilla tactics documented in the Byzantine era [Dennis, 1985; Mc Geer, 1991] despite not explicitly mentioning the underground refuges, logically suggest that the origin or, at least, the maximum development of these defensive systems could coincide with the Arab incursions period. Occupation attempts and raids, occurring *"twice, sometimes three times a year"*, [Canard, 1983, p. 274], are documented between the 7th century and the beginning of the 11th century: *"dès les années 640...jusqu'à la mort de Sayf ad-Dawla (967)"* [Kaplan, 1981, pp. 149, 155], and continued until at least the strategist Nikephoros *"Ouranos' protracted campaigns... between 1005 and 1007..."* [Mc Geer, 1991, p. 133].
In the first half of the 7th century, owing to the Arab expansion, Cappadocia become a border region and so was re-organised by the Emperor Heraclius as a *thema* (military district), in which *"the plots of land were assigned to soldiers who undertook both cultivation and defence for their heirs"* as wrote Herm [1985, p. 176]; or, as say Runciman: *"le comunità di liberi cittadini ricevevano la terra direttamente dallo Stato, spesso in cambio del servizio militare"* [Runciman, 1997, p. 47-48]. *"Venne così a costituirsi un'aristocrazia a un tempo militare e fondiaria"* [Thierry, 1971, p. 129].
Obviously such soldiers-farmers had the ability and attitude to organize suitable fortified underground structures which, considering the geological characteristics of the region, were easier carved inside the rock, more efficiently defensible, not subject to throwing weapons and harder to be detected than masonry built structures.
However, the idea of dating these structures to different periods should not be excluded on principle. There may be other periods, either previously or later on when there was a similar scenario with different protagonists [Bixio, 2002].

3.1 The tunnel of Karaburna (Ne 49)

Karaburna (or Karaburun) is located 9 km south-west of Hacıbektaş (flag 42 in Fig. 5). The village is overawed by a natural rock tower, nearly circular and flat on top, which seems to be a fortification, and is indeed called Kale Tepe (Hill of the Fort) (Fig. 9). A low double line of dry stones, roughly squared, surrounds its perimeter (about 350 m). On a slope there is a trace of a sort of access ramp with a Neo-Hittite hieroglyphic inscription carved into its side (Fig. 6).

A sinkhole, which is full of stones, is located a few metres below. There is a tunnel (Ne49) starting in the sinkhole, with a flared transversal section (sec. aa'), that descends steeply, following the hill slope. After passing through a small cavity with a flat ceiling, the passage becomes unusable a dozen metres below, as it is blocked by a large amount of stones (Figs. 7, 8).

The tunnel may have been used, in the event of a *Kale* siege, to reach the stream at the bottom of the valley to collect water, as an escape route or to attack the enemy from behind. The passage may have been connected to a more complex underground settlement, located at the bottom of the hill, among present day village houses. Only two large rooms can be accessed there, which are used as stable nowadays (Ne50). Six tunnels branch out from this point, which are now closed by dry stone walls. A closing device to house a millstone-door is also recognisable.

The three-line KARABURUN inscription [Hawkins, 2000, p. 480-483] describes an agreement (between a king and a governor bearing the same name) and the construction of a fortress by the same men. Proposed date: late 8th century B.C.

3.2 The refuge of Topada-Ağıllı (Ne 3)

This is the southernmost site. It is located 7 km south of Acıgöl, and 2,5 km north of the small village of Ağıllı. The underground structure is excavated inside a low outcrop in the middle of cultivated fields (Fig. 10), nearly halfway between the Karahöyük (Black Mound, an unexcavated archaeological hill, where pottery from the Iron Age have been found), and the hieroglyphic inscription, carved on a low cliff (flag 74 in Fig. 5), known as the TOPADA inscription (Fig. 11) [Hawkins, 2000, p. 451 ff.]. Despite its small extension (202 m), the underground structure consists of many clustered rooms of various sizes, which can be accessed through three separate entrances (E) (Fig. 12). Some descending side passages, filled with earth, suggest that a lower level exists.

The spaces are interconnected and protected by at least eight millstone-doors (M), arranged in order to provide a mutual and/or opposing defence so as to have, in the case of an attack, four sectors that would have to be progressively isolated or, perhaps, an innermost area within which to retreat (redoubt). This one had an escape route, in turn protected in both directions (M5-M6), consisting of a tunnel with an ascending shaft (P) which could lead back to the outside. On the opposite slope there are some isolated rooms including a chapel with two graves.

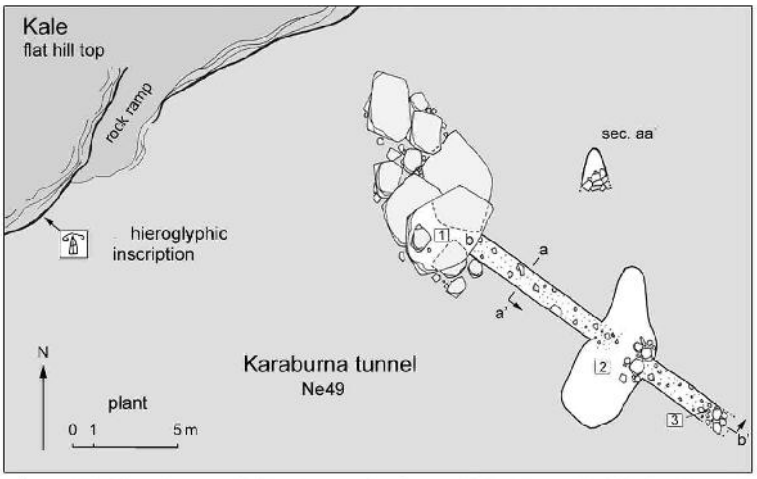

Figure 7: Karaburna (Karaburun). Plant of the tunnel of Kale Tepe (drawing R. Bixio)

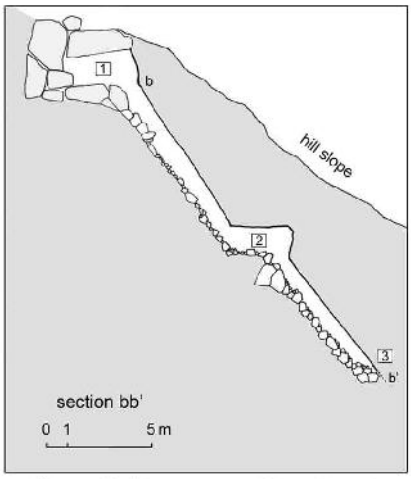

Figure 8: Karaburna (Karaburn). Tunnel section (drawing R. Bixio)

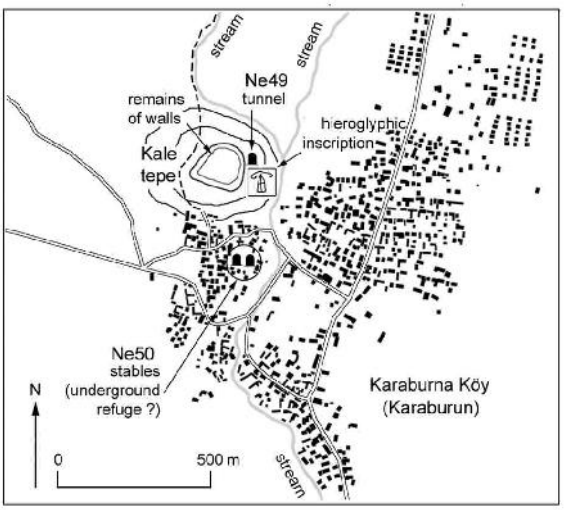

Figure 9: underground structures and Neo-Hittite remains in the area of Karaburna (Karaburun) (drawing R. Bixio)

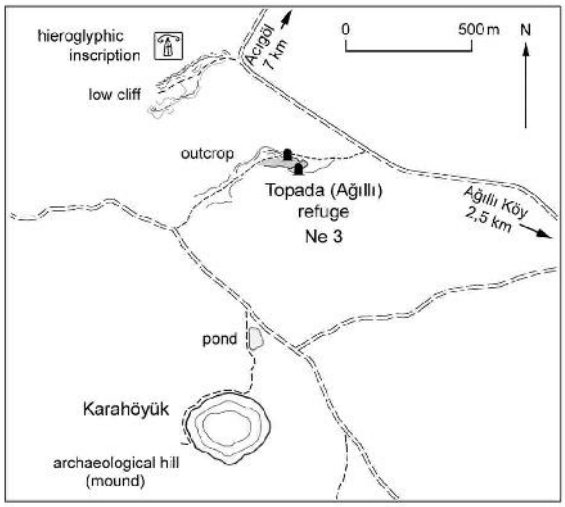

Figure 10: underground refuge and Neo-Hittite inscription of TOPADA near Ağıllı village (Acıgöl) (drawing R. Bixio)

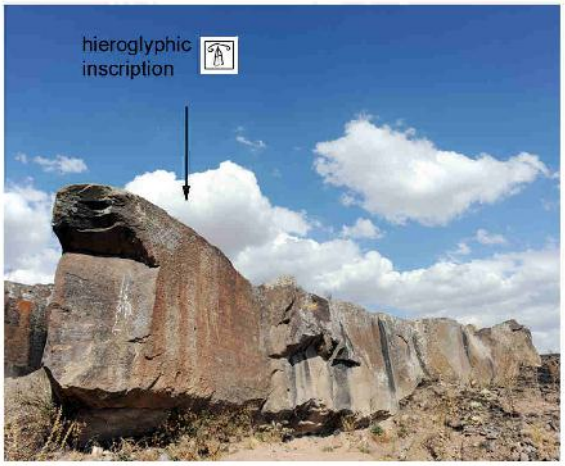

Figure 11: rocky inscription named TOPADA, in front of the underground refuge (photo A. Bixio)

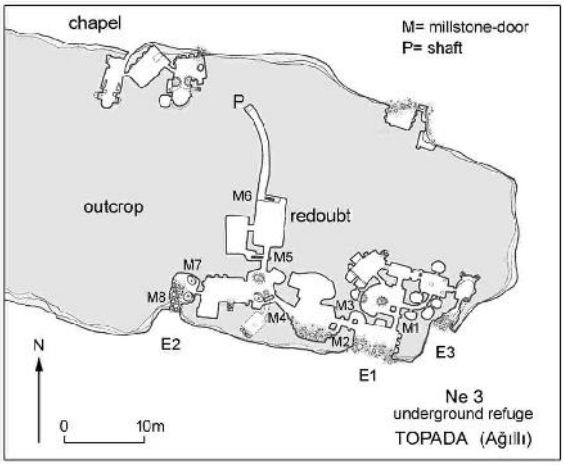

Figure 12: plant of the underground refuge of Topada or Ağıllı, south of Acıgöl (drawing R. Bixio)

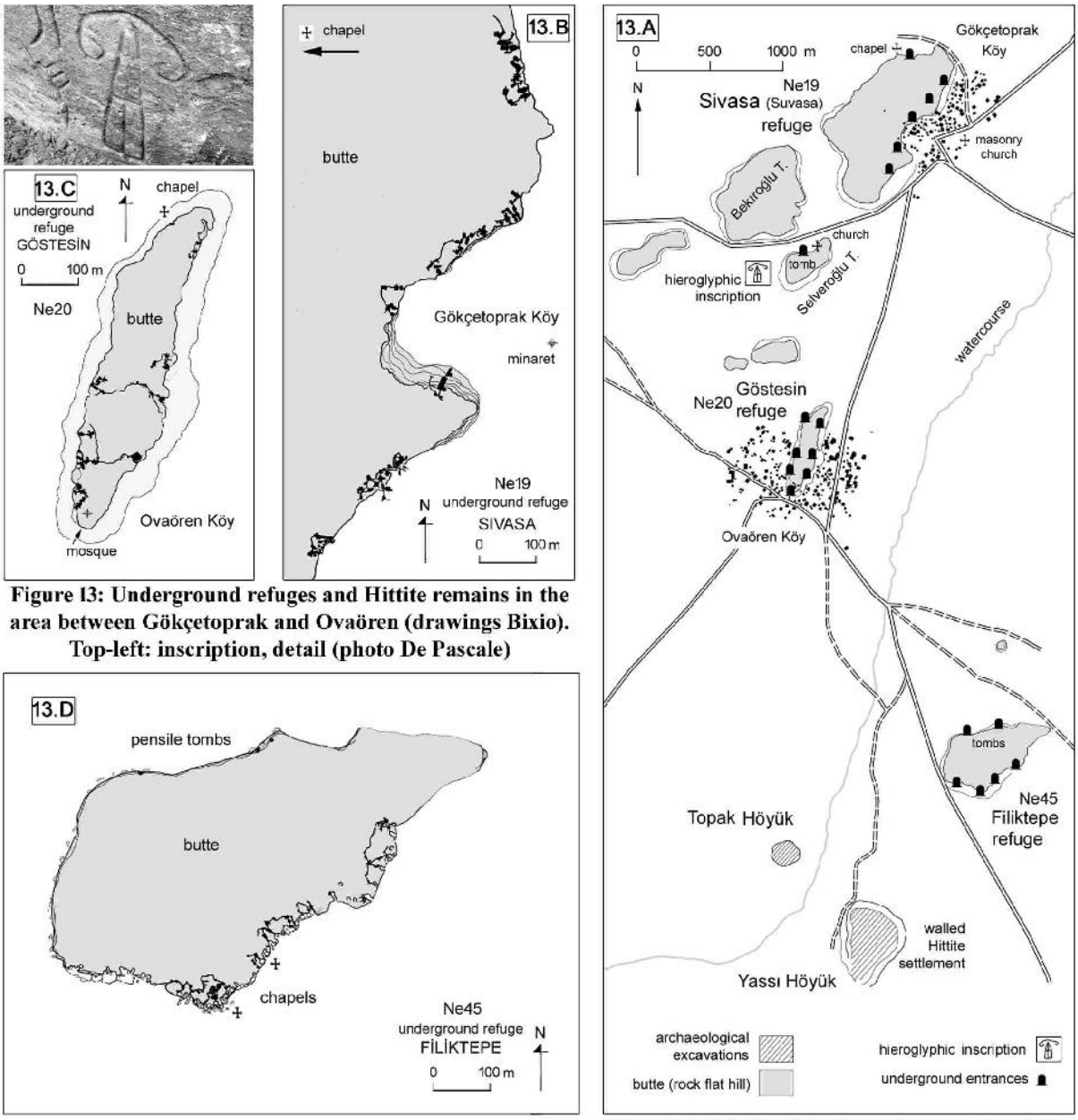

Figure 13: Underground refuges and Hittite remains in the area between Gökçetoprak and Ovaören (drawings Bixio). Top-left: inscription, detail (photo De Pascale)

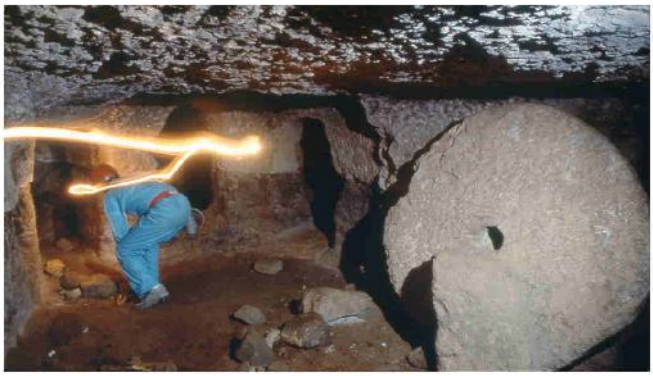

Figure 14: underground refuge of Filiktepe. A millstone-door defended the inner stores and wells (photo G. Bologna)

Figure 15: underground refuge of Göstesin. Inner well to draw out water bed (photo G. Bologna)

Figure 16: Sivasa (present Gökçetoprak). The entrances of the underground refuge are spread over the eastern outcrop, often camouflaged between the masonry buildings (photo A. De Pascale)

The TOPADA inscription is written by (or in the name of) the Great King Wasusarmas and describes military events, especially against the city of Parzuta [see Hawkins, 2000, p. 453]; in §§ 19 and 20 another city, Ta-x, is quoted; in § 6 (defensive) Walls or Fortresses [Payne, 2012] are mentioned.
The inscription, despite its archaic or archaizing style, is traditionally dated to the second half of the 8th century B.C. On the historical and geographical problems, with references also to the GÖSTESIN and SUVASA inscriptions, see the recent contribution by Weeden [Weeden, 2010].

3.3 The refuges of Sivasa (Ne 19), Göstesin (Ne 20), Filiktepe (Ne 45)

The area around the villages of Gökçetoprak and Ovaören, 40 km westward of Nevşehir, is the most complex. It corresponds to a large plain, included between the previous two sites, scattered with low flat top hills (butte), remains of the erosion of an ancient flat outcrop (mesa), inside which three large underground horizontal refuges have been excavated, no more than 2 km apart (Fig. 13.A).

In the same area important vestiges of Hittite and Neo-Hittite age have been found. The most well-known is the rock inscription of SUVASA [Hawins, 2000, p. 462 f.] (flag 68 in Fig. 5), corresponding to a large boulder (Fig. 18), almost cubic, on which a hieroglyphic inscription is carved (Fig. 19), located on the edge of the fields, at the bottom of a butte between those of Gökçetoprak and Ovaören, named Selveroğlu Tepe. On the upper (horizontal) surface of the boulder some cup-marks have been carved.

There is a chamber-grave on a nearby cliff and a Christian church where *"aside from the usual signs which mark the Virgin, we read on either sides of the nimbus: ἡ καρδιοβαστάζουσα (She who bears up the heart)"* [Uyar, 2010, p. 620], i.e. *"Vierge Kardiovastazousa"*, with paintings dating back to the *"troisième quart ou fin du XIII^e siècle"* [Jolivet-Lévy, 2015, p. 158-159].

But the most important finding was discovered a few years ago: a walled city (maybe Parzuta mentioned in the TOPADA inscription) which is currently being excavated. The ancient vestiges are emerging from an archaeological hill, Yassı Höyük, 1.000 m south-west of the refuge of Filiktepe, and from another adjacent small hill (Topak Höyük). In the stone walls of an abandoned house in the village of Ovaören there are fragments of another Neo-Hittite hieroglyphic inscription (GÖSTESIN inscription), in which a Great King is mentioned [Şenyurt, 2010].

– *Sivasa* (or Suvasa) is the ancient name of Gökçetoprak Köy. The houses of the village lean against the low eastern cliff of the butte. The related underground refuge (Ne19) was excavated in the cliff, in the outermost part (Fig. 13.B), and consists of at least eleven sectors (so far explored) with different entrances concealed among the stone walls and buildings (Fig. 16).

The known part of the system had an extension of 1.716 m and is protected by at least 50 monoliths (millstone-doors), arranged in order to provide a passive defence consisting of "isolated areas" converging on nodal points named "isolating rooms" (Fig. 17).

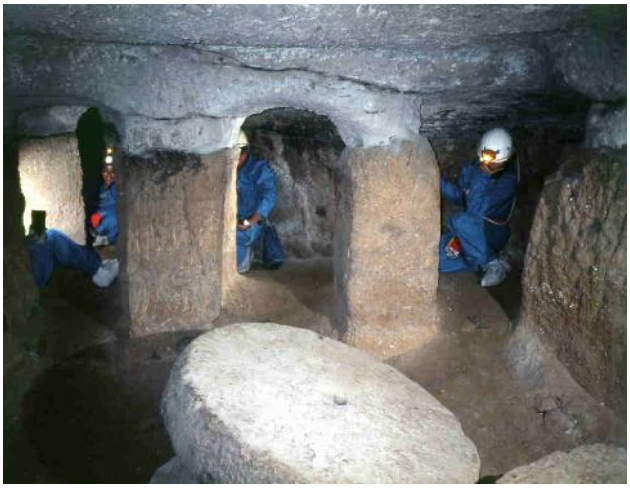

Figure 17: Sivasa underground refuge. Isolating room and millstone-door at present fallen down (photo C. Leoni)

Figure 18: Sivasa. The boulder of the inscription and cup-marks (photo A. De Pascale)

These rooms were part of a sophisticated integrated defensive system, where potential enemies on the outside would have to overpower one room before they could invade the next one. In the meantime the besieged could freely walk inside the system so as to concentrate the defence where it was most needed [Triolet & Triolet, 2002]. Furthermore, they had emergency routes to escape or to attack the assailant from behind. The refuge had food storages and internal wells reaching the water table, 17 m deep. On the north-western side of the butte there is an isolated rock-cut church in whose apse remains of paintings are barely visible. The locals call it *Zevüs Kilisesi*, evidently connecting it to the *"bassorilievo di Zeus stratiòs"* [Giovannini, 1971, p. 196], dating back to the Roman age, carved in the outcrop behind the village. Moreover, in the village there were the remains of the so-called *"Ottagono di Sivasa",* a masonry church dating back to the 5th century, still visible in the 20th century [see Rott's drawings dated 1906, reproduced in Cuneo, 1971, p. 86-87].

- *Göstesin* is today Ovaören Köy. The village surrounds the southern part of a long and narrow butte (Fig. 13.C), inside which there is a horizontal underground refuge, extended for 856 m. In this case, the two main sectors run through the whole width of the hill, passing from side to side through long tunnels excavated with the opposite fronts technique. The entrances to these tunnels are located on the opposite slopes. Five sectors have been identified, which are protected by at least 26 millstone-doors. The wells are present here too. As in Sivasa, at the north-west apex there is a small cavity, half collapsed, which seems to be a chapel. Besides *"à Ovaören existe également une église triconque (VII*e *siècle?)"* [Jolivet-Lévy, 2015, p. 159].

- *Filiktepe* (The Hill of the Goat), is the only site without remains of masonry buildings, except for some enclosures for animals made of dry stones walls, leaning against the cliff. The low flat hill (butte) is around 2 km south-east from the Ovaören village (Fig. 13.D). The related underground horizontal refuge (Ne45) extends along the south-east face of the cliff, surveyed for a total of 1.673 m. It is very similar to those of Sivasa, including the wells that are around 17 m deep (Fig. 15).

It consists of nine sectors, some of them interconnected with long tunnels excavated in the innermost part of the hill, behind the rooms that open along the external face. Some of them are small chapels, one of which still has a Latin patent cross, carved in the rock wall near the apse, which is crossed by a tunnel that was obviously carved after the excavation of the ecclesiastical structure. The whole system is defended by at least 55 closing devices (millstone-doors) (Fig. 14). A further underground level undoubtedly exists, as suggested by some descending passages, filled with earth, and some sinkholes in the slope in front of the cliff where the entrance to other tunnels can be seen. On the opposite slope (north), there are just some chamber tombs. At the top of the rock, some anthropomorphic graves were excavated.

Note on SUVASA inscription (Fig. 19): paleographic features similar to TOPADA, but partially illegible; signs that indicate the Great King Wasusarmas, the army (EXERCITUS) and a military charge are preserved.
GÖSTESIN inscription (recovered blocks walled up inside a house): signs used are similar to the TOPADA inscription; signs for 'Great King' (probably Wasusarma) are preserved.

Figure 19: SUVASA inscription (photo C. Leoni)

4. CONCLUSIONS

The written and archaeological data so far presented allow us to make some final considerations.

The survey we carried out on the available texts appears to show that while the Hittite sources of the 2nd millennium B.C. provide evidence of terms and expressions that could refer to structures, temple-like complexes, or monuments connected in some way to rock-cut (or underground?) structures, later Neo-Hittite hieroglyphic documentation from the 1st millennium, with the exception of the two inscriptions of KARAHÖYÜK and İSPEKÇÜR[9], does not seem to provide information about structures that may be connected with rock-cut or underground settlements; this could be due to the type and nature of the later texts, that are mainly funerary inscriptions or dedications.

However, in section 3, we mentioned some Neo-Hittite inscriptions that lie very close to underground structures. Therefore, we wonder whether these inscriptions were carved on stone in those particular places for a particular reason. As for these inscriptions, at least two considerations stand out: a discussion is ongoing about their proper dating (in our opinion, TOPADA and SUVASA still remain of uncertain date); in addition, they relate to military events (TOPADA), mention an army – though in a very difficult context – (SUVASA) and record the construction of a fortress (KARABURNA) [cf. also Mora, 2014]. Based on this small amount of information, we might venture to guess the existence of a link between at least these inscriptions and the digging of rock-cut galleries or houses and shelters. As in the case of the 2nd millennium ^{NA4}*hekur*, which could have been used as shelter in the event of danger, the Cappadocia inhabitants at the beginning of the 1st millennium B.C. might have used cavities dug in the soft local rock to find refuge and escape from an enemy attack, or just to store and save foodstuffs. This may be the reason why the monumental inscriptions mentioned above would have been carved in those places. In this case, it would not be surprising that, centuries later, people used again those underground rooms, deeply modifying and expanding them. But at this stage of research and knowledge, in absence of any archaeological proof, we can only speculate on this subject.

5. ABBREVIATIONS

CTH = **Laroche E. 1971** - *Catalogue des textes hittites*, 273 p. Éditions Klincksieck, Paris.

DBH 15 = **Groddek D. 2004** - *Hethitische Texte in Transkription. KUB 51*, Dresdner Beiträge zur Hethitologie 15, 160 p. Harrassowitz Verlag, Wiesbaden.

EDHIL = **Kloeckhorst A. 2008** - *Etymological Dictionary of the Hittite Inherited Lexicon*, 1162 p. Brill, Leiden, Boston.

HED 1 = **Puhvel J. 1984** - *Hittite Etymological Dictionary. Vol. 1: Words Beginning with A, Vol. 2: Words Beginning with E and I*, 333 p. Mouton Publishers, Berlin, New York, Amsterdam.

HED 3 = **Puhvel J. 1991** - *Hittite Etymological Dictionary. Vol. 3: Words Beginning with H*, 461 p. Mouton de Gruyter, Berlin, New York.

HEG = **Tischler J. 1977-1983** - *Hethitisches etymologisches Glossar. Teil 1. A-K*, 702 p. Institut für Sprachwissenschaft der Universität Innsbruck, Innsbruck.

HW2 = **Friedrich J. & Kammenhuber A. 1975** - *Hethitisches Wörterbuch. Zweite, völlig neu bearbeitete Auflage auf der Grundlage der edierten hethitischen Texte*. Winter Verlag, Heidelberg.

KBo = Keilschrifttexte aus Boghazköi.

KUB = Keilschrifturkunden aus Boghazköi.

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Bixio R., Castellani V. & Succhiarelli C. (Ed.) 2002 - *Cappadocia, le città sotterranee*, 319 p. Istituto Poligrafico e Zecca dello Stato, Roma.

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[9] But it must be stressed that these inscriptions are dated to a period of transition between the 2nd and 1st millennium B.C.

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Image-Based Modeling Techniques for Visualization and Analyses of Cave Dwellings

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Abstract
Photo Modeling is a relatively new technique for accurate digital capture of three-dimensional objects and surfaces from a collection of photographs. This method allows us to acquire metric data about photographed objects in very little time and with a good ratio between accuracy and ease of access. When even more reliable other techniques, such as laser scanning, cannot be used for various reasons, or when differences between details leads to a search for more practical solutions in data-collecting operations, Photo Modeling, if the boundary conditions guarantee its correct use, becomes a valid alternative and an excellent tool of automated data-collecting.

The aim of this study is to analyze these new methods using a commercial software package known as "Agisoft Photoscan" for creating 3D meshes of Cappadocian cave dwellings. To do this, some significant case studies have been analyzed with the purpose of understanding and verifying problems and issues of their reliability.

Keywords
Photo Modeling, digital photogrammetry, 3S surveying, Rupestrian dwellings, cave dwellings, Photoscan, Cappadocia, Akbin Valley, Ağırnas, Turkey.

1. INTRODUCTION

Photo Modeling or Multi-image Photogrammetry is an innovative survey technique that makes it possible to create a cloud point or a 3D mesh from raster images.

The technique is practical and versatile and is increasingly being adopted for cultural heritage to replace or enhance more established survey techniques such as manual survey and laser scanning [McCarthy, 2014].

The cost of renewal is particularly evident in the low price of the hardware which, unlike laser scanners, often unaffordable, relies on the common digital camera.

Photo Modeling is a product of the digital revolution that has had a profound effect on all our cultural artifacts, from images to the tools of representation, and may be considered a development of photogrammetry.

The costs, user friendliness, quality and variety of results obtained using this new technique have now succeeded in satisfying the needs and the commitments (technical and institutional) of architectural and archeological survey, freeing the end user from the complex procedure that traditional photogrammetry required during the phases that, from acquiring images, lead to geometrical reconstruction.

Recent developments in the field of image analysis, of computational vision and sensors also make it possible to automate procedures relating to the extraction of analogous points, the calibration and the orientation of images, as well as the generation of clouds of points or of polygon meshes enriched with textures [Pierrot-Deseillign et al., 2011].

This ease of approach is witnessed by an ever-growing use of this survey technique, as well as by the plans for the 3D reconstruction of historic sites or monuments based on raster images available online [Snavely et al., 2007] which, although carried out by certain research laboratories, on samples made up of thousands of images, may, in the future, represent a new way of analyzing historical buildings [Frahm et al., 2010].

In this article, a number of surveys undertaken in the region of Cappadocia using this technique are presented in order to illustrate the value of Multi-image photogrammetry as a practical and cost-effective method for accurate survey.

A non-technical overview of the technique will be given, followed by case studies illustrating how the method has been applied successfully in a specific geographic context. All the surveys presented in this paper have been undertaken with limited budgets for both survey and post-processing of data and normally with very limited time frames.

In each case study, using this technique has allowed for better, faster and more cost-effective results than would otherwise have been possible.

2. BACKGROUND

3D digital surveying and modeling of cave geometry represents an important topic for research, management and preservation of our cultural and geological heritage. Accurate surveying of cave passages, chambers and the shape of their structures has always been an important issue before attempting to describe or understand processes that takes place underground, whether they are related to the origin and formation of caves, or to the human activities occurred in them.

Cave surveying has been traditionally carried out using instruments such as distance meters, compasses and tilt meters. Although computer support is available for data acquisition, processing and creating cave maps, there is still a lot of manual work related to this task. Therefore, the quality of the final survey depends on the experience and the drawing skills of the individual surveyors [Roncat et al., 2011].

Rapid technological development in laser scanning and computer vision techniques has offered a significant contribution to this research area.

In particular, technique of laser scanning has become standard for surveying and analyzing the complexity of such structures. Laser scanning is independent of light conditions and provides a non-destructive, comprehensive and efficient method of survey, delivering high resolution 3D point clouds as input for both mapping and quantitative analysis of different features. Usage of image-based photogrammetric surveying has instead been limited in cave studies primarily because of the difficulty of achieving homogeneous light conditions.

Despite this limitation, under certain conditions, this technique offers scholars and professionals a practical alternative in terms of technical complexity, accuracy, cost and flexibility to established techniques such as manual survey and laser scanning.

Archaeologists, geologists and scholars have been quick to adopt the technology for a wide variety of studies related to cave and underground architecture, as it will be highlighted through some recent examples.

One of the most interesting applications is the Three-Dimensional Reconstruction of the “Cave” of the Grate Pyramid from Video Footage [Kawae et al., 2013]. In this experiment, the Authors employed a Structure from Motion (SfM) technique to reconstruct the three-dimensional point cloud of the surface of the cave.

Twenty minutes of footage was divided in thirty thousand frames, three hundred of which were used to generate the point cloud model of Khufu’s “cave” and to realize the line drawings of the study area for archeological research.

Several applications of the SfM technique have been used during the research activities conducted by Shumla Archaeological Research & Education Center in one of the most archaeologically rich areas in the world – the Lower Pecos Canyonlands region of southwest Texas, west of Del Rio. In this research Multi-image Photogrammetry has been applied to document and model sites, excavation units and layers and to create three dimensional models of the rock shelters, some of which contains remains of thousands of years of human occupation, including complex multi-colored murals dating from 4,000 years ago [Koening, 2014].

This technique, under certain conditions, can be also applied in underwater archeology, as witnessed by the research carried out in the underwater Mexican cave site known as Hoyo Negro. In this project, pictures taken by the scientific dive team have been used to create 3D models of the underground cave site [Ucsdnews, 2014].

These few examples serve to illustrate the future potential for use of multi-image photogrammetry as a powerful tool for recording of cave structures. The wider adoption of this method is being driven by an on-going convergence of related technologies, including advances in digital photography, in more efficient and powerful software and by increasing computing power [McCarthy, 2014].

3. METHODS

3.1 The investigation

As we mentioned before, the possible application of Photo Modeling in cultural heritage research are various. In this paper, we will analyze the use of a commercial software (Agisoft Photoscan) to study some examples of cave architectures located in the Akbin Valley in the region of Ağırnas in Turkey.

The first example is a two-room cave structure probably used as pigeonhole. The second one is a large rectangular room that was probably part of a complex underground structure used as a shelter. The final case study is a three-room structure, probably used both as storage and as pigeonhole.

All these case studies will be used to illustrate how existing techniques of three-dimensional digital photography enable us to obtain geometrical or colorimetrical information useful for visualization and analyses of cave dwellings.

Although in the last few years there has been an explosion in the range of multi-image photogrammetry software packages available, from free open-source programs to professional-grade suites, we decided to use the commercial software Agisoft Photoscan [Agisoft, 2015] for having a full control of every single operation.

3.2 How the procedure works

The transformation of 2D digital pictures into three-dimensional models is generally carried out by the different softwares in an analogous way.

The first stage is to get a large number of pictures of the architectural object. Each point in the point cloud must be visible in at least three photographs taken from different positions. The number of images necessary is dependent on the complexity of the shape of the subject. The angles

between each pair of photographs should not be higher than 15 degrees, but, at the same time, it should not be too small, or the software will be unable to correctly locate the points in space.

For the acquisition of the images, a Canon EOS Rebel T5i digital camera with a 18 megapixel sensor and a Sigma zoom with a focus range of between 18 and 55mm in APC format was used, mostly in wide-angle mode. The reason for this choice was both to be able to include in the photogram the greatest possible number of elements of the object and because it was necessary to have greater focus range and avoid possible out of focus elements. Most of the pictures were shot at 800 ISO using a tripod under natural light conditions. In all the case studies, the images were obtained in RAW mode and converted into JPG only after a phase of editing on the calculator. Our case studies use between 70 and 650 photographs each. Pictures out of focus can influence alignment results badly. In order to exclude poorly focused images from processing we used the automatic image quality estimation feature included in PhotoScan. Pictures with a quality lower than 0.7 units has been disabled and thus excluded from Photogrammetric processing.

The second stage is to load the images into the software for analysis and automatic detection of matching points across several images. These points are used to calculate the position of the cameras relative to each other. Many of the multi-image photogrammetry packages currently available use an algorithm known as Scale-Invariant Feature Transform or SIFT [Lowe, 2004] which can match features despite changes in the scale or orientation of the images. The final result of this operation is a 'sparse' three-dimensional point cloud, which includes the relative camera locations and a small number of points on the subject or feature.

In the third stage, the software uses this set of points to generate a much denser model of the subject. This takes the form of a point cloud, which gives a dense reconstruction of the shape of the object and represents its external surface.

The fourth stage of the procedure consists in the generation of polygon meshes and the texturing of the surfaces using the original photographs.

Polygon Meshes generated by Photoscan can be edited using other software packages such as Meshlab or GeoMagic. The two most common operations are generally those of filling in the missing elements inside the mesh, and smoothing the model in order to reduce whatever faults there may be, due to errors of various types.

Once the process of mesh optimization has been completed, it can be used in many different ways. Indeed, the digital data may be seen as a complex series of measures from which to extrapolate those elements that are important for a geometrical interpretation, or it may be possible to export the 3D object for use on further software, to generate plans elevations and sections.

4. CASE STUDIES

Cappadocia is a historic region of Anatolia, situated in the area that is now central Turkey, and which includes parts of the provinces of Kayseri, Aksaray, Niğde and Nevşehir. The region is characterized by its unique geological formation and by its historical and cultural heritage.

A recent campaign to catalogue and promote the region's sites was launched thanks to a national project carried out by OBRUK Cave Research Group, with the support of the International Union of Speleology.

Within this project, several methods of analysis and representation have been experimented in order to compare and test the various methodological approaches in the field of cave architecture.

The case studies presented in this chapter, which are part of the program, also play a role in research into methods and formal analyses of the structure of the cave settlements present in this area.

Among the examples studied, it was decided to survey three different caves of the Akbin Valley in the city of Ağırnas. The geometrical characteristics of these objects bear witness to the rich variety of forms present among the architectural types of these territories and provide a valid example for the application of the methods described.

The three case studies look at the potentials of structure from motion to acquire metric data about photographed objects and to create three-dimensional objects in low light conditions and with a good ratio between accuracy and ease of access.

4.1 First case study

The test subject (38°49'1" N, 35°42'29" E) is a cave located in the eastern side of the valley, consisting of two rectangular spaces connected by a small passage probably used both as storage and dovecote. The surface of the two rooms is characterized by holes of different size and niches. Natural light is provided by a small access located in the western side of the first room and by an air shaft located on top of a cloister vault in the second room. To reconstruct the geometry 356 pictures has been taken.

A set of markers have been used to set the distance known between points in order to scale the model. Despite this irregular geometry and the non-uniform light distribution, the mesh generated was generally accurate for the majority of the surface area. Some uncertain areas were present within the deep parts of the holes and in all those portions which are over or underexposed (Figg. 1-4).

After finishing the photogrammetric process the mesh was exported in OBJ format to be edited, using another software package called Geomagic Studio.

In this phase, the application called "Mesh Doctor" was used to reduce highly creased edges and spikes and to fill the small holes generated by cones of shadow present within the picture sequence.

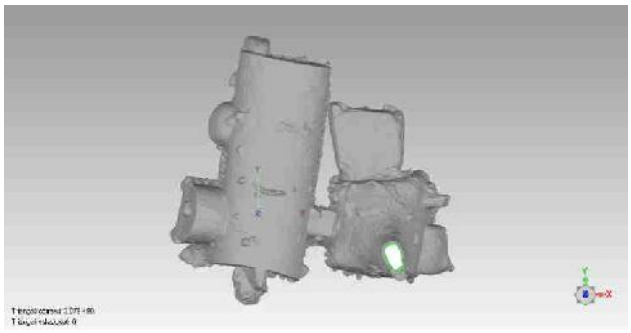

Figure 1: 3d polygon mesh of the first model (top view)

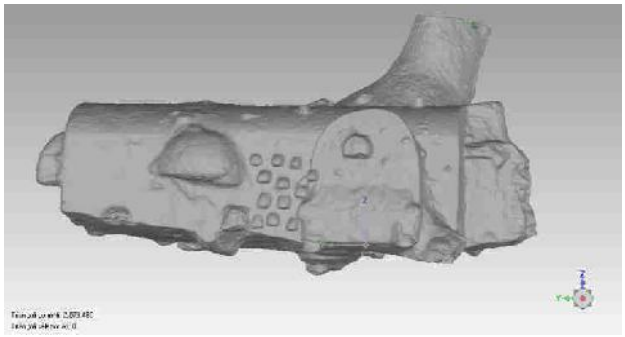

Figure 2: 3d polygon mesh of the first model (side view)

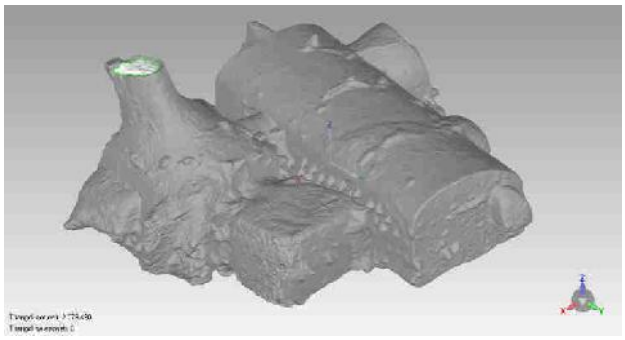

Figure 3: 3d polygon mesh of the first model (perspective view)

Figure 4: Textured polygon mesh of the first model

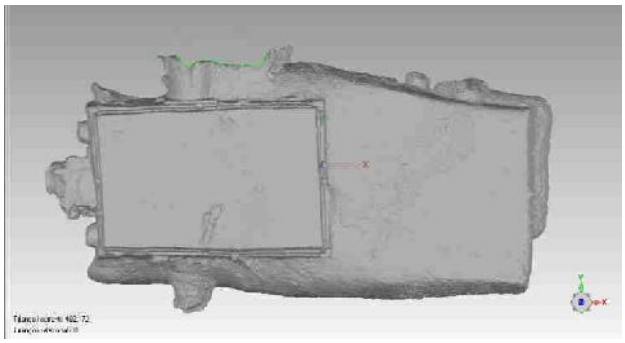

Figure 5: 3d polygon mesh of the second model (top view)

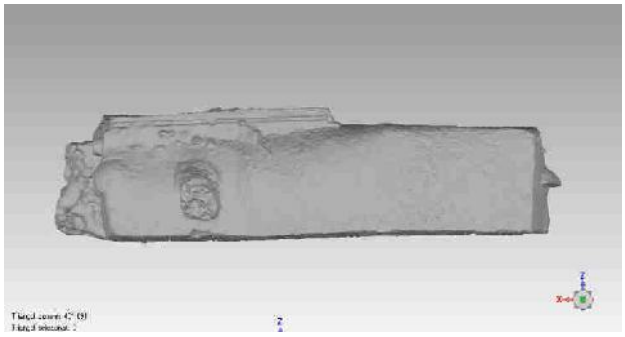

Figure 6: 3d polygon mesh of the second model (side view)

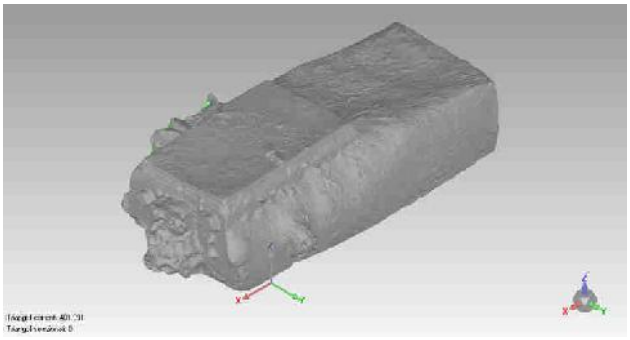

Figure 7: 3d polygon mesh of the second model (perspective view)

Figure 8: Textured polygon mesh of the second model

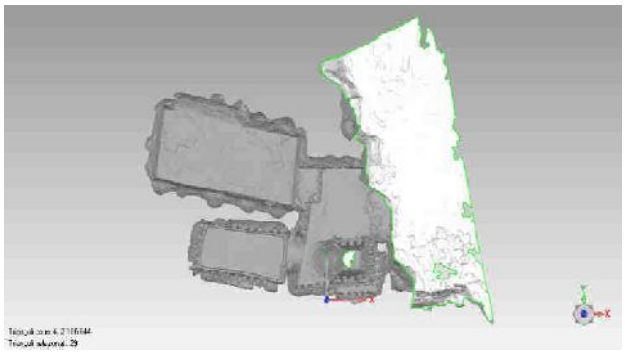

Figure 9: 3d polygon mesh of the third model (top view)

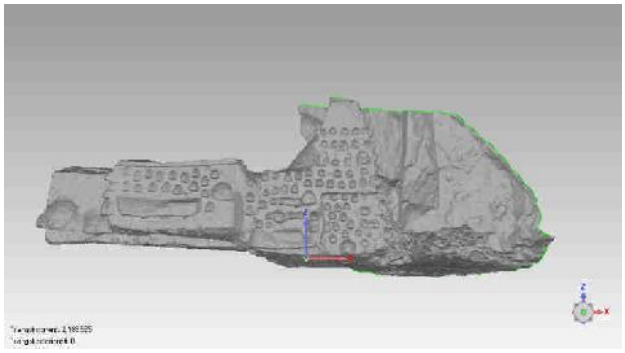

Figure 10: 3d polygon mesh of the third model (side view)

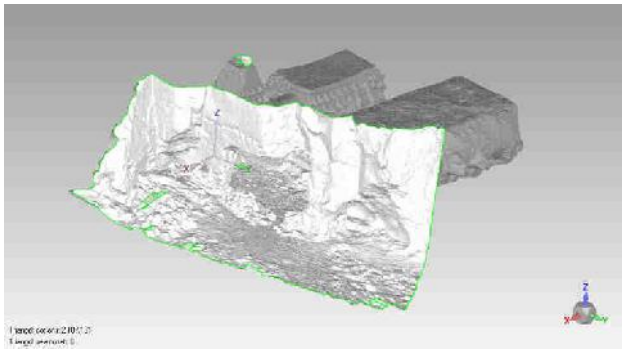

Figure 11: 3d polygon mesh of the third model (perspective view)

Figure 12: Textured polygon mesh of the third model

4.2 Second case study

The second test subject (38°49'1" N, 35°42'26" E) is a cave located in the eastern side of the valley consisting of a large rectangular room divided in two parts, characterized by the presence of several niches and a cornice that decorates the upper part. The presence of a large entrance and a rounded passage that connects this room to a small space, used as a pigeonhole, provides a good source of natural light. The regular shape of the room allowed us to realize a textured polygon mesh using just 70 pictures taken all around the perimeter. Even in this case a set of markers has been used to scale the final model.

As with the survey of the first test subject the characteristics of accuracy are uniform over the whole mesh extracted, in spite of the limited number of shots taken. Some minor operations have been required to reduce highly creased edges and spikes, using GeoMagic. The final result (Figg. 5-8) is compatible with the aims of the survey, in terms of geometrical return and accessibility.

4.3 Third case study

The third case study (38°49'1" N, 35°42'28" E), consisting in a group of three rooms of different sizes, is the most complex in terms of geometric configuration. The geometry of the plan is generated by excavation works carried out in different phases. The first room after the entrance has a rectangular shape and has been used both as a storage and pigeonhole. Two passages connect this cave to a large room used as a stall, and to a small room used as dovecote. Both these caves contain pigeonholes for the birds to nest and a collection of niches of different size. In order to reconstruct the entire surface area 650 images has been taken using a tripod. A set of markers has been used in every single room to scale the model. Even in this case the result obtained is compatible with the aims of the survey and lends itself to the possible insertion of other sequences of images (Figg. 9-12).

5. FUTURE RESEARCH DIRECTIONS

Image-based modeling to digitally record heritage sites and objects is becoming increasingly popular in a wide range of applications, due to the continuous development of new recording sensors, data capture methodologies as well as the improvement of existing software packages [Remondino, 2011a]. Although laser scanning is the most commonly used technique to obtain three-dimensional data with poor light conditions, several successful survey applications carried out on cave architecture demonstrated that image-based modeling could be an inexpensive and flexible alternative. One of the issues at the moment is related to the metric accuracy of this technique with different architectural types and in different light conditions.

Besides improving the metric performance in these peculiar environments, future research lines can be oriented towards designing solutions useful to combine and integrate different recording sensors and techniques from data

capture through to archiving. Files sharing platforms and websites can be also developed to promote skill-sharing, archiving and interpretation of the three-dimensional digital objects, leading to an enhanced record and understanding of rupestrian heritage in different geographic locations.

6. CONCLUSION

These surveys demonstrate how existing techniques of three-dimensional digital photography enable us to obtain geometrical or colorimetrical information of cave architecture in very short time and with a good ratio between accuracy and ease of access. As long as a camera is available some attempt at a Photo Modeling survey can be carried out. The technique is basically scale-independent and can be applied to some of the most common cave types if the light conditions are appropriate.

When even other solutions that are certainly more reliable, such as laser scanning, cannot be used for various reasons, or when differences between details leads to a search for more practical solutions in data-collecting operations, this technique, if the boundary conditions guarantee its correct use, becomes a valid alternative and an excellent tool of automated data-collecting. The main advantages, then, are related to the costs and the automation of the processes. The main disadvantages, on the other hand, are connected with the complete dependence of the survey on the context or, to be more precise, on the relationship between the data-yielding images and the model obtained.

It is evident, then, how in certain light conditions or when it is impossible to take a sufficient number of shots to be of use in the data-collection, it is unlikely that satisfactory results will be obtained.

What seems interesting at the present stage is thus the multiplicity of existing survey techniques, with their good and bad points, to be integrated and used in the best way possible in relation to their specific features and performance [Remondino, 2011b].

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Hiding Complexes in the Galilee, Israel: Artificial Refuge Caves in the Early Roman Period

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Abstract
Two phenomena in the Galilee shed light on the history of Jewish defense methods in that region during troubled times in the Early Roman periods. Two types of rock-cut caves found in the Galilee were apparently used by the Jewish population there. The first are natural caves at the tops of cliffs near Jewish towns and villages that existed in the Second Temple period. Work was done to adapt those caves and signs of human activity are visible in them. Historically speaking, most of these chambers were probably associated with the Jewish population that took part in the First Revolt, although some of the work in the caves was done earlier. We propose calling this sort of chamber a "cliff shelter." In two of his works, *The Jewish War* and *The Life*, Josephus describes his activity in the Galilee, where he was sent to make preparations for the Great Revolt.
The second phenomenon, discussed widely here, is that of the hiding complexes. The plans of 70 underground chambers that served as hiding complexes, which were explored under ancient Jewish settlements, are presented. These complexes are compared with hiding complexes discovered in the Judean foothills. The typology of these underground chambers in the Galilee and those in the Judean foothills is almost identical. Thus we divided the hiding complexes in the Galilee into five categories:
- *Small underground chambers created for hiding purposes.* They were hewn simply, without any attempt to make them attractive. They resemble the hiding complexes found in Judea at sites such as Horvat Etri and Horvat Zeta. The turns are not necessarily ninety-degree angles and the different levels in the caves were not hewn methodically. Apparently, it sufficed that the hiding complexes were dark and narrow, so one could only move through them by crawling blindly. Twenty-two hiding complexes of this sort are known in Galilee towns in order to prepare for times of trouble; presumably some of them were created in the late Second Temple period. We can assume that most of these hiding complexes were made shortly before the First Revolt.
- *Elaborate hiding complexes*. These hiding complexes are similar to those in the Judean foothills (e.g., Horvat Midras, Amatzia, and Horvat Ga'ada). Because the elaborate hiding complexes examined in the Judean foothills are dated to the time of the Bar Kokhba Revolt, the 15 surveyed complexes in the Galilee may have been hewn in the second century CE.
- *Hiding complexes that took over rock-cut underground facilities previously used as storerooms for agricultural produce, cisterns, olive presses, and ritual baths*. These chambers were closed, chilly, and rainproof, and it was a simple matter to turn them into hiding complexes. Similar hiding complexes were found in the Judean foothills, such as at Ahuzat Hazan. Some of the hiding complexes found in the Galilee were underground chambers that had previously been used for storing water and goods; a few had been used as olive presses. Narrow passageways leading to other rock-cut chambers were hewn in these chambers. Most of these complexes, such as those at Marut and Sepphoris, included cisterns or ritual baths, and the older facilities were eliminated. This is documented in many of the hiding complexes examined in the Judean foothills, such as Horvat Levaya. In a few cases the old cisterns remained in use, with a certain amount of water still kept in them. In these complexes the openings to the passageways were cut a few meters above the cistern floor, and only the water was visible from above. This is the case at Horvat Aked in the Judean foothills, at Horvat Nakik, and at Nahal Yatir. Presumably, it was decided in a time of emergency to eliminate these facilities because the space was needed for hiding. The passageways seem to have been hewn when the Galilee residents realized that such hiding might save lives.
- *Underground hiding complexes that took over burial caves*. These complexes are extremely rare in Judea, where they were found only Horvat Burgin and Horvat Benaya. Three of the six burial caves in the Galilee that were adapted for hiding were found within the village of Iyyei Me'arot. The other three are on the outskirts of towns or outside towns.
- *Escape passages.* This type of underground chamber was rare, both in Judea and in the Galilee. Because there are so few of them, it is hard to know how and to what extent they were used. Aside from the description by Josephus, who notes that the besieged people of Yodfat (Jotapata) used such a passage during the First Revolt to bring in goods and news, we have no

information about the use of escape passages in the Second Temple period. One such passage was found at Gischala and the passageways at Nahal Amal and Tel Amal may also have been used for this purpose. An example of an escape system in Judea can be found at Nahal Yatir (Rassem Yatir).
Thus we see that the Jews in the Galilee used underground complexes as places of refuge and as hideouts when they felt a real physical threat to their lives from the Roman authorities.

Keywords
Josephus, Hiding Complexes, First Revolt, Galilee.

1. HIDING COMPLEXES

Hiding complexes in the Galilee were discovered back in the 1960s, but at the time no historical importance was attributed to them. To the best of our knowledge, Antiquities Department inspector Netanel Tefilinsky became the first to report the existence of subterranean crawlways during excavations preceding the laying of the National Water Carrier near Illabun [Tefilinsky, 1983]. In 1974, Dan Bahat excavated a hiding complex at Horvat Hazon [Bahat, 1974]. Although at first he thought it was an aqueduct, he later published a paper on the pit and tunnel that he had excavated, defining it as a hideout [Bahat, 1983]. In the 1980s Michael Even-Esh, who had surveyed hiding complexes in the Hebron Hills, moved to the Galilee and conducted a survey of hiding complexes at Kh. Ruma and Beit Netofa (Fig. 1).

The developed hideout at Kh. Ruma was first studied and mapped by a team from the Cave Research Section of the Department of Geography at the Hebrew University of Jerusalem and a rescue excavation was carried out there, headed by Arieh Rochman [1985]. At the same time, Tepper and Shahar surveyed and mapped it as part of a preliminary survey of Galilean hiding complexes [Kloner and Tepper, 1987]. The Beit Netofa hideout was mapped by Amos Frumkin. In 1983 Aviam published an article about the Galilean hiding complexes and noted that five had been discovered so far [Aviam, 1983].

Figure 1: crawling in a hiding complex at Huqoq (photo Daniel Moral)

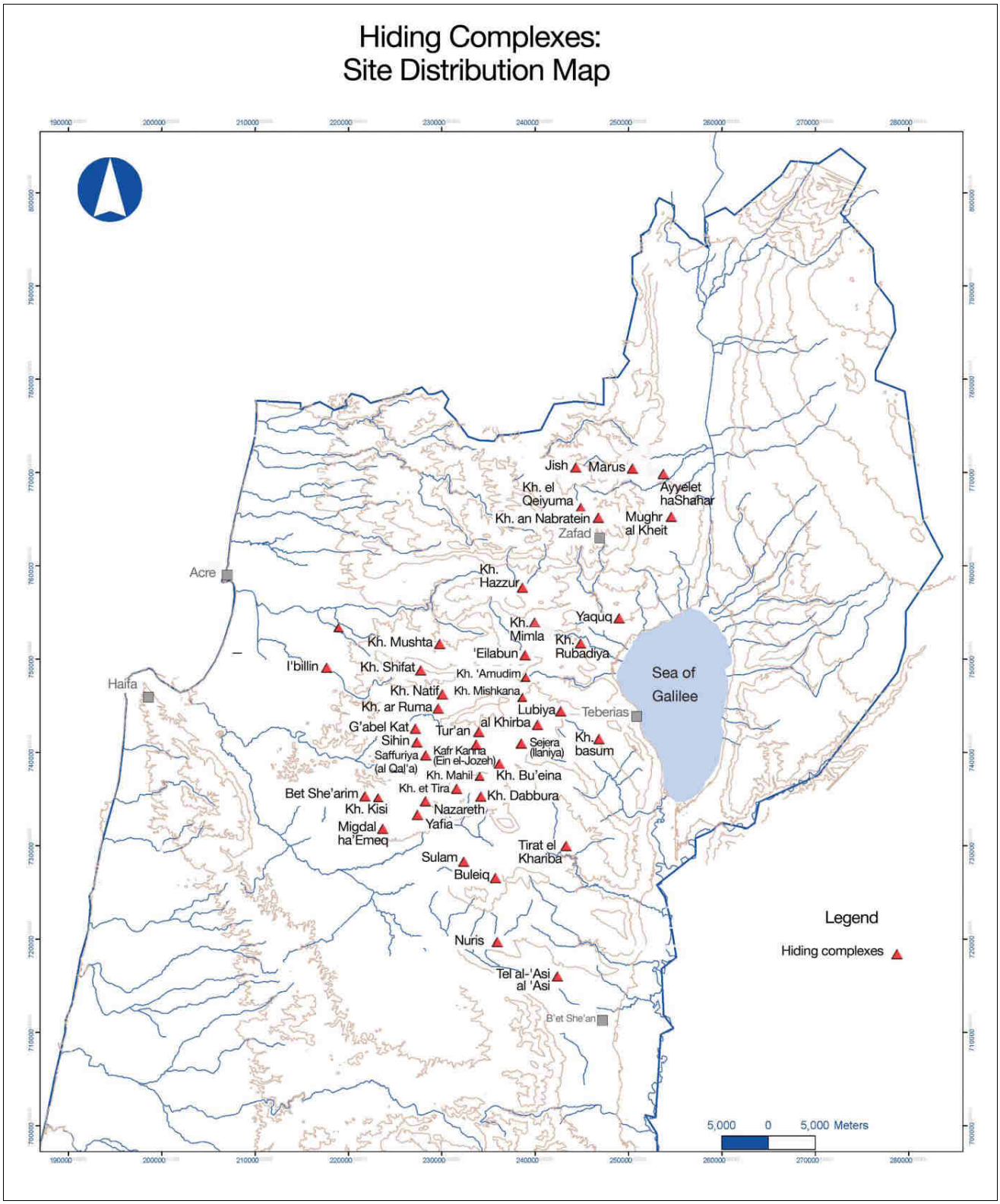
Figure 2: A typical hiding complex at Shikhin (photo Vladimir Boslov)

He discussed their dating and the connection between these caves and the revolts against Rome. During the 1980s and 1990s, workers from the Israel Antiquities Authority (IAA) reported the discovery of hiding complexes throughout the Galilee, four of which - at Ibillin, Migdal Ha'emeq, Kh. Ruma, and el-Khirbe - have since been excavated. Recently, in rescue excavations at Kafr Kanna, a hiding complex was uncovered beneath the ruins of a structure from the Early Roman period.

Shachar [2003] listed approximately 20 hiding complexes in the Galilee and argued that they should be dated to the time of the Bar Kokhba Revolt. In 2008, Kloner et al. [2008] stated that 27 hiding complexes had been found in the Galilee. Based on the finds at Jotapata (Yodfat) and Kafr Kanna, they asserted that hiding complexes were first hewn in the Galilee even before the Great Revolt, and were probably used during more than one period.

2. RECENT RESEARCH ON HIDING COMPLEXES

In the course of my doctoral research in 2006–2009, my colleague Vladimir Boslov (a CRC member) and I discovered 40 previously unknown hiding complexes in the Galilee (Shivtiel, 2009; Shivtiel, 2014). It then became possible to catalog and reexamine all the 70 hiding complexes known in the Galilee that are recorded here (Fig.2).



Map 1: Distribution of Hiding Complexes at Sites in the Galilee (drawing Silvia Krapiwko)

The presentation of the new data constitutes a major update of the hideout phenomenon in the Galilee. For the purpose of reexamining the hideouts, the subterranean chambers were documented according to the rules of speleology, as is customary at the Cave Research Center.

In this study, the hiding complexes previously discovered in the Galilee have been re-documented and re-mapped (since in some cases data were omitted from the surveys) and new hiding complexes have been documented and mapped after the crawlways and chambers were carefully examined.

Mapping and data-gathering in caves requires spending long periods of time in subterranean chambers under difficult conditions. In many caves there are ticks that infest every protective garment currently available and some of the ticks carry tick-borne relapsing fever. Therefore, complete plans of all the caves are not always available. Nevertheless, I was able to thoroughly survey the nature of the hiding complexes and to identify them according to the categories below.

The sites and subterranean cavities in the Galilee that have been identified as hiding complexes are shown in Table 1.

Table 1: Sites and Subterranean Cavities in Galilee

* = Hiding complexes discovered by the author and members of the Cave Research Center in Israel during field research

No.	Site name	Location
1	Gush Halav (Gischala)	At the top of the village of Jish, east of the upper synagogue*
2	Gush Halav	In the center of the village of Jish, in the courtyard of a private house*
3	Gush Halav	On the eastern slope of Nahal Gush Halav
4	Meroth	The area of the ancient synagogue
5	Meroth	2 km east of the village (inside a burial cave)*
6	Qiyyuma	On the northern side of the Meron-Safed road
7	Nabratein (Naburia)	Biriya Forest near Amuka, south of the synagogue
8–17	Iyei Me'arot	Hatzor Hagelilit (ten hiding complexes)*
18	Mt. Hazon	Close to Carmiel
19	Hukok	Horvat Hukok, close to the Sea of Galilee
20	Hukok	Cistern at Horvat Hukok*, leading under the synagogue
21	Mimlah	In the western portion of Horvat Mimlah
22	Mimlah	About 500 m south of the hiding complex in the western portion of Horvat Mimlah*
23	Ravid Horvat Ravid	
24	Illabun	East of the town of Illabun
25	Horvat Mistah	A hill above the town of Arraba
26	Jotapata	On the upper portion of the southwestern slope of the site
27	Jotapata	On the lower portion of the southwestern slope of the site
28–31	Ibillin	In the Crusader fortress in the town of Ibillin (four hiding complexes)
32	Ibillin	In the town of Ibillin
33	Beit Netofa	At Tel Beit Netofa
34	Khan Lubia	Near Kibbutz Lavi, east of the Golani Junction
35	El-Khirbe	The large hiding complex on a hill west of Khan Lubia
36	El-Khirbe	The small hiding complex east of the hilltop
37	Ruma	In the Beit Rimon Valley
38	Kafr Kanna	North of the Tzipporit industrial zone, on the border of the village of Mashhad*
39–40	Kafr Kanna	In the northern residential area (two hiding complexes)
41	Kafr Kanna	In the center of town (at Kh. Khueha)
42	Kafr Kanna	About 40 m west of the hideout in the center of town (at Kh. Khueha)
43	Kafr Kanna	1 km south of the town*
44–45	Tur'an	In the town of Tur'an - close to Golani Junction (two hiding complexes)*
46	Ilaniya	At Horvat Sejera*, near Afula
47	Kh. Bessum	In the Yavne'el Valley
48	Jebel Qat	North of Sepphoris (Zippori)
49–50	Shikhin	West of Jebel Qat (two hiding complexes)
51	Sepphoris	On Sepphoris hill

52	Sepphoris	About 80 m west of the Sepphoris fortress*
53	Horvat Bina	North of Ein Mahil*, near Nazareth
54	Horvat Tiria	On a hill southeast of Nazareth*
55	Nazareth	St. Joseph's Church
56–57	Horvat Devora* (Kh. Dabbura)	1 km northeast of the village of Dabburiya (two hiding complexes)
58	Beit She'arim	In the courtyard of the Zaid house, near the synagogue
59	Migdal Ha'emeq	
60	Horvat Riv	On the southern bank of Nahal Tavor*
61	Shunem (Sulam)	On the southern slope of Giv'at Hamoreh
62	Horvat Bolek (Buleiq)	Near Ein Harod*
63	Horvat Nurit (Nuris)	On Mt. Gilboa*
64	Tel Amal tunnel	At Horvat Tel el-'Asi, on the southern bank of Nahal Amal
65	Nahal Amal crawlways	In the Gan Hashlosha National Park, on the northern bank of Nahal Amal
66	Ein Mahil*	Southeast of Nazareth
67	Kabol	In the lower west Galilee
68	Horvat 'Amudim*	Near Golani Junction
69	Horvat Mishkana*	Near Golani Junction
70	Horvat Kisi*	Near Zarzir settlement

While gathering information on hiding complexes, I heard about additional ones in the Galilee. However, some of them are in army camps and therefore inaccessible and others have changed unrecognizably and the reports could not be verified. These sites are therefore not included in the map of hiding complexes in the Galilee. One exception is Yafa, where Victor Guérin [1880] described a hiding complex. Guérin visited the village of Yafa in 1870 and reported seeing two subterranean hiding complexes near the Orthodox Mission building; in them were three stories of rock-cut rooms entered via round openings.

One of the complexes, he noted, contained a cache of 200 coins of Roman emperors. In the 1980s Tepper and Shahar examined the location where the hiding complexes in Yafa were believed to be [Kloner and Tepper, 1987]; I also examined the place later. Since the place and the surrounding area are now densely built up, however, there is no evidence left of the hiding complexes described by Guérin. Yafa, according to Josephus, was a large, strongly fortified village in the Galilee just prior to the Great Revolt, and a synagogue and ritual bath have been discovered there.

Like the hiding complexes in the Judean Lowland, those in the Galilee can be divided into five main categories:

3.1 Simple Hiding Complexes

Subterranean chambers hewn roughly for hiding purposes. These small hideouts resemble the Judean ones discovered by Kloner at an unnamed site and by Zissu at Horvat Ethri [Zissu and Ganor, 2002], as well as the one found beneath the synagogue at Susya (Chamber 8); all of these hiding complexes are from the Second Temple period. The openings and crawlways were smoothed hastily, and effort was clearly put into making it as hard as possible for uninvited guests to get into the subterranean chambers.

Figure 3: Crudely hewn hiding complex at Horvat Devora (photo Yinon Shivtiel)

Turns are not necessarily at right angles (90°) and there is nothing systematic about the way the different levels of the caves were hewn. It is as though the workers simply created dark, narrow complexes in which the only way to get anywhere was to crawl. Twenty-one such hiding complexes were hewn in Galilee villages in anticipation of bad times; the finds indicate that some of them date from the late Second Temple period. It seems, then, that these hiding complexes were created in preparation for the Great Revolt (Fig. 3).

3.2 Elaborate Hiding Complexes

These complexes, hewn with great care and attractively finished and smoothed, resemble the hideouts at Horvat Ga'ada, Horvat Beit Loya (the large hiding complex), and Rasm er-Rusum in the Judean Lowland. The developed hiding complexes investigated in the Judean Foothills have

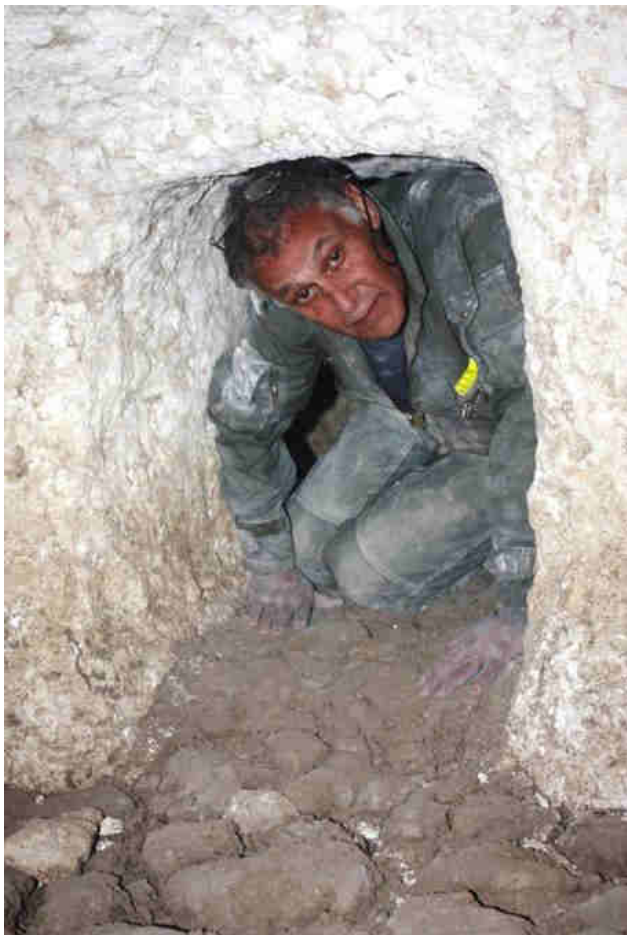


Figure 3: Meticulously hewn hiding complex at Ainot Shoaim (photo Nir Distelfeld)

been dated to the time of the Bar Kokhba Revolt, and the 24 surveyed in the Galilee may also have been hewn in the second century CE (Fig. 4).

3.3 Hiding Complexes

Hewn out of rock-cut subterranean chambers formerly used as storage facilities for agricultural products, cisterns, olive mills, or ritual baths.

These chambers were closed, cool, and rainproof, and it was relatively simple to convert them into hideouts. Similar hiding complexes have been found in the Judean Foothills (e.g., at Ahuzat Hazan and Horvat Shem Tov).

In the Galilee, most hiding complexes of this type have been found in subterranean chambers originally hewn to serve as cisterns or storage facilities; a minority are in chambers used as olive presses (e.g., at el-Khirbe and Ilaniya) (Fig. 5). In 19 of them narrow crawlways were found, some of them nicely finished and others very simple, leading to additional rock-cut chambers. Most of these hiding complexes were designed to incorporate preexisting cisterns or ritual baths, such as at Meroth and Sepphoris.

Figure 4: A hiding complex inside an agricultural installation-olive press at Horvat Ilaniya (photoYinon Shivtiel)

Figure 5: A hiding complex inside a water cistern that continued to be in use at Horvat Mistah (photoYinon Shivtiel)

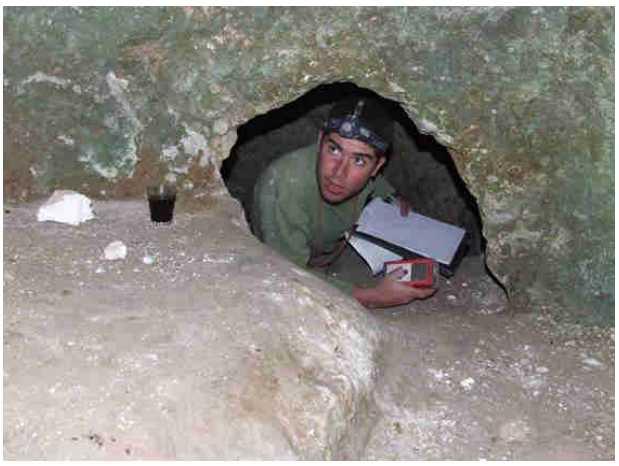


Figure 6: A hiding complex that broke into and made a ritual bath redundant at Horvat Merot (photoYinon Shivtiel)

Figure 7: Gush Halav. Opening of an escape tunnel (photo Yinon Shivtiel)

In some places, however, certain facilities were eliminated when the narrow crawlways were added. Cases of this sort are also documented in the Judean Lowland, such as at Horvat Loya, in Complexes 6, 20, and 30 at Horvat Midras, and at Kh. el-Aqed. In a few cases, such as the complex at Horvat Mistah (no. 25 above) (Fig. 6) and one at Sepphoris (no. 52 above), the openings of the crawlways were hewn a few meters above the floor of a cistern, and water continued to be stored there, up to the height of the openings. The fact that only the water could be seen from above made the hideout well camouflaged. This phenomenon is found at Kh. el-Aqed in the Judean Lowland, at Horvat Naqiq, and at the Nahal Yattir site. Presumably, in a time of emergency, when the Galileans realized that hideout complexes could save lives, they decided to do without the subterranean facilities and hewed crawlways in them (Fig. 7).

3.4 Hiding Complexes Hewn out of Burial Caves

Such complexes are extremely rare in Judea as well; they are found there only at Kh. Umm Burj (Horvat Burgin) and Horvat Benaya. Three of the six burial caves converted into hideouts in the Galilee were located within the village of Iyei Me'arot. The other three were outside or on the outskirts of villages (Fig. 8).

3.5 Escape Crawlways

This type of subterranean cavity is rare in both Judea and the Galilee, and due to their small number it is hard to characterize their use and its scope. The only written document in our possession that may describe the use of an escape crawlway in the Second Temple period is by Josephus, who recounts how the besieged people of Jotapata in the Great Revolt used a narrow, hidden crevice as a crawlway for transporting commodities and bringing news [Josephus, *The Jewish War*, I, 190–192]. The escape crawlway at Gush Halav is an example of a crawlway with a specific purpose: to serve as a hidden route to a spring and a hidden exit from the village (Fig. 9).

In contrast, Mordechai Gichon has suggested, based on Cassius Dio's description of the Bar Kokhba Revolt, that the rebels during that revolt used the hiding complexes and escape crawlways in two stages and for two different purposes: at first the hiding complexes served as bases for surprise attacks and ambushes, whereas later the rebels used the crawlways to escape from walled towns. As an example of such dual-use hiding complexes, Gichon [1982/3] points to Kh. el-Aqed, which was surrounded by a wall. Gush Halav was also walled, and dual use may have been made of the escape crawlway there as well. Another example of an escape system is found at the Nahal Yattir site. In this hiding complex two crawlways were hewn, one leading to a cistern so that water could be drawn secretly, and the other leading out of town, to the slope of Nahal Yattir.

4. DISCUSSION

In light of the similarities between the hiding complexes in the Galilee and those in the Judean Lowland, some scholars have dated the ones in the Galilee to the time of the Bar Kokhba Revolt. It is very difficult to date the hiding complexes, since they incorporate chambers that antedate the hiding crawlways and contain signs of later activity. Moreover, in most cases ceramic objects got into the complexes in various periods and antiquities thieves broke in before the complexes were studied scientifically. The fill contains ceramics and other items both from periods preceding the hewing of the hideouts and from later periods. In this study ceramic finds are not used as an indication of the dating of the hiding complexes on the assumption that the ceramics derive from later disturbances.

Recently it has become clear that some of the small, simple hideouts in the Judean Foothills were hewn before the Great Revolt. Therefore, some of the hideouts in the Galilee may also have been hewn before or during the Great Revolt. About a third of the hiding complexes in the Galilee, 21 in all, are of the simple type. The finds in the hideout on the lower slope of Jotapata and in the hideout at Kafr Kanna clearly attest that these complexes were hewn during the Great Revolt. Additional unsophisticated hiding complexes in the Galilee, such as those at Meroth, Gush Halav, Tur'an, Horvat Nurit, and Horvat Devora, may have been hewn in the late Second Temple period; the nature of these complexes may reinforce the suggestion that they were hewn in a hurry during the Great Revolt.

On the other hand, some of the Galilean hiding complexes may have been hewn in preparation for the Bar Kokhba Revolt. Because most of the hideouts in the Judean Foothills were used by the Jews during the Bar Kokhba Revolt, we cannot rule out the possibility that some Jews in the Galilee prepared for the revolt in the same way. Presumably, some of the Jews who were hidden in the Judean Foothills at the end of the Bar Kokhba Revolt survived and fled to the Galilee. Historical sources indicate

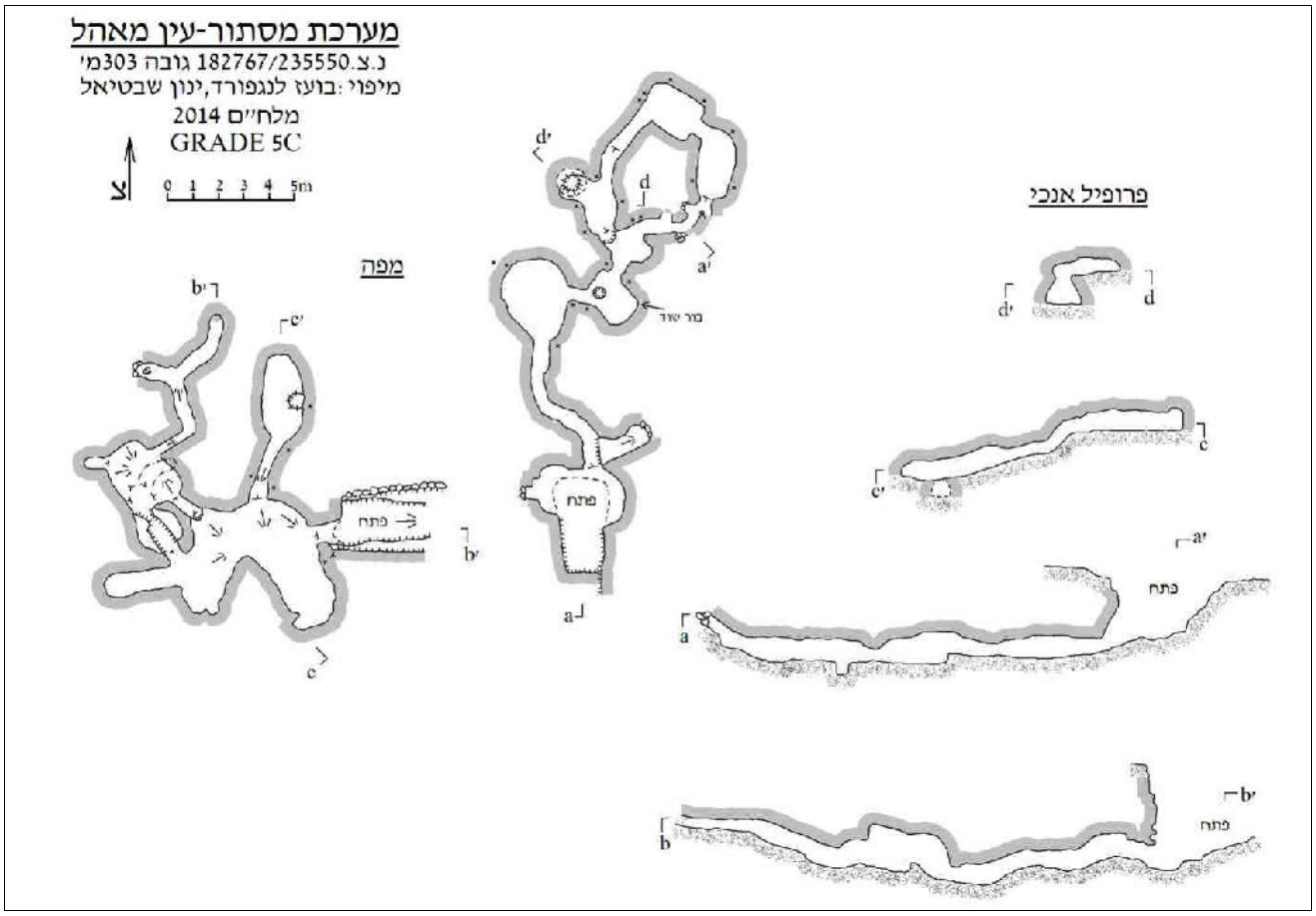


Figure 8: Ein Mahil. A typical plan of a hiding complex in Galilee (drawing Boaz Langford and Yinon Shivtiel)

that some of the Judean population moved to the Galilee following the Bar Kokhba Revolt; this is apparently reflected in a list of the 24 priestly shifts.

Ze'ev Safrai [1981] and Aharon Oppenheimer [1982] have suggested that Jews of various classes migrated from Judea to the Galilee, but that only the migration of priestly families was documented, due to their special status. Indeed, an inscription discovered in Tiberias refers to a Jewish family from Horsha in southern Judea who moved to the Galilee.

Burial in ossuaries, a method that reached the Galilee after the destruction of the Temple and was common in the Galilee in the second and third centuries CE, appears to be further evidence of migration from Judea.

This migration may also explain the hewing of hiding complexes in the Galilee: refugees from Judea brought with them knowledge that had helped them survive in Judea, so in the Galilee, too, they turned storage cellars and burial caves into hiding complexes.

The large concentration of caves in Iyei Me'arot that were used for various purposes may be indicative of this (Fig 10).

The scholars who hypothesized that the Galilean hiding complexes were hewn during the Bar Kokhba Revolt saw them as preparations for the revolt, even if the Galilee did not ultimately take part in the fighting. This hypothesis was proposed due to the similarity in terms of plans and hewing methods to the complexes discovered in the Judean Lowland, even though no finds have come to light that support this dating. Menahem Mor [1991] rejects this hypothesis, claiming that if the Galileans had been preparing for the revolt, they would presumably have taken part in it. Pinhas Dickstein [1996] notes that the hiding complexes are not unique to the Bar Kokhba Revolt in terms of either place or time, and they should not be viewed as an element of Bar Kokhba's tactical conception.

Tepper and Shahar focus on Josephus' use of the word "ὑπονόμοις". They note that he uses it to denote not only places designed as subterranean hideouts but also underground canals, crevices in the ground, and tunnels for defensive purposes or for passing through [Kloner and Tepper 1987]. According to them, Josephus uses this term only in reference to the Israelites hiding from their enemies in contexts described in the books of Judges and 1 Samuel.

Further examination of the writings of Josephus indicates broader use of the term, but still only to refer to subterranean cavities. The term "ὑπονόμοις" in Greek indicates any artificial subterranean cavity prepared for the purpose of hiding from the law or from the authorities; this would include hiding complexes. Josephus refers to the people of Jotapata seeking refuge in "subterranean vaults and caverns" ("Τοίς ὑπονόμοις και τοίς σπηλαιοίς") [Josephus, *The Jewish War*, III, 336]. In this phrase Josephus draws a distinction between two terms: "ὑπονόμοις " (subterranean vaults) and "σπηλαίοις" (natural caverns). Thus, it appears that there were both hiding complexes and natural caves in Jotapata(Shivtiel, 2011).

Based on the new information presented in this paper on the Galilean hiding complexes and their distribution, we see that the complex case of these hideouts is worth discussing, and that they stand testimony to the fear of the Roman government at various times, not only as preparations for the Bar Kokhba Revolt.

Hence, presumably, the simple hiding complexes without attractive finishing were hewn during the Great Revolt, whereas the smoother, more developed ones, such as those at Ibillin, Kh. Ruma, and Kh. Khueha in Kafr Kanna, are from the second century CE—although we do not know yet whether they were created in preparation for the Bar Kokhba Revolt or hewn by Judean refugees who knew that such hideouts could save lives. The relatively large number of hiding complexes hewn out of cisterns - which rendered the cisterns unusable for water storage - seems to indicate that the Jews of the Galilee were in such distress in the Early Roman period that they valued places to hide over available water sources.

5. CONCLUSION

Several conclusions can be drawn regarding the hiding complexes in the Galilee. Those discovered at Ibillin, Kh. Ruma, Kh. Khueha in Kafr Kanna, and Iyei Me'arot have all the typical features of well-developed hiding complexes in Judea. In the other hiding complexes surveyed in the Galilee, the outstanding features of the Judean complexes were not found. In contrast, the Galilean hideouts seem to have unique features of their own.

(**1**) In many cases, hideouts were hewn out of older facilities, causing the cessation of use of those facilities.

(**2**) Most of the crawlways in the Galilean hiding complexes were hewn roughly without attention to finishing.

(**3**) The crawlways in the Galilean hideouts are neither winding nor particularly long and do not have sharp angles.

The two types of hiding places found in both Judea and the Galilee—refuge caves or cliff shelters, and hiding complexes—show that the Jewish population was highly motivated and had impressive organizational ability. Preparing the subterranean hiding places for times of trouble was a collective activity that required large-scale, organized work.

In some cases, we can compare the preparation of the hiding complexes in the Galilee to activity in Judea between the two revolts: subterranean complexes were hewn and hiding places were prepared, sometimes eliminating important subterranean facilities such as cisterns, storehouses, and even tombs. These activities were motivated by increased concern for personal safety and attest to the distress of the Jews of the Galilee.

We cannot date the hewing of the Galilean hiding complexes with precision. Presumably, some of them date from as early as the Second Temple period (with the hewing activity intensifying during the Great Revolt); others were hewn before the Bar Kokhba Revolt, and still others afterwards. It should be noted that it is incorrect to date all the hiding complexes discovered in Judea to the time of the Bar Kokhba Revolt; the number of Judean hiding complexes shown to have been hewn in the late Second Temple period, on the eve of the Great Revolt, is growing. It seems that the Jews of the Galilee prepared subterranean chambers for refuge and hiding at times when they sensed a real physical threat to their lives from the Romans.

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SESSION 2

GEOLOGY, GEOMORPHOLOGY, ENVIRONMENTAL HAZARDS

Paleontological and physico-chemical methods for identification of limestone as a construction stone

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Abstract

The main objects of the underground study in the Moscow region are limestone mines. Gallery systems, many kilometers-long, formed as a result of extraction of building material (limestone) for the construction of White-Stone Moscow.

The main issues in the study of the quarries as a unique historical monuments are: 1. Dates and stages of mining of individual parts of the mine systems; 2. Matching of stone from mines with existing buildings and monuments; 3. Determination of the main stages of the use of white stone in the region; 4. Conservation and restoration of limestone buildings and monuments.

To resolve these problems, we used methods of physical chemistry and paleontology. The originality of the developed procedure consists of using an integrated approach of scientific methods which complement and correct results. As a part of the paleontological method we studied the micro-organisms which formed every limestone sample, namely foraminifera and fusulinida - unicellular organisms that possessed limestone shells of various shapes, and their generic and species diversity. As a part of the physic-chemical method we studied and compared the chemical composition of limestone samples by qualitative and quantitative powder X-ray diffraction analysis and X-ray fluorescent analysis.

At present time our main job is the development of the procedure which may be used and making the database which will be open to use for other researches.

Keywords

limestone, limestone mines, quarry, paleontology, crystallography, chemistry, physics, archaeology, architecture, White-Stone Moscow.

1. INTRODUCTION

The main natural building material for the construction of stone buildings in the territory of Ancient Rus, the Grand Duchy of Moscow and later the Russian Empire was the so-called "white stone". Some researchers believe that the name "white stone" refers mostly to limestone, which appears on the surface in many places in this territory. However, this is not correct. In some regions we can see other organogenic sedimentary or recrystallized rocks locally having the same name, and sometimes at first glance they are indistinguishable from limestone, for example dolomite, various types of sandstones, travertine, and alabaster.

The interest of researchers to the determination of the mining location of stone for various constructions has appeared long ago. First of all, this information is necessary for us to understand the overall picture of the development of a particular region, and relationships, commercial relations

Figure 1: Vvedenskaya church with refectory. Uspenskiy monastery. Staritsa (photo E. Ianovskaia)

between different areas of the state. Another important goal is the issues of restoration and preservation of the historic appearance of buildings that are history and cultural heritage. The choice of material in the process of restoration is always important, not only for practical reasons of quality and reliability but especially for preserving the original appearance and historic identity of the building. (Figure 1)

Another interesting task in the overall context of such studies is the research of the places of stone extraction. They are known to be open-air quarries and underground mines. Open-air quarries can be abandoned, but some are still in use. However, underground mines are of particular interest. They are systems of galleries stretching for many kilometers underground. (Figure 2) They contain evidence of human activity – tools, household items, finished products or blanks. As the archaeological objects, they can provide interesting material for analysis. Just in underground mines we can see the geological layer used for the stone extraction and we can see which layers were developed at different stages of mine evolution. Thus, a comprehensive study of mining sites and surface buildings can give us entire gamut of information.

The main question in the study of white-stone mines is the dating of development periods. The underground space sometimes was formed in several stages over a long period of time. Written sources about history of mining almost always not enough. Surface objects with exact date of construction may help us to resolve this problem.
Sometimes the determination of the mining location is quite easy. We can have detailed written sources, or place of extraction is unique, or the building is located very close to the mining place and the transportation of building materials from another region is unreasonable. But in most cases we have to appeal to additional studies and methods of natural sciences.
In our project to solve these problems, we use methods of paleontology and physical chemistry, which are successfully used for identification of natural stone as a building material in our country and abroad.

Figure 2: Mine Srednetolpinskaya-2 (Parabellum). Staritsa (photo D. Albov)

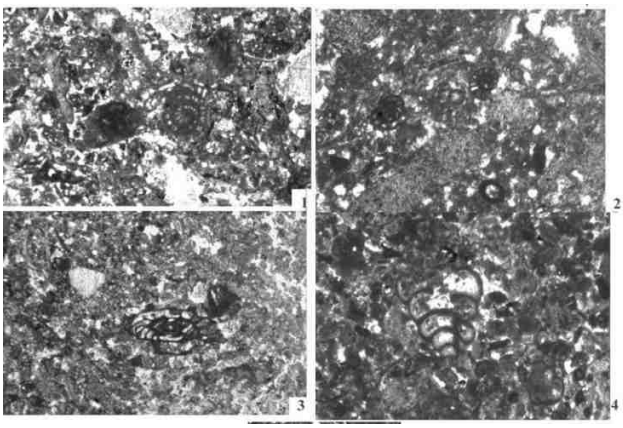

Figure 3: 1, 2, 3 Foraminifers. Samples from New Jerusalem monastery. 4 Foraminifers. Buzharovo church

Traditionally, the researches use only one of these methods [Davidovits, 1984, Alekseev, 2016]. Sometimes it may be enough, but in general it allows only to propose the area of mining. Since one of our main tasks is the dating of mines, we need results with high identification accuracy.

At present time the area of study in our project is the European part of the Russian Federation, mainly Moscow and the surrounding regions.
These areas are characterized by common historical and economic regularities, as well as topographical and geological features.

2. METHODS

2.1 Paleontological method

Back in the middle of the 20th century geologists began studies of the white stone from the buildings using rock-forming biota as a marker to determine the places of stone extraction. One of the main rock-forming groups belongs to the fusulinida order, a member of the foraminifera subphylum. These unicellular organisms produced shells of various shapes, sizing from tenths of millimeter to several millimeters, they lived in marine basins of the Carboniferous period and became extinct by the end of the Permian period. (Figure 3)

Fusulinida fossils are used in biostratigraphy – a branch of stratigraphy in which the basic method is paleontological. With the help of this method the stratigraphy of the Carboniferous period has been developed. Communities of fusulinida are unique indicators of the geological age of the rock. Different age horizons of carboniferous deposits contain specific complexes of this group of microfauna, that allows us to determine their geological age [Isakova, 2014] and the outcrop locations of the corresponding layers.

2.2 Physicochemical methods

The percentage of major rock-forming minerals is one of the main characteristics for identification of white stone.

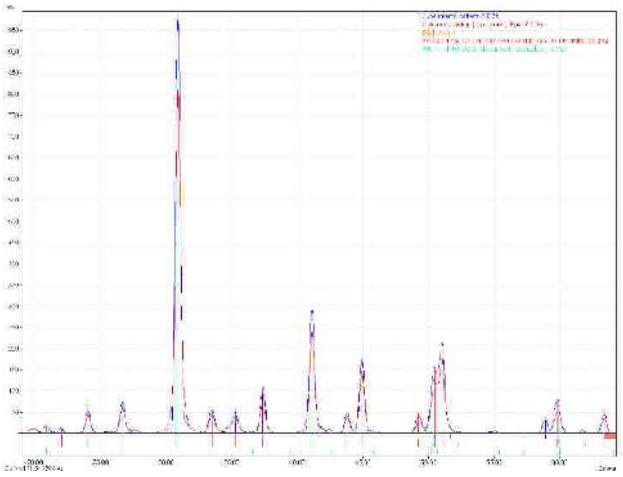

Figure 4: X-ray diffraction pattern. Sample from Lemeshovo quarry

Figure 5: Limestone. Electron micrograph. Sample from mine in Staritsa. Cherepkovskaya-1 mine

The mineral composition can be investigated using qualitative and quantitative X-ray diffraction analysis (XRD) (Figure 4). In addition to the major minerals (calcite, dolomite, quartz, gypsum, etc.), white stone contains mineral impurities in minor amounts that do not yield a visible diffraction peaks in XRD pattern (Figure 5). Such impurities may be quartz, kaolinite, muscovite, feldspars and other minerals. The composition of the minor minerals can be studied by XRD after enrichment, which is carried out by dissolving major carbonate minerals in acetic or hydrochloric acid, filtering and drying the insoluble residue.

However, not all minerals are well crystallized and the amount may be insufficient for identification by XRD, so it is reasonable to study the elemental composition of the sample, primarily qualitative and quantitative composition of cations. For these purposes the best choice is X-ray fluorescence analysis (XRF).

None of the aforementioned physicochemical methods should not be used as the sole, these methods complement each other. XRD analysis of the initial sample allows to study the ratio of the major rock-forming minerals, but small amounts of impurity minerals do not give a visible diffraction pattern.

The accuracy of quantitative XRD analysis is insufficient because of the different degree of crystallinity of the samples even after grinding. XRF analysis gives high accuracy for the content of elements but gives no information about minerals. For example, silicon can be present in the rock as quartz or kaolinite and magnesium can be present as dolomite or partially substitute calcium in calcite. The study of enriched non-carbonate impurities by the same methods (XRD and XRF) is also extremely useful because it allows to compare samples with the same composition of major minerals. The use of all methods together is a reliable way of identifying white stone.

These physicochemical methods have been successfully used to study stone samples from the pyramids of Egypt. [Davidovits, 1984]

2.3 Sampling methods

An extremely important point of the research is proper selection of samples.

The samples from open-air and underground mining sites must be extracted from the mining layer, or from the supposed mining layer for building material, judging by the quality of the stone. Samples must be clean i.e., contain no traces of modern human activities (inscriptions, deposits of combustible materials, etc.). The stratigraphic top of the sample must be marked.

Samples from the constructions (monuments) should be clean and should not contain traces of masonry mortar, leaching and traces of modern influence.

2.4 The procedure of study

Samples are cut with a diamond disk on a stone cutting machine with water supply for slices of 5 mm thick and with area of about 50x50 mm, slices are washed with water and dried in the air.

2.4.1 Lithological and paleontological study

The prepared slices are examined under an optical microscope. Potentially interesting slices are selected for making thin sections which are examined under an optical microscope for identification and counting of biota.

2.4.2 Physico-chemical analysis

100 g of the rock is ground into powder in an agate mortar to homogenize the sample. After grinding a sample of 100 mg is taken for XRD and XRF analyses. The ground sample is dissolved in excess of 10% acetic acid (hydrochloric acid is also possible) until the end of gas emission. The precipitate is filtered, washed with water to remove residual acid and reaction products, and then with acetone to remove water. The precipitate is dried in air and

ground in a mortar. The obtained powder of non-carbonate impurities is investigated by XRD and XRF.

All XRD measurements were carried out on a Stoe StadiVari Pilatus diffractometer with CuKα radiation. Powder samples were mixed with epoxy glue to form a spherical drop suitable for the XRD.

All XRF measurements were made on a Zeiss Leo Evo 50 scanning electron microscope with an Oxford Instruments INCA 450 energy-dispersive spectrometer.

The results of all analyses for each sample are included into the database, and then they are compared. If all values match within the e.s.d. of the corresponding method, the stone samples are considered to be identical. The accuracy of the identification of the samples increases with increasing the content of impurities in white stone.

2.4.3 Database.

In our project we compile a global database of samples of different rocks used for the construction of buildings and monuments on the territory of Russia. Introducing into the database the results of studies by methods of natural sciences as well as the results of the analysis of historical records, we make possible complex analysis of samples by several parameters and more precise identification of mining sites and surface stone buildings.

With time this database and the collection of samples will be available for all researchers interested in this issue. At the moment there are about 150 samples from various buildings and mining sites.

Despite the fact that our project is at the early stage of collecting samples and developing general rules of application of the described methods, we have succeeded to obtain the first results. These are primarily important as a confirmation of the applicability of the common methodology and information processing.

In this article, we intentionally do not consider data of historical researches. Such studies will be independent for each object and the results will be published separately. Our task now is to test the methods of the natural sciences and to compare their results.

3. NEW JERUSALEM MONASTERY

The New Jerusalem Monastery (founded in 1656) in the Istra district of Moscow region was chosen as the first object to study. Foundation of the monastery was a grandiose project of the famous Russian Patriarch Nikon. The New Jerusalem became the incarnation of his idea of the unity of the Orthodoxy over the world and the approval of the Russian state as its center. It was conceived as a spatial icon of the Holy Land [www.ierusalimfond.ru]. The ensemble of the monastery reproduces the Palestinian holy sites with the places of the Jesus life, making this place a revered shrine and a place of God's presence on Russian earth. The dominant of the monastery is the Resurrection (Voskresenskiy) Cathedral, which is the world's only full-scale copy of the Church of the Holy Sepulchre in Jerusalem. (Figure 6).

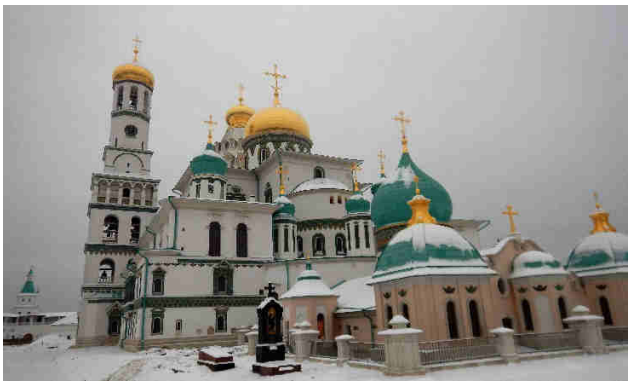

Figure 6: Voskresenskiy New Jerusalem monastery. Istra. Moscow region (photo E. Ianovskaia)

White stone was used here for various buildings since its foundation. At first as auxiliary material for creating wooden fortifications, and later as basic material for the construction of churches and other buildings.

The project of the monastery building was implemented by the usual "Moscow method" - all the available craftsmen were collected, and they brought with them their working skills and styles [Belyaev. 2012]. In subsequent ages the monastery experienced several periods of restoration, numerous extensions and transformations. It was also seriously damaged during the World War II and the period of persecution of Church (in the Soviet period).

Since 2009 archaeological surveys and reconstruction works have been carried out in the monastery and its surroundings, and these works are closely linked. Information obtained from researchers help to compose plans of restoration works and to design new structures.

An important issue for the complete study of this object is the determination of the origin of the of the basic building material – white stone. It will allow to learn more about the history of the monastery and to help restorers with the correct selection of construction material. At present time two kinds of white stone have been discovered in the monastery, namely limestone and alabaster.

From its inception geologists and paleontologists from M.V. Lomonosov Moscow State University and Institute of Geology of the Russian Academy of Sciences were invited to solve the problem of determining the source of white stone. Several studies have been performed on the identification of the building material and on the determination of possible locations of its extraction, some papers have been published. Recently samples were passed to us for physicochemical study.

3.1 Lithological and paleontological study

S. M. Zavyalov has amassed a collection of 10 white-stone samples from different buildings on the territory of the New Jerusalem Monastery, including the Efremova Tower, the basement of the Varuha Tower, the Edicule of the Resurrection (Voskresenskiy) Cathedral (Figure 7), the

Figure 7: Edicule. New Jerusalem Monastery (photo E. Ianovskaya)

basement of the Palace of tzarevna Tatiana Mikhailovna, and from the Transfiguration Church of Buzharovo village (floor, eaves, and soleas). The goal of study of the entire collection was to determine the geological age and extraction areas of white stone used for the construction of the New Jerusalem Monastery in the 17th century. Lithological and paleontological investigation under the optical microscope of 40 thin sections (thin slices of rock) made from these samples showed that 9 samples are relatively identical, they contain fusulinida species which were widespread in late Moscovian age. These species characterize the deposits of the lower part of the Myachkovian horizon of the Moscovian bed. Only one sample, taken from the soleas of the Transfiguration Church of Buzharovo village, stands out by the presence of more ancient species of fusulinida. It may indicate that this sample belongs to the upper part of the Podolskian horizon or to the boundary interval between Podolskian and Myachkovian horizons of the Moscovian bed.

Limestone of this age was mined in the riverhead of the Volga river as well as along the banks of the Moscow river below the city of Rusa near the modern villages Grigorovo and Polushkino. Mining sites were also downstream of the Moscow river, in the vicinity of the villages Vasilievskoe and Karinskoe, and closer to Zvenigorod. S.N.Nikitin (1890) noticed old quarries near the Khotyschi (Khotyazhi) village, the name seems to be distorted. Probably a part of the construction white stone could be taken in this place. However, at this stage of research another source of stone is also possible. Layers of the lower part of the Myachkovian horizon were extracted in the underground mines on the banks of Volga river downstream the city of Staritsa.

We expanded the aforementioned collection by a series of samples, which were taken in the proposed locations. Primarily these are samples from mines located on both banks of the Volga river upstream and downstream of Staritsa, as well as several samples from some churches in Staritsa. Also we added samples from quarries near Polushkino and Khotyazhi (on the Moscow river bank) (Figure 8).

3.2 Physico-chemical study

The samples were studied by X-ray diffraction (XRD) and X-ray fluorescence (XRF) analyses. In addition, two samples were dissolved to obtain non-carbonate impurities, which were studied by XRD. The results of physico-chemical study are given in the tables 1, 2, 3.

The chemical composition of all samples from Staritsa mines are quite similar, dolomite is absent in all samples. Sample 1024 has a slightly higher content of silicon. Samples of the New Jerusalem Monastery 3034, 3035 and 3037 are of higher quartz content according to XRD, silicon and magnesium according to XRF and thus these samples do not correspond to our samples of Staritsa mines. The comparison of samples 3035 and 3036 is quite interesting. At first glance, in the major minerals in these samples content of quartz varies only. However, XRD pattern of the enriched non-carbonate impurities shows different minerals, that evidently indicates different origin locations of these samples. Carbonate sedimentary rocks contain impurities of clay and other minerals, which vary in different regions [Grim, 1937].

It is not surprising that the composition of the samples 3045 and 3047 of the Staritsa buildings is very close to the composition of the samples from the Staritsa mines. However, the sample 3050 from the Church of Paraskeva Pyatnitsa (Figure 9) shows increased content of magnesium. The sample 3051 can be easily distinguished visually by yellow colour and contains a large amount of dolomite (28%). Another dolomitized sample was found in the wall around the Church of Paraskeva Pyatnitsa (sample 3046 – 16% of dolomite). The sample 3049 contains a significant amount of quartz (7%), it was taken from a white-stone blacksmith near the Church of Paraskeva Pyatnitsa. The latter samples do not correspond to studied samples of Staritsa mines. Thus we can conclude either there are mines with different kinds of stone near Staritsa or the stone in Staritsa buildings was partially imported from other regions. The last assumption is controversial due to the availability of huge local resources of stone, but it is worth to keep in mind that the white stone has different properties that can be selected for certain tasks in the construction. For example, more durable stone could be used in those parts of the heavy loaded parts of building, frost resistant stone could be used for facing or stairways. Therefore, the hypothesis about the delivery of stone from other regions with different properties and composition seems quite reasonable. The analysis of construction stone of New Jerusalem reveal a similar picture. It is quite probable that the white stone was transported from various locations. However, we cannot eliminate the presence of stone from Staritsa in some buildings on the territory of the monastery.

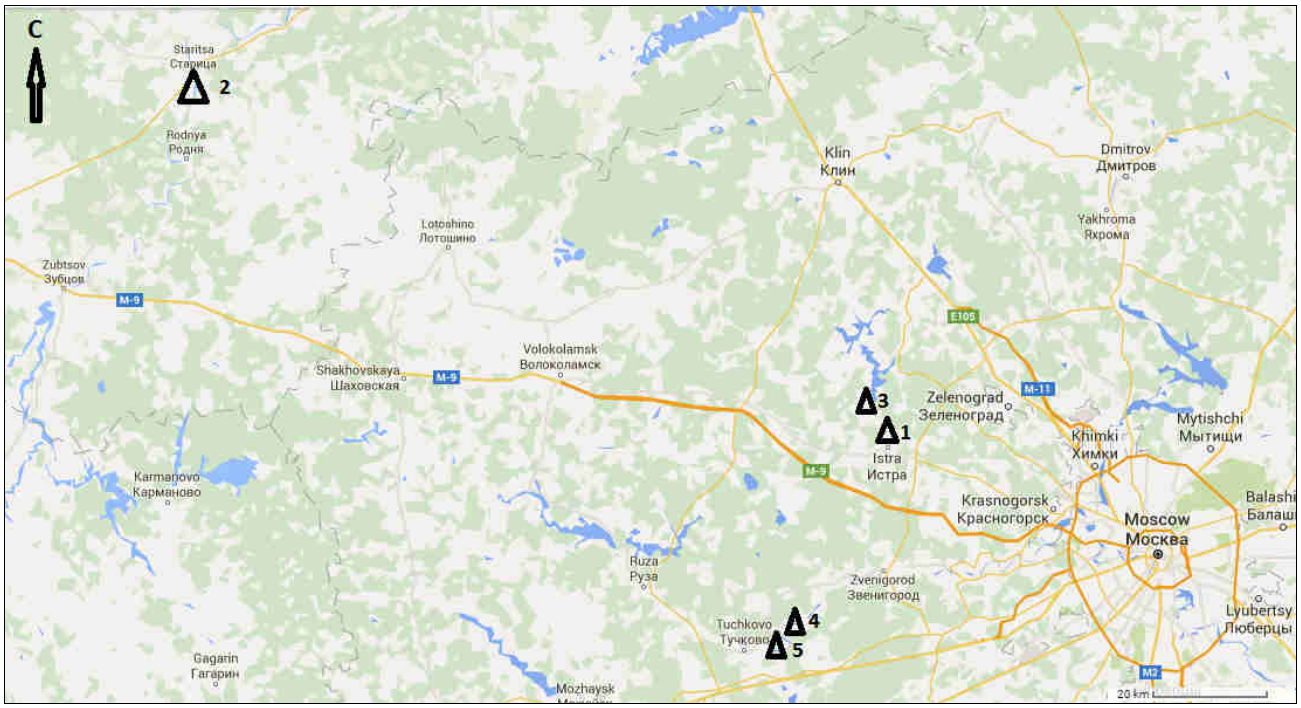

Figure 8: General map of samples for identification source of white stone for New Jerusalem monastery. 1. New Jerusalem Monastery, 2. Staritsa, 3. Buzharovo, 4. Khotyazhi quarry, 5. Polushkino quarry.

Table 1. Major mineral composition of the samples (XRD data), weight %

Sample source	Sample code	Calcite	Dolomite	Quartz
Cherepkovskaya-1 mine. Staritsa	1021	100	0	0
Verhneseltsovskaya-1 mine. Staritsa	1022	100	0	0
Verhneseltsovskaya-1 mine. Staritsa	1023	100	0	0
Nizhnetolpinskaya-1 mine (Ledyanaya). Staritsa	1024	100	0	0
Srednetolpinskaya-1 mine (Lisichka). Staritsa	1025	100	0	0
Cherepkovskaya-1 mine. Staritsa	1026	100	0	0
Srednetolpinskaya-2 mine (Parabellum). Staritsa	1027	100	0	0
Polushkino quarry (top)	2012	0	99	1
Polushkino quarry (bottom)	2013	70	30	0
Khotyazhi quarry	2017	0	100	0
New Jerusalem, Varuha Tower	3033	98	0	2
New Jerusalem, Varuha Tower	3034	99	0	1
New Jerusalem, Bell Tower	3035	98	0	2
New Jerusalem, Tomb of Jesus	3036	92	0	8
New Jerusalem, Efremova Tower	3037	99	0	1
New Jerusalem, палаты Т.М.	3038	99	0	1
Buzharovo, Church of the Transfiguration, Soleas	3039	87	12	1
Buzharovo, Church of the Transfiguration, floor	3040	100	0	0
Buzharovo, Church of the Transfiguration, copestone	3041	100	0	0

Khotyazhi, unknown building	3042	100	0	1
Staritsa, Church of St. Boris and Gleb	3043	94	0	6
Staritsa, Church of Paraskeva Pyatnitsa, serf wall	3044	100	0	0
Staritsa, Church of Paraskeva Pyatnitsa, window of bell tower	3045	100	0	0
Staritsa, Church of Paraskeva Pyatnitsa, serf wall, rubble masonry	3046	84	16	0
Staritsa, Vvedenskaya church. Molokovo	3047	100	0	0
Staritsa, Tomb of general Glebov	3048	100	0	0
Staritsa, white stone smithy	3049	93	0	7
Staritsa, Church of Paraskeva Pyatnitsa, wall	3050	100	0	0
Staritsa, Church of Paraskeva Pyatnitsa, stair	3051	72	28	0
Staritsa, Vvedenskaya church with refectory. Uspenskiy monastery (Fig.1)	3052	100	0	0
Staritsa, Tomb of general Glebov, headstone	4002	100	0	0

Table 2. Non-carbonate impurities in the selected samples (XRD data), weight %

Sample code	Minerals
3035	Quartz 61, Muscovite 39
3036	Quartz 43, Goethite 31, Megakalsilite 26

Table 3. Cathion composition of the samples (XRF data), atomic %

Sample code	Ca	Mg	Si	Al	Fe	K
1021	98.93	0.49	0.25	0.14	0.10	0.10
1022	98.59	0.56	0.39	0.25	0.19	0.01
1024	98.66	0.47	0.57	0.10	0.14	0.05
1026	99.02	0.40	0.27	0.22	0.05	0.04
3034	95.44	0.73	2.62	0.65	0.20	0.21
3035	84.56	1.29	10.81	2.61	0.36	0.37
3037	96.91	0.83	1.56	0.38	0.23	0.08
3045	99.07	0.49	0.32	0.06	0.01	0.05
3047	98.52	0.35	0.54	0.23	0.15	0.21
3050	97.36	1.59	0.37	0.14	0.16	0.05

Quarries near the villages of Khotyazhi and Polushkino were proposed as mining locations for the New Jerusalem. Samples from these quarries were studied by XRD, which indicated the inconsistency of the major mineral content of these samples with the samples from New Jerusalem (Table 1).

4. DUBROVITSY HOMESTEAD

Another object of our study is the homestead Dubrovitsy, which is located near the city of Podolsk in the suburbs of Moscow. This homestead has been known since 17th century, it was owned by the famous family of dukes Golitsyn. The city Podolsk was a heart of stone craft since middle ages till the beginning of 20th century, when the mining became industrial.

The old wooden Church of Elijah the Prophet was moved from Dubrovitsy to the nearby village Lemeshovo (also owned by Golitsyn) and 22nd of July, 1690 on the site of old church on a hill at the confluence of the Pakhra and Desna rivers was found the new white-stone Church of Our Lady (Znamenskaya). Architect Nicodemus Tessin and about 100 Italian craftsmen were invited to build the

Figure 9: Church of Paraskeva Pyatnitsa. Staritsa (photo E. Ianovskaia)

church. The temple was finished and blessed only on the 11th of February, 1704. However, it is believed that actually construction work was finished earlier, but the blessing was delayed awaiting for the arrival of the Emperor Peter the Great. Duke B.A. Golitsyn was a tutor of the young Emperor and the initiator of the construction of this church. (Figure 10).

The architecture of the church is absolutely unusual for the Russian church architecture. A lot of statues of saints and Latin inscriptions display European traditions brought to the Russian land, and that was common during the reign of Peter the Great.

The building of the church, bas-reliefs, high reliefs, carvings and other ornaments are made of white stone, which was abundant in the vicinity of homestead.

The homestead also includes other buildings of different ages with white-stone parts, namely the basement and the staircase of the main building, the surrounding wall, outbuildings and stables.

The Church underwent a big restoration in the middle of 19th century by the architect Fyodor Richter. He was a famous Russian architect, a founder of scientific restoration in Russia, he also worked on the restoration of the chambers of the Romanov Boyars, the Borovitskaya Tower of the Moscow Kremlin, the Pskov Kremlin, etc. It was then that the Latin inscriptions in the church were replaced with Russian ones. Also there were lesser repairs of the building. Unfortunately, white-stone buildings cannot keep in the Russian climate without periodic maintenance.

Nowadays since 2003 the church and homestead are being reconstructed. It allowed us to gather a collection of samples without any special tricks.

Around Dubrovitsy there are lots of mining sites, starting from the nearest quarries on the opposite riverbank as well as the quarries and mines at distances up to several kilometers. We succeeded to take samples from the church, homestead and nearby mining sites.
The map in Figure 11 shows the locations and numbers of collected samples.

4.1 Physico-chemical study

The samples were investigated by XRD and XRF analyses. The results of the physic-chemical study are given in the Tables 4 and 5.

Basing on the XRD and XRF data we can conclude that at least three kinds of white stone were used for the construction of the Church of Our Lady in Dubrovitsy. The composition of the sample 3014 from the church is quite similar to the sample 1004 from the nearby Rybinskaya mine and to a lesser extent close to the sample 1002 from the same mine and to the sample 1007 from Devyatovskaya mine. The rest of samples of Dubrovitsy (3004, 3013, 3015 and 3020) and from the Church of the Intercession in Erino (3002 and 3003) are close to the samples from the stone block in the Talalikhin Park in Podolsk (2006) and to the quarries in Salkovo (2005). All samples from quarries in Lemeshovo (2001 - 2004 and 2008) consist mainly of dolomite and do not correspond to the above samples. A finished dimension stone was found in the Talalikhin Park near the old bridge (6001), and its composition differs from all the studied samples.

Figure 10: Church of Our Lady (Znamenskaya) in Dubrovitsy (photo: D. Albov)

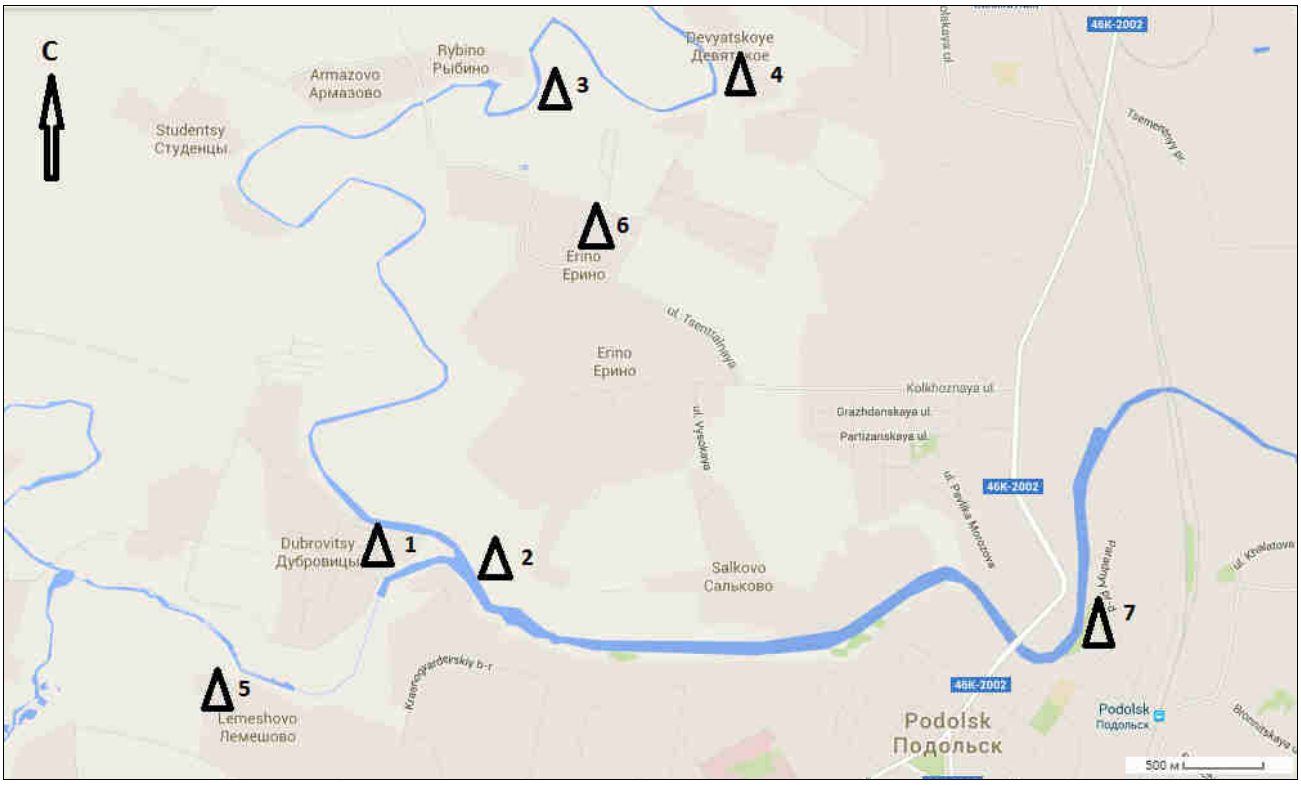

Figure 11: General map of samples for identification source of white stone for Dubrovitsy. 1. Dubrovitsy homestead, 2. Salkovo quarry. 3. Ribinskaya mine. 4. Devyatovskaya mine. 5. Lemeshovo quarry. 6. Church of the Intercession. Erino. 7. Talalikhin park

Table 4. Major mineral composition of the samples (XRD data), weight %

Sample source	Sample code	Calcite	Dolomite	Quartz
Rybinskaya mine	1001	0	94	6
Rybinskaya mine	1002	56	43	1
Rybinskaya mine	1003	5	94	1
Rybinskaya mine	1004	62	36	2
Devyatovskaya mine	1006	77	23	0
Devyatovskaya mine	1007	55	43	2
Devyatovskaya mine	1009	51	47	2
Lemeshovo quarry	2001	0	100	0
Lemeshovo quarry	2002	10	87	4
Lemeshovo quarry	2003	0	96	4
Lemeshovo quarry	2004	24	75	1
Salkovo quarry	2005	91	9	0
Talalikhin park	2006	100	0	0
Salkovo quarry	2007	67	33	0
Lemeshovo quarry	2008	0	100	0
Church of the Intercession. Erino	3002	98	0	2

Church of the Intercession. Erino	3003	100	0	0
Dubrovitsy homestead, burn	3004	100	0	0
Dubrovitsy homestead, Church of Our Lady (Znamenskaya)	3013	99	0	1
Dubrovitsy homestead, Church of Our Lady (Znamenskaya)	3014	50	48	2
Dubrovitsy homestead, Church of Our Lady (Znamenskaya)	3015	96	0	4
Dubrovitsy homestead, foundation of main building	3020	100	0	0
Talalikhin Park. Stone block	6001	86	14	0

Table 5. Cation composition of the samples (XRF data), atomic %

Sample code	Ca	Mg	Si	Al	Fe	K
3004	95.80	0.89	0.39	2.60	0.09	0.02
3013	96.28	0.73	2.33	0.33	0.16	0.17
3014	69.16	17.05	8.55	1.82	2.30	0.94
1004	69.78	17.30	8.21	2.09	1.76	0.86
2005	94.90	3.25	0.80	0.20	0.70	0.15
1006	89.99	6.28	2.67	0.45	0.4	0.17

4.2 Lithological and paleontological study

Lithologo-paleontological study of the thin sections of the above samples under an optical microscope revealed the following information:

4.2.1 Foraminifera are absent in samples from Lemeshovo quarry, one sample from Church of Our Lady and in some samples from Ribinskaya quarry.

Samples 2001, 2002, 2003, 2008 - dolomites without fossils (1)

Sample 2004 – dolomitized limestone with fossils of crinoid (2)

The same dolomites (1) are the samples 3014 – from Church of Our Lady, 1003, 1004 – from Ribinskaya quarry.

The same dolomitized limestone (2) are the samples 1001, 1002 from Ribinskaya quarry.

Consequently, complex of samples 2001, 2002, 2003, 2008, 3014, 1003, 1004 and complex of samples 2004, 1001, 1002 probably belong to one layer (or two layers) located in different places.

4.2.2 Foraminifera were found in samples 3004, 3013, 3015, 3020, 6001, 2006, 1006, 1009, 2007.

Foraminifera communities in the above samples indicate the same geological time of all samples. It is a stone of the late Moscovian age, more exactly of the boundary interval between upper Podolskian and Myachkovian horizons.

According to the similarity of foraminifera species and to the macrostructure of stones, the samples are divided into the following groups:

- Sample 3015 akin to sample 3004, but better preserved
- Sample 3013 akin to sample 6001
- Sample 6001 akin to 1006 and 2006 samples
- Sample 3020 akin to 2007, and in a less degree to 1009

Two samples, 2005 and 3002, differ from the above. 2005 is a detritic limestone without foraminifera (maybe we need to do more thin sections). 3002 - sandy limestone. Intercalation of such limestone is usual for Myachkovian horizons but there no analog in above samples.

Micropaleontological study allow to suggest that in Dubrovitsy homestead they used limestone from upper Podolskian and lower Myachkovian horizons located in quarries near Podolsk and in Devyatovskaya mine.

Consequently according to the result of paleontological issue we can made a conclusion that in the building of Church of Our Lady (Znamenskaya) and other constructions on the homestead territory was used limestone (white stone) from the vicinity of Podolsk.

Figure 12: Rybinskaya mine (photo D. Albov)

Figure 13: Salkovskiy quarry (photo D. Albov)

Physicochemical study gives us the opportunity to affiliate the supposed sources – Salkovskiy quarry (Figure 13) and Ribinskaya mine (Figure 12). Nevertheless, here we also cannot exclude the possibility of using building material (white stone) from other regions.

5. RECAPITULATION

None of the above methods separately cannot give us desired precision to the issue of determination of sources of white stone.

Also very frequently we are not enough samples base. But if we will use all these methods in complex with information of written sources and extend collection of samples, we can get the fair accurate data.

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Historical research and geological-structural stability problems in artificial cavities of Marche

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Abstract

The Marche is a region of central Italy on the Adriatic coast. Its territory contains a wide central band of hills from north to south between the coast and the mountains of Umbria and Marche. This hilly area accounts for over 70% of the territory with relief from 150 to over 300 m a.s.l. Several historical centers of medioeval origin are arranged on the east-west ridges intervening among the river valleys. These centers of great historical and architectural importance, contain many underground artificial cavities of various typology (hydraulic, residential, military, etc.). The comparative study of these artificial cavities began in the fifties in a pioneering way. For over twenty years, caving Marche groups have investigated continuously the subsurface of the historical centers, with different disciplinary outcomes: in the field of history, architecture, archeology, land management and historical buildings. The Gruppo Grotte Recanati (GGR) (Caves Recanati Group), in collaboration with the Gruppo Autonomo Speleologico Civitanova Marche (GASP) (Autonomous Speleological Group of Civitanova Marche), explored and studied the subsoil of four historical centers of the provinces of Macerata and Ancona: Recanati, Barbara, Civitanova Marche and Montelupone. Historical and architectural researches were the main goals of the first two exploration, while in the second twos major geological and structural stability problems were adressed.

Keywords

Italy, Marche, historic center, urban and architectural history, geology, structural stability.

1. INTRODUCTION

The italian historical centers have the peculiarity to concentrate in a small space a stratification of more than three millennia of civilization. Even though there are countries in the Middle East and in the Far East much older, but in none of them the concentration assumes the striking aspect we see in Italy. From the geographical point of view the Italian peninsula juts out in the middle of the Mediterranean Sea, one of the great cradles of human civilization. Not far from the other essential center and origin of civilization that has been the so-called "Fertile Crescent": the valleys of the Nile, the Jordan, the Tigris and Euphrates: the Middle East as we know it today.

In the Italian context, Marche is a central region on the Adriatic Sea side. Its territory contains a wide central band of hills from north to south between the coast and the mountains of Umbria and Marche. This hilly area accounts for over 70% of the territory with relief from 150 m to over 300 m a.s.l. Several historical centers of medieval origin are arranged on the east-west ridges intervening among the river valleys. These centers are part of the 236 municipalities of Marche. They have great importance for the Renaissance architecture and history, and contain many important underground cavities: hydraulic works, residential, military, worship sites. Essentially the historical underground Marche covers the entire typological classification drawn up by the national and international level [Galeazzi, 2013; Parise et al., 2015]. The comparative study of these cavities in the speleological field already started in the fifties in a pioneering way. For over twenty years, some caving Marche groups investigated continuously the subsurface of the historical centers, with different disciplinary outcomes: in the field of history, architecture, archeology, land management and the historical buildings. The Gruppo Grotte Recanati (GGR) was one of the first in the region to work in this field. Since 2000, in collaboration with the Gruppo Autonomo Speleologico Civitanova Marche (GASP), the GGR has explored and studied the subsoil of four historical centers of the provinces of Macerata and Ancona: Recanati, Barbara, Montelupone and Civitanova Marche. In the first two exploration they focused mainly on historical and architectural research, while in the second twos major geological and structural stability problems were adressed. These two areas of investigation, as well as having different clients, has investigative and outcomes often in divergent directions, but at the same time complementary. For the municipalities of Barbara and Recanati the clients were the Departments of Culture of the respective Town Councils, for the municipalities of Civitanova Marche and Montelupone they were the Municipal Technical Offices.

2. BARBARA: IN SEARCH OF LOST TOWER

At the end of fourteenth century central Italy was involved in many local wars between the Lordships and the free cities. From the military architecture point of view it was the so-called "transition period" with the advent of firearms

and the first artillery. The structure of the fortifications greatly changes to adapt to the destructive power of the mortars and the need to prepare workstations for the new weapons. This was a true technological revolution that forced adaptation by the vast majority of municipalities and cities.

At Barbara the old city wall necessitated changes and additions. The tower in question is to the right of the main door of the abbey Barbara Castle, that was since the thirteenth century under the monastery of Santa Maria di Sitria. The castle was built on an existing advanced Lombard settlement, along the border between the Duke of Spoleto and the Byzantine Pentapolis, headed by Ravenna. *"Barbara derives its name from an advanced settlement Lombard, on the border with senigalliese territory controlled by the Byzantine-Ravenna, who at the beginning of the Carolingian called it barbaric, that is foreign, the area in which they spoke a different language of Germanic matrix"* [Baldetti, 2008].

The Abbey of Santa Maria di Sitria was founded by San Romualdo in 1018 on the slopes of Mount Catria, on the Umbrian side of the Appennines. After the defeat of the Lombards by the Franks in 774 starts for Barbara the period as an ecclesiastical fiefdom under the jurisdiction of the Abbey of Santa Maria di Sitria. In 1257 the conquest by the municipality of Jesi occurred with the founding of the City of Barbara under the protection of Jesi. However the constraints of vassalage with the Abbey of Santa Maria di Sitria endured. Then there was the period of 1376-1460 Lordship of Atti, from Sassoferrato (Fig. 1).

Since 1453 the legal bond becomes a commendation given to the cardinals of the most important families of the Papal States: Cesi, Barberini, Albani. Barbara becomes the administrative center of the extended properties of the Abbey.

Figure 1: fifteenth-century Tower of the Gate of Barbara Castle (photo Campagnoli M.)

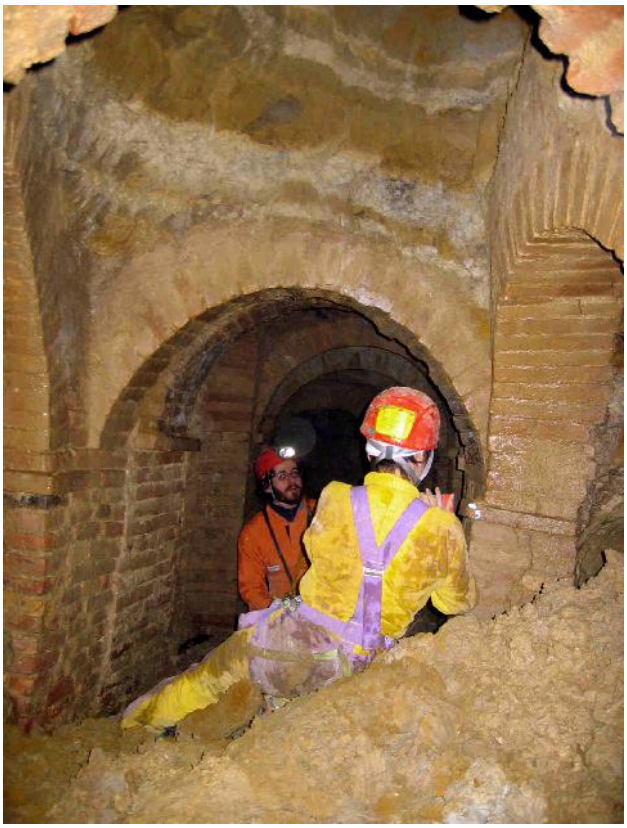

Figure 2: cellar cave under Barbara Castle (photo Campagnoli A.)

In later centuries Barbara continues its history in the Papal State by maintaining ties with the Abbey of Santa Maria di Sitria until the unification of Italy in 1861. All influences were practiced within the political events and the constant fighting between the Papacy, the Sforza of Milan, the Malatesta of Rimini, the Montefeltro of Urbino, to mention only the most important. In recent years affected by wars, sieges or other local skirmishes also the defense of the city was vital to the very existence of a settlement. The door and its two polygonal towers were part of the new walls and fortifications built at the beginning of the fifteenth century at a time of fierce battles between the States and the Italian Lordships then ended in 1454 with the Peace of Lodi, although in the Marche they continues to fight until at least 1462 [Baldetti, 2008].

Among the defenses, as is known, there were also facilities and underground environments: *"The underground galleries, probably remember like trenches by the Gritio, whose Barbara inhabitants were endowed after the Lordship of Atti - 14 July 1460 - and threatening maneuvers Malatesta of the same month, to shelter from gunfire from Rimini, could be profitably used in the following winter, and in the aftermath of the July 10 when the victorious Malatesta had to attack from the north, against Jesi and Barbara"* [Baldetti, 2008] (Fig. 2).

The explorations by GGR began in 2010 and were led initially from the clipboard, and largely absent from the reliefs in 1985-88 by the speleologist from Jesi Andrea Bocchini.

The research then focused near the "Castellaro". In the basement you seek traces of the foundations of the tower and the track of the moat of the medieval walls, more backward than the towers guarding the door.

A large room lined 15x5 meters underground along the walls was explored, which according to Ettore Baldetti, a Barbara historian, could follow the path of the ancient moat (Fig. 3).

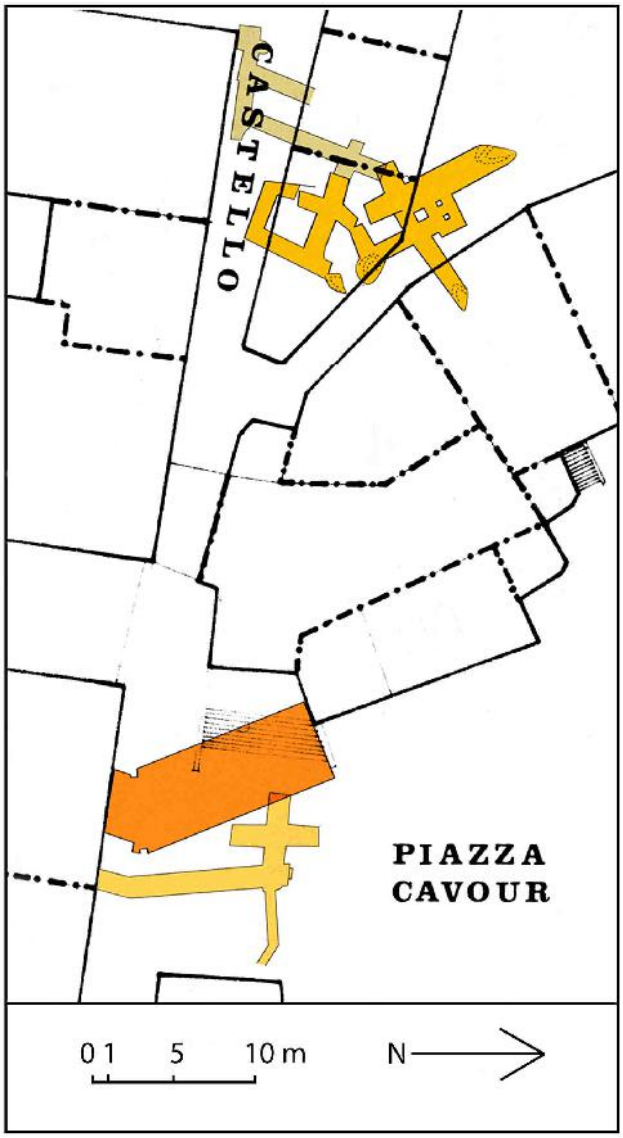

Figure 3: Topography of the caves under the Barbara Castle. The orange cave could be on the track of the Castle moat (topography Bambini R., Campagnoli A., Carestia L., Giorgetti S.; drawing Carestia L.)

GGR continue exploration further south where a well for drinking water was individuated; it is a large well of likely medieval origin, of 10,70 meters in height and 4,50 meters in diameter. It has a significant manufacturing accuracy and a cup-shaped dome cover with concentric circular appeals brick.

The water level is quite high, about 2 meters. Exploration by the experienced diver Alfredo Campagnoli brought to identification of a little tunnel coming out in the direction of the walls and out in the open country, with a probable function as an overflow.

The whole documentation was presented to the citizens in a public meeting. The exploration partial results were processed by the historian Ettore Baldetti, solving a number of questions, but at the same time opening other issues, with further needs to continue the search.

In this first example the caving exploration supported historical and archival research. The specific aim was to confirm some historical hypotheses and possibly indicate a new direction of historical investigation (Fig. 4).

Figure 4: cellar cave under the Barbara Castle, intercepting a cistern probably of the fifteenth century, with abundant dripping and lime deposit (photo Campagnoli A.)

3. RECANATI: LA "GROTTA DEI PUPI" AND A REINESSANCE ACQUEDUCT

The training and the historical events of Recanati originate in the Middle Ages, the common element to most countries of the central Marche hilly territory. About in 1179 three small feudal castles joined as a single town surrounded by defensive walls and it became the free town of Recanati.
The medieval form of the city proposes a typology of Gothic house, built on a rectangular lot from the deep part of the building and with narrow width, to accommodate the long steep-sided ridge on which insists the historical center of Recanati.

The medieval houses are well designed traditional and recurring homes in the hill towns and consist of at least 2/3 floors above ground and 2 below ground level (in the case of Recanati, usually 3). This vertical structure allowed the construction of small quarries. Later the quarries have been transformed into spaces for food storage, obviously cellar for storing wine and oil. To achieve this the quarries have been transformed into caves for hedging brick facing and times, as well as all the necessary transformations to the new use.
In the fifteenth century Recanati was an important town of Marche, especially for commercial reasons. Recanati was also fortunate to have within its territory the small town of Loreto that was heading to be one of the most important sites of the Renaissance. There was under construction in 1469 the Basilica used to house one of the most important relics of Christianity: the Holy House, that is the house of Mary, where it was announced the birth of Jesus. The pontiffs of time engaged in person to encourage a company considered a symbol of Christianity in the face of increasingly aggressive Turks in the Adriatic after the fall of Otranto (1480).

To design and execute works of such importance the popes Sixtus IV, Julius II, Paul III, Leo X and up to Sixtus V and Paul V sent from Rome and Florence their best architects and engineers: Giuliano da Majano, Antonio da Sangallo the Younger, Donato Bramante, Baccio Pontelli, Giuliano da Sangallo, Andrea Sansovino, Domenico and Giovanni Fontana, Carlo Maderno, to name only the most famous. In 1507 Julius II brought the Sanctuary under the direct control of the Apostolic See, and in 1586 Pope Sixtus V raised to the status of Loreto City permanently removing it from Recanati to jurisdiction.

However, the presence of the shipyard Loreto and many artists, architects, sculptors, painters also affects the urban and architectural development at Recanati. To cite an example, in the Massucci palace in the central via Roma, there are the so-called "Grotte dei Pupi": they are caves carved in the yellow sandstone, probably already existing in the Middle Ages and then enlarged during the construction of the building, at the end of the fifteenth century. Galleries with lateral niches of significant size, about 1.4 meters wide by 2.5 in height at the center of the cover are present. The special feature is that the caves are completely carved with different male and female figures in Renaissance style clothes, which adorn the walls and about 40 meters of the cave development.

The style and character with typical barrel for the water of Roman fountains depicted in the sculptures seem to indicate the work of a Roman sculptor, among the many who in the early decades of the sixteenth century who worked in Loreto.

From 1517 to 1579 many sculptors were working at the marble facing of the Holy House of Loreto, under the expert guidance of Andrea Sansovino, like Raffaello da Montelupo and Francesco da Sangallo [Weill-Garris Brandt, 1994] (Fig. 5).

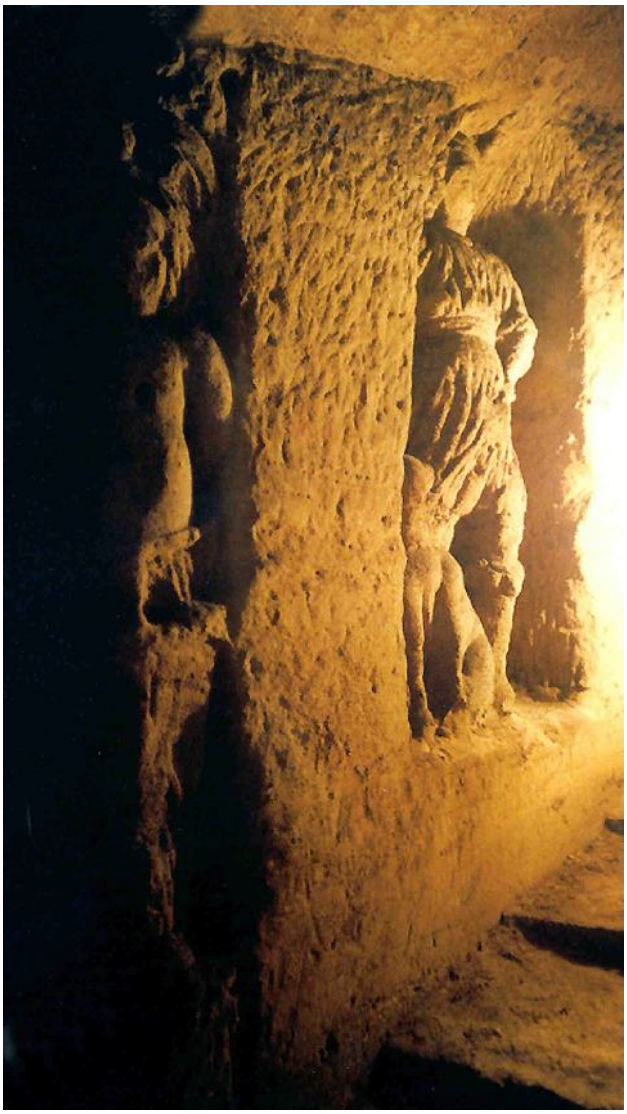

Figure 5: Recanati, "Grotte dei Pupi": sculptural figures in niches along the staircase leading to the caves (photo Campagnoli M.)

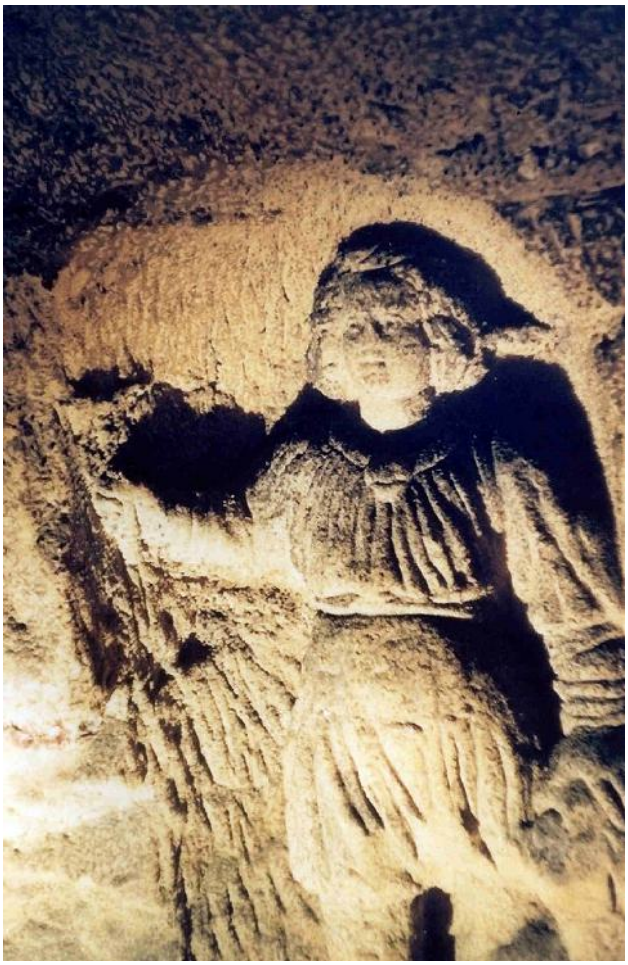

Figure 6: Recanati, "Grotte dei Pupi" sixteenth century. Young sculpture of Renaissance fashion garments (photo Campagnoli M.)

In this period one of the sculptors of Roman culture may have carved the caves in question, where he probably took refuge following a criminal event. This is the most plausible hypothesis given that the sculptures could be dated to the first quarter of the sixteenth century (Fig. 6).

The renaissance link between Recanati and Loreto does not end there. It becomes even more evident under the pontificates of Sixtus V and Paul V. Since the fifteenth century the popes were in fact trying to turn back Rome in a capital city, initially with new architectures and then providing it with urban infrastructure and a new vision that will be called the "Baroque Rome of the Popes". After the Fall (476 AD) Rome decays rapidly, and in the Middle Ages (XIV) is at a record low of about 37,000 inhabitants, following the plague of 1321 and other misfortunes, including the political uncertainty resulting from the period of Avignonesi popes (1309-1377).

From the fifteenth century onwards the papal courts of the Medici and the Della Rovere began to draw from Florence, Urbino and other parts of Italy numerous artists and architects. They will work to the enormous and challenging construction site of St. Peter's Basilica (1506-1626) but also to the numerous palaces of noble families when they have the greatest examples of Roman architecture and monuments as a reference and inspiration. The new political turmoil, artistic and social conducts the Rome of the Renaissance to climb up to the 53,897 inhabitants of 1536. In 1600 the inhabitants were already 110,000 [Sanfilippo, 2007] and Rome was already at the center of the great urban transformations of Pope Sixtus V, the urban planner pope, leading advocate the “Baroque Rome”.

Sixtus V (1585-1590) will build especially roads, squares and aqueducts, some newly designed, the other on the tracks restored the imperial aqueducts. The Acqua Felice, built by Giovanni Fontana for Sixtus V in 1587 on the ancient trace of the Emperor Alessandro Severo, and the Acqua Paola designed by Giacomo Della Porta for the Pope Paul V in 1609, on the ancient trace of the Emperor Augusto, still complete their journey in the historic center of Rome with its monumental fountains. Even the popes in the same years moved to Loreto and Recanati their urban and architectural concepts. Sixtus V conceived his innovative ideas about urban planning and he ordered his papal architects Domenico Fontana and Pompeo Floriani to design the "Felix Civita Lauretana": a new design of Loreto with many baroque ideas inside [Compagnucci, 1994]. It was a large urban extension in the form of an ideal Renaissance city that stretched over the Mount Royal in the direction of Recanati. Loreto in those years had just 2,850 inhabitants, less than half of Recanati, but the devotional fame of the Holy House of Mary carried annually thousands of pilgrims from all over Italy and Europe, Michel de Montaigne, among others. For this reason, the five monumental fountains were not sufficient [Campagnoli, 1991a]. Sixtus V in 1588 had established in Rome the *"Congregazione delle Acque*” *(Congregatio pro viis Pontibus et acquis curandis)* refreshing attention for the public water by the Romans and by the municipal statutes of the fourteenth and fifteenth centuries [Manieri Elia 1991; Simoncini, 1991; Campagnoli, 1996].

In Recanati resolution as the water supply in almost all the historical italian centers has ancient origins. In the valley of the power of the Romans we find the solutions and elsewhere in the Marche the way of the Etruscans or the Greeks Ankon (Ancona). In the free town of Recanati, born in 1179, the first solutions (wells and springs) are traceable on the hill within the city walls. With the arrival of Fontana, architects sent by Sixtus V and confirmed by Paul V, Recanati is also affected by the changes of hydraulic architecture brought by the Renaissance popes of Rome [Campagnoli, 1996]. Domenico and Giovanni Fontana, and their nephew Carlo Maderno certainly know the precepts of Book VIII of the "De Architectura" of Vitruvius, the architet of Imperial Rome whose treatise was spreading in

intellectual circles of Italian Reinessance: *"Ductus autem aquae fiunt generibus tribus: rivis per canales structiles, aut fistulis plumbeis, seu tubulis fictilibus."* (There are three types of pipelines: masonry channels, lead and clay pipelines). And again: *"Sin autem erunt average Montes et caput inter moenia fontis, sic erit faciendum, uti specus fodiantur sub terra librenturque ad fastigium, quod supra scriptum est. Et si tofus erit aut saxum, in suo sibi canalis excidatur, sin autem, aut terrenum harenosum erit, cum solum et parietes camara in specu struantur et ita perducatur. Puteique ita sint facti, uti inter duos sit actus."* (If between the city and the source of supply arise heights, making sure it will be necessary to dig underground tunnels to keeping the slope required, as has been said before. If the soil is rocky or tuffaceous nature can simply dig a canal; if it is muddy or sandy you create a masonry coating on the bottom and sides, with its vaulted ceiling, then there can make the water flow. It also creates the air shafts in intervals of one hundred twenty feet apart) [Pollione, 1990].

The architect Carlo Maderno (1556-1629) is the grandson of Domenico Fontana (1543-1607) and his brother Giovanni Fontana (1540-1614), architect of Sixtus V and designers of large public and urban accommodation work ordered by the Pontiff. Below uncles, which began in Ticino with a marble quarry workers company, Carlo Maderno learned the art of designing architecture to become papal architect of Saint Peter from 1603 to 1626.
In Loreto between 1605 and 1620 he planned and realized with his uncle Giovanni the Pontifical Aqueduct and the Fountain of Madonna [Campagnoli, 1991; Hibbard, 2001]. This particular hydraulic work also concerns Recanati because its catchments ("caput aquae") is inside its countryside. Giovanni Fontana in Rome and Lazio had an intense project activity in hydraulic engineering as a result also of the innovations of Sixtus V. He made aqueducts and hydraulic design also in Tivoli, Velletri and Frascati [Arena, 1987; Cappa et al., 2011; Germani, 2015] and given these precedents, it is natural to attribute to Giovanni Fontana the whole design of hydraulic engineering in Loreto, attributing with certainty to only Carlo Maderno the design of the Fountain of Madonna (1614-1620).

The Fontana were sent to Loreto by Pope Sixtus V, Domenico was in fact the whole town planning coordinator of the new expansion called "Felix Civita Lauretana". The aqueduct project is part of this urban design: an efficient urban infrastructure, in direct line with the modern concepts developed in the Rome of the Popes and the architectural tradition of Ancient Rome.

Carlo Maderno and Giovanni Fontana sign the contract with the Sanctuary of Loreto on 2 January 1606, pledging to implement the water collection system from the source of the "Fonte Ciatona" (Fig. 7) in Recanati, 210 m a.s.l., in "Contrada Varano", and lead for more than 7 km up to Loreto, on Monte Reale, where in the meantime it was still working to "Felix Civita Lauretana" built by Sixtus V.

Figure 7: Recanati, The Pontifical Aqueduct of Loreto sources (1620), conducted flooded (photo Sbaffi E.)

The Municipality of Recanati had already granted in 1603 the spring water use in exchange for building a public source, the current "Fonti San Lorenzo" [Campagnoli, 1991a, 1996, 1998], the architects and workers conducted the work with the excavation in open pit, chosen due to the fragile structure of the soil and the average depth of only 15 meters of the duct. To overcome the height difference of about 100 m in the hills between Recanati and Loreto they used a "reverse trap" backed down from a theory of long 400 meters arches, useful to lift the pipes to prevent their rupture, made of lead with rudimentary welds.

Along the path there are about 28 inspection wells and venting with square cross section, while the gallery has medium-sized sections of 0.7 meters by 1.5 meters in height. The vertical section reaches 3 meters in spring burrows because of attempts to follow the lowering of the water table suggested at the end of the eighteenth century by the Basilica of Loreto's architect Andrea Vici and then actually implemented in 1821 [Campagnoli, 1991].

Figure 8: Recanati, The Pontifical Aqueduct of Loreto sources (1620), the ducts Topography realized at the beginning of the eighteenth century (source: The Holy House Historical Archive)

Figure 9: Recanati, Loreto, the external duct raised on arches to a Pontifical Aqueduct plan of Loreto (1620). The conduit called "Li Archi" on the border of the territory of Recanati and Loreto are 400 meters long (photo Campagnoli M.)

The aqueduct is for its western half of the track in the area of Recanati (from top sources of the arches), and for the remaining eastern half lies in the municipality of Loreto. It follows the classical pattern of Roman origin: source and catchment, cistern ("Cassa delle Vene") conducted, arches, led, cistern ("Cisterna di Monte Ciotto" or "Castellum aquae") and finally the monumental fountain in Loreto ("Mostra dell'acqua") (Fig. 8).

The distance between inspection wells above the Vitruvian canon, around the duct coated with bricks and no stretch in free excavation, overcoming issues bypassing the slope of the two hills trying to keep the portion except for the duct which descends Monte Reale until "cisterna di Monte Ciotto": steep and interspersed with transverse barriers, also made to decant the very calcareous water. Another interesting aspect in this context is that the Pontifical Aqueduct of Loreto is a construction of new design, differently from other aqueducts in Rome and Marche, which take over the ancient tracks and pre-existing Roman [Tarini, 1998; Campagnoli & Recanatini, 2000].
What my friends Giulio Cappa and Alberta Felici called *"the Renaissance of the aqueducts"* [Cappa et al., 2011] is an historical and technological continuity that goes is worth of further studied, not only in Rome and Marche, where it is very clear and quite studied in individual artifacts, but elsewhere. And above all, it should be studied as a whole, analyzing it as a constructive phenomenon and design culture linked to the rediscovery of Roman architectural and technological culture operated by Renaissance architects in their treatises on architecture (Fig. 9).

The famous architectural treatises and even military engineering of Renaissance architects Francesco di Giorgio Martini, Leon Battista Alberti, Andrea Palladio are flanked by numerous treatises of Jacopo Barozzi (Vignola), Giovanni Branca and other architects that treating the tracking of irrigation channels and also of aqueducts.

Figure 10: Loreto, the Fountain of Madonna, in the homonymous square in front of the Basilica of the Holy House. The fountain was built from a design by Carlo Maderno between 1614 and 1620, by contract was to throw water *"venti palmi alto"* (photo Campagnoli M.)

The engineering and hydraulic design of the eighteenth century, consequence of the Enlightenment, is also continuously studied in Marche for the Renaissance, however there is still much research to be done, in the archives and explorations. As for the Pontifical Aqueduct of Loreto GGR, in memory of the speleologist Alfredo Campagnoli, intends to resume the search, starting with a photographic campaign with new digital technologies, and possible tests with a new topographic laser systems.

Since the Renaissance architecture and hydraulic engineering, though often linked to existing structures and Roman building techniques, the field of inquiry is not archaeological but architectural history: a research field where GGR and myself have accumulated experience for over thirty years. Not coincidentally the Pontifical Aqueduct of Loreto was detected in 1989 on behalf of the Superintendence for Environmental and Architectural Heritage of Marche, and bound by it in accordance with the 1089 Law of 1939. The prospect of expanding the survey to the Renaissance context of Marche and connect experiences of Loreto and Recanati with the contemporaryachievements in the Rome of the Popes, convinced us to resume the investigation (Fig. 10).

4 MONTELUPONE AND CIVITANOVA MARCHE: MONITORING THE STABILITY OF HISTORICAL CENTERS THROUGH THE EXPLORATION OF ARTIFICIAL CAVITIES

Montelupone and Civitanova Marche in the experience of GGR were a novelty compared to the previous research,

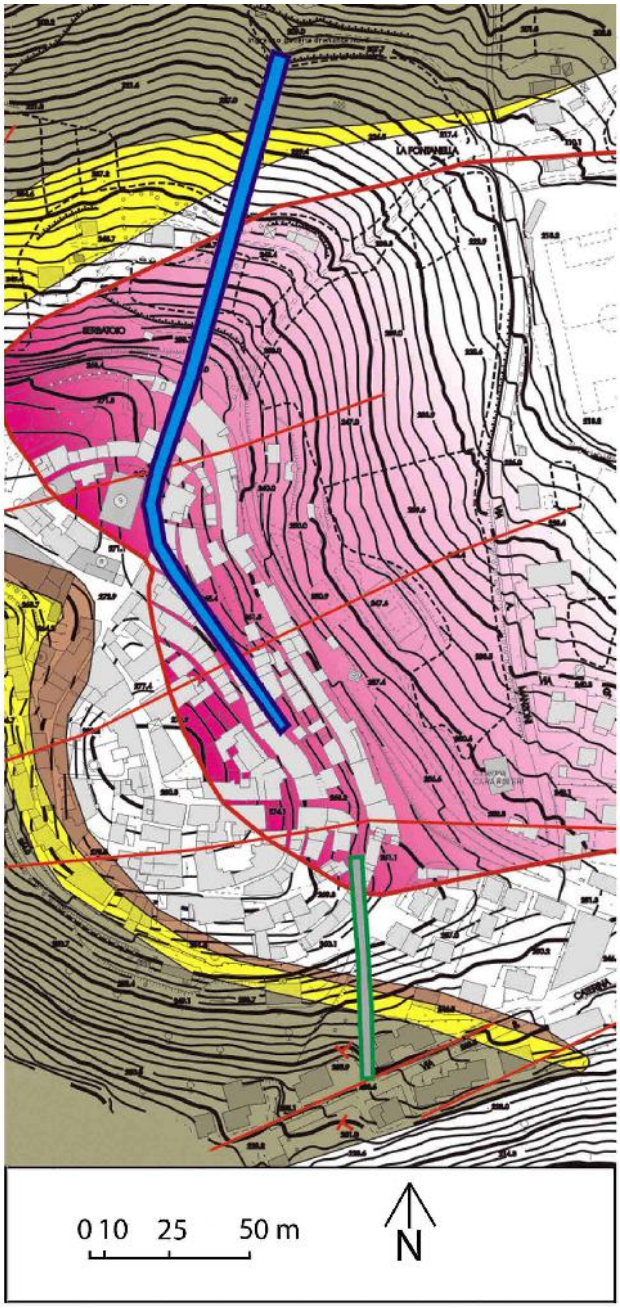

Figure 11:
Geological Plan of the historical landslide of Montelupone with track of the two drainage tunnels.
White: clayey silt and clay loam;
Brown: clayey silt and sand;
Yellow: sand and clay marl, with sands in banks;
Ocher: clay marl with sandy intercalations;
Red line: fault and position layers;
Green line: southern drainage gallery;
Blue line: northern drainage gallery;
Purple red bordered areas: crown and landslide
[after Morgoni, 2002]

since only occasionally GGR had been called to explore artificial cavities subject to structural problems, as in Recanati, Treia and San Costanzo. Similar experiences were carried out by Gruppo Speleologico Marchigiano of Ancona at Castelfidardo and Montecassiano.

In Montelupone we were called by the geologist Luigi Morgoni who was interested for some years in the historical center caves to monitor the historic landslide that hangs from the eighteenth century on the eastern half of the hill on which the village stands. In November 1980 an old town house collapsed almost entirely and sagging continued until 1985 [Campagnoli, 2002; Morgoni, 2002] (Fig. 11).

The landslide had serious episodes of movements since 1929, during the sixties and until the next decade. Finally, the Town Council approved the construction of two drainage tunnels under the historical center. The plan resolved most of the problems though with some adjustment of the operation of the drainages. Finally a survey of artificial cavities in the late nineties was appointed, from 1998 to 2000, in order to monitor all the landslides and operation of the two drainage tunnels.

At the time the technicians of the Municipality did not have a digital survey of the historical center, processed topographic now widespread and suitable to accommodate pads of artificial cavities, caves and cellars of all cavities for hydraulic use (cisterns, wells, tunnels) (Fig. 12).

Such type of digital census was possible in Civitanova Marche, in the historical center called "Civitanova Alta". In this old town in 2009 landslides partially destroyed a house and injured others, also causing partial collapse of the road surface of some streets: Corso Annibal Caro, Piazza della Vittoria and the main square near the Ducal Palace. Following these events in the spring of 2010 GGR and GASP explored and found 11 caves and 7 cisterns.

The final outcome after emergency exploration and other technical surveys was a complete digital plan of the historic center containing: the built, wiring, hydraulic supply systems, gas, electrical wiring and telephony and the surveyed caves and detected by technicians from private and municipal by cavers technicians. Such an elaborate chart is an essential tool that every Municipal Technical Department should have, especially in the historical centers located in the hills prone to landslides, and with high presence of artificial cavities (Fig. 13).

All 236 municipalities in the Marche have many caves and underground hydraulic systems (cisterns, wells, tunnels), even the cities of the plain, albeit in smaller numbers. In the thirty years experience of GGR in the field of artificial cavities the first exploratory research had historical and archaeological purposes, and activated collaborations between cavers, university research institutions and the Superintendences for Archaeological, Architectural and Environmental Heritage of Marche and Emilia Romagna. Searches then merged in numerous publications,

Figure 12: Montelupone, typical cellar cave (photo Campagnoli M.)

conferences and exhibitions also of national level. Over the last fifteen years, after 2000, GGR and GASP were involved by geologists and community leaders also in research on geological and structural stability of the historic centers through exploration, the census and monitoring the artificial cavities.

The explorations in these four historical centers (Barbara, Recanati, Montelupone, Civitanova Marche) developed in two directions, historical and technical, has indicated there may be an opportunity for cavers to offer their exploratory competence. Unfortunately, the experience has often shown itself to speleologists the unwillingness of local authorities towards the study and protection of artificial cavities if not linked to a possible tourist exploitation.

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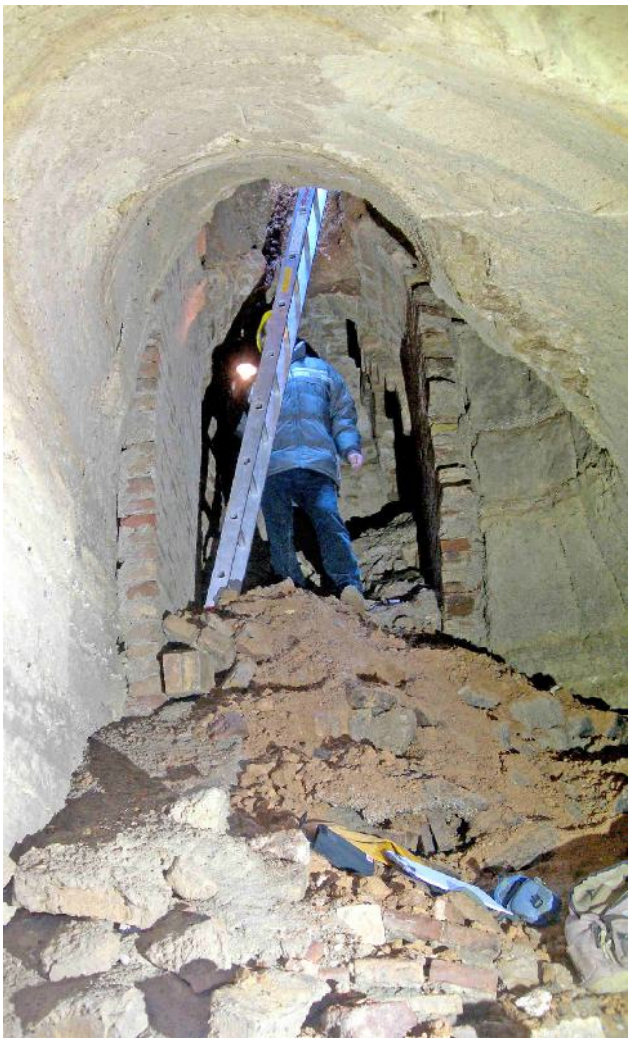

Figure 13: Civitanova Marche, the cave collapsed in the Corso Annibal Caro in the historic center, near the theater and the Ducal Palace (photo Campagnoli M.)

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This article is dedicated to my brother Alfredo Campagnoli, a tireless explorer and surveyor of artificial cavities and founder of the Gruppo Grotte Recanati. Alfredo left us suddenly September 6, 2011 while he was doing one of the things he loved most: exploring an ancient aqueduct. Special thanks of the author go to all the cavers of GGR and GASP who participated in the exploration of the artificial cavities described in this article.

The consequence of erosion caused by watercourses on the conservation of cavities hollowed in the soft sedimentary stratus in Cappadocia

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Abstract
It was established in historical times that small rivers have noticeably deepened their course each time a threshold creates a waterfall: the foot of the erosion makes it rise considerably upstream. The cliffs eroded by the current then became more unstable, there were collapses, cavities were destroyed and access to others became impossible. Cappadocia is particular interesting example of erosion of cavities and of their afferent issues related to the preservation of cultural heritage. It is illustrated here first in the case in the Church in the Valley of Meskendir, Saint Peter and Saint Paul, where the paintings are most interesting. Whereas the erosion appears to have stabilized, for those who do not practice climbing, a big ladder would be most welcome. In the second example, the case of Açıkel Ağa kilisesi Church, the building of a new road heavily increased the catchment area of a minute ravine. Following an old landslide on the side of the cliff where the Church was dug, the water flowing in this ravine goes right through the narthex. In the near future, the erosion threatens the neighboring cavity consisting of the nave which is decorated with exceptional paintings. In this case, it is easy to divert the waters from the road ditches towards another outlet thus not to have to divert them to a tunnel which is yet to be dug.

Keywords
Açıkel Ağa kilisesi, Cappadocia, conservation, water erosion.

1. INTRODUCTION

Cappadocia soft rock, everywhere, is easy to dig: a pick, a bag and a few days are enough to dig a protected habitable room cold and heat. Throughout history, particularly during periods of strong development, people have proceeded in such a way, this was indeed the case during the "Macedonian Renaissance" in the tenth and eleventh centuries when houses, monasteries were hollowed at that time.

Now it can be understood that the effect of different factors of erosion have led to great damage and even destruction of different cavities dug in the past [Del Prete and Parise 2013]. Cappadocia, because of its geology, climatology and history provides a particularly interesting example [Castellani, 2002; Hild, 1981]. Indeed, the process of destruction of the cavities can be explained as follows. Erosion deepens at the foot of small cascades which are often punctuating the streams in Cappadocia. The scour caused at this point by the turbulence of the flow is amplified because of the alteration of the soft bedrock. In addition, the frost especially degrades the base of the cascades where the capillary sources are concentrated. In consequence, the rock is reduced to a powder of compact grains: the least flow washes them downstream. Finally, the rapid recession of these thresholds entails a notable evolution at the level of the local base.

Here we present the effect of erosion by rivers in the case in the Church in the Valley of Meskendir and the case of Açıkel Ağa kilisesi Church, for which a preservation project is sketched. The locations under study are indicated in Figure 1.

2. THE OVERDEEPENING OF MESKENDİR CANYON

A first example of erosion by watercourse in Cappadocia is found in the Meskendir canyon [Burri, 2005; Couprie, 2007], a deep breach at the foot of the Aktepe plateau.

A number of channels were dug on the eastern bank to divert the watercourse. By opening a path this suite of channels helped grow gardens. Today the original gallery can be seen at the top of these channels. As shown in Fig. 2, traces of pickaxes are visible at a height corresponding to that of a man. These traces dominate at 5 to 6 meters today, corresponding to an equivalent over-deepening.

Should this established fact be related to the present difficulty of reaching the Narthex of Saint Paul and Peter Church where the entrance (Fig. 3) is close to 10 meters above the orchard situated at the foot [Hild & Restle, 1981]?

The paintings which decorate the church date from the 7th or 9th century. A rockfall cut part of the narthex, and the original entrance has disappeared.

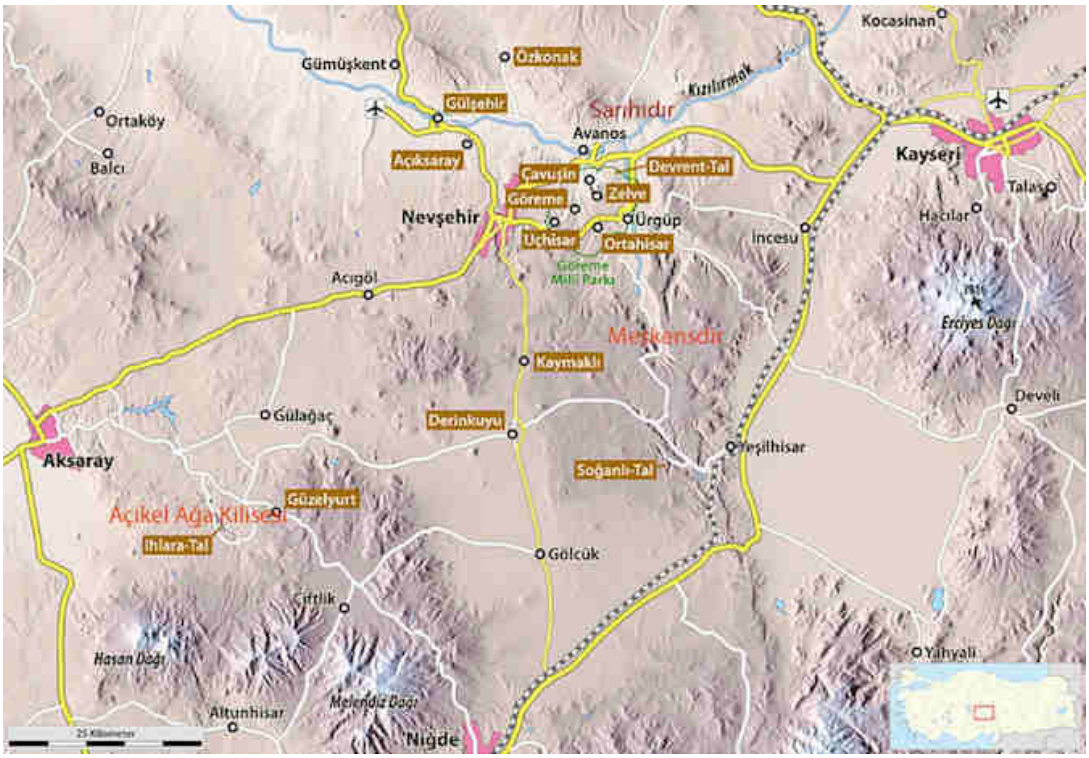

Figure 1: Cappadocia map indicating the locations under study (source wikipedia)

Further down the entrance to Saint George Church and the Church of the Archangels are close to 10 meters above the present watercourse (Fig. 4).

However, far from the thalwegs the entrances of ancient churches are notable at the level of the vineyards: it is case of the churches of Nicetas or Symeon the stylite, whereas in both cases the monk's cell is much higher in the cone.

Big piles of weathered blocks obstruct the neighboring canyons of Meskendir. The soft and porous stone of Cappadocia alters rapidly when the exposed side is not vertical: on a cliff rainwater rapidly flows, causing intensive erosion. Observation on the spot shows that the fallen blocks, about 0.50 meters in size, disappeared completely within three winters. The collapsing of high cliffs creates a very temporary obstruction of the watercourse and the recession of the cascades end up in higher and more notable cliffs.

Thus it appears that the recent overdeepening of the Meskendir happened after the caving in and the decoration of Saint Paul and Peter Church less than 1000 years ago.

In addition, according to Eric Gilli's discovery [Gilli, 2013; Gilli et al., 2014] at Sarıhıdır, the diversion of the Halys river for the Greeks leads to the fact that Kızıl Irmak is settled a little too high in relation to the present flow of the river. Therefore, it does not exclude a possible variation of about a few meters of the water level in all the region around Avanos. In consequence, successive basis level evolution has probably occurred.

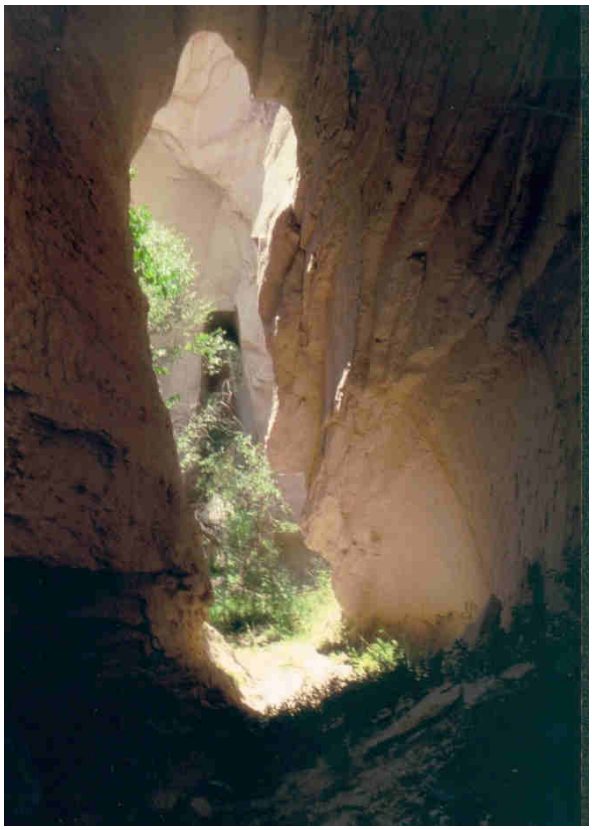

Figure 2: The diversion channel over-deepening

Figure 3: In the valley of Meskendir, St Peter and Paul

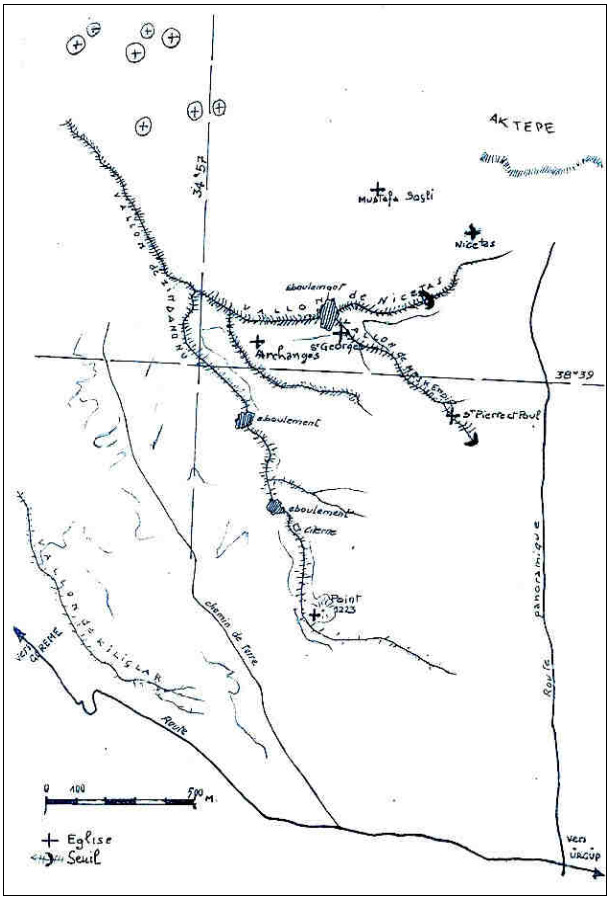

Figure 4: The churches around Meskendir

3. THE CASE OF AÇIKEL AĞA KİLİSESİ CHURCH

Among a number of examples of erosion in Cappadocia due to nature and man, let us examine the cavities that contain the Açıkel Ağa Kilisesi Church [Couprie, 2015], situated on the left bank of the Melendiz Suyu, facing Belisırma.

Figure 5: Entrance of Açıkel ağa kilisesi and the gully

Figure 6: The passing through the narthex of Açıkel Ağa kilisesi

The recent construction of a road has enlarged the basin that tips from a ravine which today pours its waters into the narthex of the Church. The preservation of the nave is thus at risk (Figs. 5 and 6).

Nicole Thierry specifies the importance of this small monument (Fig. 6) [Thierry, 2002]:

"The iconographic and stylistic list of this small church is unique in Cappadocia. The dominating ocres the pinks and whites, the wide yellow background, the uncomplicated classical inscriptions remind us Roman works of the 6th and 9th centuries, such as St. Marie-Antique and St. Sabas. On the whole one could see it as a greco-syrian monument of the High Middle Ages as can be imagined without the breaching created by the iconoclasm".

As it is often seen in the gorges of Ihlara, two cliffs overhang to form the bank of the canyon. The Church is situated at the North end of the upper cliff. A very small thalweg borders the northern extremity, and today pours its waters in a breach in the western wall of the narthex.

Figure 6: Anastasis in Açıkel ağa kilisesi

This cliff shows traces of a collapsed pile of blocks obstructing the small thalweg.

The aperture of the breach in the Narthex and the receding cliff are linked, but, a few years ago, a new road leading to Belisırma notably enlarged the basin which pours from the small thalweg: the erosion of the Narthex is more rapid.

4. CONCLUSION

For the first example of Meskendir, the erosion has taken place rapidly, and one could expect the destruction of the cavity in the near future, putting the cultural heritage of Saint Paul and Peter Church under danger.

For the second example of Açıkel Ağa Kilisesi Church, one can envision possible remediation. In a first stage, one should divert the waters from the ditches along the road. A large parking lot which was built recently can facilitate the operation. It would be probably sufficient to build a 100 meter ditch to divert these waters into the thalweg situated immediately north of the Church. Going upstream of the Narthex a few walls and ditcheswould be necessary to divert a reduced flow to its original waterway.

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Cave Settlements in Volcanic Areas of the Armenian Republic

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Abstract

About forty percentof Armenia'sterritoryis covered by products of Neogene-Quaternary Periodvolcanism represented by 2 formations -pyroclasticandlava.

Pyroclastic formations are mainly Neogene tuffs and tuff-breccia, with a thickness of 200-300 m. These have a horizontal setting and host caves on plateau slopes (Spitak, Geghard, Yelpin, etc.). In some cases, when the plateaus are carved up by a dense network of canyons, these appear in the form of natural pyramids (Goris, Khndzoresk, etc.). There are numerous natural caves and artificial cavities of various sizes in the pyroclastic formations. The natural caveswere formed as aresult ofsuffusion processes, which later were expandedbymen and converted into places of religiousactivity, fortification structures,dwelling units and sites of economic production. However, the majority of caves in pyroclastic formations have an artificial origin. Generally, these are closely places and form dense cave settlements comprising tens to hundreds of cave units. Such settlements can be found in Old Goris, Old Khndzoresk, Spitak, Yelpin, etc.

Lava formation are represented by Upper Pleistocene-Quaternary Period andesite and basalt lava flows and blankets, which reach a thickness of up to 1000m in some locations. The lava formations are composed of stacked lava flows, with some having as many as 20 separate flows. These flows are most clearly visible on the canyon walls of rivers Akhuryan, Debed, Dzoraget, Qasagh, Hrazdan, Arpa, and others. Caves with different morphologies have formed at the contact zone between various lava flows as a result of erosion and denudation, which become visible on the canyon walls. These caves were modified by humans and converted into dwelling units and places of economic production. Caves, which are placed on different levels, form cave settlements. The settlements stretch out along the lava flow. Such settlements can be found in Sanahin, Haghpat, Agarak, Ashtarak, and other places.

Cave dwellings located in pyroclastic and lava formations have different urban planning, architectural and archaeological features, which are dependent on their origin.

Keywords

Volcanic Cave Settlements, Pyroclastic formations, Lava formation.

1. INTRODUCTION

About forty percent (40%) of Armenia's territory is covered by Neogene-Quaternary period volcanism products presented in two formations – pyroclastic and lava flows. Underground settlements, some of which consist of up to several hundred human made or modified caves, exist in both formations[Balyan &Vanyan, 1986].

2. CAVES IN PYROCLASTIC FORMATIONS

Pyroclasticflowsare mainly represented by Neogene tuff and tuff-breccia, with athicknessof 200-300 meters. These have a horizontal setting and host caves on plateau slopes, such examples can be seen in Spitak, Geghard, Yelpin, etc. In some cases, when the plateaus are carved up by a dense network of canyons, pyroclastic flows are revealed inthe formof natural pyramids, such as one in Goris, Khndzoresk, etc. Throughout Armenia, there are numerous natural and artificial caves of various sizes in pyroclasticflows. Thenatural caves were formed as a result of suffusion processes, which later were modified by men and converted into places of religious activity, fortification structures, dwelling units and loci of economic production. However, the majority of caves in pyroclastic flows have an anthropogenic origin. Generally, these man-made cavities are closely clustered and form dense cave settlements comprising tens to hundreds of units.

From a geomorphological point of view, cave dwellings within pyroclastic formations can be divided into two groups:

A) Valley-canyon cave settlements
B) Cliff cave settlements.

Cave dwellings situated in valleys and canyons are generally located on steep slopes, with the depth of the valley or canyon reaching up to 150 meters (e.g., Old Goris, Old Khndzoresk, Qarahoonj, Dzorashen, etc.).

In this type of settlements, some of the caves were dug into earthen mounds and are known as *qarataker* (cave dwellings). These types of caves are prevalent mainly in the south-eastern part of Armenia, in the city of Goris and its surrounding areas.

Figure 1: Artificial Caves of Old Goris (photo S. R. Davtyan)

The area occupied by these settlements reaches tens of hectares andcontains hundreds of caves, with apopulation numbering in the thousands. For example, at the beginning of the 20th century the village of Khndzoresk, a cave settlement,had a population of 8,300 people. Many of the caves had adjoining structures built with both smoothly hewn and rough stones. According to historical accounts these cave settlements were permanent habitation sites whose residents engaged in various economic actives (e.g., agriculture, crafts, trade). The settlements contained various buildings (churches, caravanserais etc.) and infrastructures (roads, reservoirs, springs) serving the inhabitants. A number of roads crossed at the central part of the settlement connecting the different districts to one another. Large cave settlements also had fortification structures and citadels all made out of artificial cavities; examples of such fortification structures can be found in Old Khndzoresk and Old Goris (Figure1).

Cliff cave settlements are located on the slopes of cliffs having a height of 10-100 meters, such as those in Voghjaberd andYelpin. These mainly consist of small caves and served as defensive structures for the residents of neighboring settlements.

Caves in pyroclastic formation can be divided into five groups based on function: 1) residential, 2) religious, 3) social, 4) industrial, and 5) defensive.

Residential caves have a simple layout and architectural composition. They basically consist of a single room, though housing complexes with several rooms also exist. Besides the more common one-story houses, separate multi-story cave houses, connected to one another by rock-carved stairs, are also known. The habitation rooms had irregular dimensions of various sizes – 5-8 meters in length, 3-6 meters in width, and 2-3 meters in height. The rooms had one entrance and skylights carved into the ceiling, which served for smoke removal, air ventilation, and lighting. The floor was slightly inclining towards the door.

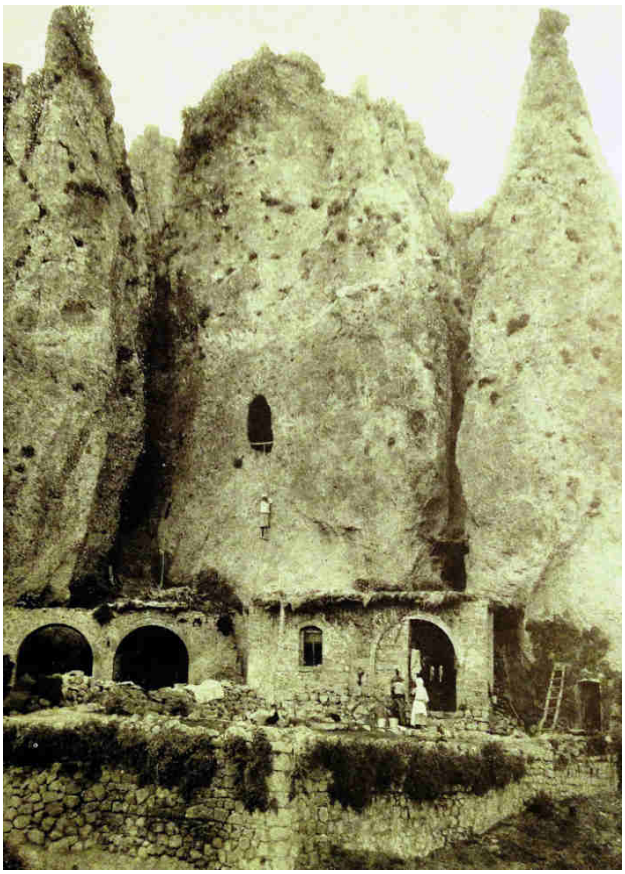

Figure 2: Woman climbing to a cave using rope (1930s photograph)

In some cases, an oven or a hearth was dug into floor. The ceiling was horizontal and flat. Small niches were carved into the walls for storing utensils and carved platforms of different heights were used for sitting and sleeping. In the same courtyard, adjacent to the living quarters, were built rooms for various economic function (e.g., cellars, barns, stables) with separate entrances. Over time, free-standing houses were built in front of the artificial caves. These houses are stacked, the roof of one house served as a courtyard for the house above[Lisicyan 1969].

Within cave settlements, some caves were built as places of worship (churches, shrines, prayer houses, etc.).
Public buildings are represented by caravanserais, which were quite large, similar to their above ground counterparts. For example, the main hall of the caravanserai in Spitak was about 15 meters in length, 7 meters in width,and contained smaller niches along the edges.

These cave settlements containvarious production facilities, such as potter's workshops, metallurgical complexes, textile and leather processing workshops, etc.

Caves built for defense purposes are devoid of courtyards. These are carved on cliff slopes with up to 3-meter height, which were accessed by ropes (Figure 2).

Figure 3: Lava flows on the walls of Debed Canyon (photo S. R. Davtyan)

Figure 4: Lava Cave in Eghegis Canyon (photo S. R. Davtyan)

Additionally, larger settlements had citadels, where the caves served as barracks. These were connected to one another by hewn stairs or secret passages.

Cave settlements in pyroclastic formations were in use through the 1960's. Today, these are abandoned and in ruins.

3. CAVES IN LAVA FORMATIONS

The lava flows are represented by upper Pliocene-Quaternary period andesites and basaltswhich in some places have a thickness of 1000 meters. Theseare composed of overlapping flows, with some having as many as 20 separate flows. Their thickness ranges from 2-3meters to 30-40meters(Figure 3). In major river valleys, these flows form stepped canyon walls. Lava flows are clearly visible on the canyon walls of Akhuryan, Debed, Dzoraget, Kasagh, Hrazdan, and Arpa and other rivers. As a result of erosion and denudation, morphologically varied caves have formed within the layers where two neighboring lava flows come into contact with one another, which become visible on the canyon walls. These caves were "cosmetically" modified by humans and converted into houses and places of economic activity. No traces of rock carving instruments have been preserved on the walls and ceilings of these caves; it is likely that they were widened by removing separate fragments with wedges (Figure 4).

They have different surface areas, ranging from 5-6 square meters to 50 square meters. In plan, the caves have an irregular shape, with the central part having a height of 2-3 meters, whereas near the walls their height does not exceed 0.5-1 meters. The settlements are formed by caves located on different levels, which are connected either by stairs carved into the rock or well-maintained natural trails. The different levels were also accessible by wooden stairs built on wedges driven into the rock. In some cases, bedrock mortarscan be found on platforms in front of the caves, which were used for processing grains. The caves located on the canyon walls were connected to the settlements on the plateaus by steep and narrow trails, which were between 1-2 meters wide. These type of trails were called *muter* by the inhabitants, likely from the word *mutq*(entrance in Armenian). In general, *muter* were built from stone steps. The cave settlements stretch out along the lava flows, generally, they are evenly distributed, but in some places they cluster, thus forming "cave-villages." Such are the cave settlements of LoriberdYaghdan, Koghes, Kurtan, Sanahin, Haghpat, Agarak, Ashtarak, and others.

4. HISTORICAL CHARACTERISTICS OF CAVES IN PYROCLASTIC AND LAVA FORMATION

Cave settlements located in pyroclastic and lava flows have served as residences for the general population, as well as for hermits, clerics, and priest (Figure 5).

Chronologically, the oldest cave settlements are located in lava flows. They have been used by man since the early Stone Age [Karapetyan 1977] and many of these caves contain Stone Age tools left behind by the first inhabitants. Many also contain pottery dated to the Bronze Age. Starting from the Medieval period, cave settlements were occupied more intensively; this is attested by the abundance of Medieval pottery found in the caves or adjacent platforms. Many of the caves were inhabited by hermits or anchorites, who founded monasteries, such as Gndevanq, Horomayr, and Qobayr. Stepanos Orbelian, a 13th century Armenian historian, describes the events in connection to the construction of Gndevanq monastery. The monastery was built on the left canyon wall of the Arpa River, on one of the lava terraces. According to the historian, the construction of the monastery was completed in A.D. 936. Caves, which were difficult to access also served as defensive structures where the local population found refuge in times of need. The caves were also used for hiding the wealth of the monasteries, ritual objects, and books. Cave dwellings located in lava flows were abandoned at the end of the 18th century A.D.

Figure 5: Geographic distribution of cave settlements located in pyroclastic and lava flows

The first cave dwellings in pyroclastic flows date back to the first quarter of the 3rd millennium B.C.E. Although, in these caves one can encounter areas formed by erosion and suffosion processes, the vast majority have an anthropogenic origin.

The caves were carved by using a sledgehammer to push a pick into the cliff and break out a fragment of the rock. Then, after obtaining the necessary surface for a room, the walls were worked with a chisel.

The abundance of unique form of relief in pyroclastic formations (e.g., pyramid-like mounds, natural caverns, cliffs, etc.) served as bases for the formation of "sacred spaces." Such a landscape was formed in the middle reaches of Azat River and in the neighborhoods of Geghard (also known as Ayrivanq) monastery.

Geghard was founded by Gregory the Illuminator in the early 4th century A.D. Initially, natural caves were used for the monastic complex (thus the name *Ayrivanq,* which means "cave monastery").Later, particularly during the 13th-14th centuries A.D. numerous rooms were carved in the soft pyroclastic flows, which served as residential complexes for the clergymen.

5. CONCLUSIONS

1. Cave settlements created in pyroclastic flows have small and compact placements and they were established around small canyons, while cave settlements in lava flowsare located on stepped canyon walls and follow the natural levels of lava flows, stretching for tens of kilometers.

2. Natural caves in lava flows were utilized by humans from a much earlier time, beginning from the Stone Age, while the earliest utilization of natural caves in pyroclastic flows date to the Bronze Age, at the beginning of the 3rd millennium BC.

3. The evidence suggests that the use of cave settlements in pyroclastic flows began in the Medieval period, while cave settlements in lava flows began from the Bronze Age.

4. Cave settlements formed in pyroclastic flows have been heavily shaped by human activities, which is attested by the interior of the caves, while settlements in lava flows are largely a result of natural activities and show minimal human modification.

5. The networks of roads and trails connecting cave settlements, individual caves, and defensive structures located in pyroclastic flowsare rather simple in structure. Such networks located in lava formations are notable for their complexity and high degree of design (there are artificial terraces, retaining walls, etc.). There is also evidence for wooden stairs connecting the different levels of the settlements to one another.

6. Cave settlements formed in pyroclastic flows are independent urban complexes, while those formed in lava flows were connected to settlements located on the plateaus and theirconnection was facilitated via *muter*(trails).

7. A brief study of cave settlements located in pyroclastic and lava formations clearly shows that these differ in architectural plan, urban design, and other features, which was necessitate by their geological and geomorphological characteristics.

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A project to promote the importance of the natural and cultural heritage of the underground environment in southern Italy

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Abstract
Occupying the natural underground spaces, or excavating the rock mass to create new voids, has been since very long times the most typical habit for ancient populations in large sectors of the Mediterranean Basin. The underground environment offers shelter (from adverse climate, and enemies), possibility to hide (but also to control the surrounding territory), provides natural resources such as water, ores and minerals, protects livestock, and allows to keep working even when outside very hot climatic conditions are present. For all the above reasons, in Basilicata and Apulia regions (S Italy), where most of the land is of karst origin, living underground is testified in about all the past civilizations. The huge natural and cultural heritage related to the underground has never been fully exploited so far. In this area, one of the most well-known sites is the town of Matera (recently designated as the 2019 European Capital of Culture). The urban history and development of Matera is strongly linked to the use of the underground space, which is still inhabited and represents the main attraction for tourists. Its urban setting is well integrated with the natural landscape, characterized by deep karst valleys, on which flanks houses, storage rooms, worship sites, and work places have been realized. In the recent past, it was also considered as a negative example, quite far from the new development and technology of the modern society. Nevertheless, most of the solutions used by ancient civilizations were highly technological: for instance, the way to collect and transport water, to keep some hydric reserve also during the dry season, were extremely ingenious.

Starting from the idea that several lessons could be learnt from the past civilizations, five institutes of the National Research Council of Italy (CNR) have recently started a joint project, aimed at exploiting the cultural heritage represented by the underground environment in S Italy. The CNR institutes involved in the project cover different fields related to the study of the underground: from direct explorations and engineering-geological analyses addressed to evaluation of the stability of underground voids (IRPI), to geophysical surveys for identification of voids, and characterization of the subsurface (IMAA, IBAM), to urban history and evolution (ISSM), to archaeological representations through modern technologies (IBAM), and to protocols for the integrated valorisation and management of the cultural heritage (ICVBC). In this contribution, the first activities jointly carried out by the CNR Team are presented and discussed, as an example of multi-disciplinary effort aimed at reaching a high level of knowledge, and at providing fundamental information and data to stakeholders, technicians, and local administrations, in order to safeguard the natural and cultural heritage, and enhance and use it in the most proper way.

Keywords
Artificial cavities, cultural heritage, underground, stability, valorisation.

1. INTRODUCTION

In wide areas of the Mediterranean Basin, occupation of the natural underground, or excavating the rock mass to create new artificial cavities, has been since very long times the most typical habit for about all the ancient populations. The underground environment offers shelter (from adverse climate, and enemies), possibility to hide (but, at the same time, to control the surrounding territory), provides natural resources as water, ores and minerals, protects livestock, and allows to keep working even when outside very adverse climatic conditions are present. For all the above reasons, many typologies of artificial cavities have been excavated underground, in different ages and with different purposes [Parise et al., 2013a]. In the Basilicata and Apulia

regions of Southern Italy, where most of the land is of karst origin, which implies a scarce presence of water at the surface [Aley, 2000; Ford and Williams, 2007], living underground is testified in about all the past civilizations. The huge natural and cultural heritage related to the underground has never been fully exploited so far.

In this area, one of the most well-known sites is the town of Matera, recently appointed as the 2019 European Capital of Culture. The urban history and development of Matera is strongly linked to the use of the underground space [Laureano, 1993], which is still heavily inhabited and represents the main attraction for tourists. Its urban setting is well integrated with the natural landscape, characterized by deep karst valleys, on which flanks houses, storage rooms, worship sites, and work places have been realized [Lionetti et al., 2015]. In the recent past, all of this was also considered as a negative example, quite far from the new developments and technologies of the modern society. Nevertheless, most of the solutions used by ancient civilizations were highly technological: for instance, the way to collect and transport water, to store some hydric reserve also during the dry season, were extremely ingenious [Laureano, 2001; Mays et al., 2007; Parise et al., 2013b; Parise and Sammarco, 2015].

Starting from the idea that several lessons could be learnt from the past civilizations, five institutes of the National Research Council of Italy (CNR) have recently started a joint project, aimed at exploiting the cultural heritage represented by the underground environment in Southern Italy. The CNR institutes involved in the project cover different fields related to the study of the underground: from direct explorations and engineering-geological analyses addressed to evaluation of the stability of underground voids (IRPI), to geophysical surveys for identification of voids, and characterization of the subsurface (IMAA, IBAM), to urban history and evolution (ISSM), to archaeological representations through modern technologies (IBAM), and to protocols for the integrated valorisation and management of the cultural heritage (ICVBC). In this contribution, the first activities jointly carried out by the CNR Team are presented and discussed, as an example of multi-disciplinary effort aimed at reaching a high level of knowledge, and at providing fundamental information and data to stakeholders, technicians, and local administrations, in order to safeguard the natural and cultural heritage, and enhance it in the most proper way.

2. SOUTHERN ITALY UNDERGROUND SPACE: FROM THE HISTORY TO THE FUTURE

Numerous manufactured structures are to be found underground in Southern Italy. Representing ways to manage natural resources, to confront the risk of conflict, or being simply goods and objects stored underground that survived the test of time, these artefacts allow us to extend our studies of design plans for sustainable growth, based on cultural heritage.

The underground presents a parallel world, the analysis of which, in its darkness, helps to throw light in many cases on the urban development of Southern Italy.

Analysis of the relationship between over-ground and underground urban development reveals many yet-unexplored realities and surprising possibilities of intervention following the roles of “best practice in architecture”. According to this approach in fact, the cultural heritage of negative building practice can be used for a contemporary approach to urban regeneration.

The idea of a negative building culture became very popular in Southern Italy in order to resolve problems caused by common social and environmental conditions, such as harsh climactic conditions, communication, religious practice, and scarcity of resources. In these cases, the dominant local building know-how was re-considered and new underground building skills were adopted.

Whatever was the use for which underground spaces were realized, and whatever their deep significance, the underground traces of ancient negative culture are now a significant part of the heritage in Southern Italy.
The remains of these “negative”, i.e. inverted or hypogean, building experiences now detain a huge evocative power in terms of cultural communication, and a unique role for developing policies. The most significant examples of the negative culture can be described following a functional classification.

2.1 From dinosaurs’ traces to the Neanderthal’s man: underground space and the secrets of Southern Italy pre-history. Natural caves are considered to be the first step in the passage from nomadic to sedentary life, and for the use of underground natural resources and spaces.
In Southern Italy the narrative role of underground starts with sites telling about the passage of dinosaurs, imprinted in the local rocks at many sites, and, later on, the first use of the underground natural caves by man, as testified by a skeleton of Neanderthal’s man of 130000/170000 years ago, found at Altamura [Lari et al., 2015], and by remains of a pregnant woman found in one of the first underground tombs of the history at Ostuni [Coppola, 2012].

2.2 Caved cities: negative building culture as a solution to face natural obstacles to urban development. Sometimes the underground experience in Sothern Italy was extreme and the *under 0 level* was itself the place where urban life took place. In this type of underground situation, the traditional building concept is inverted: unnecessary volume is removed in order to create the required space [Gizzi, 2001].
This strategy became necessary in order to solve problems regarding safety, adverse climactic conditions or lack of water. Matera, Grottaglie, Ginosa, Gravina, Palagiano, Palagianello [Caprara, 1980] and Laterza experienced this underground experience, giving shape to a unique underground urban world in perfect equilibrium with the

surrounding environment. Only a section view can show the complex use of space, and the articulation of public and private spaces in the management of natural resources.

2.3 Urban waters management. Over the centuries the answer to one of the most important collective needs has been the mechanism which every ruler has used to gain approval, create hierarchies, and leave visible traces on the territory of a cultural, political and military predominance. In Gravina [Bixio et al., 2007] the underground and the aboveground communicate in overcoming natural obstacles to the circulation of waters, in Matera private and collective cisterns always supported the aboveground settlement, while the public fountain in Laterza is organized to manage different qualities of waters for different users.

2.4 Stratification for knowledge. Stratified cities are the result of successive edifications, each domination building on top of the ruins of the previous, so that traces of the previous remained in the subsoil of the contemporary city. This happened in several cities, and recent recuperation of the vertical perspective of history sometimes offers a dramatic vision.
At Monopoli, the underground of the cathedral reveals a very rich stratification covering the whole history of the city, from the prehistoric settlement, through the Middle-age, until the Modern history.
Egnazia (Fasano) used to be a roman village and is now a open air museum, while in Taranto the archeological museum used the vertical approach to illustrate the history of the city from the Greek colonization up to the contemporary urban environmental conflicts.

2.5 Religion. Urban underground spaces have always been used for religious aims, to bury or to preserve bodies, to erase the effect of mortality from the surface of the cities, or to function as a passage to the world beyond.
In Southern Italy underground has been used for many forms of religious and cult practices, with several hundred of underground churches preserving the history of religious migrations, social conflicts and persecution [Fonseca, 1980].
In the area of Massafra and Mottola the relationship between underground and religious practice is very strong and beautiful frescos still remember us how underground took care of religious pilgrims.

2.6 Economy and finance: the role of underground space in the development of typical productions. There is a close relationship between the economic development of Southern Italy and the use of its underground.
Not only typical food production such as olive oil, bread, herbal medicines, cheese, salami and wines were stored underground, but also leather and ceramic artifacts were manufactured there.
Aboveground climatic conditions, problems of protection and the optimization of productive factors caused the location below the ground of the entire production processe.

2.7 From underground space idea to develop best practice in architecture. The use of underground space has been considered for a very long period as the emblem of social and hygienic problems in Italy, but nowadays this approach is completely inverted and new bio-architecture rules use the underground to manage natural resources and reduce the impact of urban development on the surrounding environment. Reconverting underground spaces is also an opportunity to allocate new urban functions in saturated urban contest: in Matera, Casa Cava is now a multi-functional public space, in Laterza and Massafra old caves were transformed in boutique, hotels and restaurants, in Grottaglie a exhibition centre was realized in a previous underground cave, while dismissed mines were transformed in open air theaters in Grottaglie and Matera.

2.8 Hazards (landslides, collapses and floods): from knowledge to prevention. Locally, the underground may become affected by natural calamities, due to lack of maintenance of the sites. These may be very significant for the environmental history perspective, representing a warning against excavations and/or abandonment of the underground sites in areas prone to geological hazards. For instance, at Ginosa, the collapse of a significant section of the caved system was the effect of the abandonment of the underground, in the area around Taranto the recurrent floods should suggest preventive actions and monitoring.

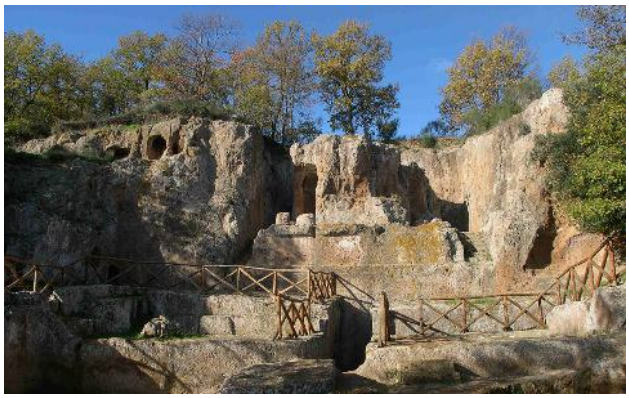

Figure 1: Etruscan Necropolis of Sovana, the Ildebranda Tomb

Figure 2: App "Necropoli Etrusca di Sovana" (© CNR-ICVBC, Regione Toscana)

3. THE ENHANCEMENT

The Italian conservation tradition and legislation is based on the cultural chain of scientific-historic knowledge, conservation, valorisation and fruition in order to promote a well-balanced approach to heritage protection. Integrating conservation and valorisation processes and reinforcing their dialogue using new information technologies is nowadays considered the most appropriate way to intervene both in historic cities and in archaeological sites, in order to promote sustainable policies.

The project developed by the ICVBC and financed by the Tuscan Region with European funds (TeCon@BC: Technologies for the conservation and valorisation of cultural heritage" "POR-CREO/FESR 2007-2013), had identified the relatively under-developed Etruscan archaeological site of Sovana as an appropriate case study to demonstrate the potentialities of such an integrated approach. Based on a multi-disciplinary research team of archaeologists, architects, ICT experts, conservators, chemists, biologists, urban historians, geologists and art historians, working in close collaboration with local authorities and private enterprises, the project managed to integrate conservation, enhancement and promotion tools in a unique intervention protocol [Porfyriou & Genovese, 2012].

The project's outputs regarded: the evaluation of innovative materials for the conservation of the stone and pictorial cultural heritage; the development of innovative technologies for the evaluation of the conservation treatments and the monitoring of environmental factors; the development of digital tools for the monitoring of the state of conservation of the study area; and finally, the elaboration of tools for the valorisation of the archaeological site. More specifically, regarding this latter point, the enhancement of Sovana site – a site lacking accessibility and tourist promotion – was undertaken focusing on three distinct territorial levels of intervention:

1. enhancing one of the more spectacular aspects of the Etruscan necropolis, that is the tuffaceous spoor, where the three monumental tombs of Ildebranda, of Demoni Alati and of Pola are located. Developed, underground, for funeral purposes, and over ground for representational reasons and decorated with architecturally elaborated façades, these tombs are of great impact, yet in advanced stage of decay, and thus difficult to be appreciated and understood (Fig. 1). The creation of the App "Etruscan necropolis of Sovana" came to bridge this gap (Fig. 2): it offers to visitors the possibility to navigate in the "antique landscape", the "contemporary landscape" and to consult the digital archive material. The 3D reconstruction of the "antique landscape" (which can be also consulted on site with GPS) allows to explore the funeral monuments visiting both the tombs and the funeral underground rooms. A video constitutes, instead, the "contemporary landscape" alternating actual photographic sequences with 3D reconstructions of the tombs, thus proposing a suggestive view of how the landscape could appear in antiquity. Finally, a digital archive (with photos, texts and 3D images) forms the database that supports all the App options;
2. elaborating a GIS interactive map, with data offered by Soprintendenza per i Beni Archeologici of Tuscany (Regional Offices responsible for protection of archaeological heritage) relative to the tens of tombs present in the necropolis, with the aim to create well traced tourist itineraries and to disseminate among experts the relative knowledge;
3. developing the software "PlaceMaker" for the promotion of the territory of Sovana (that comprises also a medieval city), by identifying cultural resources and the contemporary identity of places.

Working with a multi-disciplinary team and on different territorial levels and integrating conservation and valorisation objectives produced not only innovative results regarding new materials and technologies as well as digital tools, but it introduced, also, an advanced methodology that may become a good practice worldwide, thus promoting sustainable protection and enhancement interventions [Porfyriou, in print].

4. SOME EXPERIENCES

In this section we briefly summarize some experiences developed by the CNR Institutes involved in this project, regarding both the exploration of the underground by means of geophysical techniques, and the evaluation of the stability of cavities.

4.1 The CLARA Project

The Institute of Methodologies for Environmental Analysis of National Research Council (IMAA-CNR) has a consolidated experience on Earth Observation (EO) methods for environmental monitoring and modelling. The activities of IMAA-CNR cover a wide spectrum of research topics, ranging from realization and/or design of advanced environmental research infrastructures to the integration of the information obtained from heterogeneous platforms (space, airborne, in-situ), from the modelling of environmental processes to the integration of EO data with ICT technologies. As concerns studies dealing with the underground, IMAA-CNR is paying great attention to developing novel approaches for the integration of remote sensing observations and multi-sensor tomographic methods for investigating the soil and subsoil in urban environments (Fig. 3). One of the main challenging and interesting applications of this research activity is the mapping and monitoring the presence of voids in urban areas. At this regard, we briefly describe here the innovative approach and the scientific challenges of the CLARA project (*Cloud platform and smart underground imaging for natural risk assessment*), funded by Italian

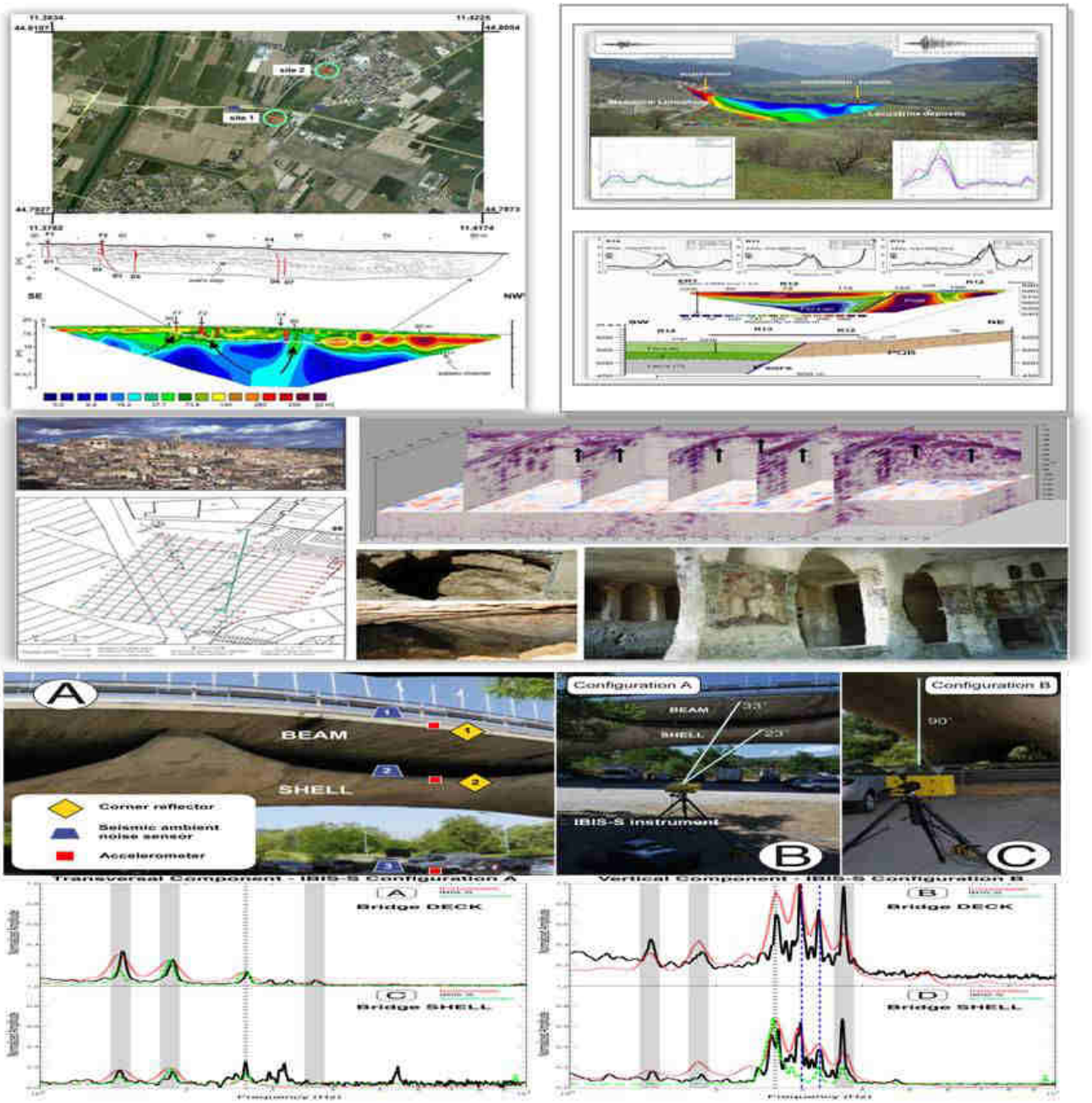

Figure 3: GPR, ERT and seismic measurements in urban areas: Ferrara, Matera, Onna (Abruzzo), and Musmeci (Potenza province) [after Piscitelli et al., 2007; Giocoli et al., 2011, 2014; Stabile et al., 2013].

Ministry of Education, University and Research in the frame of a national call on the topic "Smart Cities & Communities – Thematic Priority: Homeland Security". The project is promoted by a large public-private partnership with the participation of CNR, OGS, University of Ferrara, Roma-LaSapienza, Enna and Catania, leading national private companies and SME consortia.

It proposes a systemic approach for the characterisation of the main physical and geometrical properties of surface and subsurface in urban areas based on the full integration of geophysical exploration technologies (seismic tomography, microwave tomography, resistivity tomography, etc.), advanced sensors (fiber optic sensors, low-cost accelerometers, etc.) and ICT architecture (web-services, web-sensors, etc.) for the development of an open, scalable and interoperable platform for the sharing, the visualization and the management of geospatial data.

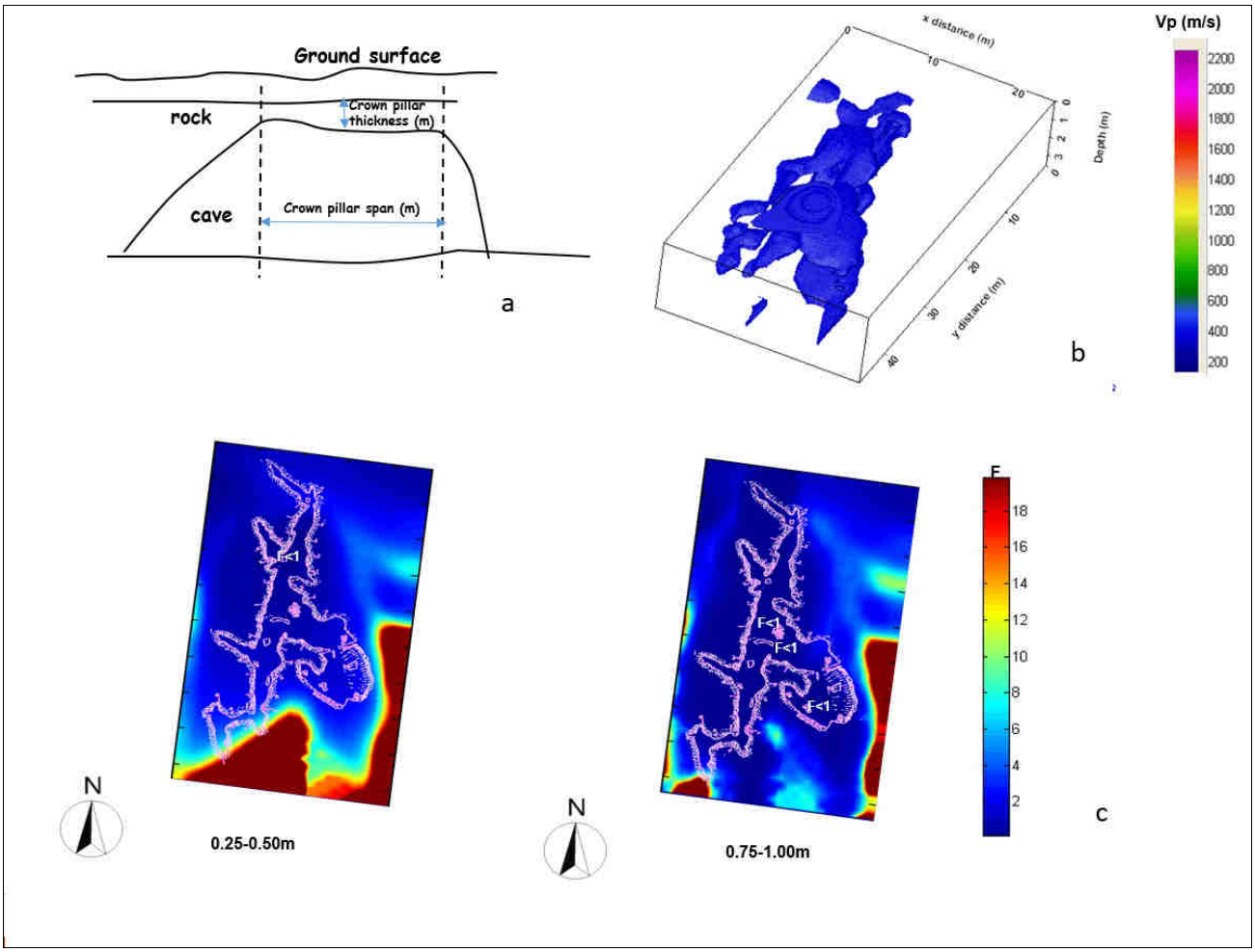

Figure 4: a) Crown pillar definition scheme; b) 3D contouring of iso–velocity surfaces; c) the models representing the distribution of the F factor at 0.25-0.50m and 0.75-1.00m in depth superimposed on the plan of the cave

To-date, there is a growing demand of innovative products for the management of activities to be implemented in the most superficial portion of the subsoil in urban settings [Showstack, 2014, and references therein]. The mitigation of the effects of natural and man-made geohazards (earthquakes, landslides, collapses and sinkholes, etc.), the realization and monitoring of strategic infrastructures (energy pipelines, mobility network, etc.) and the exploitation of the natural resources (groundwater, geothermal fluids, etc.) are strategic priorities in any approach of urban planning and strongly require a complete geological/geophysical characterization of the subsurface.

This project responds to such demand by integrating the latest enabling technologies for the geophysical exploration of the subsoil and the dynamic characterization of structure/infrastructures. The proposed system is based on non-invasive technologies suitable for 2D and 3D imaging of the subsurface in an urban environment, in which there is generally an intrinsic difficulty to work with direct surveys (surveys and invasive drilling).

The project identifies three main urban case-studies: the city of Ferrara, the Province of Enna, and the city of Matera. The latter, with its historical center of the Sassi UNESCO World Heritage Site, is interested in broadening the knowledge of the subsurface exposed to a series of hydrogeological instability phenomena. Recently, Matera has been appointed as European Capital of Culture 2019.

4.2 Geophysical methods for evaluating stability of karst caves

The stability of karst caves is being increasingly assessed through the use of geophysical surveys [Lin et al., 1996; Dobroka et al., 1991; Heikkinen and Saksa, 1998; Cardarelli et al., 2003; Leucci and De Giorgi, 2005, 2010]. In some cases, such methods are a valid alternative to direct investigation methods that are both costly and difficult to carry out, especially in relatively inaccessible places. A method to evaluate the structural failure risk in prehistoric cave was proposed and applied by Leucci and De Giorgi (2015), through four phases: a) Analysis of the geometry parameters related to the cave; b) definition of the physical

– mechanical characteristic of the rock that constitute the roof of the cave; c) evaluation of the Safety Factor (SF); d) definition of failure probability.

Karst caves have complex geometric shape, with variable thickness of the roof (crown pillars) and width (span) (Fig. 4a). These variabilities should be taken into account in the stability evaluation.

The physical-mechanical characteristics of the rock were evaluated using 2D seismic travel time tomography and 3D seismic refraction tomography. Input to the method relies upon two factors, one representative of geometry, and the other representative of rock mass quality. This latter is quantified by Q (Tunnelling Quality Index) [Barton et al., 1974]. Instability of a crown pillar is likely to occur if the scaled crown pillar span, Cs, is greater than the critical span, Sc, calculated from the equations [modified from Carter, 1992]:

$$S_c = 3.3 \times Q^{0.43} \quad (1)$$

$$C_S = S \sqrt{\frac{S.G.}{T\left(1+\frac{S}{L}\right)(1-0.4\cos\theta)}} \quad (2)$$

where:

S = crown pillar span (m), L = crown pillar length (m), T = crown pillar thickness (m), S.G. = rock mass specific gravity (= 3.5 for high grade ore; = 3 for moderate grade ore; = 2.7 for waste rock), θ = orebody/foliation dip.

The method can be applied by comparing the scaled crown pillar span for any pillar of concern to the critical span value deemed appropriate for the controlling rock mass. When the scaled crown pillar span is determined to be less than the critical span, the crown pillar would be considered stable. On the other hand, when Cs is greater than Sc the probability of failure would be high. Because of its empirical basis, application of the scaled span method allows at least a rational assessment of failure likelihood if the method is applied probabilistically [Carter, 1992]. Assuming the index named "factor of safety"

$$F = Sc/Cs \quad (3)$$

the instability of a crown pillar is likely to occur if F<1.

In order to obtain information about the instability areas along the overall development of the cave a 3D seismic tomography survey was performed, and 3D images of seismic wave velocity produced to better visualize the results (Fig. 4b). In Fig. 4b the seismic data set is displayed with iso-velocity surfaces using a threshold value ranging from 200 to 500 m/s. This Vp threshold value makes the possible location of the cave position more evident.

Next step was the study of the stability of the roof using the empirical analysis illustrated above. In this case the thickness T varies with the distance x and y. Since it takes into account the variations in thickness of the roof of the cave, T is treated as a matrix. Considering these values and the seismic tomography results the factor F (eq. 3) was estimated making a 3D calculation code in Matlab. Result is shown in Fig. 4c, where the models representing the distribution of the F factor at 0.25-0.50m and 0.75-1.00m in depth are superimposed on the plan of the cave. Several zones of instability (F<1) can be identified.

5. FUTURE PERSPECTIVES

Southern Italy hosts a large number of sites interested by presence of different types of artificial cavities, very often still used by local inhabitants for several purposes, with many of them object of tourist attraction, for historical, cultural and religious reasons.

Valorisation of such a huge cultural heritage should be the priority for local authorities and land managers and developers, especially as regards small villages in remote areas of Southern Italy. At the same time, no project can be realized without taking into the due account the hazards related to the underground environment [Gutierrez et al., 2014], and accordingly design plans and actions aimed at the mitigation of the risks to society. The recent history has repeatedly shown the high frequency of collapses linked with underground cavities [Parise, 2012, 2015; Parise and Vennari, 2013], highlighting the need of prevention works, before any exploitation and valorization plan could start, with the goal to understand the possible evolution of failures [Parise and Lollino, 2011; Lollino et al., 2013].

Thus, starting from characterization of the main physico-mechanical properties of the rock mass [Andriani and Walsh, 2006], and of their discontinuity networks, including those features strictly related to peculiarity of karst processes [Boadu, 1997; Andriani and Parise, 2015], a particular focus should be addressed toward analysis of the degradation of the material in function of the wetting and weathering processes [Zupan Hajna, 2003; Calcaterra and Parise, 2010], to properly evaluate their stability conditions [Canakci, 2007; Sunwoo et al., 2010; Parise, 2015].

All the above steps should be performed through an integration of direct (in cave) and indirect surveys [Crampin et al., 1980; Boadu, 1997; Leucci and De Giorgi, 2015], depending upon logistics and accessibility of the site to be studied, following a careful plan of surveys, in order to allow eventually the designers to have available the necessary information to correctly decide the most feasible and suitable engineering works of stabilization (if needed), or to proceed with exploitation of the site.

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Engineering-geological studies in artificial cavities, aimed at evaluating the possibility of failures in underground settings

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Abstract
Artificial cavities are an important cultural heritage, testifying the social life and the habits of past civilizations, and the harmony they reached with the natural environment. At the same time, when abandoned since a long time, and/or used to discharge solid and liquid wastes, or overload with new constructions above, they can be in precarious state of stability, giving origin to failures underground that might potentially evolve until the ground surface. This eventuality, of course, would create a direct threat to the society.
From the above considerations, it comes out the importance in having a good knowledge of the artificial cavities (where they are, what is their development, what is the typology of cavity, what are the overall stability conditions), and the need to develop (once the basic data are available) specific engineering-geological analyses addressed to evaluate their stability, or to design the most proper engineering restoration works. The present contribution illustrates the procedures followed to reach a preliminary evaluation of the stability conditions of artificial cavities, through a multi-disciplinary approach that involves cavers, geologists and engineers. The main aim of this study is to get the necessary information to eventually allow owners and land administrators to properly exploit the artificial cavities, once the safety of the structures has been assessed.

Keywords
Artificial cavities, engineering geology, underground, stability, collapse, risk.

1. INTRODUCTION

Artificial cavities are an important cultural heritage, testifying the social life and the habits of past civilizations, and the harmony they reached with the natural environment. Nevertheless, when artificial cavities are abandoned since a long time, and/or used to discharge solid and liquid wastes, or overload with new constructions above, precarious states of stability may possibly result, giving origin to failures underground that might potentially evolve, and reach the ground surface [Waltham and Swift, 2004; Parise and Gunn, 2007; De Waele et al., 2011; Parise, 2012; Gutierrez et al., 2014]. This eventuality would, in turn, create a direct threat to the society.

From the above considerations, it comes out the importance in having a good knowledge of the artificial cavities (in detail, this should include knowledge about where they are, what is their development, what is the typology of cavity, what are the overall stability conditions, etc.), and the need to develop (once the aforementioned basic data are available) specific engineering-geological analyses addressed to evaluate their stability, or to design the most proper engineering restoration works.

The present contribution illustrates some procedures followed to reach a preliminary evaluation of the stability conditions of artificial cavities, through a multi-disciplinary approach that involves cavers, geologists and engineers.

The main aim of this study is to get the necessary information to eventually allow owners, and land managers and administrators as well, to properly exploit the artificial cavities, once their stability has been carefully assessed [Kemmerly, 1993].

2. INSTABILITY IN ARTIFICIAL CAVES

Some of the most common processes of cave evolution, for both natural karst caves and man-made cavities, derive from progressive failures in the rock mass constituting the roof of the cave, until the failures reach the ground surface, thus originating collapse sinkholes [White and White, 1969; Tharp, 1995; Klimchouk and Andrejchuk, 2002; Delle Rose et al., 2004; Canakci, 2007; Palmer, 2007; Waltham and Lu, 2007; Parise, 2008; Parise et al., 2008; Fraldi and Guarracino, 2009; Sunwoo et al., 2010].

Sinkholes are the most typical hazard in karst [Waltham et al., 2005; Parise, 2008, 2015; Gutiérrez et al., 2008, 2014;

Figure 1: Sinkhole in a rural area of Apulia, caused by collapse in an underground calcarenite quarry (photo courtesy G. Quarta)

De Waele et al., 2011; Parise et al., 2015a, 2015b], associated to the presence of an underground void, both of natural and anthropogenic origin.
In particular, sinkholes related to artificial cavities may be very common when well-developed cavities are present at shallow depth. Artificial cavities have produced the greatest problems and damage in many regions of southern Italy during the last 20 years, due to a number of sinkholes (Figures 1 and 2) that had to be recorded, in particular, in Apulia, Campania and Sicily [Parise and Vennari, 2013].

The majority of the events were registered in correspondence of ancient quarries [Parise, 2010; Fiore and Parise, 2013; Parise et al., 2013a; Pepe et al., 2013; Vattano et al., 2013], which is a quite common circumstance also in other parts of Italy, as well as abroad [Carter, 1992; Hutchinson et al., 2002; Ghabezloo and Pouya, 2006; Ferrero et al., 2010]. Apart from mines and quarries, however, other types of artificial cavities, such as civil settlements and dwellings, and worship sites, have also been repeatedly affected by instability problems [Leucci and De Giorgi, 2005; Lionetti et al., 2015].

The main problem when facing sinkholes is represented by the difficulty in detecting precursory signs of instability at the surface: this issue has been recently investigated by using remote sensing techniques, as LIDAR (Light Detecting and Ranging) [Filin and Baruch, 2010 ; Filin et al., 2011]. Further, InSAR (Synthetic Aperture Radar Interferometry) measures remotely subsidence rates and ground deformation time-series over large areas with high temporal and spatial resolution, but small sinkholes and areas affected by rapid subsidence are generally overlooked. Such technique allows to obtain retrospective deformation values and to detect deformation preceding collapse [Baer et al., 2002; Abelson et al., 2003; Closson et al., 2003, 2005, 2010; Castañeda et al., 2009; Calò et al., 2011; Gutierrez et al., 2011; Nof et al., 2013].

Man-made cavities were realized by man in different ages, for a number of reasons and/or purposes. There is a wide range of typology of artificial cavities, which also may change from area to area. The main types of cavities have been categorized and ranked in the classification of artificial cavities produced by the Commission on Artificial Cavities of the International Union of Speleology (UIS) [Galeazzi, 2013; Parise et al., 2013]. The classification is organised like a tree, based on seven main categories, identified by capital letters (A to G); these are in turn divided into sub-types, by adding a number to the capital letter (Figure 3). The use is made easy by alphanumeric codes. Different uses of the same cave often overlap in time. For this reason, a single cavity may have multiple classifications representing different periods in its life.

Once abandoned, artificial cavities become sites of degradation of the rock mass, thus suffering a slow but continuous decaying process bringing to decreasing the physical properties of the rock mass, due to water infiltration, weathering processes, etc. [Fookes and Hawkins, 1988; Andrejchuk and Klimchouk, 2002; Zupan Hajna, 2003; Ghabezloo and Pouya, 2006; Calcaterra and Parise, 2010, and references therein]. With time, the precise knowledge of where the cave is located may be lost, and expansion of the inhabited areas might expose at risk the new built-up environment.

Instability processes in underground caves depend upon internal factors, such as the low mechanical strength of soft rocks [Andriani and Walsh, 2002, 2006; Hatzor et al., 2002], and upon external natural and/or anthropogenic factors that can modify the boundary conditions, the loading, or the physical and mechanical properties of involved materials [Ghosh, 1990; Boadu, 1997; Yan et al., 2001; Parise, 2015].

Figure 2: The sinkhole at Barletta (Apulia, southern Italy), which opened during the night of May 3, 2010 [Parise et al., 2013a].

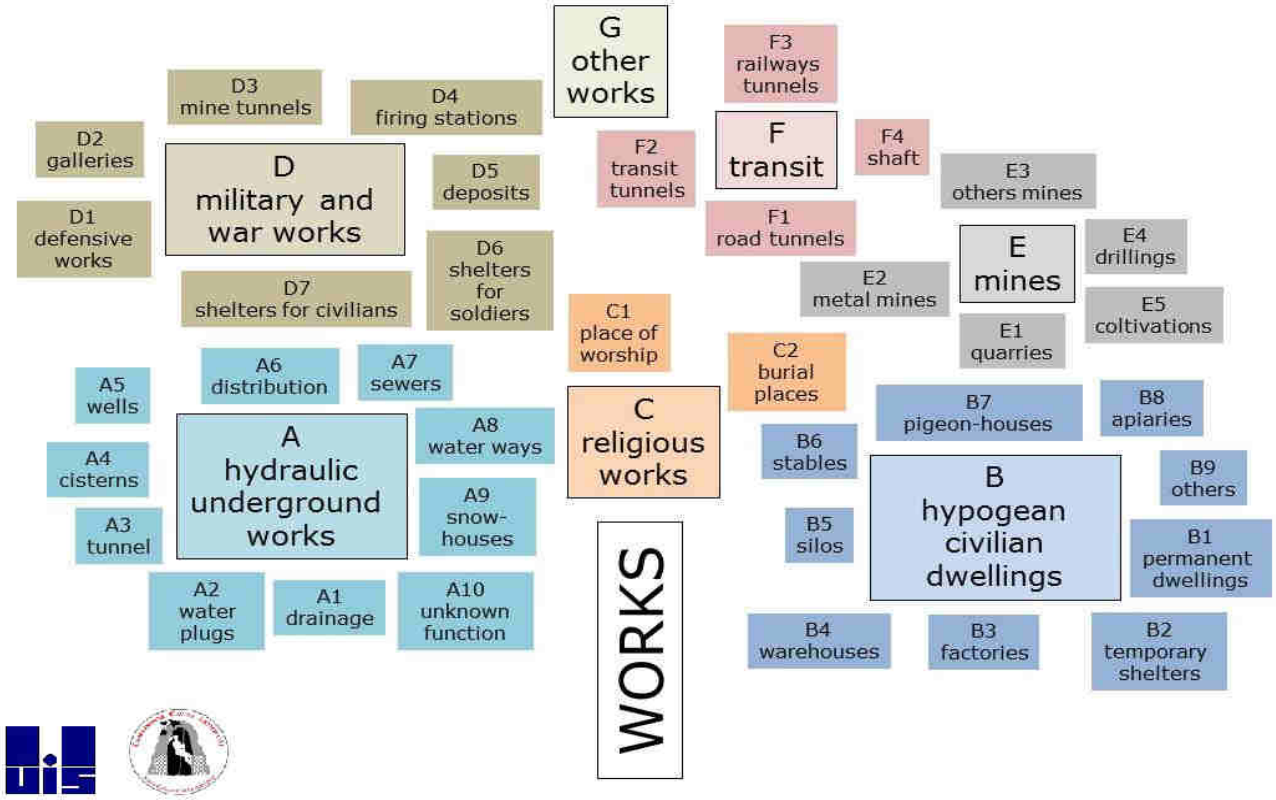

Figure 3: Typological tree of artificial cavities, showing the 7 main categories (indicated by capital letters), and the sub-categories (marked by an alphanumeric code) [after Galeazzi, 2013; Parise et al., 2013b].

Figure 4: Persistent crack in the vault of a cavity: general view (to the left), and detail of the joint (to the right), showing its opening, enlarging toward the end, and likely resulting in the near future in a wedge failure.

3. DETECTION OF INSTABILITY FEATURES IN UNDERGROUND SETTINGS

Aimed at understanding the deformations occurring in the subterranean environment, and at putting these in relation with the main mechanism at their origin [Diederichs and Kaiser, 1999a, 1999b; Liu and Wang, 2000] detailed cave surveys must be carried out, whenever logistics allows, and safety conditions of involved workers are satisfied.

Different types of failures can be observed underground, originated by different processes of rupture in the rock mass: falls from the vault often develop the formation of a single or double arch, as an effect of the reduction in the rock strength of the cave roof. These are typically preceded by formation of joints through the roof, which propagation leads to a complete or local failure mechanism (Figure 4).

Falls from the vault may also occur due to lack of support from previously existing pillars. This is actually an induced failure, since it occurs in artificial caves with a mechanism similar to the previous one; in this case, however, it is generated by failure of one or more pillars, so that the roof span becomes too long to be sustained by the rock strength [Hutchinson et al., 2002; Ferrero et al., 2010].

At the pillar corners, failures may be generated by high local compressive stress.

Lateral failures along sliding surfaces parallel to the walls (Figure 5), on the other hand, may be generated by the low confinement of the rock mass along the vertical boundaries of the cave. This process leads to development of fractures parallel to the direction of the maximum compressional stress. In this way, the cave is progressively enlarged, until reaching a critical configuration, which leads to general failure, and the consequent formation of a sinkhole at the ground surface. Before a clear and continuous fracture develops, the first signs of deformation can be observed as rock wedges protruding out of the walls (Figure 6).

Figure 5: Detached material from the walls of a hand-excavated room within a cavity for the extraction of calcarenite rocks.

Figure 6: Deformations along the walls of underground quarries, with rock wedges protruding out of the wall, due to continuing stress increase.

Failures from the pillars (Figure 7) may be particularly dangerous, since they cause a reduction in the strength of each pillar, at the same time contributing to an overall decrease in the resistance offered by pillars for the overall support of a room, or cavity. When the room is large, loosing a pillar may result in a heavy destabilizing effect, which could bring in the medium to long run to a general collapse of the cavity.

In order to understand at what stage each cavity is, and how it might evolve toward a general failure (or collapse), all the features above should be carefully identified and mapped [Parise and Lollino, 2011; Parise, 2012, 2015; Lollino et al., 2013]. Whenever possible, recognition of the instability features should be carried out directly on site, which implies the necessity to have the support of trained cavers-geologists, able to detect, measure and map the occurred failures, as well as any evidence of incipient rupture in the rock mass. As before mentioned, the on site survey must be performed only once the safety conditions for direct access to the cavities have been carefully ascertained.

Recognition of the already occurred instabilities, in the forms of breakdown materials or of cracks along vault and walls, and of deformation features as well, is of crucial importance to investigate the possibility of detecting precursory evidence of likely general failures [Swedzicki, 2001].

Figure 7: A pillar in an underground quarry, showing in the foreground the debris from the wedge failure visible in its upper portion.

4. CONCLUSIONS

Evaluating the possibility of failures in underground settings, and the likely upward propagation to the ground surface, is definitely not a simple task, due to the many variables involved, and the difficulty in obtaining real data from cavities. Nevertheless, in many countries worldwide the possibility of sinkhole occurrence has become a serious threat to society, worth to be studied and monitored.

Mapping instability features is essential to fully understand the present condition of instability within the cavities, as well as to obtain a framework of the present situation, for later comparisons, aimed at ascertaining the evolution of the features, and, consequently, the overall instability. With this goal, the classical procedure of cave surveying should be followed [Day, 2002], and the standardized symbols for representation of cave features be used [Hauselmann, 2006, 2010].

In favorable situations, or aimed at integrating data from different techniques, stability of karst caves and artificial cavities can also be assessed through the use of geophysical surveys [Lin et al., 1996; Dobroka et al., 1991; Heikkinen and Saksa, 1998; Cardarelli et al., 2003; Leucci and De Giorgi, 2005; Pepe et al., 2013, 2015], which are an alternative approach to direct investigation methods that are both costly and difficult to carry out, especially in inaccessible places.

Whatever the techniques used, and/or the numerical codes of analysis implemented, it is vital that direct surveys are performed underground, to check on-site the instability features and deformations therein occurring, and develop the most proper monitoring system, aimed at controlling their evolution.

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Carbonate deposits in artificial galleries: chronology and past-environmental reconstruction. Case studies of Versailles Palace and Northern Paris underground aqueducts (France)

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Abstract

Artificial underground water supply systems in calcareous geological areas can lead to the formation of secondary carbonate deposits very similar to the speleothems found in natural caves. The precise dating of these carbonate deposits is a key issue for archaeological and/or environmental studies since it could provide an upper age limit for the gallery in which they grow and also make it possible to build a chronological framework for past environmental reconstructions using trace elements or isotopic approaches.

In this study, we present data obtained on carbonate deposits from two underground urban structures, namely historical aqueducts in northern and southern Paris and a technical gallery of the Versailles Palace fountain system (France). These deposits developed on the walls, on the floor or above human artifacts. We present a methodology for their dating using absolute and relative chronology. For this purpose, we primarily compared (whenever possible) $^{230}Th/^{234}U$ age with the counting of annual growth layers. The determination of the initial ^{230}Th content is crucial for these very young carbonate deposits that are often loaded with detrital material. Well-dated secondary calcium carbonate deposits can be used for historical environmental reconstructions, using their trace element contents or key isotopic studies. In this article, we focus on strontium isotopes and present data obtained on the Versailles Palace speleothems.

Keywords

Speleothems, historical aqueduct, artificial galleries, environmental change, urbanization, chronology, strontium isotopes.

1. INTRODUCTION

Water supply for population, agriculture or recreation (fountains) is a major preoccupation of actual and past societies. Archaeologic remains from water supply systems exist since the Neolithic period [De Feo et al., 2013].

In the Middle East, the most sophisticated water supply system was developed using qanat in Iran during the period 3 to 2.5 kyr B.C. [Goldsmith et al., 1987]. In Europe, these systems strongly developed during the roman period, with a large number of hydraulic works and aqueducts for water supply and storage in Italy [Bono & Boni 1996; Parise & Sammarco 2015; Parise et al., 2013a; Parise et al., 2013b], but also in France [Bossy et al., 2000], Spain [Monteleone et al., 2007] or in Turkia among other [Ercan & Nuhoglu, 2014].

Artificial underground water supply systems in calcareous geological contexts can lead to the formation of secondary carbonate deposits very similar to the speleothems found in natural caves. The precise dating of these carbonate deposits is a key issue for archaeological and/or environmental studies.

In old aqueducts (from the Roman period for instance), the dating of the younger speleothem layers can give a *terminus ante quem* for the operation of the aqueduct or a *terminus post quem* for its disuse or partial destruction (Gilli & Levret, 2000). In other cases, maintenance activities of ancient aqueducts can be retraced by the chronology of carbonate deposits [e.g. Bobee et al., 2011].

Hence, the dating of these deposits can firstly give an upper age limit for the gallery in which they grow and secondly provide a chronological framework for environmental reconstructions using trace elements or an isotopic approach [Bobee et al., 2011; Pons-Branchu et al., 2014, 2015; Wenz et al., 2016]. In this paper, data obtained on "urban speleothems" from two historical locations in France are presented.

2. STUDIED SITES

2.1 Belleville aqueduct

In the Malassis plateau (northern part of Paris, France), groundwaters were drained since the 1100s by religious communities for their needs. In the following centuries, an extensive network of drains (called "*pierrés*") and aqueducts was developed, known as the "Northern Springs". Although these waters have not been used as drinking water since the 1800s, many vestiges of this network still exist and have been studied by the ASNEP group ("*Association Sources du Nord Etude et Préservation*").

Some of these springs are still active, but the waters nowadays end up in the wastewater collection system. In some of the galleries, water still flows, and dripping water from the roof is also observed.

These Ca-rich waters result in the deposition of secondary carbonates, similar to speleothems from natural caves. The study of two of these deposits is presented in this article.

2.2 Versailles palace underground system

Versailles Palace (France) was built far from any major source of running water. During the second half of the 1600s, extensive hydraulic works were undertaken in order to supply large amounts of water for Versailles inhabitants but also (and mostly) for the large number of fountains and the famous "*Grandes Eaux*" displays. These works included pumping systems, attempts to divert a river, and an extensive system of aqueducts and artificial ponds (some of them located several tens of km from the palace; [Pizzorni, 1990; Soullard, 1997].

Kilometers of galleries were built under the gardens of Versailles Palace to supply the fountains. In some of these galleries, speleothem deposits grew by water dripping from the roof or by leakage from the pipes or from the fountains. Samples were taken from an artificial gallery located between the Palace and the "*Service des Fontaines*", under the R de Cotte street (see Fig. 2). In this gallery, the water source is rainfall that infiltrates the soil.

Figure 1: Main gallery in Belleville aqueduct (a) location of Bel 0 sample (b) lamination on Bel 0 (c)

3. CHRONOLOGICAL STUDIES: METHODS AND APPLICATIONS

3.1 ^{230}Th-^{234}U chronology

The ^{230}Th-^{234}U dating method permits the dating of secondary carbonate deposits over the last 500 000 years. Briefly, ^{230}Th (theoretically absent at the moment of crystal formation) is created by the decay of ^{234}U. This method has been intensively used for speleothem chronology [Li et al., 1989; Richards and Dorale, 2003; Cheng et al., 2009]. Its use for the dating of urban or aqueduct speleothems (also called "sinters") is more recent. The first challenge is the measurement of low amounts of ^{230}Th since these deposits are young (currently some tens or hundreds of years, and in some cases up to ca 2000 yrs). Thanks to the recent development of uranium and thorium isotopic ratios measurement by MC-ICPMS, the very low amounts of ^{230}Th (as little as some fg in extreme cases) expected for young speleothems can now be analyzed. The second challenge is the correction for "inherited" ^{230}Th (i.e. not created within the speleothem by ^{234}U decay) coming from the detrital fraction. The presence of a detrital fraction is revealed by ^{232}Th, which does not belong to the ^{238}U-series decay chain. This inherited ^{230}Th induces "ageing", resulting in a calculated age that is older than the true age. Different age correction methods developed for speleothem or coral dating have been applied to speleothems from artificial galleries. In a recent paper, Wenz and co-workers [Wenz et al., 2016] proposed the construction of isochrone diagrams using coeval and non-coeval (taken along the growth axis) samples, thus assuming that the speleothem growth is rapid and that the deposit could be considered as "instantaneous". This method enabled the authors to give ages for carbonate deposits from French, Turkish and German Roman aqueducts that were in agreement with the known age of the aqueduct use. We recently proposed an alternative method for the dating of young "urban speleothems".

Figure 2: Versailles technical gallery (a), F1 sample location (b), F1 cut section (c) and polished section with visible laminae (d)

In this previous work, we constrained the $^{230}Th/^{232}Th$ ratio of the detrital fraction by using "stratigraphic constraints", following the work of Hellstrom 2006 but also coeval constrains (see the model in Roy-Barman & Pons-Branchu, 2016]. This method gives not only a mean age for the entire deposit but also the age on several levels. Both correction methods (isochrone method or stratigraphic constraints) induce an increase in the error bar of the calculated age, due to error propagation. However, even with a large error bar on the final corrected ages, these methods can be used to obtain absolute ages, which can then be compared with relative ages (see below).

3.2 Relative chronology

3.2.1 Lamination in speleothems from artificial galleries

Most continental carbonate deposits (speleothems, tufas or travertine) present lamination that can be annual or seasonal [e.g. Allison 1926; Baker et al., 1993; Shopov et al., 1994; Matsuoka et al., 2001]. This lamination has also been observed in carbonate deposits in ancient aqueducts [e.g. Sürmelihindi et al. 2013; Guendon and Vaudour, 1986, 2000; Dubar, 2006; Bobée et al., 2011]. It consists of an alternation of dense/dark and porous/white layers such as those observed in speleothems from natural caves. The timing of this lamination is due to seasonal variations in environmental parameters and may be due to dry/wet seasons (variation of water flow inducing change in Ca content) or to the presence/absence of organic matter during some part of the year within the water. It is worth mentioning that microbial activity has also been observed in some cases: Adolphe [1973] and Guendon & Vaudour [1986] found evidence for bryophyte and algal activity in calcareous sinters from the Nîmes and "Pont du Gard" aqueducts (Southern France). They showed that the dark laminae are associated with organic layers.

Some authors recently [Sürmelihindi et al., 2013] evidenced that the lamination in samples from two Roman aqueducts in southern Turkey reflected changes in water chemistry, discharge, temperature and biological activity, in relation to the strong bimodal cyclicity of the Mediterranean climate in this region.

The presence of a visible seasonal lamination in urban speleothems that grow on artificial galleries under intensively urbanized areas was evidenced for the first time in the Bel 0 and Bel 2 speleothems, from Belleville's underground aqueduct. For these samples, we compared laminae counting and U-series ages. The two samples presented ca 300 "laminae couplets" and an absolute age consistent with a 300-year growth (Pons-Branchu et al., 2014), confirming the bi-annual laminae deposition.

Similar results were obtained for the F1 sample from a Versailles palace technical gallery (this study). In this speleothem that grew above a pipe (see Figure 2), by water dripping from the roof, the laminae counting gave an age consistent with the age of the pipe (installed at the end of the 1980s), assuming two laminae per year.

In this region of northern France, there is not a strong bimodal precipitation mode. Precipitations are relatively homogenous throughout the year, though a water deficit in soil can occur during a short dry season, due to increasing summer temperatures. Thus, the lamination should be due to other factors than marked hydrological seasons. In regions with a temperate oceanic climate such as a large part of Western Europe, a seasonal peak of dissolved organic carbon occurs during autumn in riverine waters [Worall et al., 2005]. This phenomenon has been observed in speleothems from Western European regions, with the deposition of thin visible laminae attributed to an organic acid flux during autumn [Proctor et al., 2000; Borsato et al., 2007]. Thus, in intensively urbanized areas such as Paris and Versailles, an organic matter annual cyclicity may also exist within urban soils and be transmitted to the water that infiltrates the soil and feed the speleothems.

Establishing a robust chronology for speleothems from artificial galleries using laminae counting is possible under three conditions:

- the ascertainment of the seasonality of the deposition (one, two or more laminae per year depending on climate and growth mode) by comparing laminae counting with absolute chronology and/or an external marker such as the upper age limit given by the gallery construction, or anthropic markers (timing of the developing or artifact installation upon which the speleothem is growing):

-the speleothem has experienced no growth cessation;

-the speleothem was active when collected or the age of the last laminae can be estimated with a high degree of certainty.

The second condition (no growth hiatus) is difficult to ensure, and will remain in many cases only a working hypothesis.

3.3 Chronology in Belleville and Versailles palace underground galleries

The dating of the carbonate deposits within artificial galleries can give an upper age limit (*terminus ante quem*) of their construction and of the artefacts or archaeological remains found in these galleries. That was our purpose when Bel 0 and Bel 2 were collected. The exact age of the Belleville aqueduct is not precisely known [Bonamy, 1754; Girard, 1812; Belgrand, 1877].

A historical tablet present in one of the manholes indicates that part of the aqueduct was rebuilt during the year 1457 [Belgrand, 1877]. However, historical research performed by the ASNEP group showed that the aqueduct was almost entirely rebuilt between 1527 and 1530 [Renouard, 1854]. The study of the Belleville main gallery by Bonamy [1754] mentions that the Belleville aqueduct was in good condition in the early 18th century which is consistent with the extensive construction work performed in the middle of the 16th century. The two speleothems sampled in the main gallery gave a similar age (300 years before the year 2013), much younger than the supposed age of the aqueduct construction. This age (corresponding to the beginning of the 18th century) could correspond to the completion of cleaning of the aqueduct.

In Versailles palace, only a few $CaCO_3$ deposits have been collected so far. In these samples it is difficult to establish the $^{230}Th/^{234}U$ chronology. Validation with the F1 sample of the robustness of the laminae counting for chronology opens up new perspectives for the study of the numerous speleothems present in the underground galleries.

4. ENVIRONMENTAL RECONSTRUCTION USING TRACE ELEMENTS AND ISOTOPES

During their growth, $CaCO_3$ deposits incorporate major and trace elements from the water. These elements derive from water sources (rain, water table, etc.), from its interaction with the host rock, but also from atmospheric or anthropic input.

4.1 Trace elements

The study of trace elements (TE) in speleothems is widely used to monitor climatic or environmental changes [e.g. Fairchild & Treble, 2009; Bourdin et al., 2011]. In fact, TE content may vary with climatic or hydrological change due to different water sources, different water pathways or different water/host rock interactions. The growth rate, linked with climate, also influences TE incorporation within $CaCO_3$ [e.g. Borsato et al., 2007; Bourdin et al., 2011; Hartland et al., 2014]. Part of the TE fractionation (especially for Mg and Cd) between water and $CaCO_3$ crystals could also be due to temperature change [Tsusue & Holland, 1966; Gascoyne, 1983]. Thus, the interpretation of TE variations in $CaCO_3$ deposits must be undertaken with care, as it does not directly reflect the water composition. However, in cases of fast deposits (some tens to a few hundred years), with no major climatic variation, TE in urban speleothems or sinter from historical aqueducts can provide important information about environmental or man-induced changes. An interesting study by Carlut et al. [2009] of trace elements in carbonate deposits from a Roman aqueduct in the antique city of Ostia (present-day Italy) evidenced the replacement of one water source by another during the Roman period.

In the 300-year-old urban speleothems of Belleville (Paris), we demonstrated the substantial change in heavy metal content along the growth axis, linked with urbanization that started in the studied site in the middle of the 1800s. Surprisingly, we also evidenced an early period (during the early 1700s, when the land above was covered by vineyards and orchards) with a high heavy metal content that we linked with the use of domestic and industrial waste from Paris as fertilizer [Pons-Branchu et al., 2015].

4.3 Stontium isotopes

Unlike TE, isotopic compositions for "heavy" isotopes such as strontium or lead reflect the isotopic composition of the water, with no or very low isotopic fractionation processes (which is not the case for "light" isotopes such as oxygen or carbon). Strontium isotopes are an interesting case study and can be usefully applied to study $CaCO_3$ deposits in aqueducts or galleries with respect to water origin or soil use on the watershed. For instance, by comparing Sr isotopes in carbonate deposits from springs, a tunnel and an aqueduct, Sabri et al. [2015] suggested possible connections between ancient aqueducts in Palestine.

In Belleville's urban speleothems, changes in both Sr content and Sr isotopic composition underline the effect of urbanization at the end of the 1800s and the effect of backfill that contributed a new Sr source with a different isotopic composition [Thil et al., in review]. Strontium analyses were performed on F1 and F4 from a Versailles palace technical gallery. A shift between low and high $^{87}Sr/^{86}Sr$ values between the years 1970 and 1990 (see Fig. 3) was observed, reflecting a change in strontium origin or a mix between several strontium sources at that time. It could be due to road works on the street above the gallery. This hypothesis will be investigated during the course of the "Fontaine and Aqueduct" project.

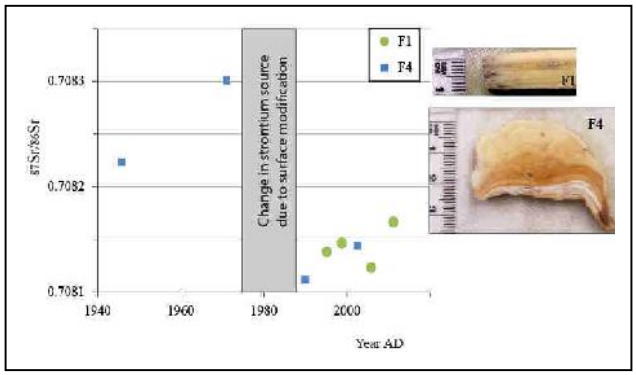

Figure 3: Strontium isotope variation within speleothems from the technical gallery of Versailles Palace

5. CONCLUSIONS

The study of urban speleothems from Paris and Versailles (France) demonstrated that in these highly urbanized areas, bi-annual lamination occurs, as in speleothems from natural caves. The analyses of trace elements and strontium isotopes in these speleothems can help to understand human-induced changes in the urban environment and the impact of soil occupation.

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SESSION 3

HYDRAULIC UNDERGROUND WORKS

Rock-cut hydraulics in Cappadocia: the tunnel-cisterns of Göreme

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Abstract
Many researches and papers have been dedicated to the architectures dug on the rocks of Cappadocia (central Turkey): rock-cut churches, residential and manufacturing complexes, underground shelters. The underground water works which, instead, play an essential role in the development of any human settlement, turn out to be less investigated. Only recently specific investigations on this subject have been carried out, not by chance, by expert cavers of various nationalities. These researches reveal, in the area around Göreme, the presence of very clever underground water works, that we can classify as: production, storage, transport and regulation works. A recent series of new explorations allows to determine a different type of storage works which revolutionise the knowledge about the methods of water collection, in addition to the exploitation of springs and water beds: the "tunnel-cisterns". These underground water works are typified by two key elements: the reservoir is not located inside a unique big chamber but is strewn across a tunnel system which volume is equivalent or greater to that of a single cistern; the water supply is not coming from a water bed or a spring or an aqueduct, but is fed by some special devices, called "loose stone trenches", through which rainfall, snow meltdown and surface runoff waters are drained and directed in the underground tunnel-cisterns. This system requires the existence of two or more entrances from which the tunnels were dug with the well known "opposite fronts" technique. Furthermore, the reservoirs are usually connected with "intake holes" and "intake rooms", for the distribution of water on the outside, achieved, in some cases, with the "pilot holes" technique.

Keywords
Cappadocia, rock-cut works, hydraulics, tunnel-cistern, loose stone trench, funnel, pilot hole, opposite fronts.

1. INTRODUCTION

Many researches and a large number of papers have been dedicated to the extraordinary architectures excavated by men on the rocks of Cappadocia (central Turkey – Fig. 1). In particular the rock-cut churches have been, and continued to be, subject to studies and papers [see e.g.: Andaloro et al., 2015; Jolivet, 2015]. Also the detection and the documentation of other underground works as the shelters, the residential complexes and the cavities for manufacturing, over the last twenty years have greatly increased thanks to many scholars from different countries, including the researches carried out in the area since 1991 by Centro Studi Sotterranei (CSS, Centre for Underground Studies, Italy).

Since 2012 CSS was invited to participate firstly to the mission *"Rock painting in Cappadocia. For a project of knowledge, conservation and valorisation"*, lead by Prof. Maria Andaloro, University of Tuscia, Viterbo (Italy); then associated to the PRIN project 2010-2011 *"Rupestrian art and habitat on Cappadocia (Turkey) and in central and southern Italy. Rock, excavated architecture, painting: between knowledge, preservation and enhancement"* (national scientific coordinator Prof. Maria Andaloro) with the support of the Ministry of Tourism and Culture of the Republic of Turkey. In these projects the CSS experts provided their specific explorative expertise, dealing with particular aspects and research themes the results of which are here partially reported.

Figure 1: Location of Cappadocia in central Turkey (drawing R. Bixio)

1.1 Studies about hydraulics

For the existence of a settlement, the water supply is essential [Juuti et al., 2007; Fahlbusch, 2008]. This important factor is today well documented for the areas of Middle and Near East, as for the Central Asia, where many are the studies about the underground water collection systems, as *karez* and *qanat* [Castellani, 2001; Kuros, Khaneiki, 2007; Lightfoot, 2009; Mays, 2010; Hu et al., 2012]. In Cappadocia, instead, the underground water works are still less investigated and known although they

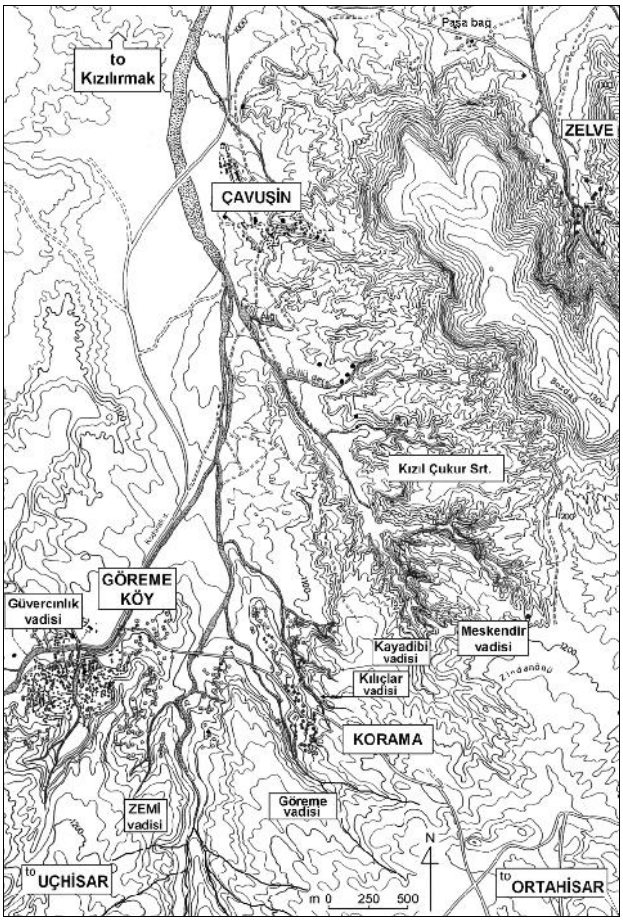


Figure 2: Partial map of the "district of erosion valleys", round Göreme Köy (formerly Avcilar), in Cappadocia (drawing R. Bixio)

had a primary and essential role for the development of the residential area and the agricultural activity of this region.

Although already Herodotus [Erodoto, I, 75], in the fifth century B.C., mentions amazing hydraulic works on the river Alis (or Halys, today Kızılırmak), in Cappadocia, attributed to Thales of Miletus, acting on Croesus' behalf during the war against Cyrus, dating back to the 550 B.C., we have to wait the Gilli's research, in 1984, to have the documentation of an underground tunnel excavated to divert the longest river of Turkey [Gilli, 1984].

During this interval of time, except for an earlier short mention to underground water supply works by Cousin[1] in 1905, and De Jerphanion[2] in 1911, we found specific studies only by Castellani, between 1992 and 2000, by Bukarenko, in 2008, to which are added the very recent investigations of Gilli and Yamaç, published in 2014 and 2015. These are, in any case, just a very limited number of publications concerning surveys lead, not by chance, by expert cavers, because of the specific nature of the explored environments.

From these researches comes to light the existence in the Cappadocian territory, particularly in the "district of erosion valleys" around Göreme (Fig. 2), of underground water systems, of remarkable intelligence and effectiveness, in complete accordance with the "negative building" techniques distinguishing this region.

2. UNDERGROUND WATER WORKS

Water works can be distinguished in functions of the purposes for which they were built, and the techniques used for their realization as well. These also depended upon the geology and climate of the local areas, typically characterized by lack of surface water.

- ***for water production***

1. *Condensers*. Although, strictly speaking, this is not a underground structure, we point out a device located near the Yeşilöz village. It is an artificial hill, 50 m high and 150 m in diameter, consisting of a heap of stones, most likely for water production by catching the humidity contained in the wind passing through, and feeding some springs at the base (Fig. 3). In other cases the condensation may occur also through natural debris deposits or cracked rocks near the ridges, feeding the well known *"peak springs"* [Maifredi, 1995, p. 104].

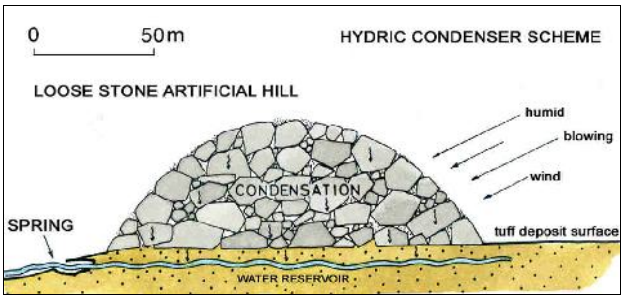


Figura 3: Hydric condenser scheme (drawing R. Bixio)

[1] Important even if short are the notes of Georges Cousin (*Maitre de Conférences a la Faculté des Lettres de Nancy*) who stayed in Cappadocia on the trail of Cyrus. He describes a long underground canal, ventilated with rectangular small windows carved in the tuff. *"L'eau voyage ainsi souterrainement pendant trois heures avant d'arriver à Urgub. Suivant les habitants, ce joli chemin a etè fait par Ibrahim-Pacha, le grand vainqueur égyptien."* [Cousin, 1905, p. 388-389]. This quotation gave a temporal reference after 1832, the year when Ibrahim Pacha's troops went in Cappadocia. Cousin mentions also another cistern from which starts an underground water canal, dotted with ventilation holes, feeding Uçhisar. It could be that documented by Gilli & Yamaç [2015].

[2] The French scholar, describing the valley lengthening over the amphitheatre of churches of Göreme, adds: *"Il faut citer un long boyau qui était, sans doute, une conduite d'eau pour l'alimentation de Gueurémé."* [De Jerphanion, 1925, p. 25]. He certainly refers to the draining ducts excavated in the stream-bed of the valley in which, indeed, trace of feeding tunnels too has been found [Bixio & Castellani, 2002].

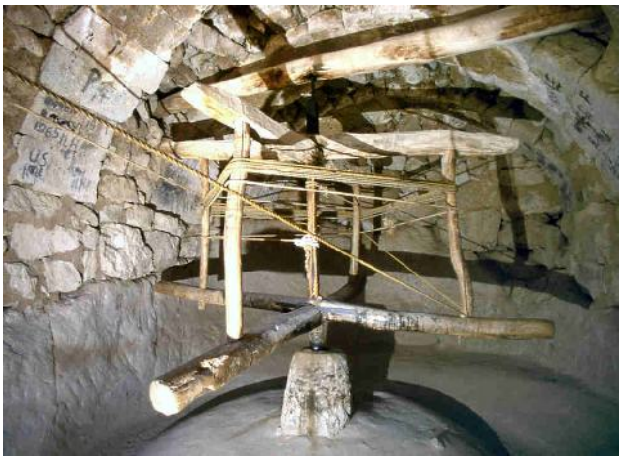


Figure 4: Çekme (Derinkuyu). Wheel to lift the water of a well, standing in a masonry room on country surface (photo M. Traverso)

It is possible that, in certain circumstances, even the tunnels dug by men could produce water by means of the atmospheric humidity condensation [Bukarenko et al., 2011].

- ***for water collection***

2. *Wells.* Vertical excavation of the rock, with quadrangular draught flue, rarely cylindrical, from 10 to 40 m deep, as in Sivasa [Triolet, 1993].
They are made with the purpose of reaching the water-table, and to take it by uplifting:
- a) from the external ground level (Fig. 4)
- b) from inside an underground settlement (Figs. 5, 6)

- ***for water storage***

3. *Ponds (basins)*. Water containers with free surface, usually with a large quadrangular perimeter, dug in the rock opencast or inside an underground room. They are fed by springs, snow meltdown and rainfalls both directly or channelized, with the aims to accumulate water resources to be distributed when needed.

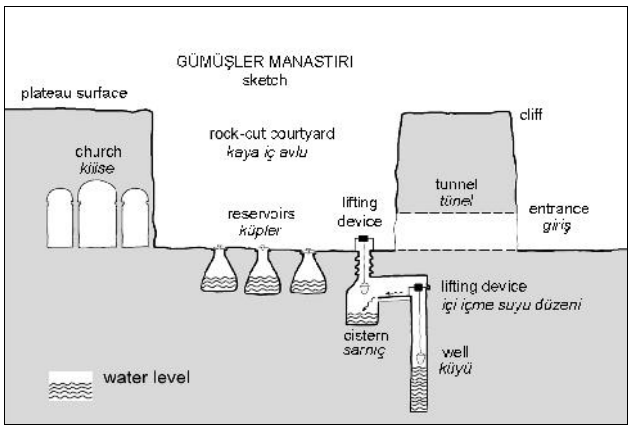


Figure 5: Scheme of lifting water system in Gümüşler Manastırı, Niğde (drawing R. Bixio, after Bildirici, 2009, p. 384)

4. *Cisterns (chamber)*. Covered basins, totally carved inside the rock, chamber-shaped, usually more or less quadrangular (Fig. 8).
Ponds and cisterns can be located also in the higher levels of the cliffs [Gilli et al., 2014].

- ***for water transport***

5. *Aqueducts*, excavated to carry the water where it is missing (with both purpose of providing drinking water and irrigation).
They consist of tunnels supplemented with devices for catching and distributing water. They can be of two types:
- a) tunnel with free surface flowing. The tunnel itself serves as duct for the water transport (see point 7);
- b) pipe flowing. The tunnel serves as container for a pipe.
In Uçhisar a tunnel system has been documented (see note 1), over 3.600 m long, containing two clay pipes from different ages [Gilli & Yamaç, 2015].

Figure 6: Ovaören (Göstesin). Well dug inside an underground shelter (photo G. Bologna)

6. *Drainage tunnels*, realized to carry away the water where in surplus. They generally consist of tunnels dug along the side of the valleys, originally below the stream-bed level, interspersed with side draining points (dissipator ducts or shafts). The purpose is to reduce and distribute the water amount generated by the rainfalls and to contain the torrential floods, so that the spaces at the bottom of the valley could be terraced and cultivated (Figs. 6b, 7).
The original rectangular section, normally 80 cm wide and from 100 to 180 cm high, over the centuries was often deepened and widened by the erosion and the cryoclastic action. in some cases over than 5 m high and 3 m wide (Figs. 9, 10), overcoming 10 m in the Zemi valley [Bukarenko et al., 2011].
This type of tunnels is almost anywhere in the water catchment basin around Göreme. That in the Kılıçlar Vadisi, for example, is 220 m long [Castellani, 2002, pp. 289-290; Bixio et al., 2012].

7. *Bivalent tunnels*. A drainage tunnel together with a pensile side canal (aqueduct) for the water supply [Bixio & Castellani, 2002].

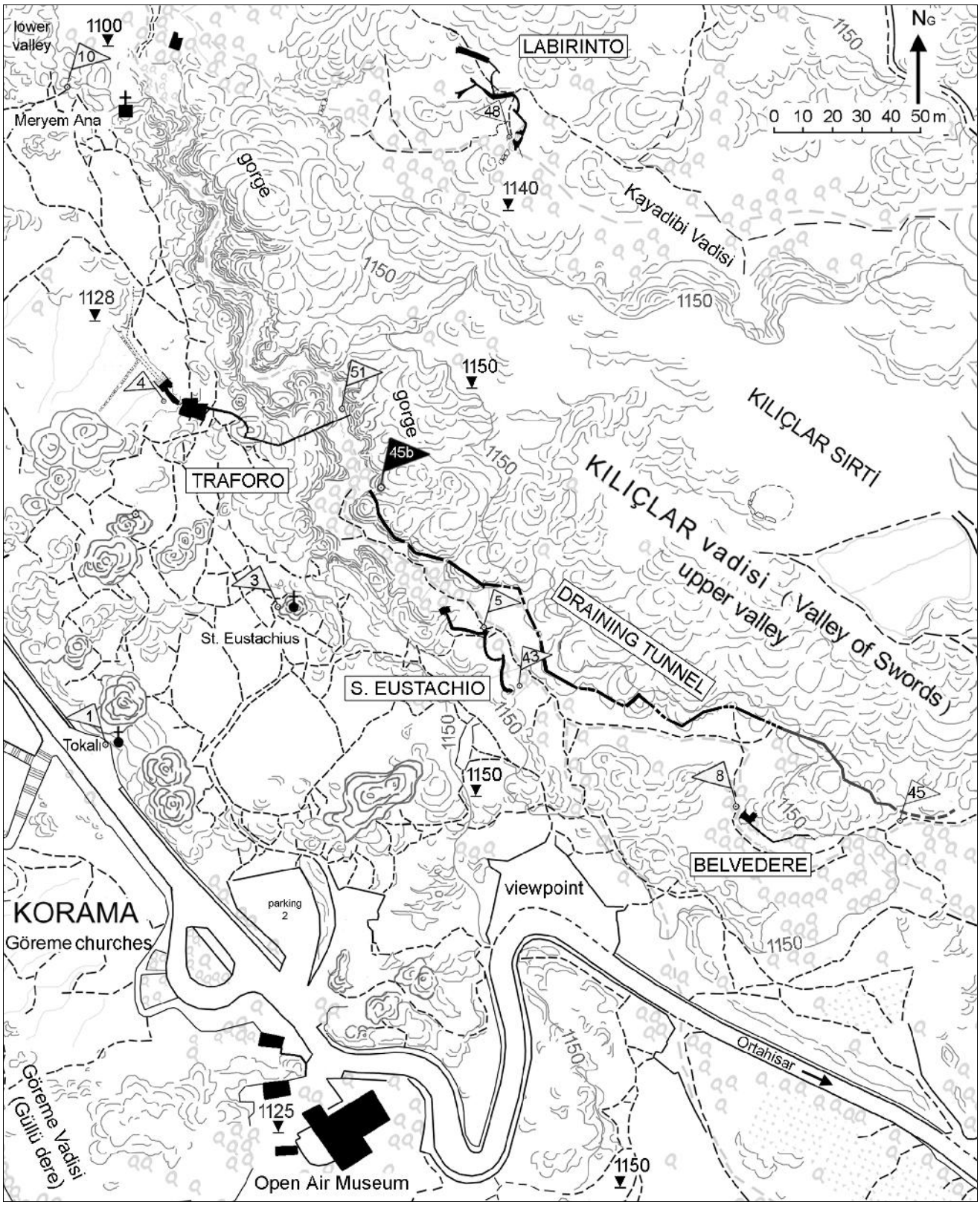
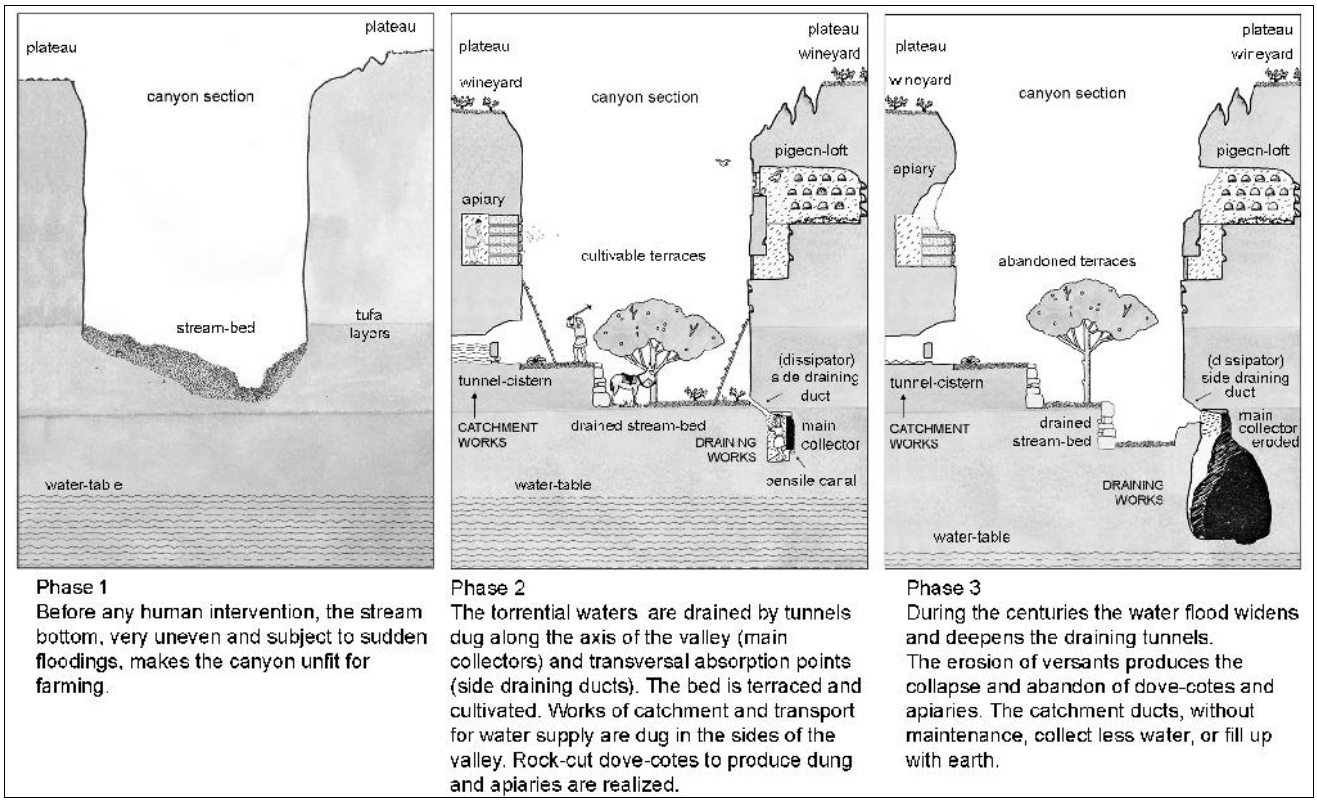


Figure 6b: Location of five hydric systems in the Valley of Swords, 150 m north-east of Open Air Museum (drawing R. Bixio)



Phase 1
Before any human intervention, the stream bottom, very uneven and subject to sudden floodings, makes the canyon unfit for farming.

Phase 2
The torrential waters are drained by tunnels dug along the axis of the valley (main collectors) and transversal absorption points (side draining ducts). The bed is terraced and cultivated. Works of catchment and transport for water supply are dug in the sides of the valley. Rock-cut dove-cotes to produce dung and apiaries are realized.

Phase 3
During the centuries the water flood widens and deepens the draining tunnels.
The erosion of versants produces the collapse and abandon of dove-cotes and apiaries. The catchment ducts, without maintenance, collect less water, or fill up with earth.

Figure 7: Scheme of the morphologic evolution of a Cappadocian valley consequently to the ancient anthropic impact (drawing R. Bixio)

Figure 8: Kayadibi Vadisi. Underground cistern with pensile collecting tunnel (photo A. De Pascale)

Figure 9: Meskendir V. Draining tunnel enlarged in circular shape by erosion and cryoclastic action (photo G. Bologna)

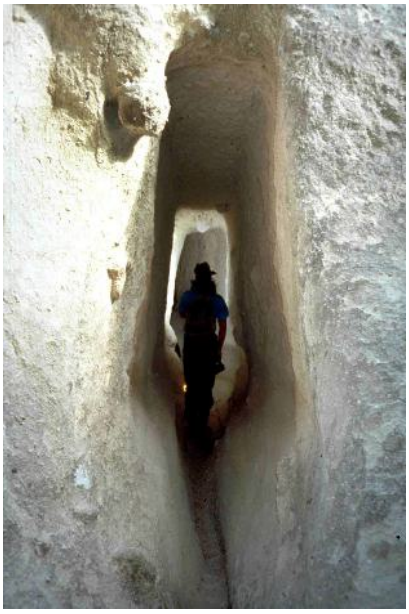


Figure 10: Kılıçlar Vadisi. Draining tunnel deepened by erosion in keyhole shape (photo L. Pagano)

Figure 11: Sarıhıdır, River Kızılırmak. Ancient by-pass carved by man (photo A. Bixio)

Figure 12: Tunnel-cistern "Belvedere", Kılıçlar Vadisi. Despite the drought, the water stops the exploration of its innermost part (photo A. Bixio)

Figure 13: Kılıçlar Vadisi. Tunnel-cistern 'Traforo' (photo A. Bixio)

8. *By-pass*. A specific type of drainage tunnel (or trench) to divert the water flow or to lower the level with the purpose of overcome obstacles. To create a ford across the Kızılırmak river[3] a tunnel (Fig. 11) 200 m long, 10 m wide and 4 m high was excavated [Gilli, 1984; Gilli et al., 2014].

9. Tunnel-cisterns. It is a known type in ancient times for others areas, with works both built underground and dug in the rock [Bryer & Winfield, 1985, p. 27/35/104; Marzano, 2007, p. 455/465/477/485/493/543; Fahlbusch, 2008, p. 5], as the famous *spelunca magna* (the catacomb of Pretestato) in Rome, a long tunnel dug in the second century A.D., originally used as underground cistern, then re-used and refitted as cemetery in the third century A.D. [Spera, 1999, pp. 201-204]. This type, never found before in Cappadocia, has been now recognised in some cases described below.

3. THE TUNNEL-CISTERNS

Already in the 1990s, during the investigation about the underground water works performed in the "district of erosion valleys", in the area around Göreme (Figs. 2, 6b), it was noticed, besides the drainage tunnels, parallel to the axis of the stream beds, and the connected orthogonal draining ducts (see point 6 above), the presence, along the sides of the valley, of several independent tunnels. This additional duct system, usually flooded (Figs. 12, 13), was undoubtedly planned to ensure the water supply for the irrigation of the crops obtained by draining the stream-bed by means of the drainage tunnels [Bicchi et al., 1995; Castellani, 2002; Bixio & Castellani, 2002; Bixio et al., 2012].

It was believed that these cavities were dug in the rock in order to improve the discharge of existing springs, or to reach the local water-tables. However, recent surveys in the Kılıçlar Vadisi (Valley of Swords) and in the Zemi Vadisi, while confirming their irrigation (or domestic) goal, allow to discover the real nature and the realization technique of these specific works.

Actually they are real underground cisterns, i.e. structures with the purpose of storage and preservation of waters, which, rather than being kept inside one wide room (chamber cistern), extend across a narrow and long space (tunnel), with equal or greater volume. Two types of reservoirs have been identified:
- a) linear tunnel-cisterns (or linear cisterns), consisting just of tunnels, with longitudinal extension (Figs. 14, 15) or grid[4] development (Fig. 18);
- b) tunnel-cisterns with chamber, i.e. integrated units consisting of a tunnel (linear cistern) ending inside a chamber cistern (Fig. 8).

Obviously, these structures, as any other work for water supply, are supplemented with devices for the intake and the distribution of the accumulated reserves. Their peculiarity, however, is most of all in an unexpected, simple and clever feeding system consisting of the "loose stone trenches" which deeply changes our knowledge about the methods for the water supply in this region, alternative to the exploitation of springs and water-tables. During recent expeditions six structures recognizable as "tunnel-cisterns" have been identified and documented, everyone with its peculiarities, but with common features. In this paper we point out some graphic details extracted from the topographical surveys of some systems to which we will refer to outline the general digging sequence and method (Figs. 14, 15, 16, 17, 18).

[3] See the quoted tunnel of Thales in sixth century B.C. This technique is mentioned too in a Byzantine war strategy treaty written by an anonymous war engineer in the middle of the sixth century A.D.: *"It is also possible to dig trenches in a semicurcular shape along the bank of a river...and enables the whole army to cross over without danger. Cyrus was the first to do this."* [Dennis, 1985, p. 67].

[4] The simplest and oldest way to realize underground reservoirs for water storage was to excavate and to waterproof tunnel agglomerations [Bixio & Galeazzi, 2009, slide 62]. Several examples are in Italy: at Forte Antenne, in Rome, there is a cistern consisting of a grid of plastered tunnels [Del Pelo Pardi, 1969, fig. 67]; in Genoa, a linear cistern was obtained inside the rampart walls of 1500s where now the De Albertis Castle is. These are tunnel-cisterns similar in concept to those near Göreme, but different for the excavation technique and the feeding system. The tunnel-cisterns in Cori, near Latina, are more alike in configuration. Their grid, with orthogonal arms, was carved inside the tuff for a length of 368 m, starting from different shafts through which the rainfalls were carried underground. It is assumed that they had been realised by the Romans around the fourth century B.C. [Germani, 2002].

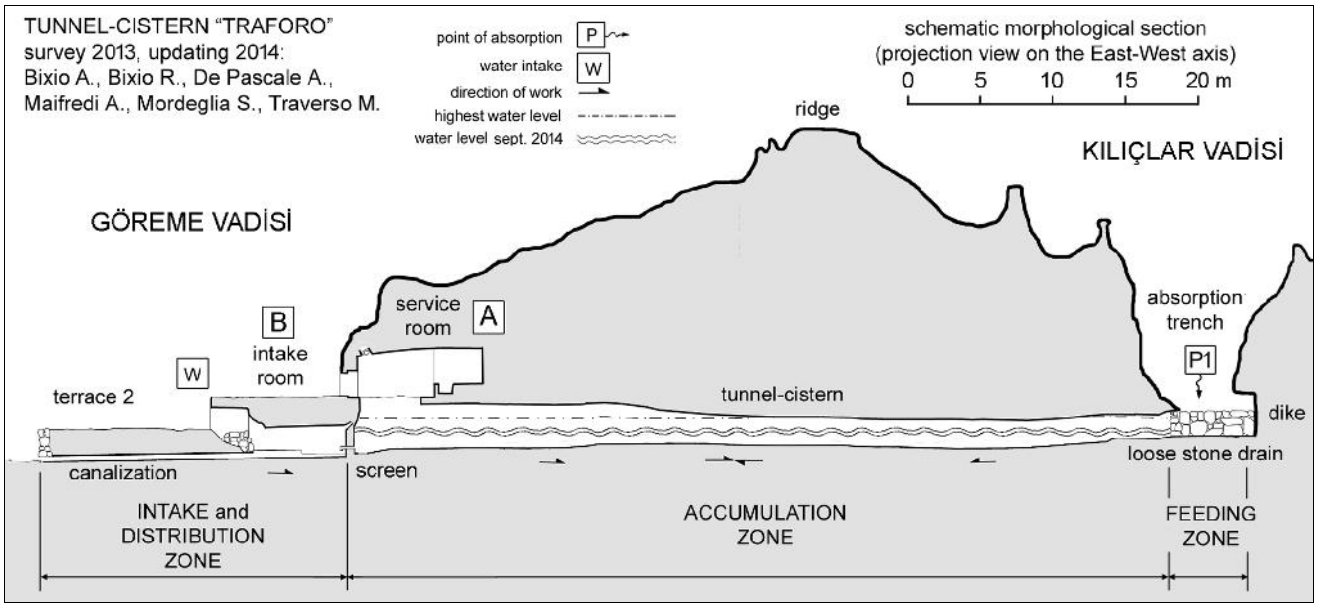


Figure 14: Longitudinal section of tunnel-cistern "Traforo", a *crossing cavity* between Göreme and Kılıçlar valley (drawing R. Bixio)

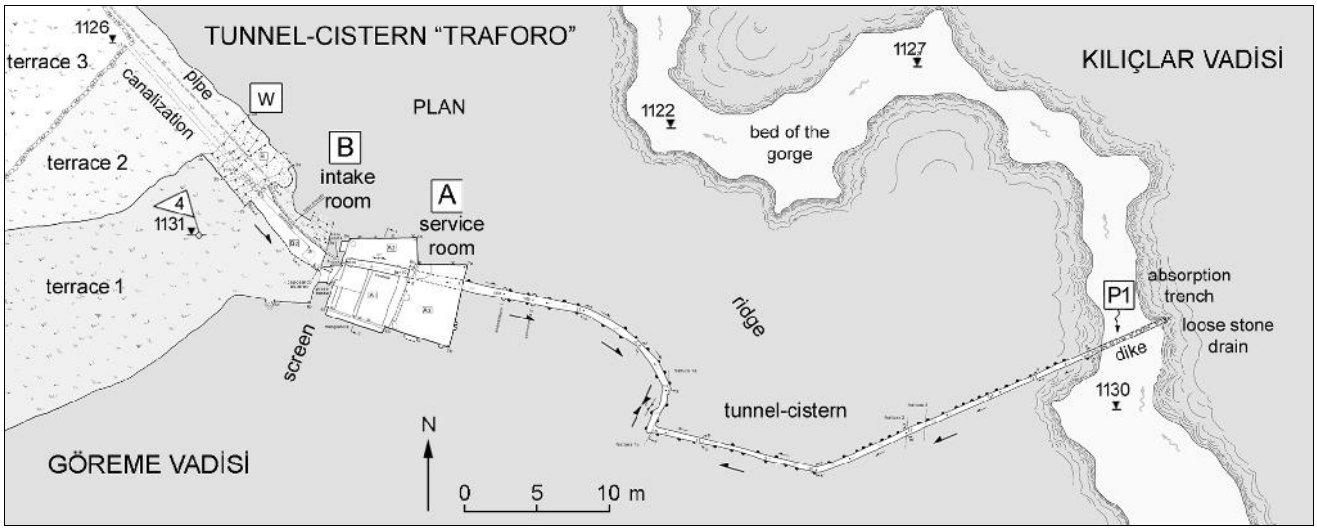


Figure 15: Map of tunnel-cistern "Traforo", a *crossing cavity* between Göreme and Kılıçlar valleys (drawing R. Bixio)

3.1 Configurations

Not all the structures can be fully documented: some parts are not accessible because are flooded (Fig. 12) and/or clogged by stones or debris. Without generalising, we point out some observations about the tunnel-cisterns for which the complete surveys are available. It is particularly interesting to compare two systems with a similar development.

- "Traforo" (Figs. 14, 15). It is a "*crossing cavity*" because the water is taken in one valley and distributed on the adjacent valley, passing through the ridge with a tunnel 60 m long. It is feed by one absorption point consisting of a dike across the Kılıçlar Vadisi stream-bed (flag 51 in Fig. 6b and point P1 in Fig. 15), corresponding to a loose stone drain in a trench 5 m long, nearly 50 cm wide and approximately 1,70 m deep (Fig. 22 left).

The tunnel width is between 40 and 60 cm; the average height is around 1,70 m, except in the final section, near the exit and the intake hole, where the tunnel deepens to 3,40 m. An empirical calculation, taking into account the total length of the underground structure, the width of various sections, as well as the average thickness of the sediments, and considering as highest level of water the line currently visible on the rock sides of the tunnel, suggests that the total capacity of the reservoir should be approximately 50 m³.

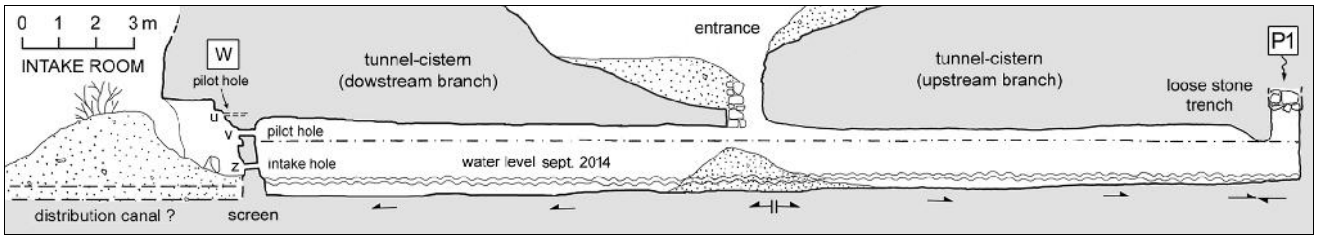


Figure 16: Section of tunnel-cistern "Saint Eustachius": detail of the entrance and intake/distribution zone (drawing R. Bixio)

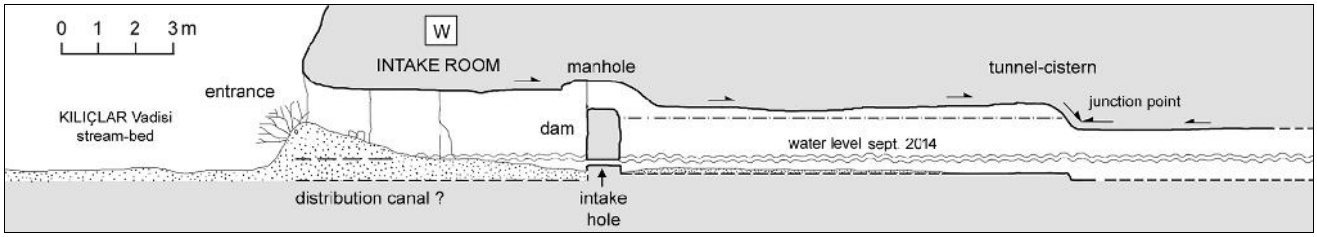


Figure 17: Section of tunnel-cistern "Belvedere": detail of entrance and intake/distribution zone (drawing R. Bixio)

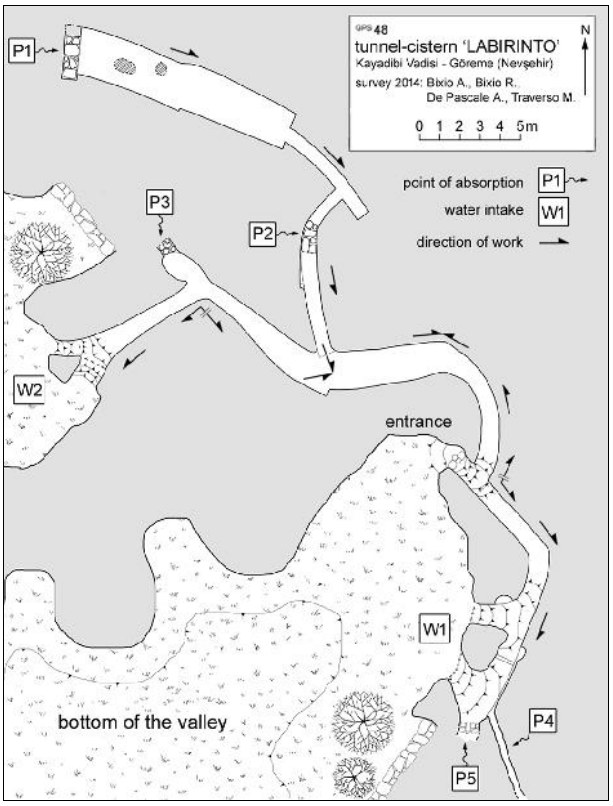


Figure 18: Kayadibi Vadisi. Tunnel-cistern 'Labirinto' (drawing R. Bixio)

- "Labirinto" (Fig. 18). This structure, unlike the previous, is a "*concentrate cavity*". It has a total development of 67 m, slightly longer than the Traforo, but extended in a very small area, entirely within the stream-bed of the Kayadibi valley (flag 48 in Fig. 6b), where the farther absorption point is only 15 m from one of the entrances. It consists of a network of tunnels, interconnected, fed by five absorption points from 2,60 m to 3,50 m deep. The width varies between 70 cm and 180 cm, and the height between 113 cm and 240 cm. The total capacity, empirically calculated as above, is approximately 90 m³.

3.2 Digging sequence and method

From the analysis of all the identified systems it appears that the planning and digging procedure was the following.
Having identified the best point [P] for the water catchment on the surface depending from the site [W] determined for the intake and the distribution in the cultivated area, the workers started to dig in the rock the two entrances at both ends of the system. The first one could have been a trench or a shaft (Fig. 21), from 2 to 4 m deep. The second one could have been also horizontal (Fig. 17).

After that, from both the entrances two tunnels were dug, probably at the same time, one towards another, with niches for lamps carved on the side walls. The excavation was carried out with the opposite fronts technique (as one can see from the symbols on the surveys), up to the junction which normally is characterized by a progressive change of direction of the axis, often combined with a vertical and/or horizontal rock spur where the fronts joint (Figs. 15, 17, 18).
After the excavation of the tunnels, the trench (or the shaft) upstream was filled with stones of different sizes, in some cases retained with tuff slabs, so to have a "loose stone drain", that is a combination of stones without cohesion for the tunnel-cisterns feeding (see chap. 3.4 – Figs. 21, 22).
On the opposite end the installation for the intake and the distribution of the waters stored inside the tunnel system was prepared. It consists of a room (intake room) separated from the tunnel-cistern by a rock divider, obtained by saving the excavation: this part could be an open barrier (dam) or a closed barrier (screen). In the first case, the intake room was excavated consecutively with the tunnel-

Figure 19: Tunnel-cistern "Saint Eustachius". The intake room, with two pilot holes (u-v), in the upper part, and the intake hole (z), below (photo A. Bixio)

cistern and the passage (for control and maintenance) is guaranteed by a manhole above the dam (Figs. 17, 23). In the second case, obviously, the entrance to the tunnel system is independent from the intake room (Fig. 14), and could be at a certain distance (Fig. 16).

In any case the water intake is still today permitted by a through hole, about 10 cm in diameter, drilled in the lower part of the rock divider (Fig. 19). The intake was, and is regulated, where the device is still in service, by a simple wooden stopper or by a valve on an iron pipe coming out from the hole, often supported by wooden blocks or concrete. The distribution was carried out by means of canalizations carved on the rocky floor (Figs. 14, 15) which, starting from under the intake hole that fed it, reached the cultivated fields. Today they are all earth filled and in two cases have been replaced by permanent or temporary (rubber hose) pipes.

3.3 The pilot holes

As regards the intake holes, when they are drilled in a closed rock barrier (screen), we document an interesting digging system, in order to locate the exact spot where to drill the throughout hole, so to have the maximum water availability when the flow rate is lowest, and without dispersion in the high part with the highest flow rate. The sequence is explained by the hypothesized sketch in accordance with the observations carried out in the tunnel-cistern of Saint Eustache (Figs. 19, 20):

- 1) The opposite fronts of the tunnel and the intake room were approached at the same time, without to joint them, trying to gradually find the alignment, using the noises and the vibration of the tools hitting the rock.
- 2) Once approximately reached the right distance, the first hole was drilled (hole [u] in Fig. 20.a), likely with a tool like a drill bit, in order to check the remaining thickness of the screen, the high and the real alignment of the opposite fronts, with the aim of rectify the excavation and to correctly locate the intake hole. We would point out that the pilot hole [u] is located in the high part, probably for not to prejudice with a wrong opening the final location of the intake hole, which needed to be drilled in the lowest part, near the bottom of the reservoir.
- 3) In the case outlined in the sketch, the pilot hole [u] was too high and lateral, so it did not reach the tunnel. Another attempt was therefore made, if necessary after the widening of the intake room, by drilling a new pilot hole [v], lowest and more centred, that finally reached the opposite front (Fig. 20.b).
- 4) Thanks to the new reference point, it was easy to reduce the thickness of the screen without the risk of breaking through, and to drill the low intake hole [z], in the best location to route out the water contained in the tunnel-cistern (Fig. 20.c).

It is possible that the pilot hole technique could have been used more often than imagined, also in the case of tunnels whose fronts finally joint. It is obvious that, in this case, the screen was completely demolished, deleting all evidences of any throughout holes.

3.4 The loose stone trenches

The loose stone trenches (or loose stone shafts) consist of a vertical digging, long and narrow (or circular), starting from the surface (ground level) and reaching the planned level of the horizontal tunnel. The depths of those identify so far are between two and four metres.

The space thus obtained was filled with dry stones of different sizes (loose stone drain), suitable to allow, by gravity, the percolation of the water throughout the gaps, by absorbing it from the outside and carry it in the tunnel below. In this way the water, accumulating in all the branches, still evenly distributes on the horizontal plan of the whole system of tunnels as they are a unique reservoir; then it decreases, always evenly, when taken away (see the signs of water level in Figs. 8, 12, 13, 22). Consequently, the water circulation is mainly vertical, combined with a secondary horizontal flow toward the intake hole, as it happens in every chamber cistern with intake in a side of the bottom.

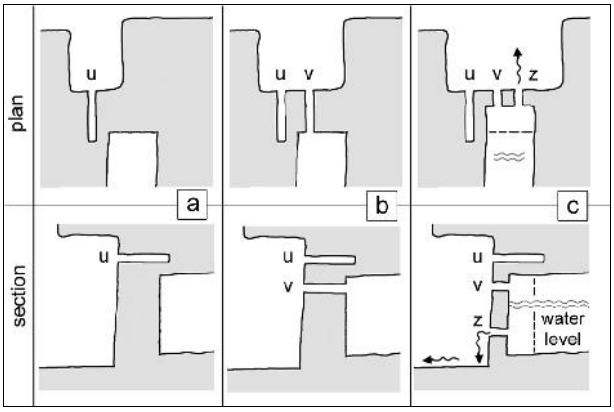


Figure 20: Sketch of the excavation sequence with two pilot holes (u-v) and one intake hole (z) (drawing R. Bixio)

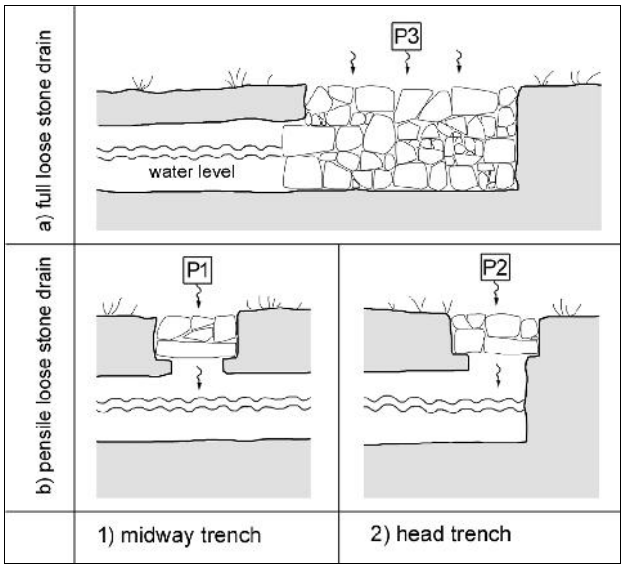


Figure 21: Sketch of different types of trench-loose stone drain systems (drawing R. Bixio)

This means that the tunnel gradient is almost irrelevant, and indeed, in one case (the Belvedere tunnel-cistern, Fig. 17), we found a positive difference between the upstream and the downstream parts, clearly due to a slight error during the digging of the opposite fronts. Obviously, with the minimum level, part of the water in the reservoir is unavailable.

The loose stone trenches until now documented are of two types (Fig. 21):

- a) full loose stone drain (integral), with the stones filling the whole trench, from the surface to the base, corresponding to the bottom of the tunnel below. The front of the loose stones is maintained in the tunnel by a reinforcement wall made of squared stones (Fig. 22 left);

- b) pensile loose stone drain, in which the stone filling is only between the ground level and the ceiling of the tunnel, whose underlying part remains empty (Fig. 22 right). In this case the support for the stones above is made of tuff slabs or rough-hew bulks, leaning on horizontal offsets cut on the borders of the trench.

Moreover, the loose stone drains, depending on the trench position in the tunnel, can be:

- 1) head trenches, at the ends of the tunnel;
- 2) midway trenches, along the tunnel.

In both cases they can be longitudinal or transversal to the tunnel below. Some water systems have multiple loose stone trenches. It should be noted that these devices are hardly detectable from the outside because of landfills, while from the inside they are still visible and, in some cases, still in service. However, the abandonment of the water systems and the subsequent lack of maintenance are producing the gradual deterioration of rocks and stones, that are in precarious equilibrium, with possibility of falls.

3.5 Feeding sources and methods

As regards the formation of the water reserve, we think, based on observations carried out in Cappadocia over the last 25 years, that the waters were accumulated during the year in fairly short periods, especially in springtime, in particular in consequence of snow melting. The winters come, indeed, generally early, very cold and snowy, while in summer the rainfalls are rare. For this reason, at least around Göreme, there are not active watercourses although there are many old valleys deeply carved, wrecked with many side gullies.

So we think plausible that the loose stone trenches were mainly designed to quickly absorb the water of the snow melting and, occasionally, the rainfall gathered directly or in consequence of the runoff. Therefore, it is likely that the tunnel-cisterns were sized to store a water volume sufficient for the water needs for all the subsequent period in which there would be low rainfalls, not having available any permanent spring.

Probably at the end of May the reservoirs reached the maximum amount which was gradually used during the summer, with little or no new water supply, reaching its lowest level at the end of September/October, when the need for irrigation ended.

We cannot exclude that the water feeding might depend, at least partially, upon condensation phenomena of air humidity (see point 1 in chapter 2) passing through the tunnels because of the difference of altitude (even if minimal) between the loose stone trenches and the entrances downstream. In any case it is clear that, unlike we could think before, the water system so organised was not fed through water-tables in the subsoil, but directly from the surface as a result of weather events concentrated in short periods and/or intermittent.

We finally point out that inside the documented tunnel-cisterns there are no signs of plaster (except in some fractures inside the “Traforo” tunnel-cistern): it follows that the tuff rock types in which they are excavated allow, once the rock

Figure 22: To the left: full loose stone drain based just to the bottom of the tunnel. To the right: Pensile loose stone drain (photos A. Bixio)

Figure 23: Kiliçlar Vadisi, tunnel-cistern "Belvedere". View of the manhole above the dam dividing the water intake room from the flooded tunnel (photo Traverso)

is saturated, to ensure negligible water dispersion. It is also clear that the evaporation on the surface of the water stored underground will be nil, allowing its optimal conservation.

4. THE TUNNEL-CISTERNS WITH CHAMBER AND THE FUNNELS

In some cases integrated systems have been identified: they consist of tunnel-cisterns (or linear cisterns), coupled with chamber cisterns (Fig. 26). The features of the feeding (loose stone trenches), intake and distribution devices are the same, except that the tunnel system ends inside a large room with an additional increase of the total capacity of the reservoir. We note just one substantial difference for the water flow, in the case when the tunnel floor is higher than the bottom of the cistern (pensile tunnel). In this case the tunnel at first will behave like an aqueduct, transporting the water from the absorption point to the cistern itself (horizontal water flow). When the water level exceeds the altitude of the tunnel floor, also this latter will become a cistern and the system will behave as described above (prevalent vertical water flow) (see signs of water levels in Fig. 8).

Another water feeding system, not necessarily connected with the tunnel-cisterns, consists of "funnels" (Figs. 24, 25). It is a combined device with a collecting basin, or rock-cut trough, located on the top of the cliff, near the border, connected with a duct, more or less vertical (downpipe), which draws the gathered water inside a reservoir below, both excavated inside the cliff. The upper basins are opencast carved in the rock cliff top so placed as to catch (like the loose stone trenches) the snow melting water, mostly in spring and, sometimes, the rainfalls.
In the case of the cistern documented in the Zemi valley, in Göreme, the downpipe, about 3 m long, is inside the rock except for the middle section that is half open. In Yarlağan Tepe, near Şahinefendi, many collecting basins have been identified on the cliff top, their downpipes are no more presents because of the collapsing of a large part of rock where the ducts were passing down before to probably connect with pensile cisterns.

5. CONCLUSIONS

In short, the tunnel-cisterns around Göreme are, essentially, water reservoirs (only partially for transportation), equivalent to real underground cisterns. Their main features are summarized as follows:
- They are fed by rainfalls, snow melting, runoff and, maybe, condensation, not by springs or water-tables.
- The inner water flow is mainly vertical, with a secondary horizontal component.
- The excavation of the tunnels is carried out with the opposite front technique, combined, in some cases, with the pilot holes technique.
- The systems investigated until now are of two types, "*crossing cavities*" (Figs. 6b, 14, 15), providing water supply between two adjacent valleys and *"concentrate cavities"* (Figs. 6b, 18) in which tunnels and absorption points (sometimes multiple) develop in a confined area, in the same place for the intake and the distribution.
- Finally, the most important element is the ingenious feeding system, consisting of a draining structure carried out with a shaft or, more often, with a trench containing a loose stone drain (loose stone trench), through which the water percolates, by gravity, and accumulates in the tunnel-cistern below. Another system for the water gathering is by means of funnels, not necessarily connected with tunnel-cisterns, with the same rainfall feeding source.

The question is whether, like in the underground water system known as *qanat* or *karez*, widespread in all countries with arid and semi-arid climates, from Persia, where probably first were realised, to China and the Mediterranean countries [Castellani, 2001, 2009], carried out by specialists called *muqanni* [Wulff, 1968, p. 82], there were in Cappadocia, too, a special workforce for the planning and the realisation of this specific type of works, for the whole community. Or if, the rock-cut technique being deeply rooted on the whole Cappadocian territory, not limited to the water works but applied to an impressive number of dwellings, agriculture structures, worship places, and large shelters, all the inhabitants were able to self-realize their own installations.

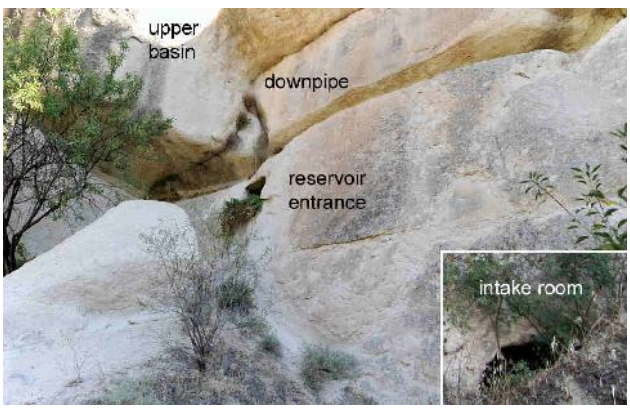


Figure 24: Zemi vadisi. Funnel-cistern (photo A. Bixio)

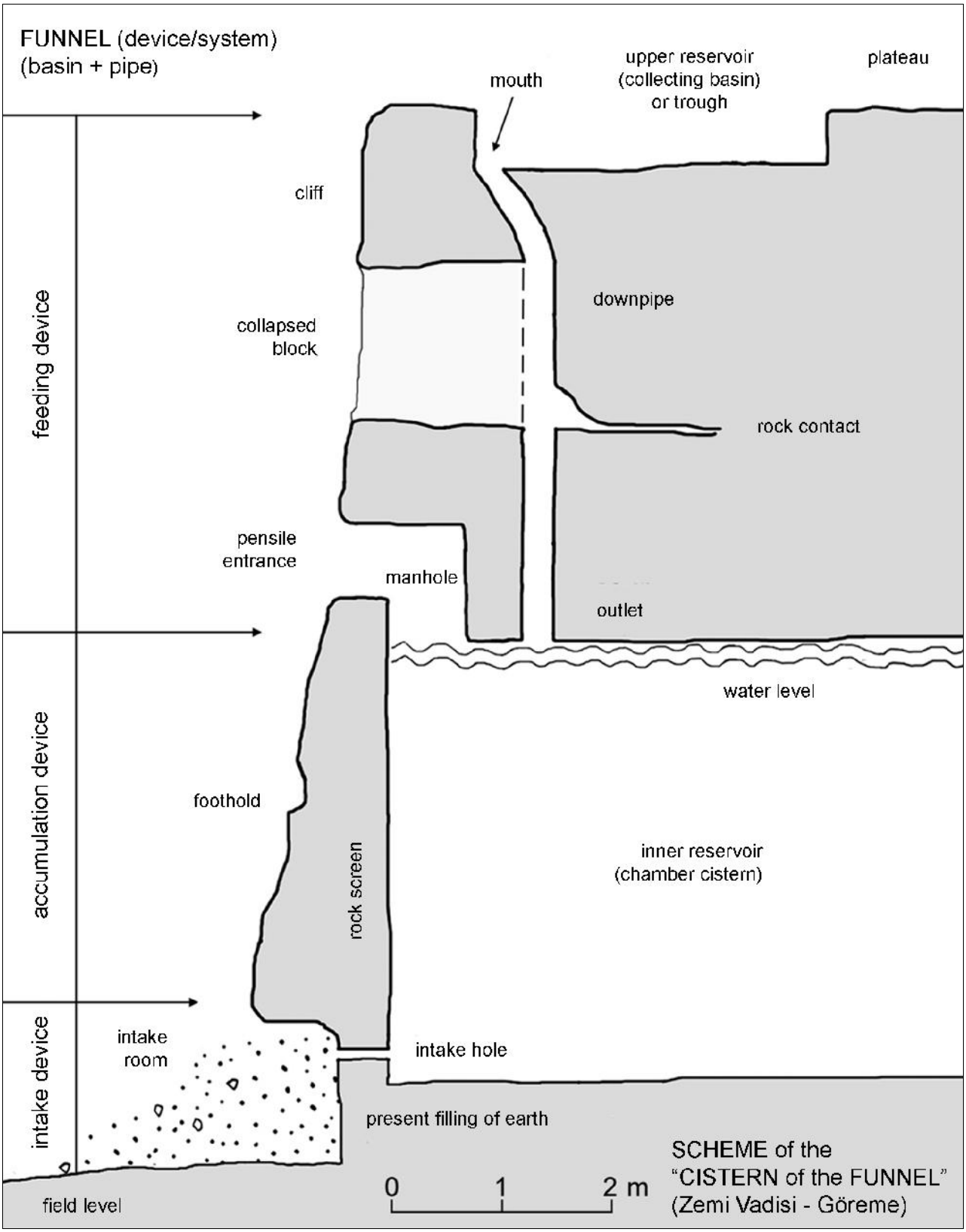


Figure 25: Zemi vadisi. Funnel-cistern scheme (drawing R. Bixio)

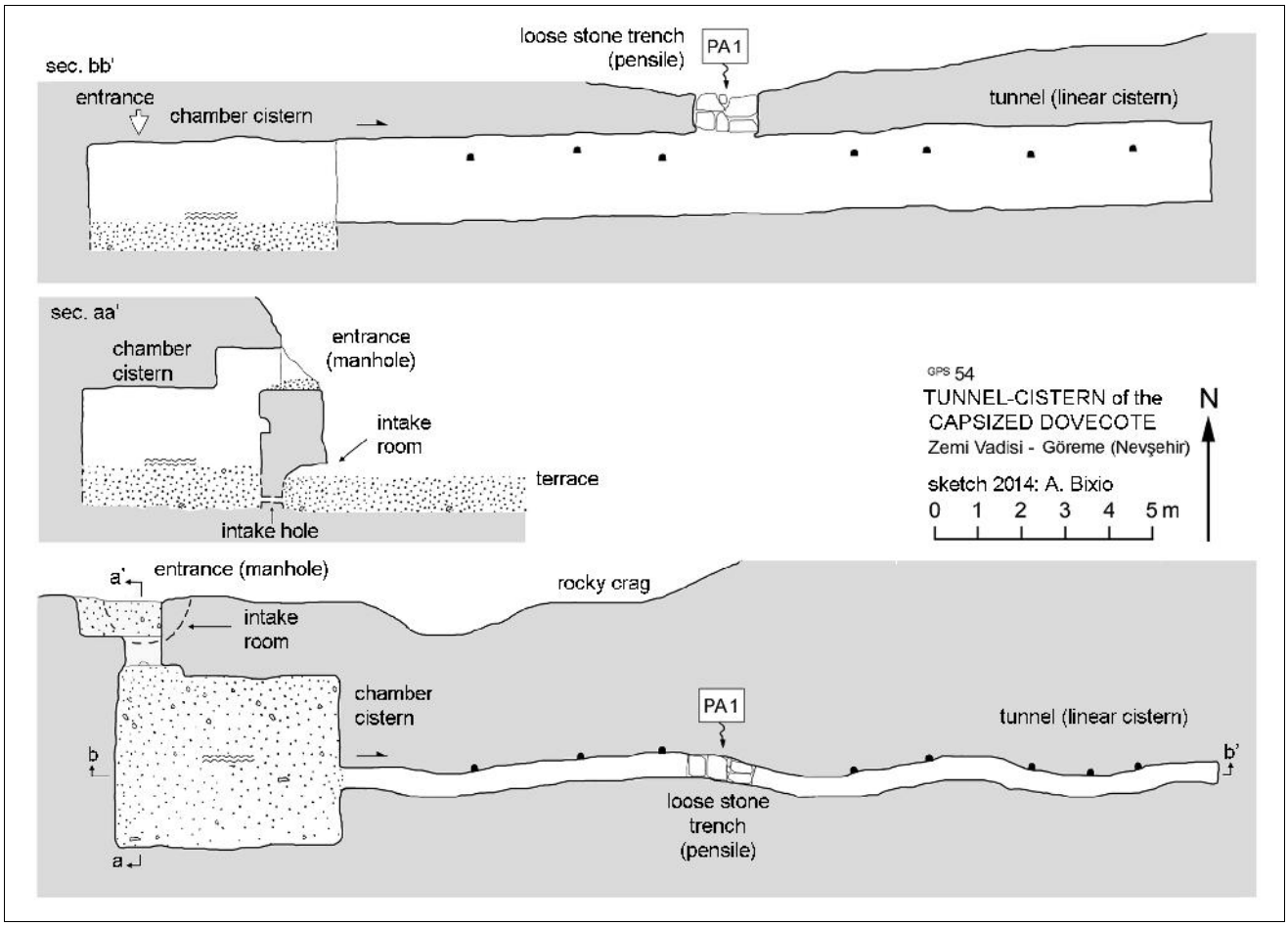


Figure 26: Zemi Vadisi. Sketch of the tunnel-.cistern near the "capsized dovecote" (drawing A. Bixio)

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The culverted streams in the historical amphitheatre of Genoa city (Italy): flood risk or geoheritage protection?

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Abstract
The historic city of Genoa is developed in the natural amphitheater bounded between the western ridge of the old *Lanterna* Promontory and the east ridge of Carignano hill. This historical amphitheater is characterized by several small catchments, from W to E: San Bartolomeo, San Lazzaro, San Teodoro, Lagaccio, Sant'Ugo, Carbonara, Sant'Anna and Torbido.
These watercourses, modified over time in channels, flow culverted under the streets of different neighbourhoods: the name of alleys are often referred to their presences. All the brooks of the historical centre flow fan-shaped into the Genoese port basin and show flood discharge ranging from 22 m^3/s to 82 m^3/s.
The hidden hydrography is the memory of the urban development during the history of the city; it is possible, through walls and heterogeneous construction methods, establish that the culverts were realized starting since the Middle Ages.
The culverted streams in the historical town of Genoa are typical artificial cavities: these underground structures show historical and scientific values and could represent an issue for cultural and economic developments.
At the same time, they may become a preferential area of geo-hydrological hazards, due to limited hydraulic sections, land use change in the catchments, structural feature of the culverts and the acknowledged changing in rainfall regime in the Genoa Metropolitan area: so we can recognize a risk due to vulnerable elements on the surface.
A better knowledge of these culverted streams in Genoa historical city becomes basilar for hazard and risk assessments related either to land planning activities either to the recognition of this important hypogeal cultural heritage.

Keywords
culverted stream, geo-hydrological hazard, cultural heritage, Genoa.

1. INTRODUCTION

The management of territory in Italian cities is a complex activity because the urban fabric is characterized by an overlap of settlements built over time: several underground cavities have been realized during different urban developments.

These underground voids have scientific and historic interest; their knowledge is also basic for geo-hazard assessment in key of urban planning.

Artificial cavities offer double reading in terms of risk: they both could represent a vulnerable element linked to building activities or a potential hazard for the overlying settlements and infrastructure.

In fact there is the possibility to have instability phenomena underground and that the resulting deformation might propagate at the surface [Parise & Lollino, 2011].

Nowadays the disastrous events related to artificial cavities represent an underestimate phenomenon in Italy, but equally it is able to cause heavy damages and economic losses [Parise & Vennari, 2013]. On national territory, there have been several cases of underground structures collapsed over the past decades, with considerable problems and damage to the involved population.
Liguria region presents several underground voids: 385 artificial cavities have been registered, 178 of which are only in Genoa municipality.

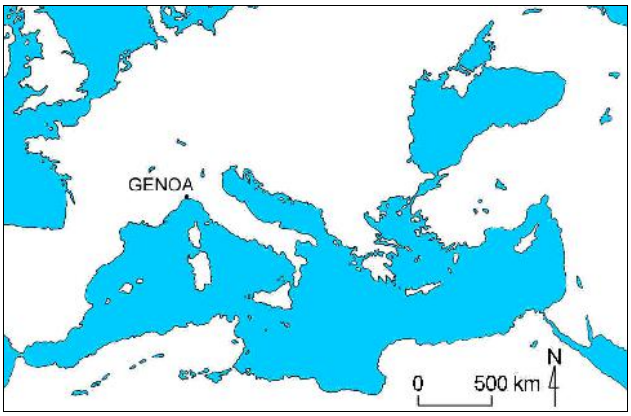

Figure 1: Geographic sketch map with Genoa location in the Mediterranean area (drawing R. Bixio, T. Bonassi, S. Saj)

Figure 2: Genoa and its related historical port; the arrows show the direction of the culverted streams flowing toward the port area (photo R. Bixio)

More in detail 88 water projects are listed, subdivided in 33 culverted streams and water channels, 38 cisterns, 5 sewer channels, 9 aqueducts, 3 wells (reference: Commission on Artificial Cavities of the Italian Speleological Society archive).

However, certainly there are much more. It is estimated that every building in historical centre had a cistern. The culverted brooks, suburb areas included, should be at least 52, for a total length of 120 km.

This research regards a preliminary description of watercourses in the historic amphitheatre of Genoa: they are characterized by a short length with a significant difference in altitude. These underground brooks are almost totally culverted, so they show all the features of artificial cavities.

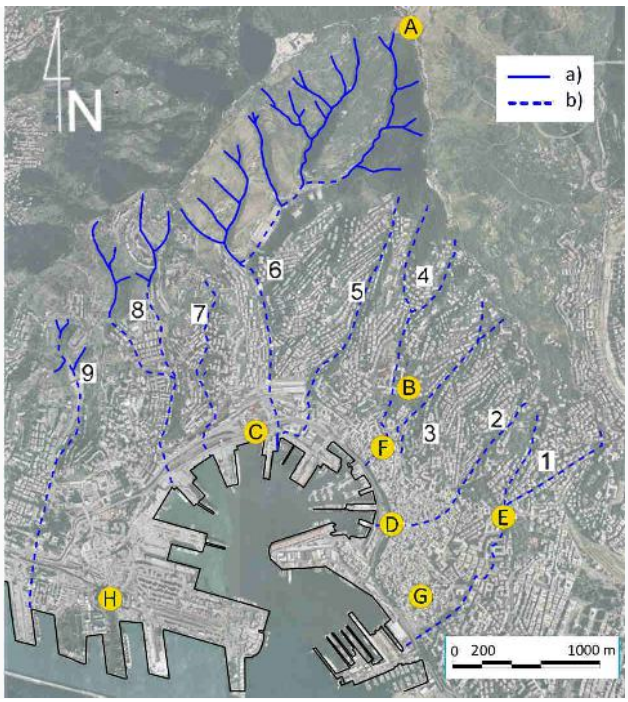

Figure 3: Overview of Genoa historical amphitheatre and related watercourses (from Google Earth Pro). Legend: a) natural watercourse; b) culverted brooks

Construction of the culverts of these underground brooks was started since the Middle Ages: modified over time in channel-sewers, nowadays they present a limited hydraulic section. The urban sprawl and changes in rainfalls regime in Genoa metropolitan area suggest to obtain a better knowledge of culverted streams in historical city, either for hazard assessments related to land planning, and for cultural heritage enhancement linked to underground environment.

2. GEOGRAPHIC SETTINGS OF GENOA

Liguria is one of Italian region mainly characterized by steep slopes very closed to the shore line. The coastal plains are rare: only some portions of territory are crossed by streams which are characterized, from a landform point of view, by a braided river system type.

Historically, due to lack of plains, the resident populations have always used small strips of land to grow and live.

Civilization has requested over the centuries more areas for cultivated fields and above all for building, mainly at disadvantage of the watercourses area.

Genoa in particular, located in the central part of coastal region (Fig. 1), has required more and more flat areas both for urban development and for industrial progress; the latter were also projected towards the sea to meet the traditional age-old seafaring tradition. With the term "amphitheatre of Genoa" the part of urban area behind the port inlet of the old city is indicated.

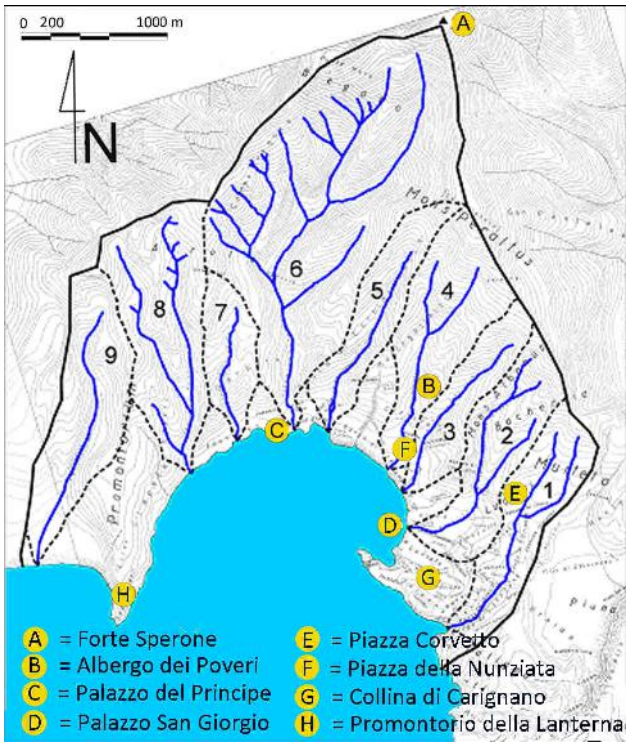

Figure 4: Ancient catchments sketch map of Genoa historical amphitheatre (drawing L. Perasso, S. Saj, base map: "Genova anno 0" [Barbieri, 1938])

N°	Catchments name	A (skm)*	L (m)	S (%)	Flow discharge (m^3/s) for T=50 y			Urbanized areas		Natural areas
								buildings	roads	
1	Torbido	1.17	2102	3.7	44	55	63	58	30	12
2	Sant'Anna	0.72	1145	6.8	35	44	51	62	28	10
3	San Gerolamo	1.10	939	11.0	54	68	77	38	37	25
4	Carbonara		1632							
5	Sant'Ugo	0.80	1688	11.2	35	45	51	45	35	20
6	Lagaccio	2.36	2082	5.2	82	103	118	23	18	59
7	San Teodoro	0.54	855	10.8	35	44	50	32	20	48
8	San Lazzaro	1.33	1943	10.7	59	74	84	33	28	39
9	San Bartolomeo**	0.49	1877	6.6	22	27	31	50	32	18

Table 1: Main features of the stream networks in Genoa old amphitheatre (see fig. 2 for catchment's location). Legend: A = catchment's area; L = total length of main watercourse; S = mean slope degree of channel; *from Basin Master Plan of Genoa Metropolitan area, technical report; **Values from Regional Map at 1:5,000 scale

It is a large morphological basin, bounded by two rocky promontories nowadays partially cut by the urban sprawl (Figs. 2, 3, 4).

The historic city develops in the natural amphitheatre which culminates with Mount Peralto, on which stands Fort Sperone (Fig. 4). The two W and E branches, crowned by the 17th-century city walls, divide the Polcevera and Bisagno valleys.

The western ridge follows the old *Lanterna* Promontory, while the eastern ridge descends toward the Carignano hill, just E from the right bank of Bisagno stream.
Until ancient history period the Amphitheatre was characterized by several watercourses, arranged with a sunburst pattern and declined toward the sea. The streams showed knick points with meanders and falls.

These watercourses, modified over time in canals-sewers and nowadays with a man-made hydraulic pattern, flow culverted under the streets of different neighbourhoods (Fig. 2): the name of alleys often refers to their presences.

Figure 5: The stilling hypogean cistern of Rio Torbido, located below Piazza Corvetto (photo C. Leoni)

3. HYDROGRAPHY OF THE HISTORICAL CITY

Culverted streams in the historic amphitheatre of Genoa are listed below (Table 1): some brooks flows toward the sea, while others flows in a sewer-channel along the coastline [Cabella et al., 2001].

3.1 Rio Torbido ("Turbid Brook")

The stream originates by the confluence of two watercourses flowing in linear culverts (no. 1 in Fig. 4). They joins in an empty room located in the middle part of the catchment with a stilling basin function (Fig. 5). A drain starts from this point and conducts the water in the coastal channel.
Currently the tunnels are built mainly in stone ashlars or masonry; the last part is recently built by reinforced concrete prefabricated and shows rectangular section.
In the upper and middle part of the catchment, the watercourse crosses neighbourhoods built in the 19th century; in the lower part it continues in a part of the city deeply modified over the 20th century, mainly after the second world war period. The culvert stream presents a low hydraulic hazard level.

3.2 Rio Sant'Anna ("St. Anne Brook")

The stream originates by several temporary brooks (no. 2 in Fig. 4). The two main of these were culverted in the 19th century; they connects in a tunnel toward the terminal coastal channel.
In ancient times the catchment crossed the huge cisterns for water reserve of a noble palace (Fig. 6) and the underground levels of the ancient city hall (Figs. 7, 8); before the large Genoa urban sprawl it was located very closed to the stream mouth.
The neighbourhoods crossed by the channel are the most important from an historical and architectural point of view. The end part of culvert is not sufficiently wide to drain maximum flow rate even in a 10-years return time; for this reason, recently, improvement measures of the culvert's hydraulic section have been realised.

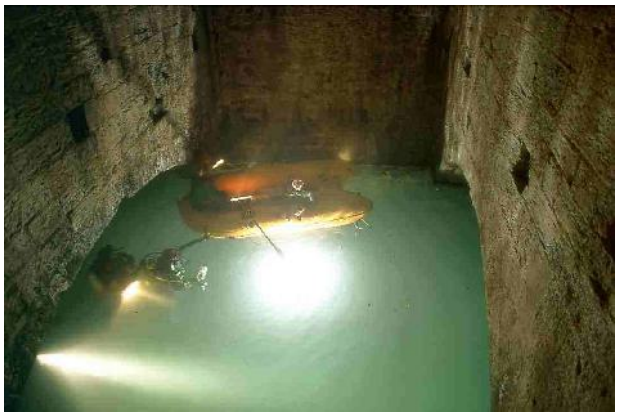

Figure 6: Exploration activity of a medieval cistern (1 million m^3) connected to Rio S. Anna (photo G. Bologna)

Figure 7: Flooded underground environment below Palazzo San Giorgio (photo C. Leoni)

Figure 8: Palazzo San Giorgio, built in the middle of 13th. In the 15th century it became headquarters of San Giorgio's bank, which took its name (photo R. Bixio)

3.3 Rio San Gerolamo ("St. Jerome Brook")

Nowadays the watercourse is totally culverted and flows under a complex urban fabric (no. 3 in Fig. 4). It passes below an important church built at the end of 12th century and flows under an historic local market.

Figure 9: The Albergo dei Poveri complex (photo R. Bixio)

Figure 10: The lower catchment of Rio Carbonara where the culvert joins the coastal channel (photo R. Bixio)

Currently, in the lower section, the stream is to the West diverted toward the confluence with the nearby Rio Carbonara brook. The channel that received the waters from original path is still functioning: it receives the waters from the overhead district.

3.4 Rio Carbonara ("Carbonara Brook")

The streams featuring the middle-eastern part of Genoa Old Amphitheatre join to form the Rio Carbonara (no. 4 in Fig. 4) which flows below the seventeenth century monumental complex called *Albergo dei Poveri,* an hospice for poor people (Fig. 9). In the middle catchment, the culvert shows a complex water works: there are several weirs, falls (up to 7 m difference in height), large empty rooms (up to 5 m in width and 7 m in height), overlapping channels, underground branches, with different architectural typology.

Inside this underground environment there are also evidences of typical archaeological buildings (Figs. 25, 26): e.g. ruins of iron grating from the vault located at the historical water path through the renaissance walls.

The last part of the stream presents a general reduction of the hydraulic section. Moreover near the confluence in the coastal final collector, there is a pillar inside the channel (Fig. 10).

Figure 11: The Commenda medieval complex built astride the Rio Sant'Ugo (photo R. Bixio)

Heavy rains during the autumn 2014 caused disastrous floods in Genoa metropolitan area: a sinkhole along the culvert, in the botanical garden, closed to *Albergo dei Poveri,* occurred, fortunately without damages for infrastructure and buildings.
The original culvert made with brick, rock stone and concrete has been rebuilt with reinforced concrete.

3.5 Rio Sant'Ugo ("St. Hugh Brook")
The watercourse crossed historic neighbourhoods (no. 5 in Fig. 4): in the lower catchment near the port area they date back to the Middle Ages.
The outlet in fact was placed in one of the oldest part of Genoese port area; nowadays it is directly channelled in a water purification plant.
It is interesting to highlight that the Rio Sant'Ugo flows below a medieval building - as in the case of the Rio S. Anna and Rio Carbonara - called *Commenda di San Giovanni di Pré* (a hospital for the pilgrims of the Crusades) intentionally built above the riverbed (Figs. 11, 12, 13).

3.6 Rio Lagaccio ("Pool Brook")
The stream flows trough municipalities mainly built during the last century (no. 6 in Fig. 4) and featured by a moderate historic and architectural value, except the famous sixteenth-century Prince Palace.
Rio Lagaccio is the only one in the Genoa old amphitheatre that features an upper catchment fairly defined and scarcely urbanized.
The lower part of the catchment shows a critical situation due to the low dip of culvert and a very complex arrangement of the underground environment: there are large foundation structures interfering with the regular water flow.

3.7 Rio San Teodoro ("St. Theodore Brook")
The stream flows trough neighbourhoods built during the last century (no. 7 in Fig. 4), featured by a moderate historic and architectural value, except religious buildings.

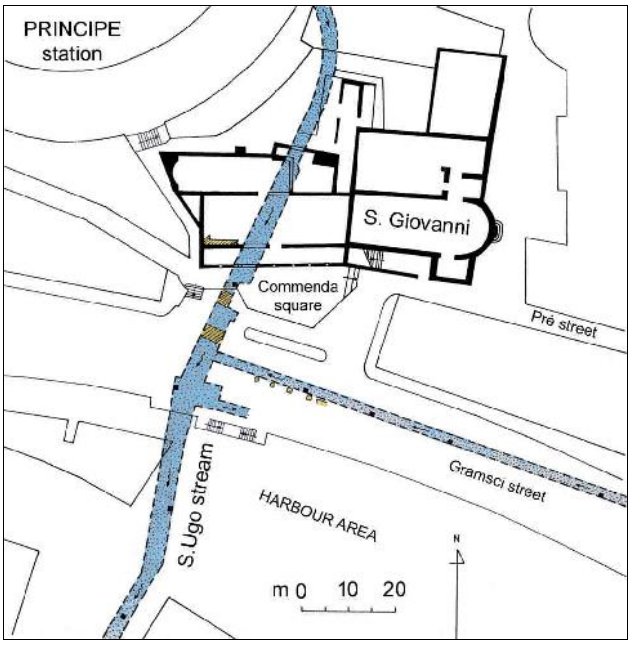

Figure 12: Plan of the Commenda complex (church, convent and hospital) and of the underground S. Ugo stream (drawing R. Bixio)

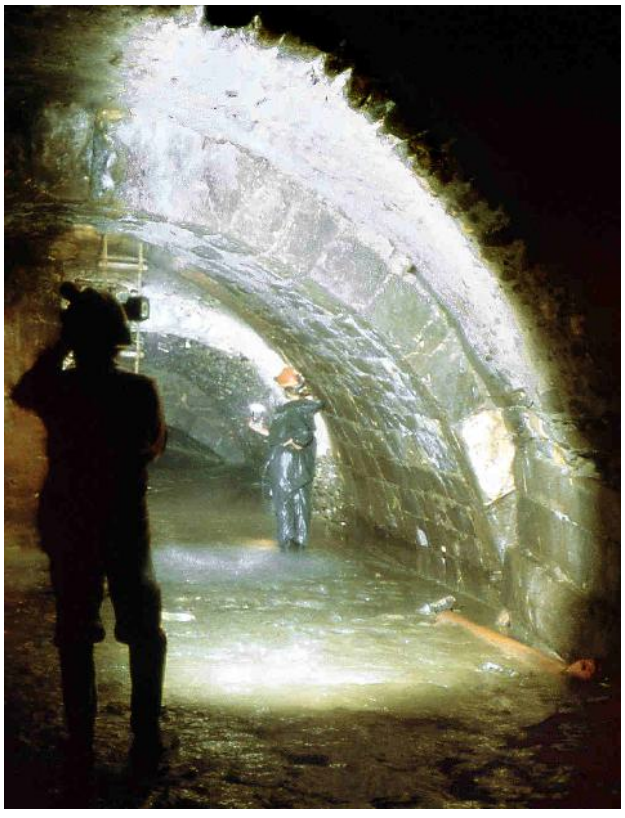

Figure 13: Rio Sant'Ugo. The arch of foundation of the Commenda is incorporated in the stream covering (photo M. Traverso)

The lower part of the channel shows a limited hydraulic section and a consequent flow-rate reduction with potential overflowing upstream.

3.8 Rio San Lazzaro ("St. Lazarus Brook")

The brook cross neighbourhoods built in the last century (no. 8 in Fig. 4), mainly after the Second World War period: they features a moderate historic and architectural value. A critical element is related to the first 50 m of the culvert after the confluence of watercourses in the main channel.

3.9 Rio San Bartolomeo ("St. Bartholomew Brook")

The brook is located in the western part of the morphological amphitheatre of Genoa historical city (no. 9 in Fig. 4). The brook is culverted and flows below a cemetery and toll booth highway. The culvert below the urban fabric crosses buildings made over the last two centuries of urban peripheral sprawl.

4. A CASE STUDY: RIO CARBONARA CHANNEL

Based on historical documents Rio Carbonara was mentioned with different denomination (Fiume or Fossato di Santa Sabina, Fiume di Santa Fede, Rivo Vastato, Fossato di Carbonara) until it assumed the current one: it derives from the ancient toponym of the place where several streams joined into the main stream [Bixio et al., 2015].

The stream flowed naturally in a riverbed at open air: it was culverted by the growing urbanization [De Negri et al., 1969].

The city of Genoa, which praised an history of 2,500 years, from the fifth to the seventeenth century provided a seven fortified walls, increasingly extended and adapted to the development of military technology [Forti, 1971]. Until the 11th century the Carbonara stream flowed in a not yet urbanized areas located at west of the old city enclosed within the 2nd fortified wall date from Carolingian period (Fig. 15).

The historical documents show this stream as Fiume o Fossato di Santa Sabina, named by the homonymous monastic complex built near the mouth and founded in 1008 by Benedictine Monks.

Figure 14: The Rio Carbonara culvert below Piazza della Nunziata. The flows continued below Via delle Fontane and directed toward sea (photo M. Traverso)

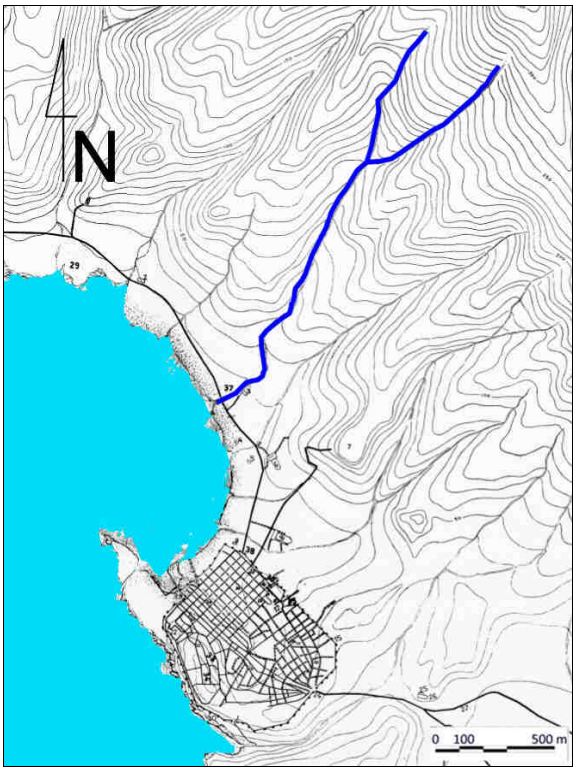

Figure 15: The Rio Carbonara stream network in the 11th century, totally natural (drawing T. Bonassi, S. Saj, base map: "Genova anno 1000" [after Barbieri, 1938])

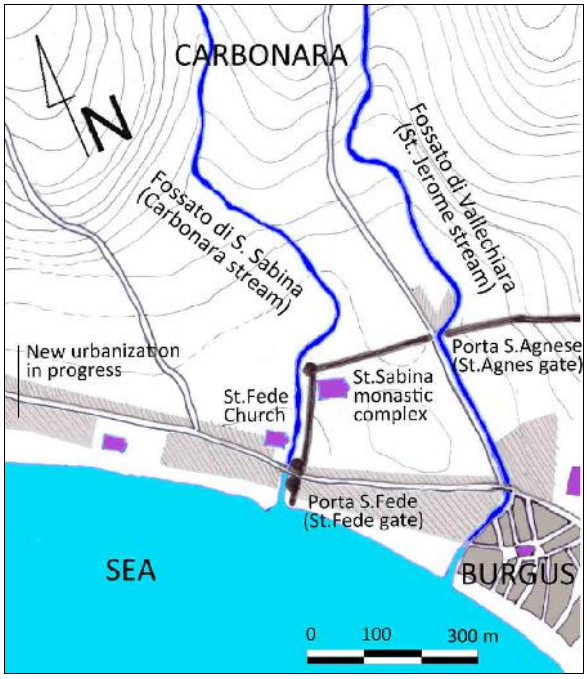

Figure 16: Lower part of Carbonara and San Gerolamo streams in the 12th century (drawing T. Bonassi, S. Saj, base map: "Tav. II – Crescita urbana nel secolo XII" [after Grossi Bianchi et al., 1971])

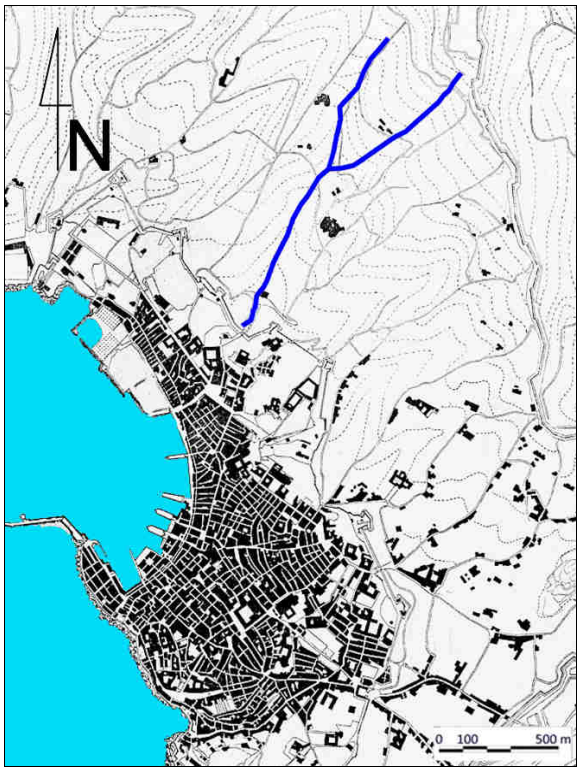

Figure 17: Rio Carbonara in the middle of 17th century, partly culverted in lower basin (drawing Bonassi, Saj, base map: "Genova anno 1656" [after Barbieri, 1938])

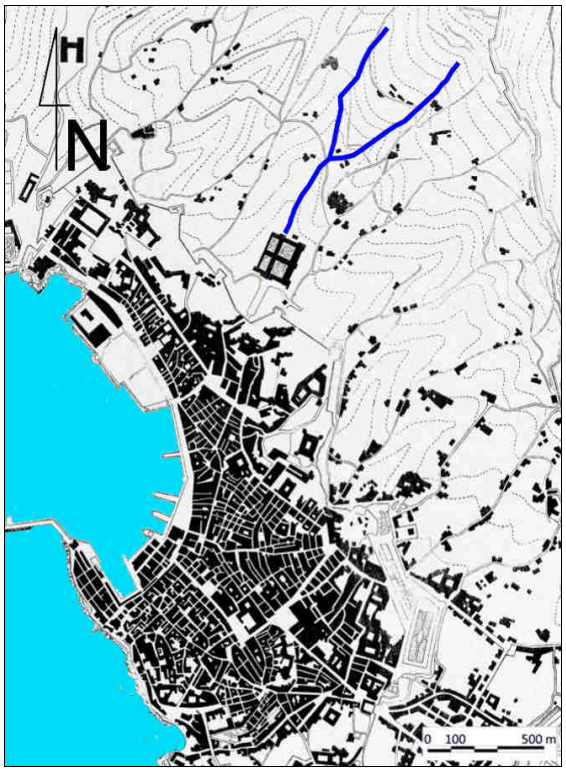

Figure 18: Rio Carbonara in the middle of 19th century extensively culverted (drawing T. Bonassi, S. Saj, base map: "Genova anno 1840" [after Barbieri, 1938])

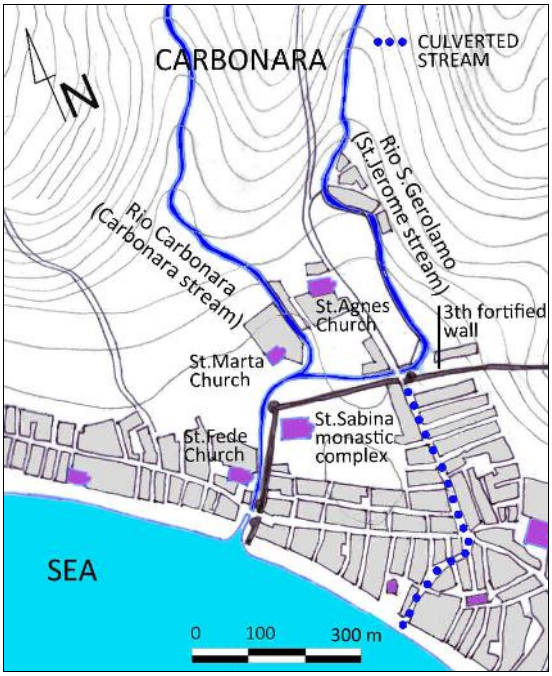

Figure 19: Lower part of Carbonara and San Gerolamo stream in the 13th century (drawing T. Bonassi, S. Saj, base map: "Tav. V – Crescita urbana nel secolo XIII" [after Grossi Bianchi et al., 1971])

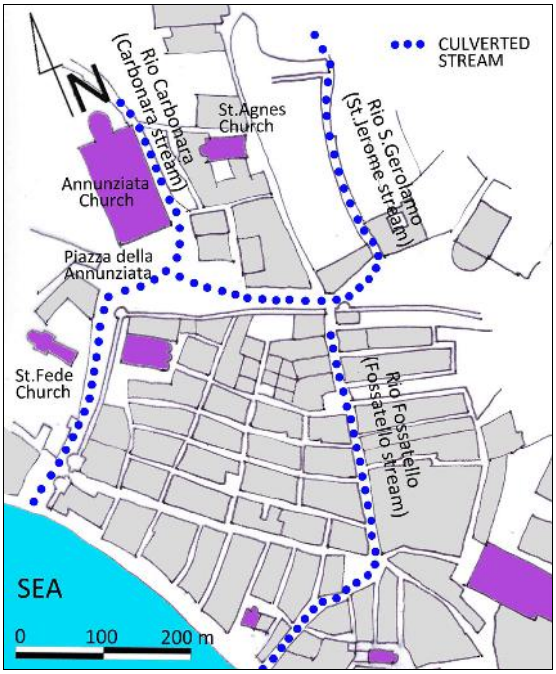

Figure 20: Lower part of Carbonara and San Gerolamo stream in the second part of 16th century totally culverted (drawing T. Bonassi, S. Saj, base map: "Tav. XVI – Tav. XVII" [after Grossi Bianchi et al., 1971])

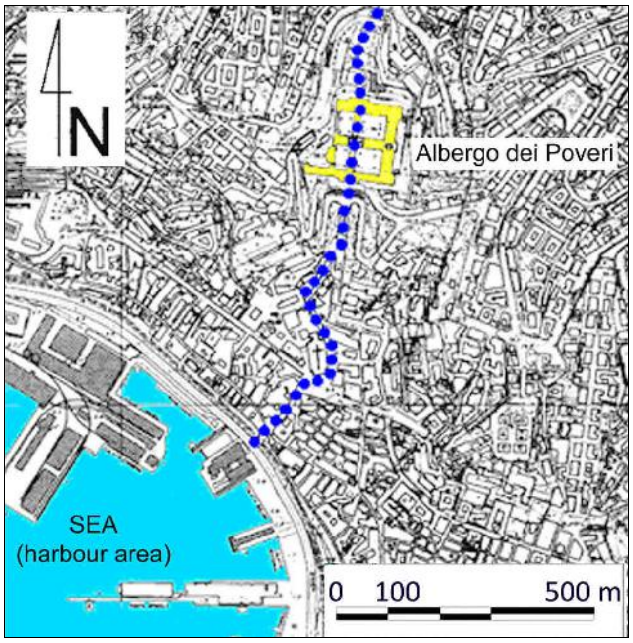

Figure 21: The current water path of Rio Carbonara, totally culverted (drawing T. Bonassi, S. Saj, base map: Technical Regional map at 1:5000 scale)

In the 12th century the Carbonara stream represented the western limit of the 3rd fortified wall (built between 1155 and 1163) and flowed in front of one of western entrances of the city [Quaini, 2005].
At that time even the San Gerolamo stream (until 19th century named Fossato Vallechiara) flowed at open air flowing through the city by a specific hole in the wall, named Porta di Sant'Agnese (Fig. 16).

In the 13th century its riverbed was diverted just at Porta di Sant'Agnese and joined with Carbonara stream (Fig. 19) according to the current pattern at Piazza della Nunziata [Grossi Bianchi et al., 1971].

In 1520 the construction of the large and important church of Annunziata began [Belloni, 1965] and in 1548 the Carbonara stream was culverted (Fig. 14). The riverbed crossed Piazza della Nunziata, in front of the church, and the San Gerolamo brook, which joined in the Carbonara channel (Fig. 20).
It was necessary to got areas for new infrastructures and urban transformation [Poleggi et al., 1981]: the medieval buildings gave way to modern and splendid architecture of the palaces. It was the historical moment of greatest power and prosperity of Genoese's families (Fig. 17).

A symbol of this wealth was certainly the construction of *Albergo dei Poveri* (Hotel of the Poor): a new hospital or refuge where accommodating the city's poor. The buildings works began in 1652 (Fig. 9).
Due to this building site, located across the valley of Carbonara stream, the watercourse was culverted to its mouth in the port area (Fig. 18).

Figure 22: The underground survey sometimes requires small rubber boats to cross deep pools which develop at the base of the dikes (photo C. Leoni)

An additional culvert of the watercourse was realized at the end of the 19th century: this was due to the hilly urban sprawl and to the upstream ring road construction, designed to subdivide the upper part of the city but closed to the downtown historical centre (Fig. 21).
In its underground path the Carbonara channel shows a stepped longitudinal profile in the upper and middle segment (Figs. 22, 23); the slope angle of the culvert decreases approaching to the mouth (Fig. 14).

In some sections the tunnel shows a significant size, as well as the water depth in the culvert; the exploration of these artificial cavities has required a specific equipment and skills (Fig. 22).
From an hydraulic engineering point of view, the great heterogeneity of channel size sections and mean slope angle are the main causes of hydraulic network insufficiency.
In the final segment there are several considerable criticality due to culvert inadequacy and expected maximum water discharge arising from the catchment [Bixio et al., 2006].

Figure 23: Weirs in the middle catchment of Rio Carbonara culvert (photo C. Leoni)

5. CULTURAL HERITAGE VS GEO-HAZARD

The progressive and often irrational development of urban fabric in Historic Amphitheatre Genoa city has caused an overall width reduction of the watercourses: they have been transformed over time into culverts [Rosso, 2014].

The transition from a natural riverbed to a culverted stream is at the origin of several hydraulic and structural engineering hazards: these are emphasized by changes in rainfall regime.

In the Middle Ages the hydraulic section of a culverted stream could be considered efficient to drain the maximum water flow by catchment: today it is not enough.

The current urban system is characterized by large sealing areas (roofs, parking areas and/or vehicular movement, pavements and paved roads) that bring to culverted brooks almost 100% of the precipitations [AA.VV., 2014]: heavy rainfalls become more intense in recent years [CIMA, 1999].

The buildings closed to or above the culverted brooks caused, in several cases, structural settlements and collapses of these historical artificial cavities: the culverts were built with improper materials related to current excessive loads. These disasters are often unexpected and not announced by any early warning system. They cause social costs and considerable traffic blocks.

Recent studies on rainfall history in Genoa urban area show an almost constant annual cumulate rainfall of 1300 mm / year in over two centuries.

The mean air temperature has increased (from 15° to 16°C) and the number of annual rainy days has decreased (from 100 to 80 days / year). The rainfall rate in Genoa city show an increasing value over 182 years ranging from 10

mm/day to 14 mm/day: the rains are definitively more intense [Faccini et al., 2015].
At the topographic surface and in underground environment these climate changes cause an increase of rapid water flows in undersized and obsolete culverts. By this way damages are caused to surrounding infrastructures and buildings, characterized also by historical and commercial heritage.
Due to the 2010, 2011, 2014 and 2015 catastrophic meteorological events in Genoa metropolitan area a direct survey of culverted streams was conducted [Trovatore et al., 2012; Onorato et al., 2015].
These researches joined a quick survey and a largest artefact collections from a geological, hydraulic and structural engineering point of view [Burlina et al. 2015]. By this way the public authorities have received an upgrade tools useful to manage the culverted streams for land planning and maintenance activities. The collected information are stored in a specific database that can be consulted and periodically updated.

The on-site study of the historical water-network carried out by urban speleologist teams with interdisciplinary skills, provides also basic and useful informations in other scientific fields: e.g. environmental history, buildings and built features, urban planning, archeology, urban speleology, ecology, entomology, etc.
The technical survey of these underground architectures can provide useful information on urban fabric development.
These artificial cavities represent a stock of ancient remains: without speleological scholars studies, they would be lost [Melli et al., 2006].

As an example some specific situations recorded during surveys carried out in culverted streams are listed: karstic phenomena that covered man-made landforms (Fig. 24);

Figure 24: Karstic concretions due to limestone flow solutions. The image shows also pisolites in the small pool, named also "cave pearls" (photo M. Traverso)

Figure 25: Underground environment belonged to Rio Carbonara, closed to the ancient fortified wall. On the back the red and white yardstick shows the iron grating remains hanged from the vault (photo C. Leoni)

Figure 26: Detail of the iron grating remains of Figure 21 (photo C. Leoni)

Figure 27: Nests of a colony of thousands of spiders has completely covered dozens square meters of walls by cobwebs silk (photo R. Bixio)

Figure 28: Detail of a marble aqueduct pipe surveyed along a tunnel in the Rio Fossatello, formerly Fossato Vallechiara or Rio San Gerolamo, before the works for the separation and deviation (photo R. Bixio)

Figure 29: Water pipeline in earthenware tile located in a tunnel of Rio San Gerolamo. These secondary pipelines of public aqueduct were realised by clay elements, wedge in each other and sealed with mortar (photo R. Bixio)

remains of an iron gate, located along the underpass of Carbonara brook with the Fifth ancient wall: this gap was realized to prevent the entry of persons in the city without check point (Figs. 25 and 26); favourable habitats to several animal life forms (Fig. 27); archaeological remains of ancient aqueduct built in Carrara marble (Fig. 28) and those made by clay pipes technique (Fig. 29).

6. CONCLUSIONS AND RESEARCH PROJECTS

The preliminary study of the culverted stream in Genoa historical center represents a further contribution to urban planning in a significant geo-hydrological complexity environment.

The comparison and overlapping between the underground stream networks and the ground surface is therefore necessary: a) to evaluate the precisely location and projection of channels; b) to analyze the environmental hazard; c) to detect which measures could contribute to the preservation of the landscape from a social and environmental point of view.

In fact these underground structures may also be assessed in the light of a cultural and tourist exploitation, even if only some portions of the culverted streams could be effectively feasible for a tourist purpose, for example through guided speleological tours.

For this reason it is mandatory to enhance other technical and scientific analysis and surveys in order to better evaluate the potential development and the structural stability conditions related to a possible risk increase.

The knowledge of the underground track of each culverted stream outflow under the urban fabric has a dual function: 1) guarantee a detailed map of buildings constructed over the centuries close to or even on the streams themselves, highlighting the potential hazard of flooding or sink-hole phenomena; 2) properly plan the layout of underground infrastructure or the provision of a building whose shape and development could constitute an obstacle to the historical water flow of culverted stream.

This aspect will also be an essential item regarding the development of the plans by the Basin Authority, in analogy with what has already been achieved in other regions or in other Ligurian basins.

It is therefore mandatory the involvement of experienced and scientifically qualified speleologists and professionals to gather information and measurements of fundamental importance both for the subsidence hazard assessment and risk mitigation and for the cultural development of the artificial cavities.

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Challenges and conflicts in preserving traditional underground water channels (*qanāt/kārīz*)

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Abstract
A particular type of underground artificial cavities is a traditional technique of extracting and transporting water in arid regions of North Africa and Asia generally known as *qanāt* or *kārīz*, or other local names. It is characterised by sophisticated (mainly empirical) knowhow, high labour demand on construction and maintenance, and demand on specialised traditional equipment. Such water networks – whether for irrigation or drinking – consist of underground canals leading water from the source (generally near a mountain) to the places of consumption, and are visually traceable through the rings of accumulated soil dug out from the aligned shafts between the mother-shaft and the outlet of the underground canal. It is worth mentioning, that such techniques were applied later in some underground Roman aqueducts in Central and Western Europe.

The scope of the present study regards recent "rediscovering" this technique and introducing it into the heritage discourse and tourism policy in several North African or Asian countries such as Algeria, Iran, PR China, and Oman. A major issue in these discourses is the alleged sustainability of this traditional technology when compared to other water capturing and transporting techniques, e.g. drilling wells or simple over-ground aqueducts.

The present study focuses on two claims. The first regards the alleged overlapping (if not identity) of the attributes "traditional" and "sustainable". Historical evidence (e.g. from the early experiences in Marrakech during the 12th century) on past and actual conflicts indicate that this technology – seen in a network of users – is not more or less sustainable than conventional well drilling. The second touches the issue of societal embedding. Sustainability in *modern using* of the traditional *qanāt* network can only be achieved under the condition of engaging local interests and enhancing public awareness for the traditional technology – e.g. in rehabilitating and/or exhibiting past constructions, such as in the museum projects in Yazd (Iran) and Turfan (China).

Keywords
Qanāt, underground water channels, China, Iran, sustainability.

1. INTRODUCTION

A traditional technique of extracting and transporting water in arid regions of North Africa and Asia – from Middle East up to East Asia – is generally known as *qanāt* or *kārīz/kārez* (or other local names such as *foggara* – local pronunciation of the Arabic word *fuqqārā* – in Algeria and Tunisia [English 1968)], *khaṭṭāra* in Morocco, *falaj* (pl. *aflaj*) in Oman, *kǎnérjǐng* in Mandarin/China). It is characterised by sophisticated (mainly empirical) knowhow, high labour demand on construction and maintenance, but low-tech demand on (traditional) equipment.

Such water networks – whether for irrigation or drinking – consist of underground canals leading water from the source (generally near a mountain) to the places of consumption, and are visually traceable through the rings of accumulated soil dug out from the aligned shafts between the mother-shaft and the outlet of the underground canal.

The present study focuses on current "rediscovering" this technique and introducing the issue into the heritage discourse and tourism policy in Xinjiang, Western China, by comparing it with similar issues in Iran.

In the case of Yazd (Iran) the existing underground channels which traverse the city have been made accessible to the public – albeit not in use. The rehabilitation project of the whole old town – including the technological requirements – has been focused on the traditional water-and-wind issue. In the case of Turfan (Xinjiang, Western China) two branches of the *kārez* network have been arranged as exhibition museums for the public in the outskirts of the oasis-town, while maintaining other branches in use.

In both cases, as well as in the mainstreaming discourses in other regions, such as Algeria or Oman [Schneier-Madanes & Courel 2010], the alleged sustainability of this traditional technology is a common issue when compared to other

water capturing and transporting techniques, e.g. drilling wells or simple over-ground aqueducts.

The present study argues that the alleged overlapping (if not identity) of the attributes "traditional" and "sustainable" is part of an official rhetoric the aim of which is to integrate the technique in the frame of national traditions and developments. Historical evidence, however, contradicts this assertion.

The present study argues that both technical and social sustainability of the technique are related to the issue of societal embedding. Sustainability in *modern using* of the traditional *qanāt* network can only be achieved under the condition of engaging local interests and enhancing public awareness for the traditional technology – e.g. in rehabilitating and/or exhibiting past constructions, such as in the museum projects in Yazd (Iran) and Turfan (China).

2. UDERGROUND WATER-EXTRACTION AND WATER-TRANSPORT CANALS: TRADITIONAL WATER MANAGEMENT IN ARID REGIONS

Talking about the traditional water management technique known in different regions between the Iberian Peninsula and China (and even beyond these limits) under the terms *qanāt, kārīz (kārez)* or *kǎnérjǐng* poses some terminology problems.

These problems begin already when attempting to describe the technique and to justify – or reject – the necessity of using a variety of terms related to the existence of the technique in several regions and cultural environments. In modern representations this technique comprises a mother well which guarantees the access to the water, and numerous vertical wells (shafts) to the underground tunnel canal which runs between the mother well and the final surface outlet. In most cases there is also a distribution network of several tunnel canals.

Functional descriptions of the technique tend to preconceive interpreting models of its historical development; therefore, such descriptions have given rise to controversies. Whereas most authors consider it as a network of underground water canals, Goblot [1979] stresses the relationship to mining activities. From a different point of view Th. Glick [1995] refers to *qanāt/kārīz* as a "filtration gallery", since ground water continuously filters into the canal [see also English, 1968].

The *motivation* – if not for the initial shaping, at least for the further development and application of the technique in irrigation networks – is based on the specific water demand of arid, dry regions with poor rainfall. The technique is characterised by constructing a sloping underground tunnel from or through the aquifer to a surface outlet.

Important *conditions* are (a) sustainable water source (e.g. neighbourhood to mountain with snow/water), and (b) impermeable ground layer(s) underneath the sloping tunnel. More detailed descriptions can be found in the special literature on the *qanāt/kārīz* technique [Goblot 1979, Semsar Yazdi & Labbaf Khaneiki 2010, Semsar Yazdi & Labbaf Khaneiki 2012].

For general considerations, like the issues summarised here, and for further orientation the works of English [1968], Glick [1970], Goblot [1979], Golab [1951], and Kortum [2004] are very informative. In the introduction of his treatise Goblot [1979] presents a critical comment of several approaches.

Characteristic *advantages* of the *qanāt/kārīz* technique are the following:

a) Water comes to surface by gravity flow; thus there is no need for elaborate or expensive water raising devices.
b) Water is trapped underground – not merely transferred – by the network.
c) Water losses by evaporation are strongly prevented or at least reduced.

Typical *qanāt/kārīz* landscapes are marked by rings of dug-out soil from shafts (vertical wells) along the underground tunnel. The shafts are dug every 20-70 (in some cases up to 150) m, and their depth is ca. 20-200 m, or even more; English [1968] mentions that the depth of the mother well at the village of Gunabad near Birjand in Iran is more than 300 m. The lines of rings on the earth surface mark the *qanāt* trajectory over 10-100 km between the mother shaft and the water outlet. At the exit of the canal there is generally a water distributor, followed eventually by metering weirs and a network of irrigation canals. Although some of the above characteristics are visible or traceable on the earth surface, the major parameters remain invisible. Thus, the construction of *qanāt/kārīz* depends strongly on mental or material representations of the *unseen* system (i.e. of the earth layers and the ground-water table).

3. TERMINOLOGY AND TRANSMISSION HYPOTHESES

The technical terminology regarding the underground water extraction and transportation studied in this paper varies in the various geographical regions in which this technique is encountered. The embedding of the linguistic perspective in the debates on presumed origin and ways of presumed technology transfer is discussed broadly in the literature [see Canavas, 2014, Castellani, 2001; Parise et al., 2015; Parise & Sammarco, 2015]. For the scope of the present study we should take into account the terms *qanāt* (pl. *qanawāt*) used in Syria, Egypt, Western Iran, Norman Sicily, Al-Andalus), as well the term *kārīz/kāhrez* used in Eastern Iran, Afghanistan, and in Western China (here in the form of the Uyghur term *karez or korag*), whereas in Western China the Mandarin term *kǎnérjǐng* is also used – at least in the documentation in Han Chinese.

The term *qanāt* was most probably transported through the Arab-Muslim expansion eastwards and westwards. The methodological question remains, however, open: does the linguistic basis imply *necessarily* technology transmission

paths, i.e. from Iran – through the correlated with the *terminological* background and the *functional representation* inherent in any approach? Regarding the areas considered in the present study, Iran and Xinjiang (Western China), two opposing approaches should be mentioned, those presented by H. Goblot [1979] and J. Needham [1971].

H. Goblot [1979: pp. 10-43] focuses on the mining tradition as "mother" technology. According to his approach, "the *qanāt/kārīz,* a mining installation or technique using galleries of cross-cuts to extract water from the depths of the earth…" can only have been initially developed in regions and societies with rich (underground) mining tradition and experience – eventually as a by-product of the attempt to follow the slope of the ore layer and to conceive an effective drainage of the water in the mine; both goals could be achieved by using *qanāt/kārīz* canals. In this sense the technique should be of Iranian origin, and should have been transmitted from the Iranian plateau both eastwards and westwards. According to some interpretations of extent archaeological evidence [e.g. Neely, 1974; Braun, 1974] *qanāt* systems could have been first used in Iran in Pre-Achaemenid times. The Iranian-origin hypothesis has been contested recently by al-Tikriti [2002] on the basis of archaeological finds in the Arabian peninsula – this debate, however, does not affect the Iran-China comparison.

Focusing on the affinity to water extraction (snow water; ground water table) and water transport technologies via underground canals, J. Needham [1971] considers independent development in several hydraulic civilizations as possible. Moreover, the construction of immense water canals since the Han dynasty (e.g. a canal mentioned to have been built in 150 BCE), and the references to long-distance water transport in the historical sources render early imperial China a favourite candidate for the earliest *qanāt/kārīz* realizations. The author considers the underground water transport as the main *qanāt/kārīz* feature, and argues on the basis of the functional similarity between a subterranean canal which is often constructed in order to circumvent a mountain, and the Iranian *qanāt/kārīz* constructions. Recurring to the Han dynasty has become a mainstreaming issue in dating *qanāt/kārīz* in today Chinese discourse, as it is depicted in the Turfan exhibitions. This issue will be discussed later in this study.

4. UNDERGROUND WATER TECHNOLOGY IN DIFFERENT REGIONS AND CULTURES: IRAN AND WESTERN CHINA (XINJIANG)

Similarities on a functional level, however, may lead to erroneous conclusions if they are considered with no reference to the societal and historical conditions under which the specific aquatic technique was realized. A comparison of the societal embedding of *qanāt/kārīz* networks in different environments is indispensable, if the question of preservation or sustainability of the aquatic networks in the specific environment has to be tackled. In the following the cases of the Iranian highlands and pre-modern Xinjiang will be considered in respect with the societal conditions of building and preserving the *qanāt/kārīz* networks.

Ethnographic studies on still functioning *qanāt/kārīz* systems in the Iranian highlands provide us with invaluable information on the traditional forms of work organization. These organization models correspond to extent historical evidence, and, therefore, can be with some confidence projected back to the pre-modern past. The *qanāt/kārīz/kāhrez* systems are still built and repaired by the *muqannīs* – specialists whose knowledge passes from father to son.

The organization of repairing and maintenance of the *qanāt/kārīz* network was one of the traditional functions of the (central or local) ruler. Braun [1974] describes several activities relevant to profession groups involved in the designing and constructing *qanāt/kārīz* networks in the Iranian highlands, e.g. the water-finder, the diggers etc.

Similar ethnological material is also documented by English [1968] [see also Lambton, 1978, especially for historical evidence, and Schneier-Madanes/Courel, 2010]. In a recent workshop on *qanāt/kārīz* held in November 2015 in Yazd the author of the present study had the opportunity to attend a session in which five Iranian *muqannīs* reported extensively from their experiences. Oral presentations by practitioners go far beyond written documentations [Semsar Yazdi & Labbaf Khaneiki 2010, Semsar Yazdi 2010].

The provenance of the *qanāt/kārīz* networks in Xinjiang, Northwest China, has been assessed differently by scholars, and is integrated into diverging narratives [Hu et al., 2014]. The assumption of an early Uyghur (i.e. Turkic) development – perhaps under Iranian influence across the Silk Road, as proposed e.g. by Kortum [2004] – would imply a local water administration regime.
In the issue of Han Chinese influence the role of the imperial or the provincial government would appears more dominant. The extent *qanāt/kārīz* networks were presumably constructed during the Qing dynasty, i.e. after 1644 CE.

5. CONDITIONS OF PRESERVATION

Qanāt/kārīz networks are not only hard and complicated to dig; they also demand for a great effort to preserve them – e.g. to keep the numerous wells and canals free from sand. All these human actions or reactions are based, of course, on the assumption that the know-how is preserved in the society of the given region. The various factors which determine the capability of the *qanāt/kārīz* technique to survive through the history in a given region can be summarized as follows:

a) Capability of the technique to be adapted to the changing social, political and environmental conditions (*adaptability*).

b) Specific *vulnerability* of the technique, i.e. sensitivity towards loss of know-how (interruption in the transmission of experience), failure of maintenance, environmental changes, or hostile human impact (e.g. intentional destruction during war).
c) Persistence and efficacy of know-how transmission through generations.

The determinants of assessing the above factors depend on the modalities through which the management of the technology is embedded in the local societal system (e.g. the societal agreement on distributing work load and costs for construction and maintenance). Therefore different local organization forms may result to a high or low vulnerability of the *qanāt/kārīz/kǎnérjǐng* technology with corresponding impact on its efficiency.

In the following the above issues will be discussed by comparing the recent developments and the actual situation of preserving the *qanāt/kārīz/kǎnérjǐng* aquatic systems in modern Iran and in Xinjiang, Western China.

6. PRESERVATION OF THE *QANĀT/KĀRĪZ* (*KĀHREZ*) NETWORKS AND TOURISM POLICY IN IRAN

Qanāt/*kārīz* (*kāhrez*) networks were used in the past for the largest part of irrigation in agriculture in the Iranian highlands. According to Beazley & Harverson [1982] and Kortum [2004], in the 1960s ca. 60% of the systematically irrigated land for agriculture use depended upon 22,000 *qanāt*/*kārīz* (*kāhrez*) segments, with a total length of ca. 275,000 km. Based on older references, English [1968] estimated the number of water-carrying *qanawāt* towards 37,500, from which 21,000 were fully operated whereas 16,500 needed repair; according to English, the estimated total length should exceed 160,000 km. *Qanāt*/*kārīz* systems were (and are still) a major contributor of the water supply of Teheran. *Qanāt*/*kārīz* systems were also indispensable for the water-intensive sugar production – not only in irrigation of sugar beet, but also for sugar processing in the plant operations. Kāhrizak is the emblematic name of a *qanāt* village near Teheran, where such a sugar plant was run using *qanāt* water [Kortum, 2004]. Although the intensive exploitation of *qanāt* water at Kāhrizak diminished considerably till the end of the 1970s, the traditional water technology still remained a challenge.

Ownership regimes – a crucial factor for preservation arrangements in the *qanāt*/*kārīz* networks – vary considerably. As Kortum [2004] points out, ownership of a *qanāt*/*kārīz* system is generally not identical with ownership of land. Joint ownership schemes are often established; maintenance is then also considered as a joint duty; in many cases religious institutions (*waqf*) are involved in the ownership and maintenance. As already mentioned, maintenance of *qanāt*/*kārīz* (*kāhrez*) was considered in the past as one of the traditional functions and duties of the local ruler.

Modern conditions of urban life and rural economy introduce new threats for the traditional *qanāt/kārīz* technology. Motor-driven wells, surface water reservoirs and dams cause lower ground-water horizons; under this influence, as Kortum [2004] remarks, *qanāt/kārīz* (*kāhrez*) networks increasingly get out of use.

The re-assessment of the *qanāt/kārīz* based traditional water technology in Iran gained impetus and institutional representation at the end of the 1990s. The International Centre of Qanāts and Historic Hydraulic Structures in Yazd is a symbol of and a leading institution in this development. The new impetus led to the foundation of the Yazd Water Museum in 2000 (www.agnic.org/mtg/2000/qanat). Conference and workshop activities on the *qanāt/kārīz* technology (a recent one was held in November 2015) underline the increasing academic, political, and public interest. International training courses on preserving traditional knowhow on *qanāt*/*kārīz* technology and water management are also organized in Yazd (http://iconf.org).

Extensive projects on rehabilitation of the traditional urban infrastructure and architecture of Yazd are still ongoing (2016). A major topic is the still existing traditional network of underground channels which traverse the city. Parts of this network have been made accessible to the public – albeit not in real function. In the major national Yazd Water Museum as well as in further (partially private) exhibitions the traditional urban water management on the basis of the *qanāt*/*kārīz* technology is demonstrated. The dominant Iranian *qanāt/kārīz* discourse and the ongoing preservation projects consider the *qanāt/kārīz* networks as sustainable ancient systems for exploitation of underground water and as major representative examples (if not the most important ones) of traditional Iranian technology [Koocheki, 1996].

7. REVIVAL OF *KĀREZ*/*KǍNÉRJǏNG* AND TOURISM POLICY IN XINJIANG (WESTERN CHINA)

An interesting example of politically and socially motivated changes in the adaptability of the *kārez* technique is the case of the installations in the Turfan basin, Xinjiang province. A real revival of the *kārez* technique in Xinjiang set on with a movement of *kārez* (re)construction in the 1950s-1960s. The motivation and the organisational basis (e.g. arrangements with the potential users for participating at the reactivation and maintenance of the *kārez* system) were provided by the local communist authorities [Golab, 1951]. 60 years later the *kārez* water is not considered as the main source for irrigation and water supply in the Turfan region and the province any more. The interest has shifted from the role of survival technology in the 1950s to a factor of political influence and prestige in the relations between the (autonomous) provincial and the central government.

According to data from the documentation in the two *kārez* museums in Turfan, including additions and adjustments

based on data provided by the local authorities for heritage preservation in August 2011, the Xinjiang *kārez* system today has a length of 5272 km (312 km open channel length). The diminishing interest for *kārez* water in the last years and the changes in respect with labor cost, alternative water resources, as well as in respect with the power of the local authorities in comparison to the first years after the proclamation of the People's Republic are determinant factors of the negative trend in the use of *kārez*. In 2003 there were 614 water-carrying *kārez* systems out of a total of 1190 *kārez* systems in Turfan; in 2011 only 432 of them were still in function. Nevertheless, a large part of Turfan's water supply (ca. 30%) still depends on underground *kārez* – a significant fact for this city exposed to extremely high temperatures, especially during the summer.

The increasing touristic significance of the *kārez* technique and its preservation has been documented in several occasions. On the provincial level, the Xinjiang authorities promoted and supported the presentation of the traditional technique in a *kārez* museum located in extant *kārez* segments in Turfan (Turfan Karez Paradise).
The museum was launched in 1992 with an investment by the Xinjiang Karez Research Association. Some years later, in 2000, a second *kārez* museum opened its gates, Karez Folk Custom Garden, with more pronounced event and commercial character.
Both exhibitions stress the strong linkage between society and the specific traditional water technology. In both Museums the attention and the involvement of the Central Government in the integration of the traditional technology into the political programs is demonstrated by documents (photographs, signed agreements, etc.) of visits to the Turfan *kārez* museums attended by several members of the Central Government. This engagement demonstrates how the *kārez* issue becomes a part of the strategic balance between Central and Provincial Government regarding the major issue of ethnic minority nationalities in the PR China.
The increasing touristic significance of the Turfan *kārez* was accompanied by an increasing political awareness. On September 29th 2006 the "Ordinance of the Karez Protection in Xinjiang Uyghur Autonomous Region" was released by the Standing Committee of the Tenth National People's Congress of Xinjiang Uyghur Autonomous Region. The Chinese text uses the term *kǎnérjǐng*, the English translation uses the (transliterated) Uygur term *karez*. The ordinance took effect on December 1st 2006; it sets the *kārez* networks in Xinjiang under the protection of the Water Administration Department of the Province, the Xinjiang Uyghur Autonomous Region.
By means of the Protection Ordinance the provincial authorities recognise the status of the *kārez* wells as key regional monuments, formulate technical guidelines to prevent *kārez* water source from exhausting, and claim a "protecting" role in local policy by adjusting specific symbolic parameters in the relations to the Uyghur ethnic group in the PR China. A key issue in this policy balance is the dominant discourse concerning the harmonious link between the traditional water-management technique (*kārez*) preserved by an ethnic minority, and the major irrigation networks of East, Han-dominated China.

As we have indicated above, this link obtains its scientific legitimization through the technology diffusion model claimed by the highly estimated scholar J. Needham [1971], but it is also compatible with a model suggesting the autonomous development or at least the maintenance of the *kārez* network by the local populations.

The abundant information in both exhibitions is an important element in representing the dominant discourse, in demonstrating political interest, as well as in stimulating public awareness and motivating public interest towards a traditional technology which links local history with national preoccupations and global sustainability potentials. The *kārez/kǎnérjǐng* tradition – associated with its preservation by the local minority nationality – was thus raised on the level of national heritage which deserves to be protected and preserved – beyond efficiency assessments or economic indications.

8. *QANĀT/KĀRĪZ/KĀREZ* AND THE NARRATIVE OF SUSTAINABILITY

The major argument in the national discourses on *kārez* in Xinjiang and *kārīz* in Iran is an alleged overlapping (if not identity) of the attributes "traditional" and "sustainable". The argument follows the reasoning that the traditional water management systems just trap flowing water without intervening in the global water balance. However, the validity of this reasoning depends on the limit line of the water system considered. Already in earlier times we have reports of conflicts because of the impact of excessive water trapping through *qanāt*/*kārīz* systems, e.g. in Marrakech during the Almoravid dynasty (11th-12th century), where the enlargement of the local *qanāt* system of Marrakech deprived the lower regions from large water flow-rates.

9. CONCLUSIONS

Construction and maintenance of the *qanāt/kārez* network presuppose a more or less large degree of collective participation – primarily on the material-organizational, but also on the symbolical level; thus, they become eminently societal and political issues, and that is how they get inscribed into public awareness.

In the modern Iranian discourse *qanāt*/*kārīz* (*kāhrez*) canals represent a pre-modern elaborate, large-scale water-extraction and irrigation technique.
In the modern Chinese discourse the narrative on the origin touches not only scientific questions, but is also politically connoted.

Whether the technology is linked to the Han Chinese hydraulic tradition, or entirely affiliated to the Iranian/Turkic subterranean canal experience (i.e. a

technology imbedded in the Uyghur ethnic minority group) becomes thus an issue in the politics of balance among the Han majority and the minority ethnic groups.

In both cases, the *qanāt/kārez* technique has become a political issue in regional and national networks of power relations. Moreover, its association with the challenging sustainability narrative, provides arguments beyond efficiency-orientated modernization narratives.

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Background history on the presence of an underground snow-house in Potenza Picena (Marche, Italy)

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Abstract
This work aims to present traces of a hypogeum structure used to store snow in Potenza Picena's historical centre. All documents were collected during extensive research based on the reporting of the existence of such an underground snow-house. The construction of this structure was made in 1872, by the municipality of Potenza Picena, a town located in the lower valley of the Potenza river. Eighteenth and Nineteenth century cadastral sources, municipal resolution records, and administrative correspondence kept at the historical archives of the town, have all provided the trail that lead to the unfolding of the various stages of planning and utilization of this underground snow-house.

Keywords
Snow-house, historical archives, Potenza Picena, Italy.

1. INTRODUCTION

Fascinating examples of hydraulic engineering, snow-houses are the foremost symbol of an obsolete economy that had to cope with the natural process of ice melting. Snow-houses were built to decelerate the melting process in order to ensure the conservation of ice for longer periods of time, providing the benefit of food preservation and for various therapeutic purposes.
Snow-houses consisted either of simple holes dug into the ground or of larger rooms built partially or totally underground. Since the eighteenth century, the growing diffusion of snow-houses was accompanied by a careful use of dedicated technical and design features which offered increased heat insulation [Aterini 2007].
In the territory of Potenza Picena, the presence of such structures was witnessed as early as 1765, a year in which a snow-house appeared in the Federici land registry [*Catasto* 1765].

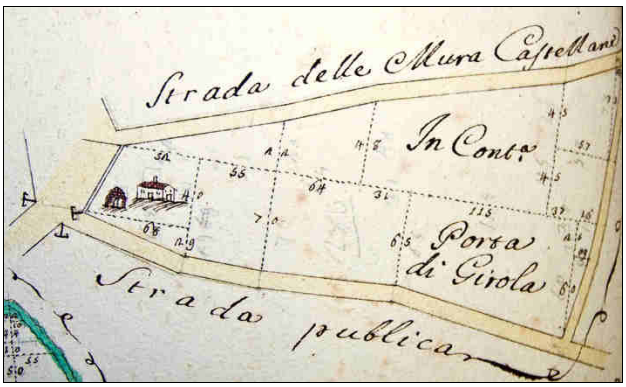

Figure 1: Detail of the Eighteenth-century land cadastre kept at the Municipal Historical Archives of Potenza Picena (hereinafter referred to as "MHAPP")

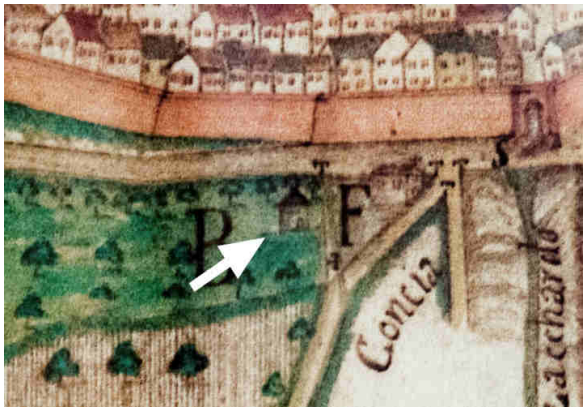

Figure 2: Detail of the 1765 cadastre signed by the surveyor Giuseppe Federici. There's a possibility that the snow-house served the nearby Civic Hospital, established in 1737 by Monsignor Alessandro Buonaccorsi (1663-1737) (MHAPP)

This building was located in "Contrada Porta di Girola" and was listed among Earl Roberto Carradori's possessions (Fig. 1).
A further indication of a snow-house can be found in a cadastre of the land assets owned by the Buonaccorsi family in Monte Santo (Monte Santo is the old name of Potenza Picena). In this case the snow-house was located in the southern side of town, in the area formerly called "Contrada della Retta" (Figure 2).
Both snow-houses stood partially above ground and they shared a circular plan with a small atrium through which one could access the compartment where the snow was accumulated. Located outside the city walls, their presence is traced to the 1818 land cadastre, particularly in the particles 484 and 550 of the map of Monte Santo's city centre (Figure 3).

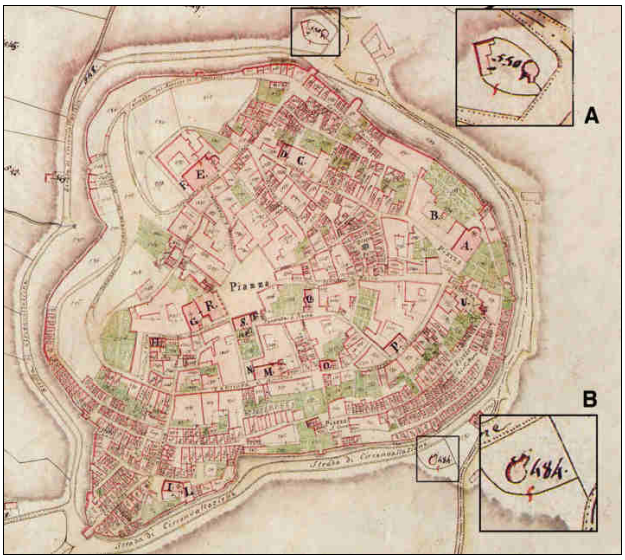

Figure 3: Map of Monte Santo drawn in 1818 by engineer Girolamo Lambertini. This plan highlights the snow-houses owned by the Carradori (A) and the Buonaccorsi (B) families (MHAPP)

The last years of the nineteenth century saw the rise of the city's need for a snow-house. The demand was very high, so the request was examined and various proposals were evaluated.

A research conducted mainly at the MHAPP has brought to light a significant number of documents related to this structure. The consultation of these sources allowed us to get to know in depth the proposed solutions and the related projects and reports. Furthermore, the municipal resolutions collected between the second half of the Nineteenth century and the early decades of the Twentieth century, unveiled details and events which led to the construction of this snow-house and its subsequent use and maintenance.

2. PROJECTS FOR A SNOW-HOUSE

During the second half of the nineteenth century, the need and demand for a snow-house was increasing, the city council of Potenza Picena declared its willingness to realize this project on November 12th, 1872. The acceptance of the construction was approved unanimously by the Council and especially by the members of the "arte salutare". Through a warning given by the president of the Health Commission on May 9th, 1872, those members had invited the citizens to pay more attention to the "*healthiness of food, housing and public spaces*" as an essential duty to ensure an improvement in public health.

Mr. Giuseppe Pierandrei (1836-1921), municipal engineer of Potenza Picena, was appointed to identify a suitable location and to make an estimate of the budget needed.

Mr. Pierandrei, in order to gather insights for the realization of this project, made contact with engineer Gustavo Bevilacqua (1830-1906) from Ancona - to whom Pierandrei submitted a first draft in 1873.

At a later stage Pierandrei began an exchange of letters with engineer Pompeo Marini from Turin, asking him for indications in building the most suitable structure for the community's needs. Mr. Marini, in his response dated February 17th, 1879, described in detail all the features needed in order to build an inexpensive snow-house (Figure 4).

His proposal consisted in digging a truncated cone well (with a circular plan) layered with dry-stone walls. The roof would be conical and would be made of straw bundles leaning on a chestnut wood structure.

However, this proposal showed problems related to the fragility of the surface coverage, which required constant maintenance. Furthermore, the structure was standing partially above-ground but this represented a disadvantage.

The snow-houses built entirely underground - although more expensive - would surely guarantee better thermal insulating properties.

Marini's proposal was followed by the one of engineer Bevilacqua dated February 9th, 1886 (Figure 5). Mr. Bevilacqua's significant experience in the construction field led him to look for the weak points of the standard underground snow-houses. Particularly, he paid great attention in avoiding to ensure the ice preservation solely on the airtightness of the structure's closure.

This method, although being used on the majority of the province's snow-houses, was ineffective. Most of the stored ice tended to melt quickly and the little leftover barely reached the summer season when it was needed most. Evidence of the above is found on Bevilacqua's report in which he states that many owners, after building a snow-house with the above characteristics, decided to discontinue their use. Therefore, in order to prevent as much as possible the melting of the snow, he suggested to set up a ventilation system.

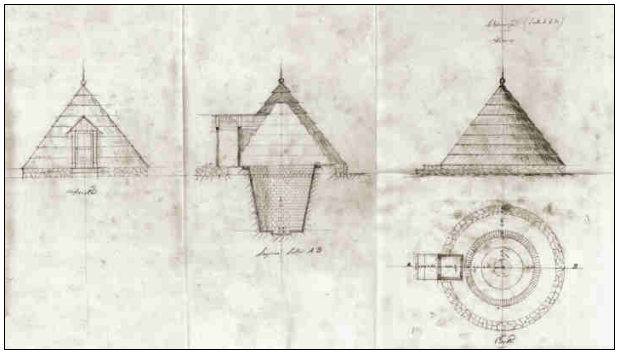

Figure 4: Snow-house drawn by engineer Pompeo Marini. This sketch was attached to Marini's letter dated February 17th, 1879. Although with some variations, there are interesting similarities with an already known Eighteenth-century model [Griselini, Fassadoni 1770]. This type also remains in subsequent periods as the "economic model" to be imitated (MHAPP, *Ufficio Tecnico*, n°16).

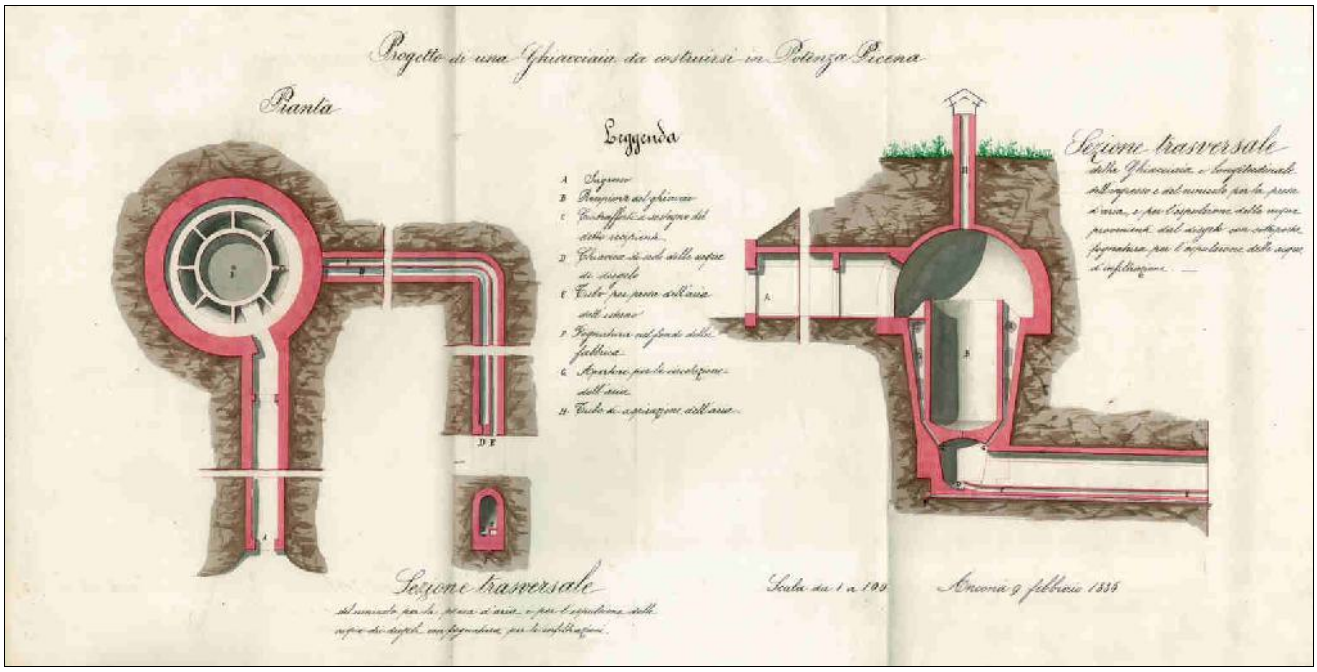

Figure 5: Underground snow-house project dated February 9th, 1872 drawn by engineer Gustavo Bevilacqua (MHAPP, *Ufficio Tecnico*, n°16)

His proposal was to install an air outlet on the North face of the building. Once in the outlet, an air shaft would convey the airflow under and around the container in which the ice was preserved. A suction pipe installed at the top of vault would let the airflow out to prevent condensation. That of condensation was a serious issue because if not appropriately treated, it could lead to an ever faster melting rate. Unfortunately, Bevilacqua's proposal was rejected due of its high construction cost.

The estimate of 4000 lire was way too high for the available budget. However, Bevilacqua's suggestions were partially taken into account by Pierandrei in his project dated August 8th, 1887 (Figure 6).

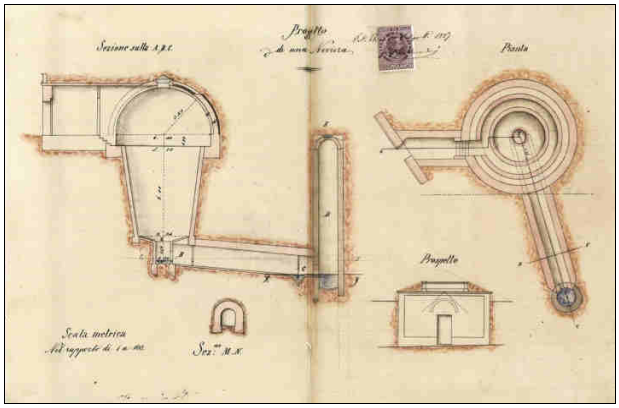

Figure 6: Underground snow-house project submitted by municipal engineer Giuseppe Pierandrei and dated August 8th, 1887 (MHAPP, *Ufficio Tecnico*, n°16)

In a report attached to his project, Pierandrei indicates as appropriate location for the underground snow-house the "orchard by the market" of San Francis' convent. As a matter of fact, this area seemed more suitable than others due to its limited sun exposure and its dry soil.

The demolition of the building next to the orchard would facilitate the transportation and the subsequent input of snow into the snow-house along Via Castelfidardo, formerly known as Via Bufalari.

Another area taken into consideration was that of "Fonte della Cava". It seemed perfect at first sight, but after being examined, was discarded due to its landslide terrain. Obviously, the lack of firmness of the soil could undermine the stability of the entire structure.

The underground snow-house would have been shaped as an inverted truncated cone, measuring 6,80 m in depth with a diameter of 5 m on the top and 3,34 m at the base.

The top part would have been closed by a 3,20 m radius dome. Around the ice container, a 70 cm wide aisle would be used to store food and drinks and to preserve meat from the summer season's heat.

The underground snow-house could store up to 80 000 kg of snow. In order to mitigate the melting process, the center of the vault would be provided with a vent to allow the ejection of the condensation.

The meltwater would be collected in a small well positioned centrally at the base of the structure and through a pipe would be drained to the existing well of the convent's orchard.

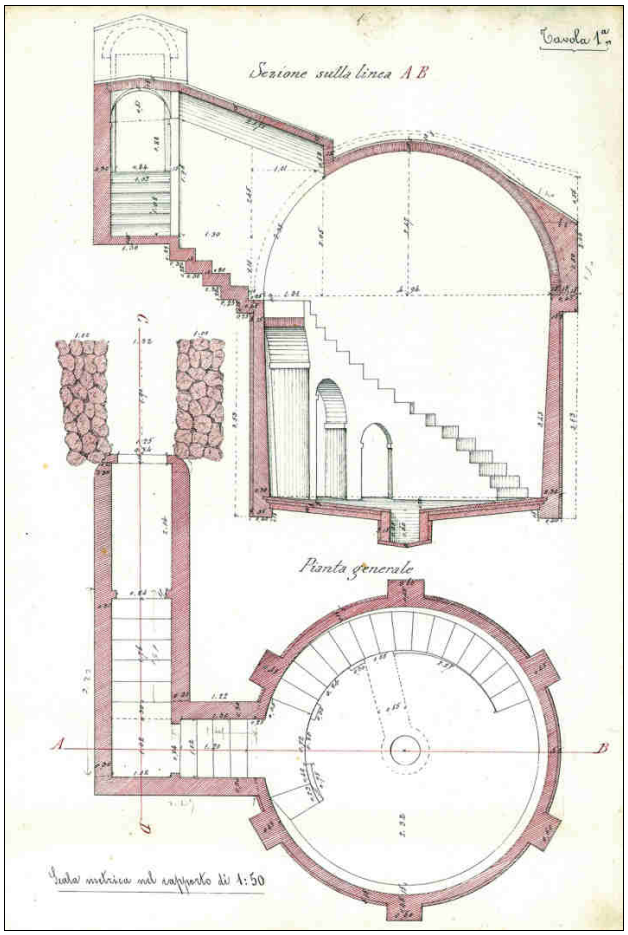

Figure 7: Plan and sections of an underground snow-house. Anonymous project of the nineteenth century (MHAPP, *Ufficio Tecnico*, n°16)

An additional proposal, although anonymous and devoid of information about its features, was that of a circular underground snow-house, with a diameter of 4,94 m and a height of 6 m. The access corridor would stretch to a ninety degree angle leading to a staircase leaning against the arcaded walls of the ice room. The stairway would descend to the bottom of the structure. The cockpit and the conduit for the wastewater would be located in the center of the structure (Figure 7).

3. A MODEST SNOW REPOSITORY

The municipality of Potenza Picena could not afford the building of an underground snow-house made according to modern techniques and standards; therefore, it was obliged to build a small and inexpensive repository.

The underground snow-house had also become a priority, especially for therapeutical reasons. With the resolution dated October 6th, 1892, the city council commissioned the technical department to do the preliminaries for the procurement of the construction work.

The budget assigned was 2000 lire of which 1500 was in cash, and the remaining 500 in materials derived from the building demolished to broaden Piazzale Garibaldi. On December 13th, 1892 the procurement for the construction of the underground snow-house was assigned to Potenza Picena's based company Giuseppe Clementoni.

The project was partially inspired by the 1887 proposal and foresaw the building of an underground repository with a circular plan.

The lower diameter would be 4,20 m and the higher one 4,50 m, on top of which a 30 cm thick dome would be leaning. The height of the structure, from the bottom of the drain sump to the center of the vault, was 8.30 m (Figure 8).

This underground snow-house had a capacity of 80 m^3 and the responsibility for its filling was the warden of the roadhouse.

He would throw the snow in the conical chamber through a funnel and a manhole placed on top of the dome. The meltwater would be collected through a pipe in a small well centrally positioned at the base of the structure.

Access to the underground snow-house was possible through a door positioned at the North face of the building. A 3 m long and 1 m wide sloping hallway lead to a second door which needed to limit the air flow coming from outside. The site where the underground snow-house was built corresponds to the area assigned, in 1923, to the hosting of the Rimembranze garden and where the "Fontanelle" park stands nowadays.

On February 11th, 1895 the snow was sold at a price of 0,18 lire per kilo, and 10 kg was the minimum purchase quantity. That same year, on September 11th, the minimum was halved and the price reduced to 9 cents per kilo. In case of illness, the poorest would pay only 5 cents per kilo.

In the following years, no particular events were registered except for those referring to the purchase of ice by the City Council. On May 10th, 1897 the City Council approved the purchase of a 100 kg of artificial ice, on an experimental basis. The artificial ice was bought at Giuseppe Nicolini's factory in Ancona for 7,80 lire.

A further indication is dated July 6th, 1907, in the register of municipal resolutions regarding the ice supply destined to the poorest patients during the summer season.

With that act, a 50 lire budget was assigned to Nicolini's factory "*with the usual terms and conditions*". This lead us to assume that purchasing the ice supply from third-parties was practiced on a regular basis back then.

The new facilities for artificial ice production ensured a purer product, avoiding the disadvantages of the traditional underground snow-houses. These new facilities entered a fast growing market, and their convenient deals easily met the needs of Municipalities and Charity Congregations. The growing demand for artificial ice created an inevitable decline of snow-houses which, if not affected by a sad and progressive abandonment, were subject to structural changes so that they could serve uses different from the original ones.

Such was the fate of this underground snow-house that, starting from October 1910, was used as garbage deposit. As a matter of fact, in that same year, the city council approved the cost estimate for the opening of a passage

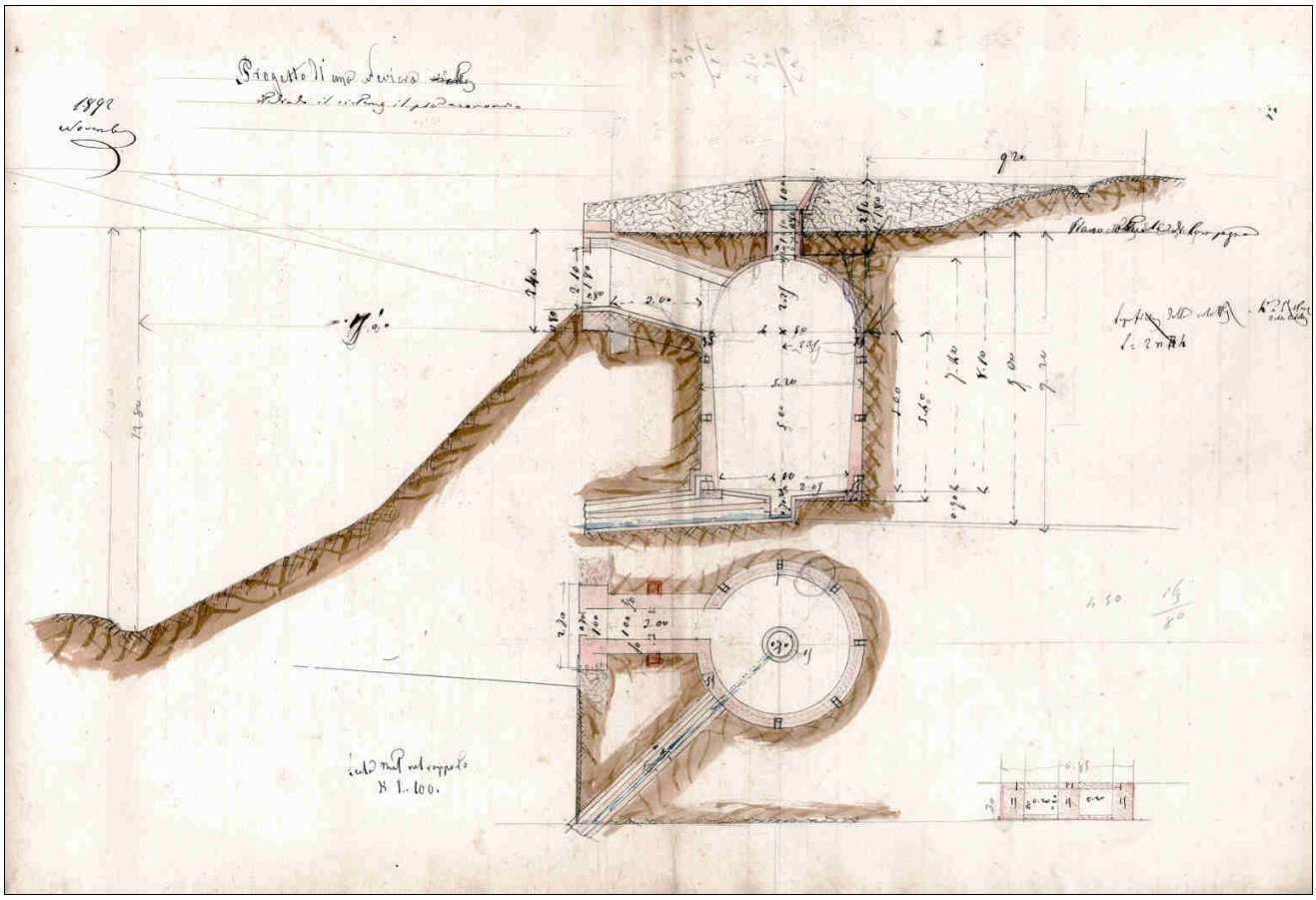

Figure 8: Project of the underground snow-house built in Potenza Picena in 1893 (MHAPP, *Ufficio Tecnico*, n°16)

through the town walls which would allow the garbage to be conveyed into the former snow-house.

The "lack of interest" of the Municipality in the underground snow-house was obvious as the structure was actually offered to a private citizen as a laboratory.

The buyer refused the offer and the property remained Municipality owned, and in 1923, readapted the underground snow-house into a garbage deposit (in the latter years the garbage was left outside the city walls). In fact, in the Resolution of December 14th, 1923 the underground snow-house is referred to as "an ancient cistern" in the Parco delle Rimembranze area (Figure 9). While building this park, the manhole used to let the snow in was closed. In subsequent years, the memory of this place slowly faded, recurring from time to time depending on someone's need or remembrance. As a matter of fact, on January 21st, 1944, some citizens requested the authorization to use the underground snow-house as a refuge from enemy attacks, also proposing to readapt it at their expense.

A further reference to this underground snow-house is found in the vernacular work of Severino Donati (1915-1982) [Donati 2006], who, recalling his past use compares its size to the size of a cave located in its neighborhood, in

Figure 9: "Parco delle Rimembranze", Carlo Balelli, 1931. This picture shows the area where the underground snow-house was located (Macerata's Mozzi-Borgetti Public Library, *B.C.MC BAL.* 53.106)

a sector of the city where there are references and evidences of underground structures.

Besides the presence of tunnels used for protective purposes during the Second World War, in this zone occurs particularly often the toponym "Cava" (quarry): "Contrada della Cava", "Fosso della Cava", "Porta del Cunicolo o

della Cava" and "Fonte della Cava"; the origin of this term would be attributed – according to Cenerelli Campana – to former mining activities [Cenerelli Campana 1852].
Although the text of the historian Cenerelli Campana does not mention if the quarry type was open air or in a tunnel, the tradition has always supported the existence of a "gallery" in this area. This hypothesis does not seem to be unfounded. As a metter of fact, during this research, documents from the first half of the last century with explicit reference to a "quarry gallery" and to inspection operations carried out by municipal technicians to its interiors have emerged.

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All images appear courtesy of the municipality of Potenza Picena and of Macerata's Mozzi-Borgetti Public Library.

A study of an Underground Medieval Water Distribution Network and other structures in a Spanish town

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Abstract
This paper presents the results of exploration, survey and analysis of an ancient water distribution system in a small city in eastern Spain. This network has to be considered in the context of other types of infrastructures with related functions, as qanats and aqueducts.

It has some special characteristics that make it of special interest. The first is its medieval origin, linked with the water supply to an old palace. The water is distributed via an underground gallery network that feeds cisterns under city houses. Today a total of one km of tunnels and up to 15 cisterns are accessible, but the total size of the network was probably much greater. The system is an exceptional example of how, in the past, the basic need of fresh water was satisfied in an unusual way. The system was in use until 1955.

In addition to this system, other underground structures with different purposes have been identified and studied.

Keywords
Water distribution, underground cistern, medieval tunnel, Spain.

1. INTRODUCTION

Valencia Region, in eastern Spain, is a Mediterranean climate region, with dry and hot summers, mild but dry winters and two rain seasons in spring and autumn, with a total rain amount of about only 600 mm per year in the area of the city here studied.

Water has been always a priority in all human populations in the region, and the knowhow of water distribution, control and use has reached traditionally a remarkable level. The use of underground cisterns for rain water is frequent in the region, receiving their after an Arab term as "aljibes" or "aljubs". Nevertheless, these cisterns are present before the Arab period, as some of them are dated in the 4th century BC, or even before [Egea, 2010; Llanos, 2010]. Close to the area of study, in the remains of the Iberic settlement of Covalta (Albaida), one of the cisterns is 23 m long, and also in the area, the Great Cistern in the Iberic city of Castellar de Meca (Ayora) has a capacity of 132 m3, carved in the bedrock. These structures are exceptional testimonies of community management of natural resources.

This kind of structures were in use during Roman times, and some Classic authors, as Appian [Appian, The Spanish Wars, 54], mentions its presence in cities in the Iberic Peninsula, as Intercatia:

> *Finally when a mound was completed so that they could batter the enemy's walls, they knocked down a section and rushed into the city, but they were speedily overpowered. Being compelled to retreat and being unacquainted with the ground, they fell into a reservoir where many perished.*

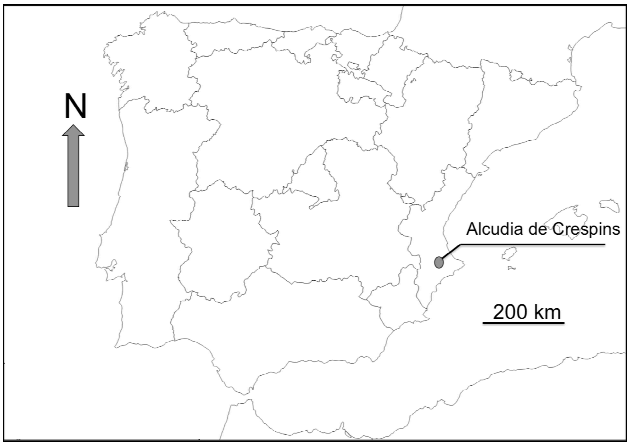

Figure 1: Location of Alcudia de Crespins (A. Carrión)

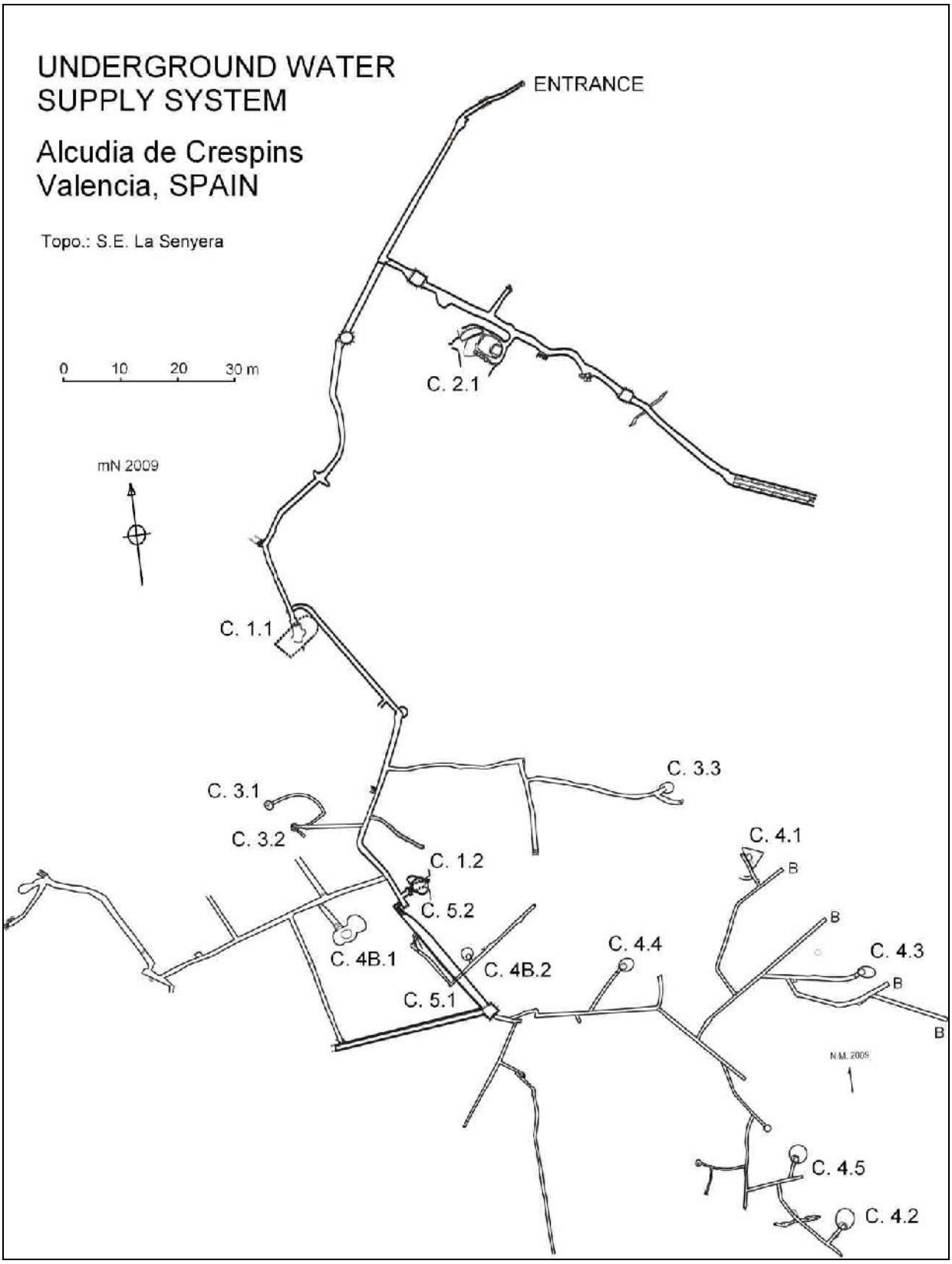

Figure 2: General plan of the network with indication of the cisterns [Carrion and Fornes, 2016]

During the Roman period (in this region approximately 150 BC to 450 AD), important water infrastructures were constructed, and relevant aqueducts can be found in Tarragona, Chelva, Albarracín and other places (Leather 2002). These aqueducts include not only the well-known image of arches crossing a valley, but also tunnels, hundreds of meters long.

In the Arab period (from 700 AD to 1250 AD) the use of water for agriculture reached high level not only in infrastructures (probably based on Roman schemes) but also in water management, as is proved by the existence of the "Water Court of the Plain of Valencia", better known by its shortened name of "Water Court", the oldest existing justice institution in Europe, dating from the X/XI century, and still active [Prytherch, 2009].

Water mining activities started probably in this period, as Arabs imported to the dry regions of Spain the construction of "qanats" or water mines, long underground galleries to capture water springs [Juncà Ubierna, 1998].

With this historical background, the idea of water underground storage and conduction has been easily incorporated into daily life, and where geological characteristics and water availability allow, we can find interesting examples of these water infrastructures.

Other aspect also present in the Mediterranean facade of Spain, and in many other countries of the Mediterranean basin, is that of cave settlements and artificial caves used for different domestic or industrial services (cellars, deposits, etc.). While in Alcudia there are not cave settlements, certainly there can be found, under the city houses, a relevant number of manmade caves, used with different purposes. In this paper some of these will be described.

A last element included in our research, but not in this paper, is an industrial tunnel, dating in the change of 19th – 20th centuries, that deviates water from Los Santos River to move a turbine placed in an underground camera under a paper industry.

2. THE CITY OF ALCUDIA DE CRESPINS

Alcudia de Crespins, in eastern Spain (Fig. 1), with 5000 inhabitants, lies in the Cañoles River Valley. Near to the city, the spring of "Los Santos" is one of the most important in the region, supplying water to villages of the area. This spring forms a river named Los Santos River, tributary of Cañoles River.

The town is over a low hill of travertine, easy to dig. These materials were deposited in a lake area formed by an important travertine structure, probably dated to the Medium Pleistocene [IGME, 1976; Garay, 2015].

3. THE UNDERGROUND WATER SUPPLY SYSTEM

Since the XIV century existed in the center of the village a the Lord's Palace. In a moment that cannot be precisely determined, due to lack of documents, a branch of the channel that takes water from Los Santos spring, was constructed. This branch consists in a tunnel of about 130 m, ending in an underground cistern. The cistern was under the Lord's Palace to serve its water requierements. Today the Palace has disappeared, and Constitution Plaza (the main city square) occupies its location, but channel and cistern are still there, five meters under the surface. The tunnel was excavated from an older one, not related to the water supply system, as it is about two meters over the level of the supply, probably a communication gallery.

After this first channel, the network of water supply tunnels started to grow. Three meters before arriving to the cistern, in the right side of the tunnel a new gallery starts, forming a 90º angle and drawing a curve around the cistern (thus proving that is more recent than the cistern).

From here, new branches of the network were excavated to provide water to other neighbors' houses and to a well of public use. In Figure 2 the plan of the network is shown. Under many houses, a cistern was excavated. The public well consists in a cistern with double well, likely to host some type of water wheel.

The general structure of the network consists in a main tunnel traversing the village and lateral tunnels feeding the houses' cisterns. Better than a net, the general shape is like a tree.

4. THE GALLERIES

The galleries were excavated using methods inherited from Romans and Arabs. Using Roman terminology and following Vitruvio [VIII, 7], tunnels have regularly spaced wells, named *putei* that had a triple purpose: they allow excavating simultaneously from these wells; they also had a ventilation function; and they served for material extraction purposes during the excavation process.

In our network these *putei* can be found in different places of the network, but they are not so frequent as should be according to Vitruvio's recommendations, due to the fact that cisterns also serve for this purpose. In any case, at least six wells were found.

Tunnels section varies frequently, but the typical is 0.60 m wide and 1.80 m high. Depth of circulating water was about 30 cm, as it can be noted from the waterproofing cover of tunnel walls. In figures 3 and 4, remains of this waterproofing material can be seen in the lower part of the section. In some places depth could had been greater, especially in the gallery cistern, where water seems to fill almost completely the tunnel, creating a reservoir, before reaching a level that permit the water to continue to other parts of the network.

Total length of the network is 1010 m, corresponding to the galleries that can be visited. Twenty-eight galleries are closed by masonry, rubble work or rubble, meaning that the true length of the network is certainly greater. The gradient of the network galleries is about 1.5/2 per thousand.

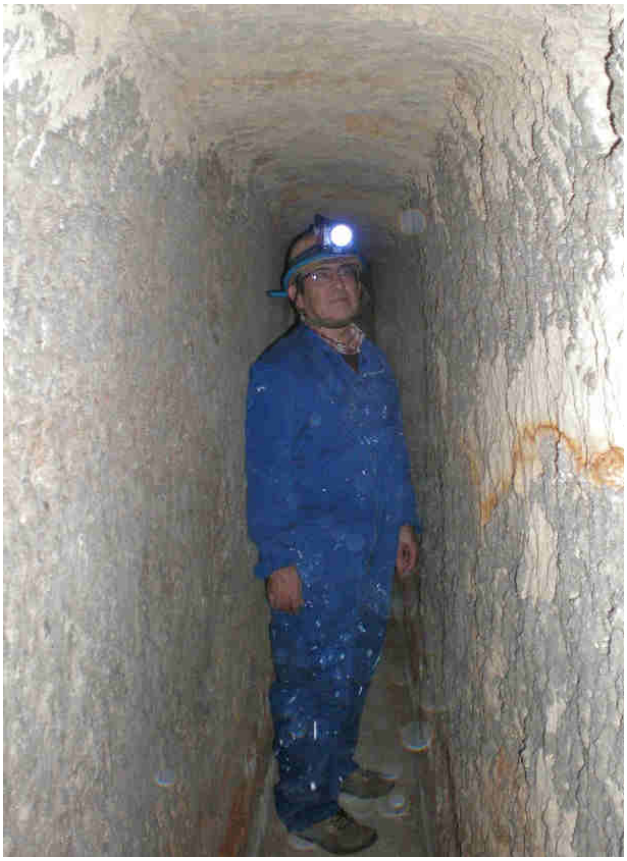

Figure 3: View of a main gallery section (photo A. Carrión)

Figure 4: View of a secondary gallery section (photo A. Fornes)

One of those closed galleries was also the exit of the network to the open air, essential in the operation procedure of the system.

There are an important number of light points excavated in walls and suitable for putting an oil lamp or similar. Figures 3 and 4 show some of these light points in the upper right corner.

5. THE CISTERNS

Fifteen cisterns were identified and studied, with approximate capacity ranging from 3.6 to 67 m^3 of the Palace cistern and 75 m^3 in the gallery cistern. Figure 5 shows the distribution of the cisterns' capacity.

The total capacity registered in these 15 cisterns is 269 m^3. Almost half of this capacity corresponds to only two of the cisterns (Palace Cisterns and Gallery Cistern). The old public well cistern had capacity of 30 m^3.

Beside these three special cases, the rest of the cisterns correspond to domestic reservoirs for private use, with capacities ranging from 3.6 m^3 to 17 m^3, with a mean of 8 m^3.

Generally cisterns have a sub-circular plan of 2.5 m diameter, a deep of 1.5 m and a well to extract water almost in the center of the ceiling. Relevant exceptions to this general shape are:

- Cistern 1.1, (Palace Cistern). It has a rectangular plant with one end rounded. Its dimensions of 8 x 3 m plant and 4 m deep show its relevance.
- Cistern 1.2 (city public well). Plant is round, but it has greater dimensions than regular cisterns. Its main characteristic is its double well, with similar structure to those wells with a type of chain water wheel called "*noria de cangilones*", in which the double well serves one for the descent of the water recipients and the other for the ascent (Fig. 7).
- Cistern 5.1 (Gallery Cistern). Two are the peculiarities of this cistern. The first one is that the same gallery of the tunnel has reservoir functions. The second one is that is the only part of the galleries that is below the general level of the water flow. The walls of the galleries are waterproofed, usually about 30 to 50 cm-high, but in the gallery cistern waterproofing is up to the ceiling. It is difficult to understand the role of this cistern in the network, and it seems to be relatively modern. Graffiti at the entrance of this section warns about the fact that the gallery can be completely inundated.

Figure 6 shows different cisterns: a typical domestic cistern (4.2), plus two of the non-standard ones (1.1 and 1.2).

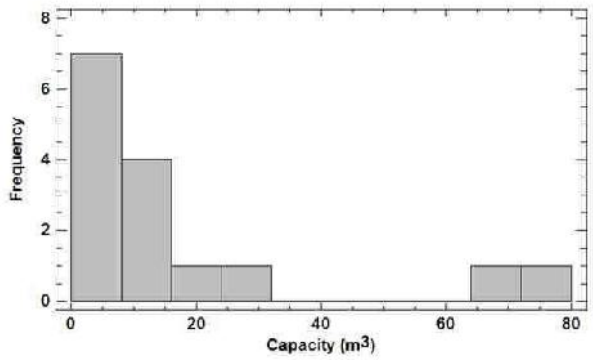

Figure 5: Distribution of cisterns' capacities (author A. Carrión)

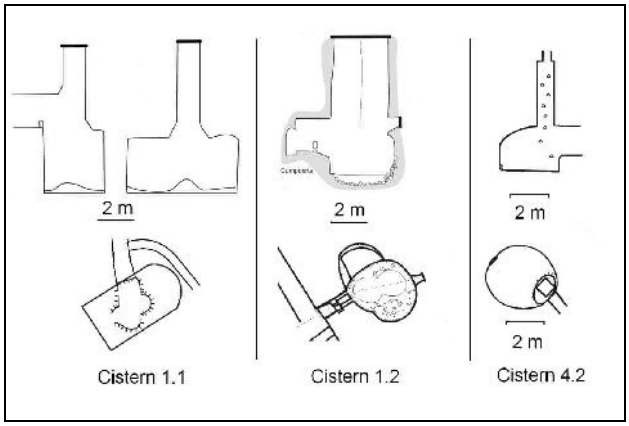

Figure 6: Cistern types in Alcudia [Carrion and Fornes, 2016]

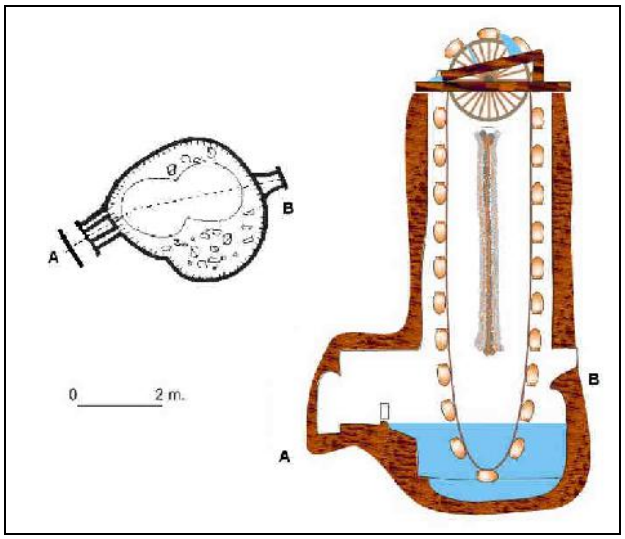

Figure 7: Hypothetical reconstruction of the chain water wheel in cistern 1.2 (author V. Benedito)

Figure 8: Eight shaped section of cistern 1.2 (photo A. Fornes)

Figures 7 and 8 show the hypothetical reconstruction of the chain water wheel in the cistern of the public well, and an aspect of this well. A ceramic piece found in the cistern may be part of one of the recipients.

While today only fifteen cisterns are accessible, the network includes other cisterns.

At least 28 galleries are closed and eventually each one communicates with a cistern, or maybe more.

Some of them are partially isolated from the main galleries, closing the passage with masonry, but leaving an entrance for the water feeding the cistern. This entrance usually consists of a ceramic tube, and corresponds to ancient structures, compatible with the use of the tunnel network as water supply system.

In some cases closures completely block the passage, and indicate the end of the function of the corresponding part of the network. Some are clearly related to changes in the streets of the city, as is the case of closures marked with B in Figure 10, related to the construction of a new avenue: Closures are aligned and made with the same type of masonry. In other cases the property of the house over the cistern closes the access tunnel when cistern became out of use, instead of simply closing the well as was the case in the accessible cisterns.

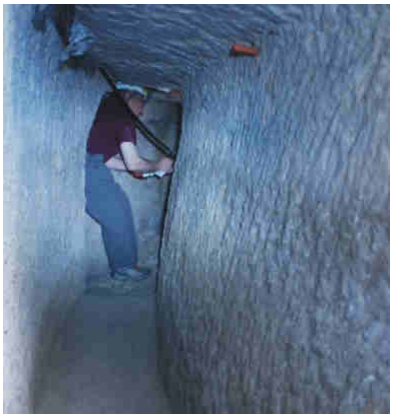

Figure 9: Cave under 6, Iglesia Street (photo A. Sisternas)

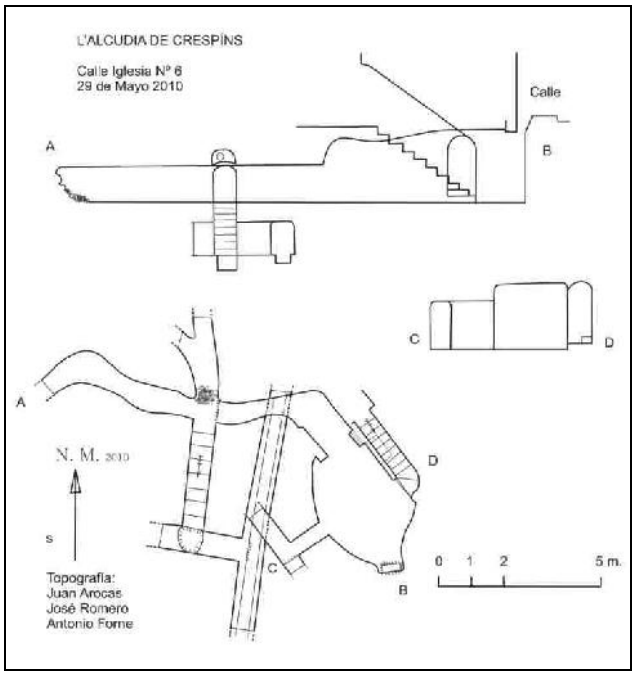

Figure 10: Cave under 6, Iglesia Street (author A. Fornes)

Figure 11: Entrance of the grape juice into the cave (photo A. Fornes)

Considering these non accessible cisterns, a conservative estimation of the total capacity of cisterns in the network increases from 269 m^3 (only accessible cisterns) to about 500 m^3, considering that all these hidden cisterns are of domestic size.

6. ARTIFICIAL CAVES UNDER CITY HOUSES

Single or multiple cave settlements is a reality in the Valencia Region and in other regions in the Spanish Mediterranean. Cities like Requena and Bocairent have a historic downtown with a relevant number of caves, almost as an unavoidable part of old houses. Warehouses, wine

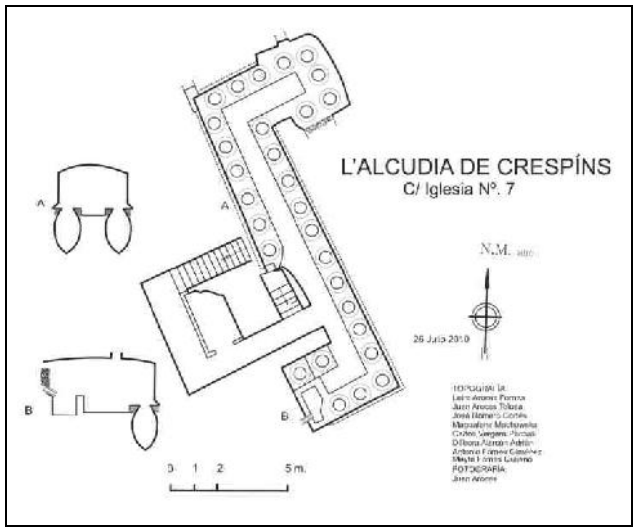

Figure 12: Cave under 7, Iglesia Street (author A. Fornes)

cellars, stables and mangers for animals, reservoirs for oil, grain and even snow, are among the more frequent use of this type of artificial caves. A secondary use of some of these caves has been to serve as refuge in troubled times.

In other cases, as in Paterna, Rojales and in general every town where geologic conditions have allowed, home caves are a characteristic (and sometimes dominant) element of the urban landscape.

Climatic conditions and low construction cost are probably in the basis of the relevance of cave homes in the East and South-East of Spain.

In the city under study, Alcudia, we find some good examples the first above-mentioned type: caves under city houses, usually with economic use. All the caves considered are under the old part of the city, and the presence in some of them of captured galleries, remarks the age of the phenomenon.

Caves as those in 14 - Iglesia Street or 5 Constitución Square, were used as warehouses for different materials and agricultural equipment. The cave under the Police Station is linked to one of the cisterns mentioned above in this paper, the public well cistern. More complicated is the case of the cave under 6 Iglesia Street, which includes a warehouse area and some galleries, some of them clearly captured by the excavation (and in consequence older).

Special mention requires the cave under 7 Iglesia Street, a real industrial facility for producing and storing wine. We find even a natural cave captured by the excavation of an artificial cave, and then used as cellar.

Not all the houses in the area were visited, so probably there are many others; nevertheless, an interesting sample of what lies under the streets has been investigated. We will describe in the following three representative examples.

Figure 13: Reservoirs in Cave under 7, Iglesia Street (photo A. Fornes)

6.1 Cave under 6, Iglesia Street

From the main room in the ground floor on the house, we access to the cave (Fig. 9). A stair descends forming a 90º angle, and leading to the widest area of the cave (about 3m x 2,50 m x 1,80 m). In the upper south wall, a small window (B in Fig. 10) gives some natural light to the house. In the central part of this space, a gallery connects the main cave with a tunnel (parallel to the cave), closed with masonry in both ends (C in Fig. 10).

From the northern side of the main cave, a wide passage communicates with an irregular gallery oriented to the east, ending in a crossroad. A second stair allows to arrive to the level of the water distribution system. Both ends of this section are closed with masonry, impeding the connection with the network.

Back in the crossroad, we find in the northern side a gallery re-used to connect a pipe, ending only two meters ahead. In this same place, but looking east, an irregular gallery, closed five meters ahead, is probably the oldest part of the cave, captured during the works related with water distribution system. This cave has a length of 35 m and a depth of 4 m under the street level.

6.2 Cave under 7, Iglesia Street.

This is maybe the more interesting of the caves studied under the city houses. Is formed by a long room (2,5 m x 15 m), with a second room at its end of 5 long. The roof, slightly arched, is 2 m high.

On the southern side, we find a container for receiving the grape juice, coming to the cave by a pipe from the surface, where the grapes were crushed (see Figs. 11 and 12).

The cave contains today 29 ceramic reservoirs (160 cm depth, 75 cm diameter), completely buried except its upper part.

Reservoirs are ordered in both sides of the cave, leaving a central passage for filling, empting and maintaining the wine deposits (Fig. 13). Three small windows in the ceiling, closed with masonry, originally illuminate the cave.

6.3 Cave under 14, Iglesia Street.

This cave is a typical domestic warehouse. It includes the place for the ceramic containers (for oil, wine or other products), and space adequate to preserve products as potatoes, onions, etc. Very similar caves were located under the Medieval Downtown of Bocairent.

From the ground floor, a stair allows to access the cave. The stair has an irregular structure, as if it was looking to find the cave. It is formed by a single room of 5m x 4m, 1.80 m high, with a space for five ceramic containers. On the eastern side a light point communicates with the street (Fig. 14).

The cave was modified when the present house was built, and the original entrance was on the northern side.

7. CONCLUSIONS AND FINAL COMMENTS

To our knowledge, this supply system extended to a relevant number of houses in a village is unique in Spain. In other Mediterranean, as Italy there relevant examples of structures for water storage and transport, to some point parallel with our case (Parise et al., 2012) . The system has provided fresh water to the citizens during centuries, and became obsolete when a modern drinking water distribution system was established. Its memory has been at risk of disappearing, and young generations were not aware of it until these researches.

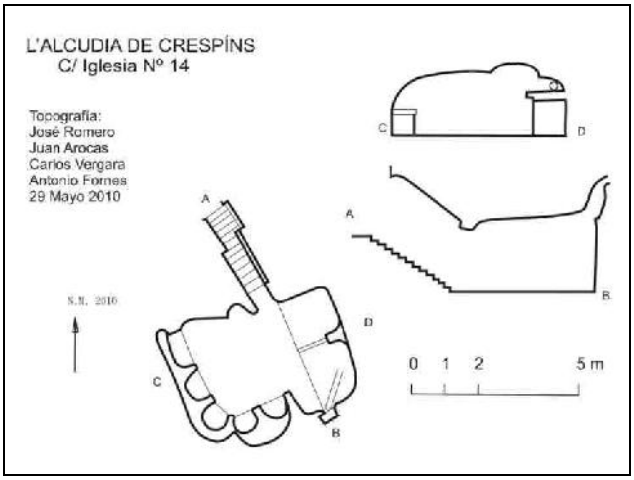

Figure 14: Cave under 14, Iglesia Street (author A. Fornes)

Caves and cellars under the houses are sometimes well preserved by the property (as is the case in those included in this paper), but frequently are abandoned as the practical use is lost. Closed and forgotten, these caves are also in risk of disappearing.

Underground civil infrastructures are frequently underestimated, but they are a relevant part of the history of how humans have faced challenges of daily life. Its preservation starts with the public knowledge, and needs the support of public authorities and professionals.

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9. ACKNOWLEDGMENTS

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Hellenistic-Roman underground water systems: The case of Ma'abarta - Flavia Neapolis, southern Levant

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Abstract

The continuously inhabited Roman city Flavia Neapolis (Arabic: Nablus; Hebrew: Shechem), founded in 72 CE, and its predecessor Ma'abarta, are located close to Israel's water divide. Flavia Neapolis prospered due to the abundance of water from local springs, associated with its setting along the natural outlet of the Eocene karstic aquifer of Mt. Gerizim, the holy site of the Samaritans. We studied complicated systems of tunnels collecting spring water, partly starting from natural karst voids, as well as underground water distribution and drainage systems of the city by gravitation. Various finds, in addition to the integration of the hydraulic system with the early phases of Ma'abarta-Neapolis, indicate that the tunnels were planned and constructed mainly during the initial development of the city in the Hellenistic-Roman periods. Since then, only minor modifications and maintenance activities took place. Usage for cult activities is inferred at the larger springs, Ras el 'Ein and 'Ein Qaryun. Historic sources mentioning the subterranean water system indicate that they have been partly known since their construction.

Keywords

Water tunnels, Shechem, Mt. Gerizim, Spring, Ras el 'Ein, 'Ein Qaryun, 31 BCE earthquake.

1. INTRODUCTION

The hydrogeology of Ma'abarta - Flavia Neapolis (Arabic: Nablus or Nabulus; Hebrew: Shechem) is a special case among southern Levant cities, affecting its history and archaeological record in various ways. The water systems discussed here reflect this in an elusive way, as today they are completely concealed underground.

1.1 Hydrogeology

The southern Levant is located at the desert border, with dry Mediterranean to arid climate. The ancient cities along the backbone of Israel's central mountain ridge (Fig. 1) commonly experienced water shortage, as springs in this high area are rare and mostly small [e.g. Frumkin, 1999; Mazar, 2002]. As most cities had no large springs within their urban area, a lot of effort was applied to overcome water shortage. For example, Jerusalem population during Hellenistic-Roman periods exceeded the capacity of its single, low elevation spring [Benami-Amiel et al., 2010]. This necessitated applying various strategies in Jerusalem, such as runoff harvesting into cisterns and large reservoirs, as well as construction of long aqueducts and tunnels bringing water from remote springs [Amit and Gibson, 2014].

Similar strategies were applied in Sebaste [Frumkin, 2002] (Fig. 1b), a city without any springs within its boundaries. Low-elevation cities, such as Akko - Ptolemais [Frankel, 2002], Caesarea [Porath, 2002], and Dor [Peleg, 2002] (Fig. 1a), also lack springs within their limits, but the low-altitude setting allowed for bringing large amounts of water from regional sources. The above-mentioned cities became increasingly dependent on water supply from distant sources when their population increased during Hellenistic-Roman periods.

Ma'abarta - Flavia Neapolis is a hydrogeological exception, having large springs within the city and less than 1 km from its boundaries. This is due to the city's unique hydrogeological setting; it is located within a deep transverse valley which breaches the central synclinal divide ridge, between Mt. Gerizim to the south and Mt. Ebal to the north (Fig. 2).

The main recharge zone of Ma'abarta - Neapolis springs is the elevated parts of Mt. Gerizim. Structurally, this ridge is a syncline, forming the upstream edge of the north-eastern mountain sub-aquifer, which is the most important Eocene aquifer in Israel [Cook et al., 1970] (Figs. 1c and 2).

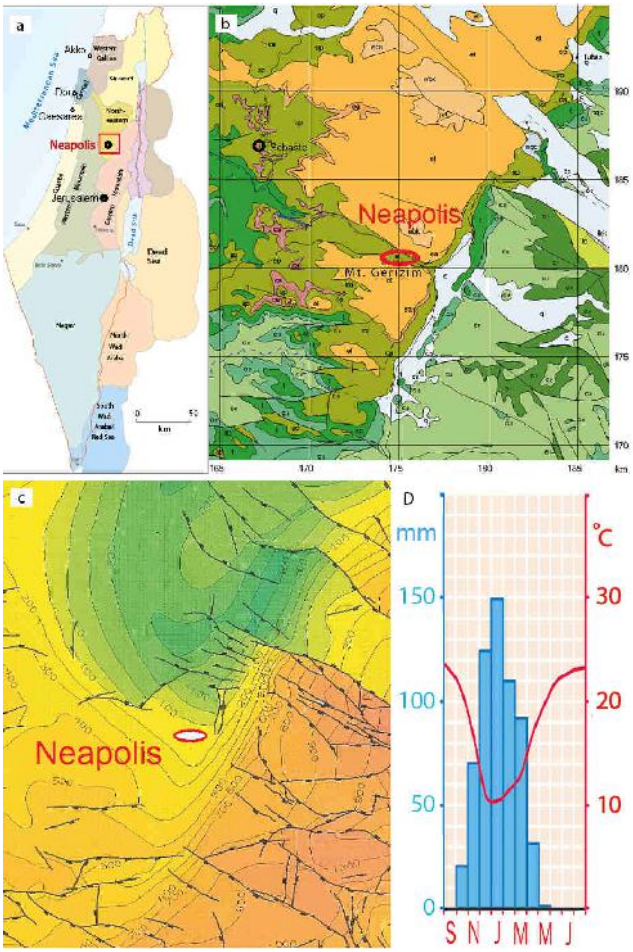

Figure 1:

a) Location map with the main groundwater catchments of the region;

b) Geologic map of the research area (map area marked on Fig. 1a).
The aquifer of Neapolis springs is within et = Eocene Timrat Formation cropping out on Mt. Gerizim, south of the city (courtesy Israel Geological Survey). Square=5 km. lck=lower Cretaceous; c1=Albian- lower Cenomanian; c2=middle Cenomanian; c3=upper Cenomanian; t=Turonian; sp=Senonian-Paleocene; ca=Campanian; ea= lower Eocene; et= lower-middle Eocene; ebk=middle Eocene; nqc=Neogene-Quaternary; q=Quaternary.

c) Structural map (top Judea Group) of Neapolis region. Map area same as b (courtesy Israel Geophysical Institute). Thin lines are structural contours in meters relative to mean sea level (msl). Thick lines are faults; teeth note downfaulted side.
Note that that Neapolis is located at the focal point of Mt. Gerizim dips.

D) Neapolis rainfall and temperature (Atlas of Israel)

The limestone is underlain by Paleocene marls of Mt. Scopus Group forming an impervious aquiclude [Cook et al, 1970]. The synclinal structure of the ridge plunges northward, so groundwater converges from Mt. Gerizim northward, towards Neapolis (Figs. 1c and 2). The ridge is steeply entrenched by Shechem valley, in which Ma'abarta - Neapolis had been built at the foot of the steep Mt. Gerizim.

Rainfall infiltrates easily at the fracture-dissected karren outcrops of the Timrat Formation Eocene limestone on the mountain (Fig. 1b). This formation is well-bedded, promoting sub-horizontal flow along bedding planes northward, along the dip of the syncline axis.

Mean annual rainfall at Gerizim - Neapolis area is 594 mm (Fig. 1d). The warm temperatures induce annual potential evaporation of 1600 mm [The new Atlas of Israel, 2011]. Within this Mediterranean climate zone, rainfall is concentrated from November to April, while the summer is hot and dry. Only the larger rainstorms occurring from December to March replenish the aquifer [Sheffer et al., 2010]. Ma'abarta - Flavia Neapolis springs discharge reflects this annual pattern, with late winter-spring flow much larger than late summer-autumn (Fig. 3).

The water of the studied springs is supersaturated with respect to calcite, and undersaturated with respect to dolomite (Sabri et al., 2015). This is typical for the Eocene limestone aquifer. The main water solutes are derived from the limestone bedrock, together with some soil-derived solutes. Low values of Sr isotopes indicate that Ras el 'Ein has the lowest concentration of soil-derived solutes, 'Ein Qaryun is slightly more enriched, and 'Ein Dafna has the highest Sr/Sr isotopic values, indicating more such solutes [e.g. Frumkin & Stein, 2004].

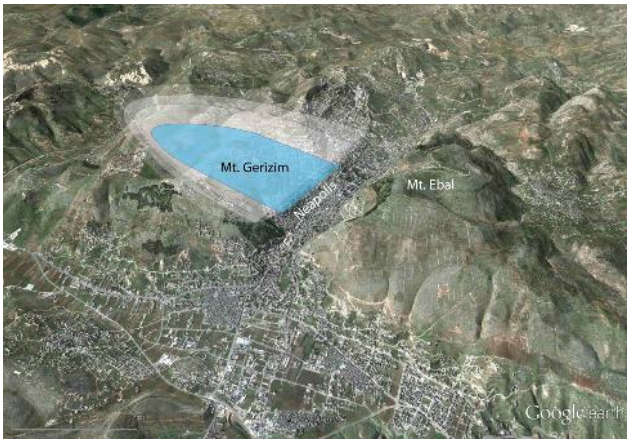

Figure 2: The topographic setting of Neapolis-Shechem, between Mt. Ebal and Mt. Gerizim, diagonal Google Earth view from NE. The synclinal aquifer of Mt. Gerizim is shown schematically. The main springs flow at the northern (right) edge of Mt. Gerizim

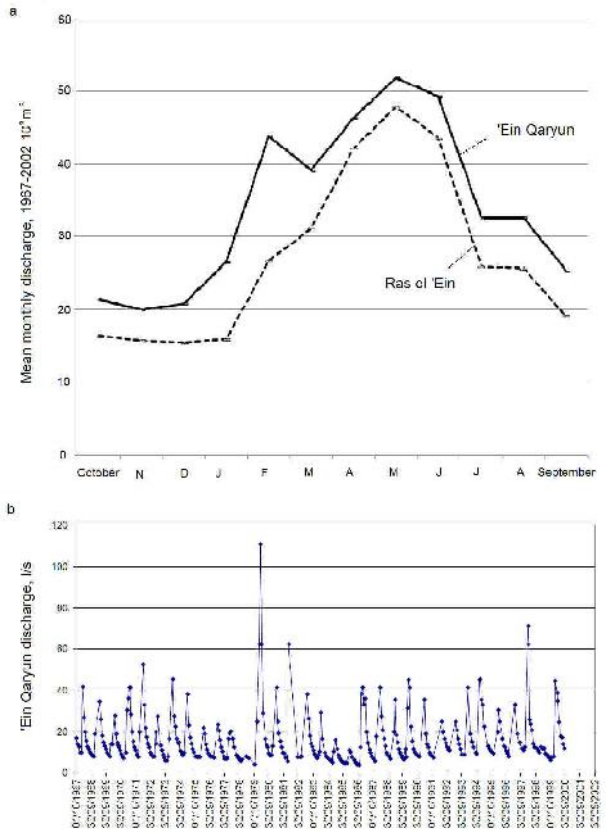

Figure 3: Discharge of the two major springs of Neapolis: a) Mean monthly average of 'Ein Qaryun and Ras el 'Ein; b) 'Ein Qaryun discharge 1967-2000

1.2 History And Archaeology

The Roman city Flavia Neapolis (henceforth: Neapolis) was founded by the Romans in 72-73 CE, as indicated by the city coins (El-Fanni, 2007), on the site of the Hellenistic town 'Ma'abarta' [Flavius, Wars, 4:8:1] or 'Mamortha' [Pliny the Elder, V:14, p. 427] close to the Biblical city Shechem [Wright, 1965]. Neapolis is well-documented from archaeology, coins, and historical records, but its predecessor Ma'abarta is hardly documented and still needs to be studied [Magen, 2009]. While the population of Ma'abarta is unknown, Neapolis was a gentile city with a pagan temple during Roman times, with later increasing Christian population, subsequently replaced by Moslems. Samaritan and Jewish minorities also played a role in the city's history.

Several historic records mention briefly the abundant water sources of Neapolis. Al-Muqaddasi [1994, p. 146] described the city around 985 CE: "It lies in a valley shut in between two mountains...The town is paved and clean, with a stream of running water through it". The running water is mentioned also by other writers, such as Dimashki, followed by Ibn Batutah [quoted in Le-Strange, 1965, p. 513-4].

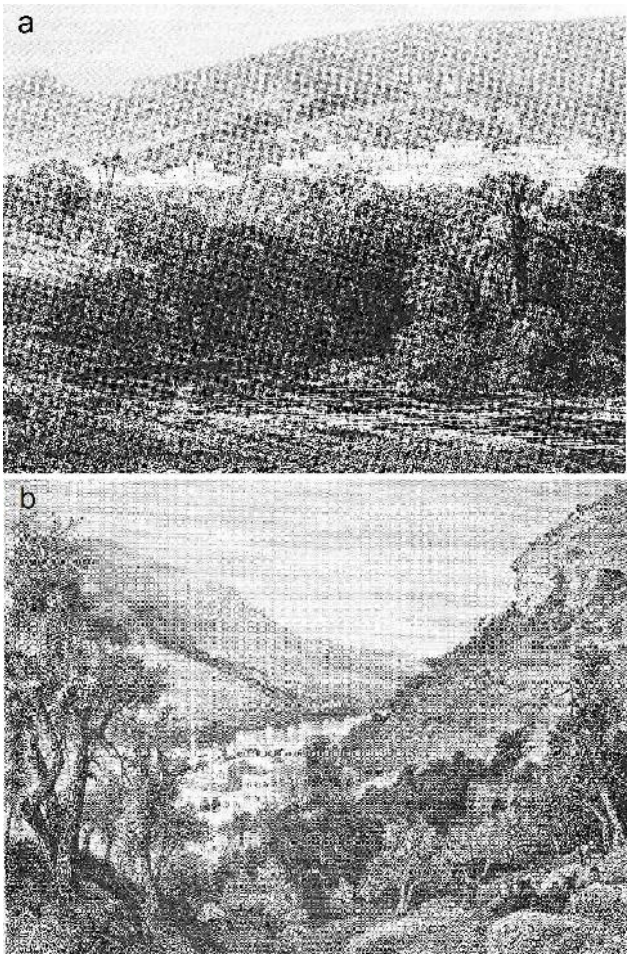

Figure 4: Copper etching drawings during the 19th century around Nablus, prior to the major recent usage of water in the city. a) Nahal Shechem west of Nablus. Note cows wading in a significant flow of water [Busch 1863]. b) View from Ras el 'Ein to the city, at the foot of the steep slope of Mt. Gerizim (right). Note a water-operated flour mill at the lower right, which must have been using the water of Ras el 'Ein [Wilson, 1881]

The medieval geographer Yaqut al-Hamawi, writing around 1225, noted that "Nabulus has much water, for it lies adjacent to a mountain, where the soil is stony" [quoted in Le-Strange, 1965, p. 512]. This description fits the karstic nature of Mt. Gerizim with its many springs, which still supply water to modern Nablus (below).

Geographers and travelers expressed the abundance of flowing water in the city during the 19th century in art (e.g. Fig. 4), maps (e.g. Fig. 5) and textual reports: fifteen springs within the city walls were reported by Guérin [1874, vol 4: 267], and 22 springs in the city's neighborhood were mentioned by Conder and Kitchener [1878, vol. 2:150]. Our study indicates that some of these are just secondary surface openings of shafts connecting with the intricate underground water system.

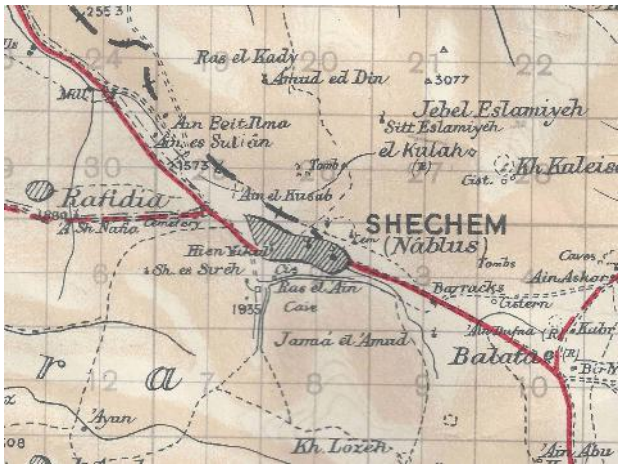

Figure 5: Map of Nablus in the 19th century [Conder and Kitchener, 1878]. The city occupies approximately the central area of Neapolis. Note Ras el 'Ain Cave and 'Ain Dafna. Square=0.4 km.

Three of four major springs within the city, reported in yhe 19th century by the travelers Wolcot and Buckingham respectively quoted in Ritter [1965, p. 302-303] seem to reflect the actual number of springs.

Today the modern city and the old *Kasbah* at its heart hardly hint its ancient water systems. These ancient underground systems of Ma'abarta - Neapolis are difficult to study, partly because they have become part of a rather complicated underground complex, still used by the contemporary city of Nablus.

Recent archaeological studies, such as Bull [1965], El-Fanni [1999], and Magen [2009] mentioned briefly some subterranean water systems in Neapolis, but these were not studied, except for some of their entrance structures. Our previous study of the water systems of Samaria-Sebaste [Frumkin, 2002] revealed that the combined high discharge of Neapolis springs allowed some of the water to be carried by an aqueduct to the city of Sebaste.

The Muslim geographer Ahmad Al-Ya'qubi, in *Kitab al-Buldan* (*Book of the Countries*) around 891 C.E. [quoted in Le-Strange, 1965, p. 511] noted: "Under the town is an underground city hollowed out in the rocks".

The present study is aimed to reveal the background of this statement, by documenting parts of the underground city for the first time. This would decipher how the unique local hydrogeological setting was utilized for a sophisticated system supplying running water to the entire city, beyond the standard in most southern Levant cities. The study also suggests a possible date and additional usage of the water systems.

2. METHODS

The underground water systems were accessible to us via certain entrances. The tunnels associated with them were surveyed by tape, compass and inclinometer.

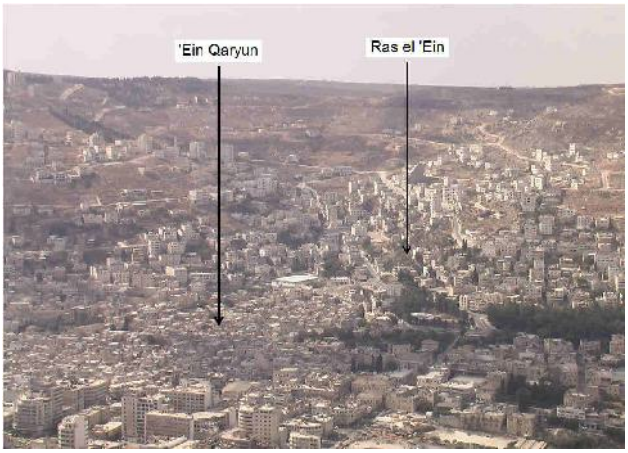

Figure 6: Nablus today with the two major springs at the foot of Mt. Gerizim, which serves as their recharge zone. View from the north. The old *Kasbah*, built on central Neapolis, surrounds 'Ein Qaryun (photo Boaz Langford)

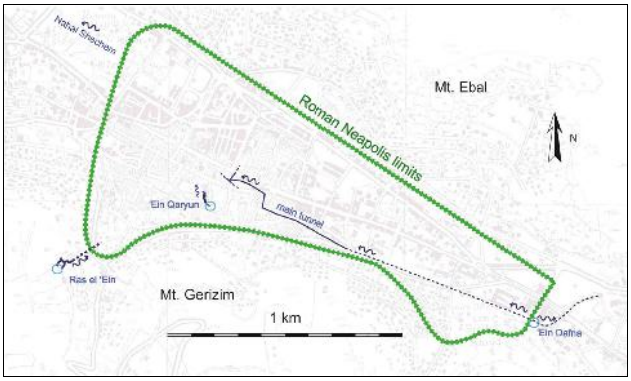

Figure 7: The underground studied systems superimposed on a hypothetical plan of Neapolis [city walls after Magen, 2009] and 20th century city map (background). Wavy arrows indicate water flow direction. Circles indicate subsurface point of springs (bedrock-tunnel interface)

The term 'tunnel' is used here both for bedrock-hewn elongated voids and for covered channels, which, in the case of Ma'abarta - Neapolis are usually buried deep underground.

The hydrogeology, morphology, archaeology and architecture of the underground water systems were documented in the field and reviewed from available sources. Historical records are interpreted according to the relevant geographic-archaeologic context, allowing for additional understanding of the water network. Written documentation and personal communication were used where the water systems could not be accessed. Considering the elapsed time, such segments of the water system may have been destroyed, blocked, or their entrances were unknown to us, taking account of the densely populated city and continuous modification of the

water systems, including recent intensive construction works.

The studied sub-systems were chosen according to accessibility and importance. Not always could the interconnection and chronology of the various segments be precisely determined, as common in such systems which remained in use long after their construction.

3. RESULTS

The major water systems of Ma'abarta - Neapolis discussed here comprise the following underground systems: 'Ein Qaryun, Ras el 'Ein, and 'Ein Dafna, and the city's so called 'main tunnel'. The springs flow outlets are hidden today from surface observers, as the emanating water flows entirely underground, within the tunnels. The combination of the studied parts in different locations and usages allow a reasonable understanding of the functioning of the entire water system. 'Ein Qaryun and Ras el 'Ein are the largest springs supplying water to the city (Figs. 6 and 7). 'Ein Dafna is important due to its location on the country's water divide, and due to the 'main tunnel' which apparently started from this spring. The studied water structures provide insights to the main architectural methods, hydrologic significance, and functional types of water tunnels during the Hellenistic-Roman periods. Another large spring, 'Ein Beit el-Ma, is not included in the present study, because its location to the west of the city, at a lower elevation, prevented its use within the urban area. It has been shown earlier [Frumkin, 2002], that its water was carried by an aqueduct to Samaria-Sebaste, in addition to usage for agriculture and flour mills.

3.1 'Ein Qaryun

'Ein Qaryun is the largest spring within Neapolis city walls, and probably the focal point of the initial settlement of Hellenistic Ma'abarta. It is a karstic spring flowing from well-bedded Eocene limestone of Timrat Formation, on the foot of Mt. Gerizim, 550 m a.s.l. (Figs. 6 and 7). The mean annual discharge is 386,000 m^3, with large seasonal fluctuations, as common for such karstic springs (Fig. 3). Maximum recorded discharge is 110 l/s during spring time of a rainy year, while a minimum flow of ~5 l/s was recorded during the autumn following a dry year.

The spring system is reached today by 25 steps descending from a *Qasba* alley, near et-Tineh Mosque. The spring entrance system is closely associated with an apsidal wall topped by a semi-dome, built of well-cut ashlars, standing on a round raised platform, first reported by Clermont-Ganneau [1886, p. 315].

At the bottom of the steps one reaches the main spring tunnel (Fig. 8). To the left (SE), one enters a 14 m long hewn spring tunnel, in well-bedded limestone with chert nodules, of the Eocene Timrat Formation. This tunnel leads to two narrow, inaccessible karstic conduits of few cm in diameter formed along bedding plains, from which the water emanates into the tunnel. Local widening of the tunnel with smooth walls indicates that it follows natural karstic voids. All the water flows underground through ancient built tunnel systems (below).

The downstream side of the spring tunnel is artificially built, but its upstream segment has a bedrock floor. After a few m the tunnel bifurcates to several passages, forming an intricate labyrinth-like system of built tunnels from various periods, generally sloping NWN, along the topographic slope (Fig. 6). The measured slope of the tunnels ranges between 0 and 3°. The northern (downstream) parts present ancient remains from classic periods, including many sherds, mosaic stones, 1.6 m long column, marble tablet, broken glass, and carved stone items.

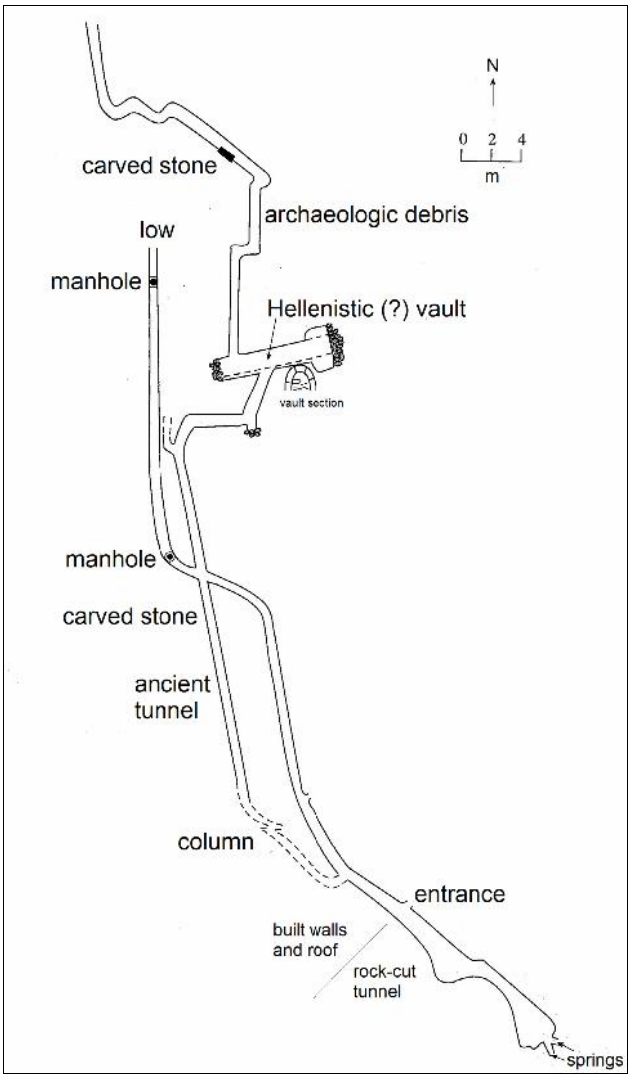

Figure 8: Plan of 'Ein Qaryun tunnel system, probable site of the initial Hellenistic settlement of Ma'abarta. A short rock-cut tunnel drains the water from the spring point to masonry built tunnels, partly with bedrock bottom (survey A. Frumkin)

Figure 9: 'Ein Qaryun tunnels. a) Barrel-vaulted tunnel, 1.5 m wide; the shelf on the right is a secondary water channel. Note the blocking wall at the rear (photo Boaz Langford). b) Tunnel built of large ashlar masonry at the left, stone slabs roof, with minor recent mortar repairs. Tunnel width is 60 cm (photo Ze'ev H. Erlich "Zabo")

However, as usual in such systems, the presence of these remains does not necessarily date the tunnels and the time of construction, and may be in secondary context. Most tunnels have rectangular cross sections, are built with roughly-wrought stones, and covered with flat stone slabs (Fig. 9). In places, recent renovations of the tunnels with concrete can be observed. An exception is a 1.5 m wide barrel-vaulted tunnel (half cylinder in shape) built of well-wrought ashlars. Today this tunnel segment is blocked at both ends by later walls, limiting the presently accessible part of the barrel-vaulted tunnel to 8 m (Fig. 9a).

Some parts of the tunnel system were renovated in various periods, until recently (Fig. 9b), damaging the ancient remains. The water flows today in an iron pipe within one tunnel downstream to a reservoir, from where it is distributed to consumers. Other tunnels seem not to be in use today, except the 14 m long hewn spring tunnel where the water still emanates from the bedrock.

3.2 Ras el 'Ein

Ras el 'Ein is one of the largest springs of Ma'abarta - Neapolis (Figs. 6 and 7). This highest spring of the city, 620 m a.s.l., emanates from well-bedded Eocene limestone of Timrat Formation at the southern slope of Mt. Gerizim, just above the ancient core of Ma'abarta - Neapolis. The elevated topographic setting allowed directing its water to any desired point within the city by gravitation. The mean annual discharge is 308,000 m^3, with large seasonal fluctuations, as common for such karstic springs (Fig. 3a). Maximal discharge is 30-40 l/s during spring time, while minimal flow is ~5 l/s during the autumn, indicating the small amount of water stored in the aquifer.

Ras el 'Ein (رأس العين, Arabic for 'Head of the Spring') is a common name for several important large springs in the Levant, e.g. in Israel, Syria and Jordan.

Guérin [1874] mentioned this spring following his 1870 visit, and it is also noted in the PEF map (Fig. 5) and associated text [Conder & Kitchener, 1882]. However, Conder and Kitchener did not refer to the elaborate underground system in their text about the spring (p. 150).

A copper etching drawing shows that Ras el 'Ein water was used also for operating an old flour mill located between the spring and the city [Wilson, 1881], utilizing the elevation difference (Fig. 4b). The remains of additional mills are still observed along the Shechem valley, downstream of the city to the west.

Recent archaeological studies (e.g. El-Fanni, 1999) noted the impressive spring entrance structure (Figs. 10 and 11a) which gives access from the surface to the underground system. The original rectangular shaft-like structure is made of well-dressed ashlars with marginal drafting. It is preserved to a height of fifteen courses, most of which are 0.6 m high, except for the first and the seventh, which are 0.75 and 0.5 m high respectively. A plastered, well-built channel carried the spring water at the bottom of the entrance shaft structure from west to east. The water flows from the entrance structure towards the city via a barrel-vaulted, ashlar-built tunnel (Figs. 10 and 11b). The individual blocks of stone are perfectly carved, fitting tightly to each other. Today this tunnel is accessible for some 40 m downstream from the entrance structure, but its further continuation towards the city was known in the 20th century [Magen, 2009]. Today the water flows to two reservoirs about 150 m away from the spring, from which the water is distributed to consumers.

In the present study the Ras el 'Ein spring system was studied, on the upstream side of the entrance structure. Its first part is a 4 m-long, finely-built, 1.3 m wide tunnel (Figs. 10 and 11c). The vaulted roof of this short tunnel segment slopes from a height of 3.4 m at the entrance to 2.3 m at the innermost end, away from the entrance structure. This tunnel segment is built of well-dressed ashlars with marginal drafting, bound together by white mortar. A 30 cm deep plastered channel in built in the floor of the tunnel.

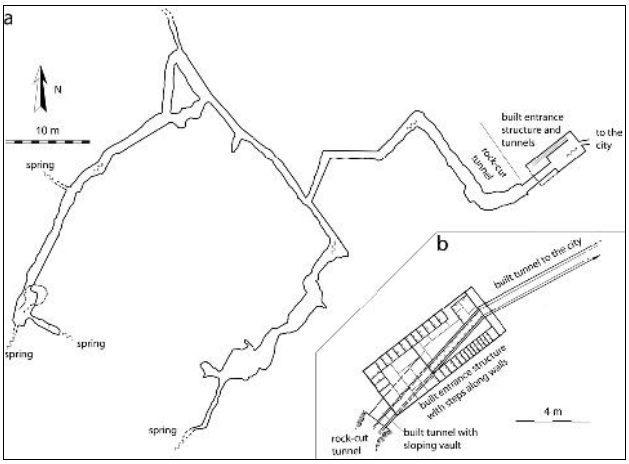

Figure 10: a) Plan of the rock-cut spring tunnels and entrance structure of Ras el 'Ein (survey A. Frumkin). Wavy arrows indicate water flow direction. b) Entrance structure map enlarged [modified after El-Fanni 1999; Magen 2009]

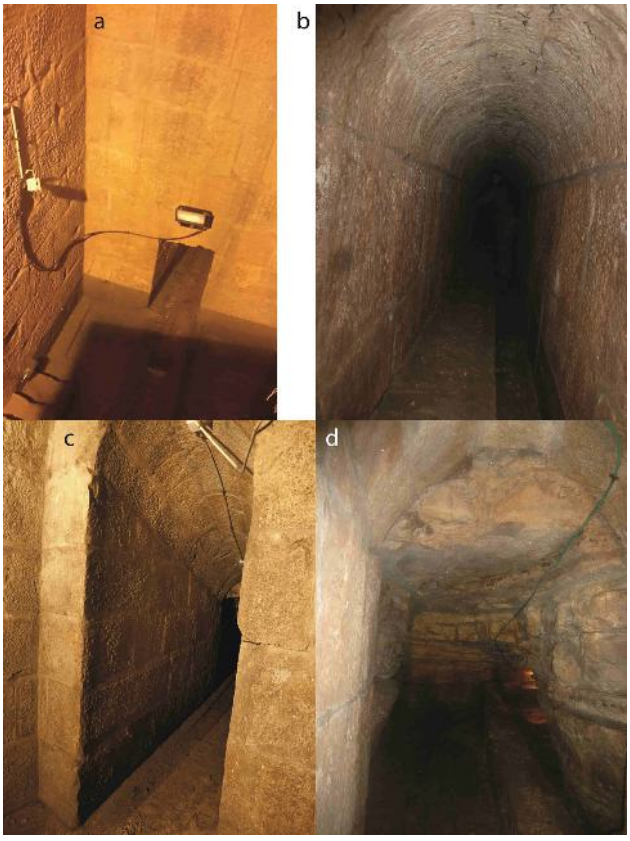

Figure 11: Ras el 'Ein water system. (photos Ze'ev H. Erlich "Zabo"). a) The bottom of the entrance structure and the outlet towards Neapolis with high water level water (wet year, spring 2015). Most ashlar courses are 60 cm high. b) The barrel-vaulted built tunnel leading from the entrance structure towards Neapolis. Width of tunnel 75 cm. c) The sloping vaulted roof tunnel connecting the bedrock tunnel and the entrance structure. Tunnel is 1.3 m wide. d) Rock-cut tunnel draining the karstic spring system. Bedrock is well-bedded Eocene limestone. Tunnel is ca. 2 m wide.

From the end of the built tunnel segment, a sub-horizontal bedrock-hewn spring tunnel continues upstream in a dendritic form into the mountain (Figs. 10 and 11d). It is one of the most complicated spring tunnels in Israel, all of which are aimed to concentrate and increase the flow of water [Yechezkel and Frumkin, in press]. The bedrock tunnel was hewn mainly along bedding plains, fractures and karstic voids which originally led the flow of water. Chert nodules are observed along the tunnel within the limestone bedrock of Eocene Timrat Formation. The cross section is usually rectangular, making use of the bedded limestone for the commonly flat, bedding-controlled ceiling (Fig. 11d). Occasionally the original karstic morphology is observed, with smoothly rounded walls and small, inaccessible side-passages. The bedrock tunnel is mostly lower than 1 m. The tunnel direction alternates along various guiding fractures and karstic voids. After the first 36 m from the beginning of the bedrock tunnel, it bifurcates to two main branches, directed to opposite directions along a single NW-SE trending fracture. Further upstream, both branches turn to SW. Naturally-karstified voids become more obvious at the upstream parts of both passages, particularly where small side-passages are observed. The southern passage ends where water emanates from a tight inaccessible natural conduit. The northern passage has more side passages, with three inlet points, where water emanates into the main passage. The depth of the flowing water is usually only few centimeters, but during the rainy season of 2015 the water level was observed to rise along the system, rendering the tunnels hardly accessible (Z. Erlich, private communication, 2015). The slope of the hewn tunnels ranges between 1 and 5^{o}. All the water flows underground through the ancient tunnel systems and modern pipe running at the bottom of the hewn and built tunnels.

The Ras el 'Ein water system is well preserved. Today the system is still in use, and the water in the downstream parts flows through an iron pipe.

3.3 'Ein Dafna

Located at the Israel's water divide, close to the eastern limit of Neapolis, 'Ein Dafna water could be directed by gravitation both eastward and westward (Fig. 7). The mean annual discharge is 103,000 m^3, with large seasonal fluctuations, from 1.5 to 11 l/s during autumn and spring respectively.

A 13 m-deep vertical shaft leads from the surface, at the bottom of Mt. Gerizim, to the spring. Although bedrock is not presently exposed at the spring, the water probably emerges from a karstic void similar to the spring discussed above. The local watertable in the Eocene aquifer is tens of meters below the surface, evidenced by the water level in the nearby Jacob's Well. The spring water flows today a distance of few hundred meters, in a recently plastered tunnel with rectangular cross section. The tunnel flows first to the east, and then it changes direction northward via a long arc on map view, reaching a reservoir close to Tell Balatah [Biblical Shechem; Wright, 1965]. Conder & Kitchener [1882] drew on their map (Fig. 5) a line from 'Ein Dafna to the northeast, curving eastward, to the vicinity of Tell Balatah. This could represent a water system, but their textual description of the spring (p. 150-151) does not refer to this feature.

Two blocked tunnel outlets from the spring to the north and west were recorded during our study. The western outlet was directed towards Neapolis, and could have been connected with the main tunnel running along the city's main artery (below).

An elaborate description of the underground water systems of 'Ein Dafna, alas without graphic presentation, was given by Bull [1965, p. 218-221]. However, the two additional outlets from the spring to the north and west were blocked

also during his exploration. Thus the eastern tunnel is the only one carrying water at least during the last 50 years. Bull [1965, p. 221-228] did provide an elaborate description and plan of 'Ein Balatah spring tunnel, located to the east of 'Ein Dafna. 'Ein Balatah was not connected with Ma'abarta - Neapolis water system, and is therefore not discussed here.

3.4 The 'main tunnel'

This longest tunnel of Ma'abarta - Neapolis ran partly under the *Decumanus*, the main street of Neapolis, approximately directed ESE-WNW (Fig. 7). We entered the tunnel through a Roman (?) staircase of 56 stairs, descending to a depth of 14 m below the *Decumanus* level, which was unearthed by El-Fanni [2007] under Za'far el-Masri school during its construction. Lamps found along the staircase date to the 3-4th century CE, indicating that the tunnel is of older age.

The tunnel is commonly 60-70 cm wide, and 1.2-2 m high (Fig. 12). In places, the tunnel is higher or lower. The cross-section decreases at the upstream parts due to calcite flowstone deposits, and at the downstream part due to renovations. Both render the passage less traversable. The tunnel is built of ashlar masonry, covered with slabs of stone (Fig. 12a), alternating with a barrel-vaulted roof of ashlars (Fig. 12b). These features indicate that it was initially dug as an open channel, followed by masonry roofing. This built roof is covered by a thick layer of debris upon which the *Decumanus* was subsequently constructed along the eastern part of the tunnel. The debris accumulated above the *Decumanus* was excavated by El-Fanni [2007]. Checking this deposit during the excavation on 1987, I observed poorly-sorted natural debris, including cobbles and clay soil, together with collapsed archaeological material, which have accumulated since the Roman period. The most probable source of this material is debris flows from the nearby steep northern slope of Mt. Gerizim, as well as collapsed man-made structures.

The tunnel still contains water, slowly flowing along the general topographic slope of Neapolis valley, from ESE to WSW. We performed a rough survey of the tunnel along 593 m of its course, 354 m upstream from the staircase, and 249 m downstream. The measured slope of the tunnel ranges between 0 and 3^{o}.

Several shafts connecting the main tunnel with the surface were observed, such as Dullab shaft, which connects the tunnel with the modern street level, 16 m above. Most shafts were found blocked at the top, except one, at the easternmost surveyed part, which has been open during our study, and consequently underlain by a pile of modern debris, partly blocking the tunnel.

Upstream from the staircase the water is clear, and the tunnel is almost straight in plan view (Fig. 7). Some 354 m east of the entrance the thickening flowstone deposits forced us to halt our survey.

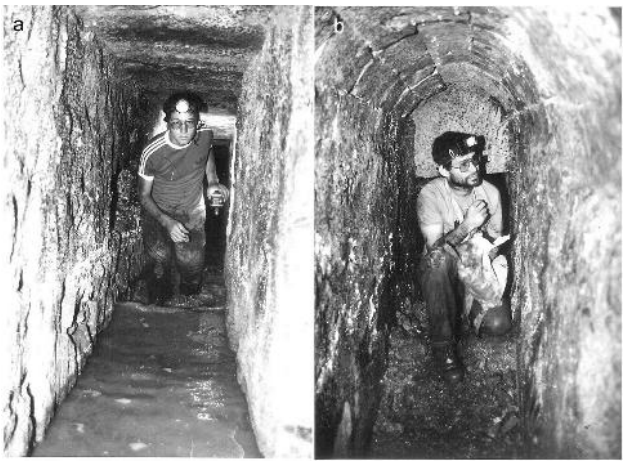

Figure 12: The main tunnel, built under the main street of Neapolis. Tunnel is ca. 70 cm wide. a) Section covered with stone slabs (photo A. Frumkin). b) Section with barrel-vaulted roof (photo Ofer Lavi)

Downstream from the staircase the water becomes gradually polluted by sewage. Reaching Sha're Naser road after 60 m, the tunnel turns sharply west to reach the Great Mosque, Jami' al-Kebir. Being the major mosque in Nablus, it still bears signs of serving earlier as a major Byzantine-Crusader church [Conder & Kitchener, 1878, p. 203, 208].

After 240 m the tunnel turns four times by 90^{0}, and two side tunnels join the main one, increasing the flow. Several phases of construction and repair are observed at this part of the tunnel, including a modern stage with concrete. During our survey the water level approached the ceiling, at which point our survey had to be halted.

Bull [1965, p. 221] apparently visited the same tunnel, entering through a different point: "The 850 m long tunnel...appears to be of Roman construction and runs from a point near the prison and is part of that city's water system. The eastern opening of this tunnel could not be found".

Thus the tunnel is at least 600 m long according to our survey, reaching 850 m according to Bull (1965). It probably carried water from 'Ein Dafna towards mid-Neapolis and further downstream along Nahal Shechem. The tunnel flows along the southern slope of Mt. Gerizim, not far from the southern wall of Neapolis.

A local inhabitant at 'Ein Beit el-Ma (Ain Beit Ilma, Fig. 5), west of Neapolis, reported to us that during the 1940's he went along a high, impressive tunnel, from the vicinity of 'Ein Beit el-Ma upstream, emerging at the vicinity of Mt. Gerizim. He noted that this tunnel segment was blocked about 1965, so we could not check it [A. Naji, personal communication, 1977]. We did observe the remains of several surface water channels at the vicinity of 'Ein Beit

el-Ma, some of them ancient, including an aqueduct which we traced along 15 km towards Sebaste [Frumkin, 2002].

The main tunnel is still used as a drainage system today, at least along the segment that we explored.

4. DISCUSSION

The unique situation of a southern Levant city with surplus water, allowed a high standard of living, but water flow had to be controlled and planned appropriately. A carefully engineered system was needed, not only for using the water, but also for preventing the flow of excessive water along undesirable routes, which could undermine the urban infrastructure, in addition to being a nuisance.

Indeed, the studied systems suggest several utilitarian objectives. A rock-hewn sub-horizontal tunnel system increased water extraction from the aquifer in Ras el 'Ein. This is one of the most elaborate rock-hewn tunnel system for extracting groundwater in the southern Levant. In general, the earliest chronologic origin of such sub-horizontal tunnel water extraction systems can be traced to the late Iron Age [Yechezkel and Frumkin, in press]. The hewn tunnel of 'Ein Qaryun is considerably shorter than Ras el 'Ein, possibly indicating that the larger flow of 'Ein Qaryun was sufficient without further extraction by a long hewn tunnel. Being outside the city, Ras el 'Ein could be used for irrigation and powering mills (Fig. 4b), for which larger amount of water would have been helpful.

The discharge of both 'Ein Qaryun and Ras el 'Ein fluctuates considerately between wet to dry seasons and between dry and wet years (Fig. 3). In addition, urban usage of water is larger during the day compared with the night. Large capacity, centrally-controlled reservoirs could store excess water for time of shortage. Indeed, a system of masonry-built tunnels convey the water of all studied springs to such reservoirs. The elaborate system of built tunnels leading northward from 'Ein Qaryun may indicate the division of water between users, and/or the modifications made in the system during ca. 2000 years of usage. At Ras el 'Ein, a single built tunnel leading from the entrance structure to the reservoir is observed today, but additional conveying systems may have existed.

As the reservoirs are currently in use, they could not be checked during the present study. 'Ein Dafna built tunnels conveyed the water to both sides of the water divide: eastward and westward. The western tunnel is the longest, conveying the water roughly along the main axis of the city. The topography and oral description (A. Naji, personal communication, 1977) indicate that the main tunnel continued to the WNW end of the city.

This raises the question if the only purpose of this 'main tunnel' was only conveying 'Ein Dafna's water. In Jerusalem, a Roman period subterranean tunnel was excavated along the Tyropoeon Valley, for draining runoff water [Reich and Shukron, 2007]. Drainage was even more important in Ma'abarta - Neapolis, as the surplus spring water had to be drained year-round, in addition to runoff during winter rainfall events. Thus it can be assumed that 'Ein Qaryun and Ras el 'Ein could have had some kind of overflow spillway tunnel, connecting them to the main tunnel. However, such connection between the systems has not been identified during the present study or a geochemichal study (Sabri, et al., 2015). Thus the main tunnel could drain excess water from 'Ein Dafna, from the streets during rainfall event, and possibly from other, springs. The shafts connecting the tunnel to the surface could be used for drawing water out of the tunnel, or alternatively for draining street runoff into the tunnel.

The great depth (14 m) of the main tunnel below the Roman *Decumanus* is puzzling, considering the great work needed for building and covering a tunnel in this depth. For comparison the Jerusalem drainage tunnel is much-shallower, up to a few meters [personal observation; Reich and Shukron, 2007]. Why would the builders of Neapolis dig to such a depth to build the water tunnel, which could be easily built at a more northern and shallower route?

An indirect clue can be found in the writings of the famous historian Josephus Flavius. He reports that on 31 BCE: "there was an earthquake in Judea such a one as had not happened at any other time and which earthquake brought a great destruction upon the cattle in that country. About ten thousand men also perished by the fall of houses..." (Antiquities 15,5,2: Marcus, 1976). A similar report is found in another book of Josephus [Wars 1,19,3: Thackeray, 1976] but the number of casualties mentioned there is 30,000. Based on these reports and archaeological evidence, it is agreed upon most researchers that a strong earthquake of magnitude M_L ranging from 6 to 8 hit the Holy Land on 31 B.C. [*e.g.* Ben-Menahem, 1991; Amiran et al., 1994; Karcz, 2004; Migowski et al., 2004]. In addition, Neapolis-Nablus has suffered severe destruction and hundreds of casualties from many consequent earthquakes, as it is built on soft natural and anthropogenic sediments at the foot of a steep slope [*e.g.* Amiran et al., 1994]. The 200 m lower slope of Mt. Gerizim attains its maximal steepness, 36°, above the excavated *Decumanus* tunnel entrance (Fig. 4b). This is above the repose angle of most unconsolidated granular sediments [Lemaitre, 2002], suggesting instability of colluvial loose sediments.

Following the above considerations, it is suggested here that the major earthquake of 31 BCE triggered debris flows and structure collapse in Ma'abarta which had been built at the foot of Mt. Gerizim. The tunnel could thus be covered by a thick deposit of debris. The *Decumanus* was built later on top of this deposit, and a 14 m deep staircase has to be constructed through it, in order to connect this main road with the tunnel, 14 m underground.

Additional lines of evidence may support the suggestion that the water system originated during the Hellenistic period. The names 'Ein Qaryun and 'Ein Dafna are themselves probably Hellenistic in origin [Magen, 2009]. As the built area of Ma'abarta has not been documented yet

in archaeological excavations, the tunnel systems may be the best way to penetrate the Hellenistic city for additional study.

Tunneling technique for water was well established in the ancient world during the Hellenistic period [e.g. Frumkin and Shimron, 2006; Angelakis and Spyridakis, 2010; De Feo et al., 2013]. In the land of Israel, the construction of long water tunnels took place already around 700 BCE and possibly earlier [e.g. Shiloh, 1992; Frumkin et al., 2003]. It was commonly practiced during the Hellenistic period [e.g. Frankel, 2002; Amit & Gibson, 2014; Frumkin, 2015].

Barrel-shaped vaults of well-cut ashlars are common in the roofs of most studied water systems in Ma'abarta - Neapolis, including 'Ein Qaryun, Ras el 'Ein, and the main tunnel. The barrel-vaulted tunnels are commonly nested deep below the present surface, and also well below the surface of Roman Neapolis, up to 14 m in the main tunnel (above).

The construction of barrel-vaults became popular in Israel since the Hellenistic period [Netzer, 1992], and is particularly common in Hellenistic underground systems, such as the Hellenistic aqueduct of Akko-Ptolemais [Frankel, 2002], The Biyar and Solomon Pools springs leading to the low-level aqueduct to Jerusalem [Mazar 2002; Amit & Gibson, 2014] and at the underground systems of Maresha [e.g. Kloner, 1993]. During the Hellenistic period the barrel-shaped vaults apparently became a fashion rather than a constructional necessity, because some vaulted tunnels are narrow and close to the surface, where they could be safely covered with slabs of stone, without inducing tensile stresses in the stone slabs. On the other hand, roofing by horizontal stone slabs was practiced apparently during other periods in many water systems in Israel, including renovated parts of the main tunnel of Neapolis.

This suggestion, if true, and the deep level of the Qaryun and main tunnel vaults below the remains of Roman Neapolis may suggest an original Hellenistic age of some of the water tunnels discussed here. If so, they might be a remnant of the enigmatic Hellenistic town Ma'abarta which had existed here for over 180 years since the 3rd century BCE [Magen, 2009, p. 355]. Further additions, modifications and maintenance of the systems took place during the last two millennia, involving a variety of architectural styles.

The entire water system provided appropriate solutions for several utilitarian needs: enhancing spring discharge, conveying the water to reservoirs, and draining excess water of springs and rainfall. However, some architectural features may indicate additional usage.

The apsidal semidome structure of 'Ein Qaryun is similar to the one in the ancient entrance chamber of 'Ein Harun spring tunnel at Naqura, seven km NW of 'Ein Qaryun. Braslavski (1924-5) suggested that pagan ritual was practiced 'Ein Harun spring. Like 'Ein Harun, the finely built entrance structures of 'Ein Qaryun and Ras el 'Ein are too elaborate for a utilitarian access for water quality control. With adequate precaution, one can raise the possibility of some regional water-associated ritual undertaken at major springs, during the pagan stage of the city. Ritual pagan usage of springs associated with underground cavities can be compared with other southern Levant sites, including Caesarea Philippi - Banias [Berlin, 1999], Te'omim Cave [Zissu et al., 2011], and Afqa [Garreau, 2011].

A historic source seems to support a long history of ritual use in a spring cave at Mt. Gerizim, most probably Ras el 'Ein. The medieval geographer Yaqut al-Hamawi wrote around 1225 CE: "The Mountain (Gerizim) is mentioned in the Pentateuch. The Samaritans pray towards it. There is here a spring in a cave which they venerate and pay visitation unto" [quoted in Le-Strange 1965, p. 513]. Preserving ancient pagan rituals was attributed to the Samaritans by several historic sources since biblical times [e.g. Kings 2,17, 24-34]. A Samaritan cemetery situated around Ras el 'Ein entrance structure supports the identification of Ras el 'Ein with the spring cave of Mt. Gerizim venerated by the Samaritans, as indicated by Yakut.

5. CONCLUSION

The underground water systems within Ma'abarta - Neapolis seem to be more elaborate than within most other southern Levant cities. This was a function of the abundance of large springs inside and close to the city, unequalled in other southern Levant cities. This feature explains also the rarity of urban rainfall harvesting systems, unlike Hellenistic-Roman Jerusalem, where the only spring was at the lower end of the city, and too small to provide water for the increasing needs. For the same reason, Ma'abarta - Neapolis did not need any aqueducts to bring water from a distance, unlike other southern Levant cites, such as Jerusalem, Caesarea, Akko - Ptolemais, and Dor,

Three types of tunnels were observed in Ma'abarta - Neapolis: (1) sub-horizontal rock-hewn tunnels for extracting groundwater; (2) masonry-built tunnels conveying water from the source toward the users/reservoirs; (3) masonry-built main drainage tunnel.

The main tunnel ran along the city of Neapolis, from 'Ein Dafna towards the WNW end of the city, along Nahal Shechem. Along its course, the main tunnel was possibly joined by side tunnels leading the overflow of the major springs, Ras el 'Ein and 'Ein Qaryun, whose upstream tunnel systems are reported here. These finds corroborate the report of Ahmad Al-Ya'qubi, that "Under the town is an underground city hollowed out in the rocks".

The 14 m elevation difference between the *Decumanus* and the underlying main tunnel, suggest that this tunnel was built already during the Hellenistic stage of the city,

Ma'abarta. This is supported by dated barrel-vaulted water tunnels in other places, an architecture style common in Hellenistic underground systems. This may indicate that Ras el 'Ein, as well as part of 'Ein Qaryun system may also date to the Hellenistic period. The 31 BCE earthquake could be responsible for the thick debris which accumulated above the tunnels, as the city was highly vulnerable to earthquakes.

The elaborate architecture of spring entrance structures may indicate that the main springs in and around Neapolis have been used as pagan worship sites. This may be associated with a later source on a Samaritan holy site within a spring cave at Mt. Gerizim. This possibility and the Hellenistic dating still need validation from further evidence.

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Artificial Outlets: analysis of the drainage-related functions during planning. Integrated systems?

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Abstract
After the numerous studies we performed in Latium (central Italy), the review of the artificial structures for the control of the level of the volcanic lakes devoid of natural outlets has suggested the possibility (still under study) that these works might have been planned with more than one purpose in mind. Since 2003 we have been analyzing the complex structure and the different functions of the outlet of Lake Nemi, a situation that prompted us to call it "integrated system". Further results and updated interpretations of other drainage systems (including the outlets of Albano, Pavona, Giulianello, etc.) strongly suggest the possibility that all artificial outlets (or at least a large part of those found in Latium), might have been conceived as "multi-purpose". The hypothesis would find some justifications when considering the huge investment in human and technical resources required by such works. It is known that in many cases the outlets were repaired and reused over the centuries to operate mills, to water fields, etc. But today is it possible to understand whether these structures responded to diversified needs already in the planning stage? How many integrated systems existed in Latium?

Keywords
Artificial cavities, drainage systems, artificial outlets, integrated systems.

1. INTRODUCTION

In ancient times many lake basins have been drained to obtain fertile soil, for protection against floods or, more simply, to regulate the water flow. On the Alban Hills, artificial outlets have been implemented for the volcanic lakes of Albano, Nemi, Giulianello, Pantano Secco and Pantano Borghese. Not far from Rome, the same happened for the lakes of Baccano, Martignano, Stracciacappa and the Reatine plane and, in the Abruzzo, for Lake Fucino. All over Italy twenty artificial outlets are known, most of which are found in the extinct calderas on the Alban Hills, a well known volcanic structure a few km South-East of Rome.

About 40.000 years ago, after the end of the volcanic activity, the Alban craters were filled up by waters, giving origin to a dozen of lake basins. From the 6th century BP [Caloi et al. 2012; Germani et al. 2012] first the Latin populations and after the Romans built, for each of these water basins, artificial outlets, both underground and on the surface (Table 1), at an epoch generally indicated between the 6th and the 5th centuries BP. Construction of an artificial outlets was, and would be even today, an enterprise requiring quite a substantial effort in planning and in economic resources from the community involved in the project.

Advanced technical and hydraulic knowledge had to be ready at hand or, at least, had to be easily acquired from those who already were masters in the subject, such as the Etruscans or the Greeks in Magna Graecia. The Alban Hills in the first half of the I millennium BP benefited largely of such an occurrence. Over the centuries the drain systems maintained almost intact their operation; many of them have been readapted (mainly during the Middle Ages) in order to operate factories and mills for grinding wheat, as well as to water fields. After the neglect following the fall of the Roman empire, many of these works were abandoned until the Renaissance, when they were put again into operation.

The regions interested by the above mentioned interventions have been inhabited without interruptions until today, and the destiny of the waters drained from the basins have suffered accordingly countless adjustments. It is therefore difficult to reconstruct the history of their usage.

Being at the moment almost at the conclusion of the investigation on Italian outlets, we thought not an idle question to ask whether or not these structures were intended to satisfy a variety of needs already when planning them, that is in Roman or pre-Roman times. In other words: when planning a hydraulic system demanding an extremely complex and taxing effort, had the builders in mind only the main purpose (that is, water drainage), or the system was arranged in advance to satisfy other possible usages? In the attempt of answering the question we have analyzed all available data from a technical, documentary and architectonic point of view.

Id	Name	Type of basin	Type of emissary	Type of intervention	Probable intervention period
1	Gabii	Crater	underground+ surface	drainage	(R) + 17th century
2	Pantano Borghese	Depression	surface	drainage	(R) + 17th century
3	Laghetto di Monte Compatri	ancient quarry or sinkhole	underground	water regulation	20th century
4	Prata Porci	Crater	surface	drainage	(R)
5	Pantano Secco	Crater	underground	drainage	R + 17th century
6	Valle Marciana	Crater	surface	drainage	?
7	Campi di Annibale	Crater	surface	drainage	?
8	Valle Ariccia (Vallericcia)	Crater	underground	drainage	5th sec. BPE or earlier
9	Pavona	Crater	underground	drainage	(PR) + 17th century
10	Pratoni del Vivaro (Pantano della Doganella)	Depression	surface	drainage	6th - 5th century BPE
11	Giulianello	Sinkhole (?)	underground	water regulation and drainage	(PR)
12	Albano	Crater	underground	water regulation	4th century BPE
13	Nemi	Crater	underground	water regulation	5th century BPE or earlier

Table 1: Present situation of our knowledge about the ancient outlets of the Alban craters. The poor historical documentation makes it difficult to fix the epochs of construction; approximate dates are indicated in the table by the symbols: R=Roman; PR=pre-Roman; ? = not available indication. Brackets indicate that the datum is presumed

2. ALBAN EMISSARIES

Considering the Alban outlets, we note that they were almost all dug to dry up completely the shallow water basins at risk of turning into swamps; the streamlets so obtained were not exploited in any way [Germani et al. 2012]. The purpose of emptying the basin was, in these cases, to gain a fertile and well drained piece of land. It is possible that, at least starting from the 3rd century BP, the Romans planned the drainages also to fight marsh fever, that they did not identify as such, but knew to be related to swamps. In fact, these backwaters were full of *"small animals with biting stings which fly in clouds against us"* [Columella, De re rustica, I, 5]. The lack of use of the waters emerging from the drainage is likely due to the small sizes of the basins or to the reduced difference in level between the water basin and the stream end, generally the river Tiber. The only meaningful exceptions are the lakes Giulianello and Gabii, beside the two largest ones, Nemi and Albano.

2.1 Giulianello outlet

The drain system consists of two tunnels and a series of open sky channels. A first duct about 360 m long drains the Cioccati plane (or Marsh), carrying the water towards the NE side of lake Giulianello. The proper outlet begins at the SW lake border and passes the hill which separates the lake from the hydrographic basin of the river Teppia. There is no evidence of mills or other factories downstream of lake Giulianello, anyway it is known that, more downstream, the river Teppia has been navigable for some time with small boats or barges.

2.2 Gabii or Castiglione outlets

Literary sources [Lombardi et al. 2004] suggest that a natural outlet has been active for centuries on the SW side of the crater; perhaps it has been re-arranged/widened by the Romans and changed in a channel to connect the lake with the streamlet entering the river Osa. The drying up by the natural outlet was likely only partial. Instead, the underground outlet found on the N side was apparently dug at an older epoch, with the technique of digging from two opposite sides. At an unspecified time, it got blocked and forgotten. In 1838, during the new digging performed by the Torlonia family in order to dry up completely the lake, the older tunnels were discovered. Unfortunately, the technical documents relative to the Torlonia intervention, which would have been quite useful for the present study, have been lost. It is not known whether the neglect of the ancient underground outlet has been casual or intentional in order to allow, in imperial times, the use of the surface channel as a water way to carry the Lapis Gabinus (litoide tuff similar to lava stone, coming from quarries located in the territory of ancient *Gabii* but also from Tusculum; it was mainly used from 2nd century BP).

2.3 Albano and Nemi

In ancient times, all the Alban lakes have been completely dried up, so why lakes Albano and Nemi would have not? The first and most obvious reason is their depth (33 m at Nemi, over 170 m at Albano), that prevents the possibility of tapping the bottom by means of an underground channel of acceptable length. Besides, emptying the lake would not have left a fertile soil, but a muddy bottom, as it is well known to all the divers who plunge into the two lakes with very steep banks. The second reason is given by the presence, in the entrances (*incili*) of both outlets, of control rooms (Fig. 1). As regards Albano, the control room is a monumental structure built together with the outlet. As for Nemi, the structure has been modified more than once, but it remains sufficiently old to be considered as an integral part of the initial project. In both cases the streams leaving the outlets pass trough fields and operates factories.

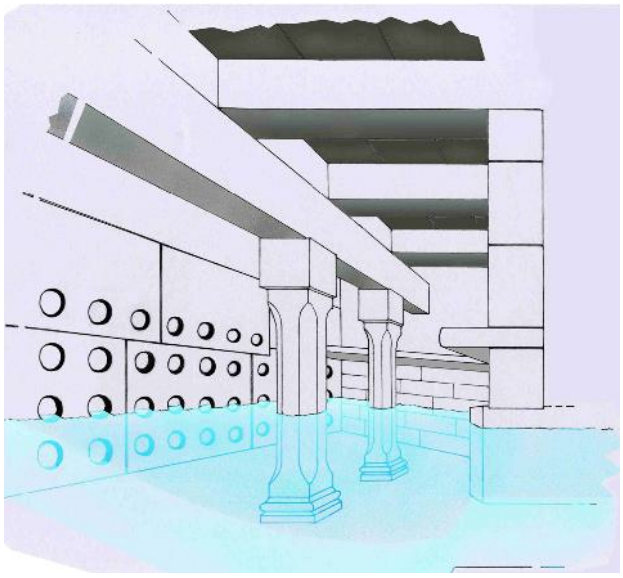

Figure 1: The control room at the Albano outlet (drawing Luigi Casciotti)

- Use for watering fields

The hydraulic systems made up by the lakes and their artificial outlets have been working, without interruptions, for more than 2000 years; they have also been a reference point for the many settlements that followed one another over the centuries. In both cases, we find control rooms provided with floodgates, built together with the outlets, in order to regulate and filter. This suggests the presence of a project foreseeing the use of the basins for watering purposes. As a matter of fact, in both cases the streams from the outlets have been used to water a second, dried up crater plane, in turn drained by an outlet (Figs. 2, 3). It has to be noted that the outlet of Vallericcia is contemporary, if not older, to the Nemi outlet [Castellani 1999], while the deviation towards the Pavona crater of part of the stream from lake Albano dates back to the Renaissance [Serra 2014 p. 29 and following]. On the other hand, the Pavona outlet is likely Roman or even older.

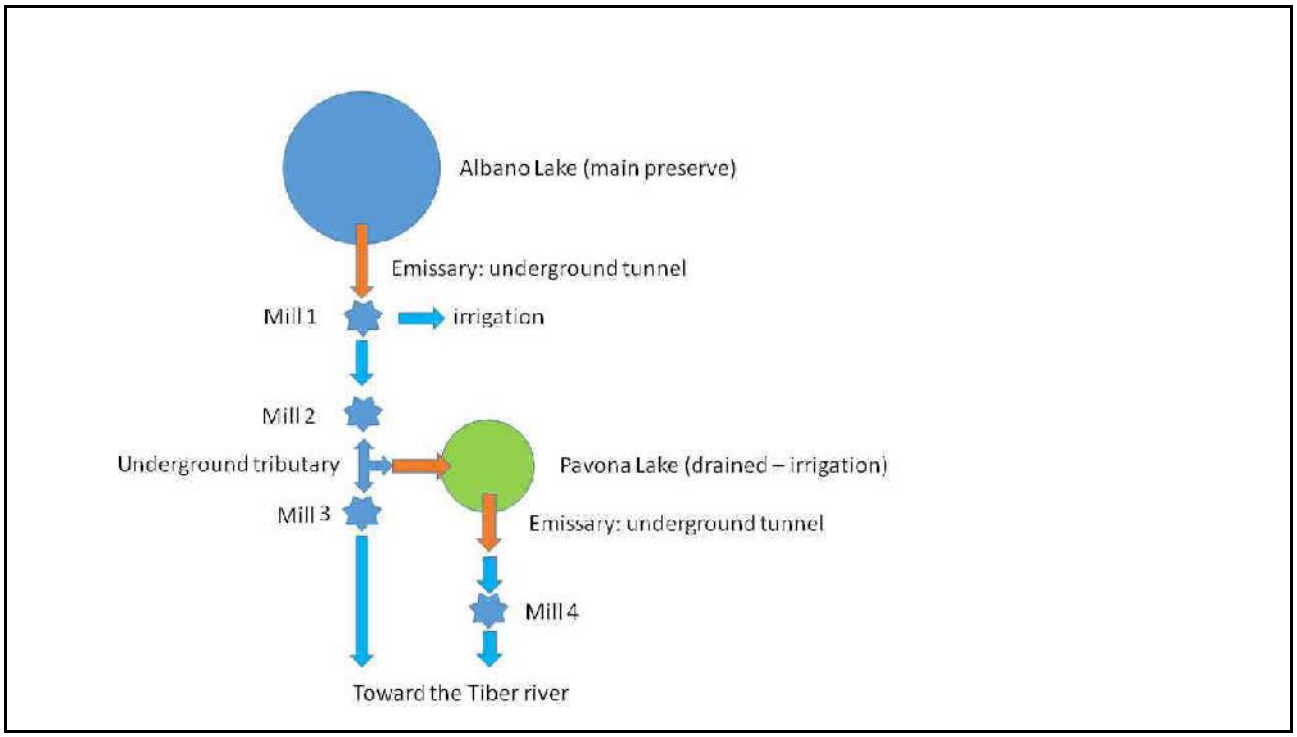

Figure 2: Structures related to lake Albano outlet (drawing Carlo Germani)

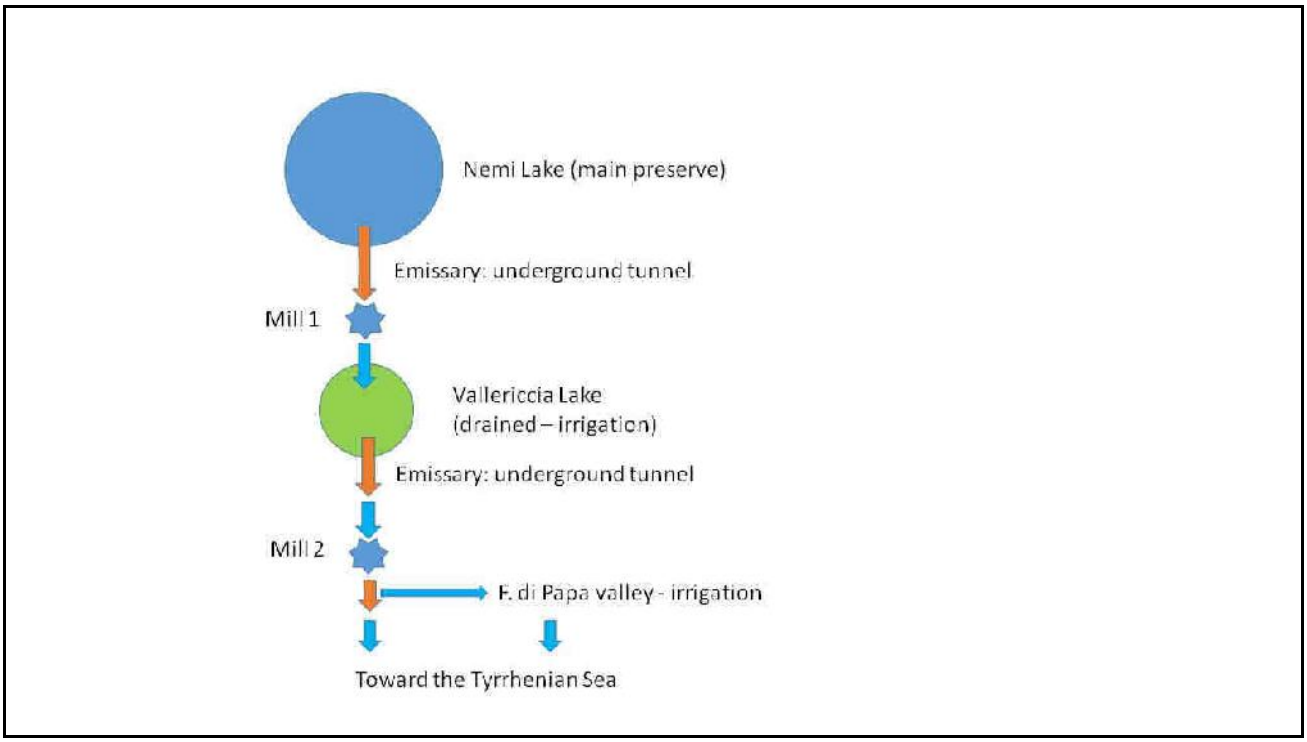

Figure 3: Structures related the lake Nemi emissary (drawing Carlo Germani)

- Use to operate mills and factories

The exploitation of hydraulic energy to power mills to grind wheat (or other products) spread all over Europe in the Middle Ages - the hydraulic wheel had been already investigated in Hellenistic time, and was well known to the Romans, even if not much exploited. Vitruvius, in the 1st century BP [Vitruvio, in Ed. Studio Tesi, 1997, pp. 483-485] reports of mills powered by hydraulic energy, and of the hydraulic wheel used to lift up water.
The mills of Roman epoch known in Europe are not many, and none is in the Alban area; they were built mainly in wood and were largely lost. What is left consists of the ruins of residual masonry structures and traces of channels [Lombardi 2011].
Many mills are known along the streams coming from the Alban outlets; they were built between the 9th and 15th centuries and later on, almost until today [Giannini 2006]. Even if some of them were built over pre-existing structures, in no case they could have been realized at the same time with the two largest Alban outlets (6th - 4th centuries BP).

3. CONCLUSIONS

Notwithstanding the ample researches, the question asked at the beginning of the present work, that is, whether the hydraulic structures here investigated are the result of centuries of use, or derive from a precise project, remains, according to us, without a clear answer. Greek and Latin literary sources almost never deal with these subjects from a "technical" point of view; even with regard to the Albano and Nemi outlets, the literary sources [Livy V,13-19 in BUR, 1999, pp. 39-51; Strabo V, 12 in BUR, 2001, p. 157] prefer to relate their construction to myth rather than mentioning their benefits and numerous uses. As for the lesser outlets, there is no trace about them in the literature.

Also archeology can be of little use, since the ancient tunnels offer very few information, and the related structures date back generally to the Middle Ages, while the eventual pre-existing structures have been wiped out.
The outlets of Gabi and Giulianello were likely used for freight downstream, even though no clear evidence has been found in this respect.

The data are more numerous for the two major systems.
The Nemi outlet is crucial in the history of the Latin people, since it protected the Diana Nemorensis temple and the surrounding fields from floods, and watered the Vallericcia plain until the first years of the 20th century. The tunnel shows signs of renovation and maintenance, performed over the centuries, and along its stream the oldest mills are found. Therefore, the hypothesis of a project foreseeing also the watering of the Ariccia plain appears plausible.

In turn, the making of the Albano outlet is strictly related to Roman history, that is, according to the literary sources, to a single episode of increase in the water level due either to a peculiar meteorological event, or to secondary volcanism. Some authors [among these, De Benedetti et al. 2014] think that the Albano outlet is the first example in history of control of volcanic risk.

Inside the tunnel there is no evidence of substantial changes after the epoch of construction. The mills along the stream coming out from the outlet have been built between the 13th and 14th centuries, while the system connecting the outlet to Lake Pavona dates back to the 17th century. Therefore, the Albano outlet, contrary to what found at Nemi, appears to have been planned exclusively as drainage of the lake, and only in a second time the resulting stream would have been used to water the fields and, in the Middle Ages, to power the mills. However, in this case some doubts would arise. To our knowledge, the Nemi outlet is dated to about the 6th century BP, and the Albano to the 4th century BP; that is, the older outlet only would have been planned as an "integrated system". Finally, the making of an enterprise like the Albano outlet with the only purpose of draining, in consequence of a single episode of overflow, appears difficult to reconcile with the difficulties involved.

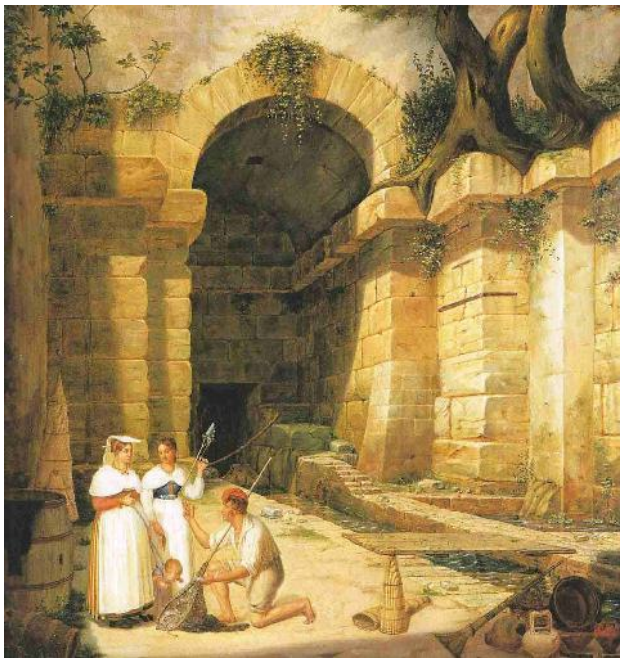

Figure 4: Johan Bravo, 1831

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Underground areas of the Villa Farnese in Caprarola (Viterbo, Italy)

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Abstract

In 2013, the speleologists of the Organization for Underwater Archeology and Speleology (A.S.S.O - *Archeologia Subacquea Speleologia Organizzazione*), acting as technical advisors for the Superintendence for Architectural Inheritance and Landscape of the Provinces of Rome, Frosinone, Latina, Rieti and Viterbo, were given the task to explore and survey Villa Farnese in Caprarola (Viterbo province, central Italy): one of the best known and charming examples of a Renaissance residence in Europe. The Speleologists of A.S.S.O, given the value of this architectural masterpiece and the importance of the task they were given, requested the collaboration of their colleagues from the *Centro Ricerche Sotterranee Egeria (Egeria* Centre of underground research). This contribution illustrates the results of the collaboration between these two teams.

Keywords

Artificial cavities, speleological investigations, hydraulics works, water management, Caprarola, Villa Farnese.

1. THE VILLA

The Villa Caprarola is the most intact example of Villa-Castle as an expression of the neofeudal ideology characterizing Europe at the end of the sixteenth century (Fig. 1). The architectural quality of the work is related to the way the volume of the building is defined, superimposing the orders and the proportional scheme, as well as to its insertion into the natural landscape, which frames the image of the villa in the scenario of the village. Cutting through the old city center with a straight line dividing two areas named Corsica and Sardegna, Architect Vignola arranged – as a prelude to the vision of the villa - a sort of an approaching path, where the main façade of the villa plays the role of an imposing background.

Figure 1: the Villa Farnese in Caprarola (Viterbo, Italy) (photo C. Germani)

The Villa takes its name from the Farnese family, which extended its power from the Tuscia to the heart of the city of Rome, becoming the main actor in the Italian and European political scenario of the sixteenth century. The Palace and the Villa were included in an urban plan where the large pentagon of the palace - the residence of the Lord, connected with the village by a straight road - dominates the village, interpreting the will of Cardinal Farnese junior (1520-1589), who wanted to celebrate the power of the family with a palace even more magnificent than that in Rome.

This majestic project was assigned by the Cardinal to Jacopo Barozzi da Vignola (1507 -1573), who had the task to design a residence of delight and hospitality within the pre-existent fortress.

The building was in fact designed and started by Sangallo in 1530 and it was interrupted at his death in 1546. When the works were resumed many years later, the fortress was intact and with a regular shape until its external frame. It was not an abandoned ruin, but a building presumably inhabited only partially at the ground floor. Subsequently, starting from the wright wing of the fortress, an underground floor was excavated for the cellars, which were not envisaged in the Sangallo's project, then the excavations continued under the yard, the vaults of the cellars were built, the walls were consolidated, and new foundations were made. The fortress was radically restructured.

For this reason, the access to the underground areas is from the large yard facing the villa, through the so called *Portale del facchino*, or through an underground corridor starting from the *Cantinone*.

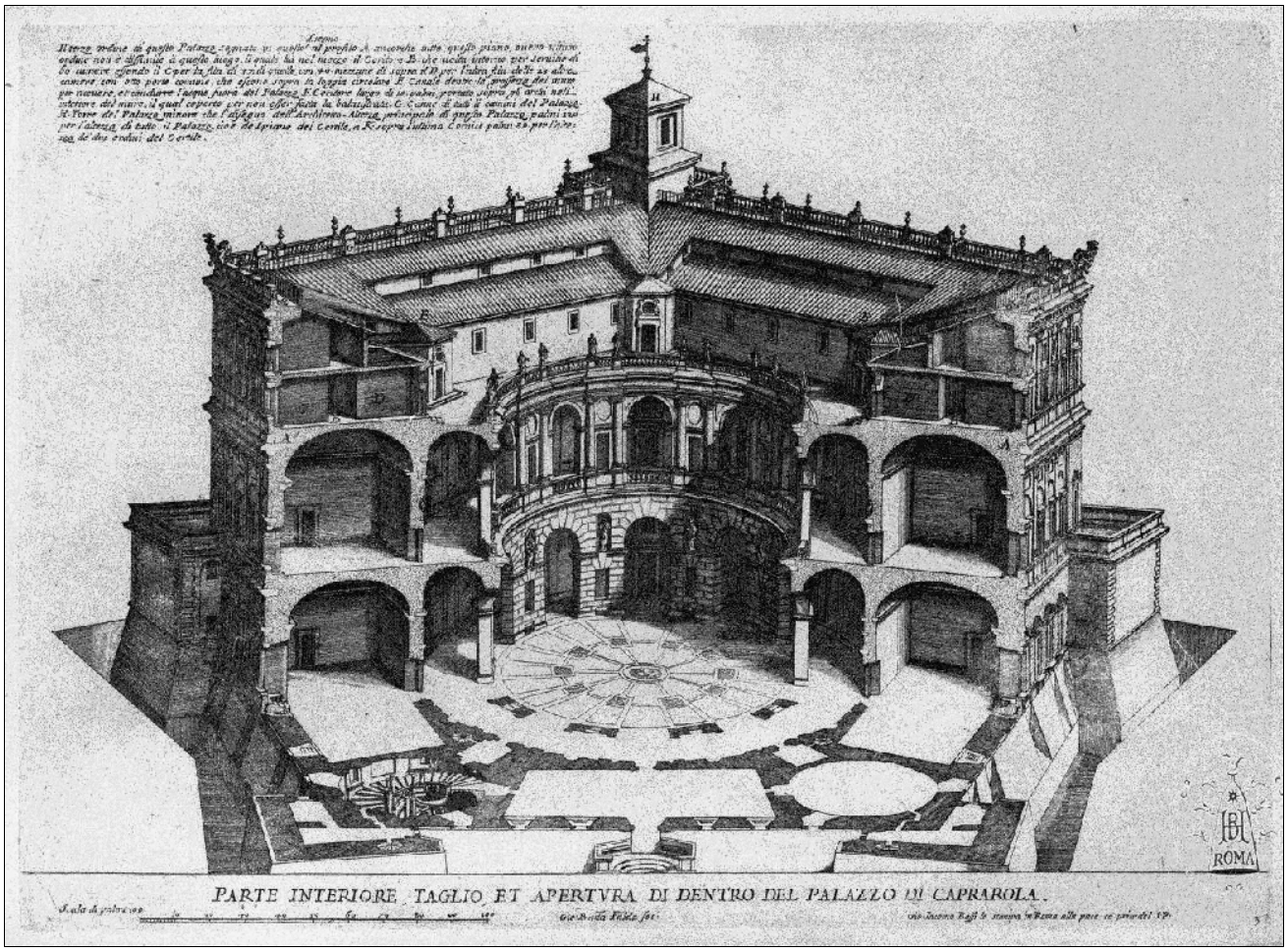

Figure 2: Giovanni Battista Falda (1643-1678): *inside, cutting and opening inside the Palace of Caprarola* (from web 30/09/2016, public domain)

The internal areas of the pentagonal and 5-story building were organized by Vignola around the circular yard with perfect symmetries, and arranged based on their function and on the hierarchical level of their inhabitants [Portoghesi, 1996] (Fig. 2).

The palace is also known for its 7650 m^2 surface of a late mannerism painting cycle, which involved the work of the most famous humanists of that age, Annibale Caro, who, inspired by classical mythology, sacred history and history, elaborate this iconographic cycle painted by the most famous artists of that age, such as Fulvio Orsini, Onofrio Panvinio, Taddeo and Federico Zuccari.

In addition to the Villa, there are the so called "*Casina del piacere*" (little house of delight), an Italian labyrinth gardens, fountains with water plays, sculptures, paintings… all this to represent a powerful family of ancient origins. Each detail of the villa had to be perfect: all the nuances of aesthetics, the structure, and the content. The walls decorated with the story of the Family's rise to power, the magnificent spiral staircase designed by Vignola and all the other spectacular details express the utmost opulence and sumptuousness, impressing all visitors, even the most prestigious.

The *Giardini Segreti* (secret gardens), built in 1583, the Park with the *Casina del Piacere*, and the terracing with fountains and water plays created in 1584-89 by Jacopo del Duca and Giovanni Garzoni are particularly remarkable. Putting the gardens at the back of the Villa, Vignola created a sort of a merging between nature and architecture, which is typical of the Lazio Villas in the age between the sixteenth and the beginning of the seventeenth century. Furthermore, inspired by the French experience, he exploited the springs in the hills to supply water to the fountains and to irrigate the gardens.

He got the secret gardens from the excavation of the hill and he designed them on a square module, with internal sub-modules, creating a labyrinth. Within the complex, the perspective axes of the two secret gardens fan out from the north-west and north-east façades, through the drawbridges, and to the two fountains, the "*Fontana dei Satiri*" (Fountain

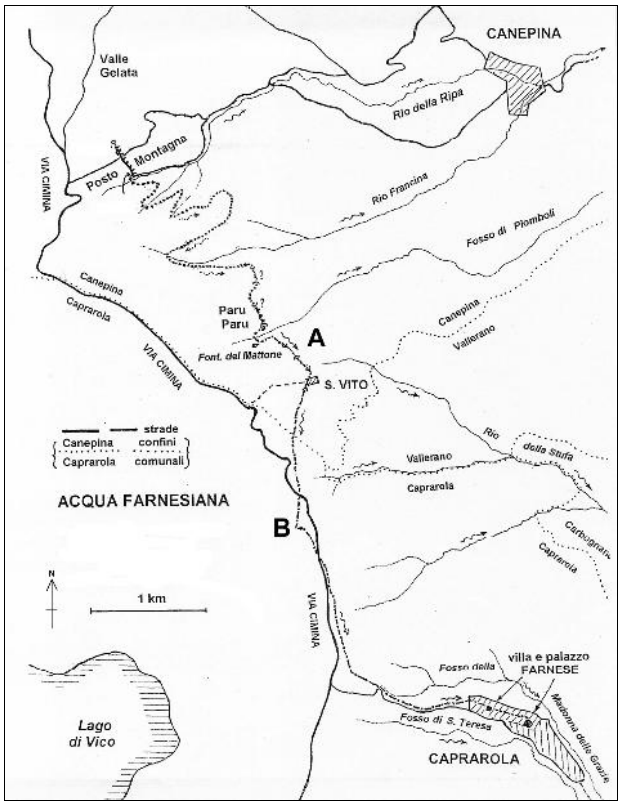

Figure 3: Farnese aqueduct track (from Cappa, 2011, modified)

of the Satyrs) and the "*Fontana della Venere che sorge dal mare*" (Fountain of Venus rising from the sea).
The avenue of the hill behind the villa was levelled out and planted with trees, as Cardinal Farnese and his guests could enjoy the wood and the variety of flowers and plants, together with the view of the architectural work and the water plays. The last intervention, dating back to 1584, is the creation of the *"Giardini grandi di sopra"* (big upper gardens), following the hill slope in a path dotted with fountains and with the *"Casina del Piacere"* as a background.

The design of the garden is by Vignola, but its first executor was Giacomo Del Duca, who realized the *Casina del Piacere*, the *Giardino Grande*, the *Cordonata*, the water chain, and the fence with the *"Fontana del bicchiere"* (the Fountain of the glass). In 1620 he was succeeded by Girolamo Rinaldi, who gave the complex a more pronounced plastic and scenografic imprint with the reorganization of the level of the Caryatids, the junction with the upper Garden, the inclusion of two pavillons at the beginning of the Cordonata, and some modifications to the *"Fontana del Bicchiere"*.

2. THE *FARNESIAN* AQUEDUCT OF CAPRAROLA

The palace desired by Cardinal Alessandro Farnese, with its gardens and water fountains, required a consistent water supply. The water captation works, which had been used until that time by the population, were insufficient, so building a new aqueduct became necessary.

The main spring (*Capodacqua*) was identified in the village *Posto Montagna*, belonging to the municipality of Canepina, whereas other springs are located in *Paru-Paru*.

The course of the aqueduct develops underground for about 9 Km. (Fig. 3) through the tuff of the Vicano volcanic district, roughly following the curves of the first tract and then mostly parallel to the *SS Cassia-Cimina* in the second tract.

An aqueduct, even if it develops underground, is a vulnerable structure and building it is a challenge. However, the relative stability of the Pontifical State allowed to carry out this complex work, which, as it frequently occurred during the Renaissance, seems to be structured following a previous aqueduct, probably built during the Roman Empire [Passini, 2002].

Unfortunately, as it happens for many ancient hydraulic works, there is no historical documentation on this aqueduct. Most probably, it was built in 1600 on a project designed by Jacopo Barozzi da Vignola, charged with the task of transforming the unfinished fortress designed by Antonio da Sangallo into a residential villa, with nymphaea and Italian gardens.

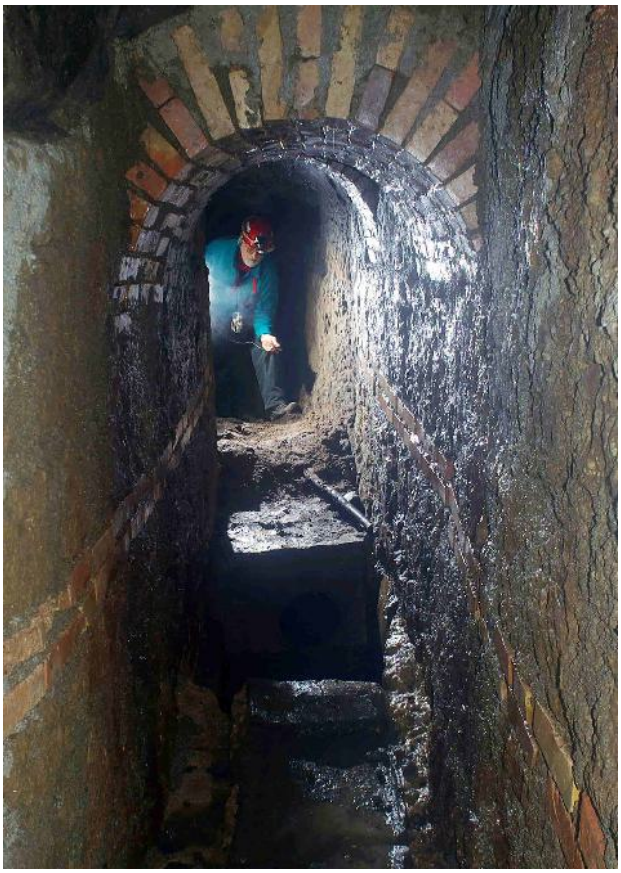

Figure 4: Farnese aqueduct (photo C. Germani)

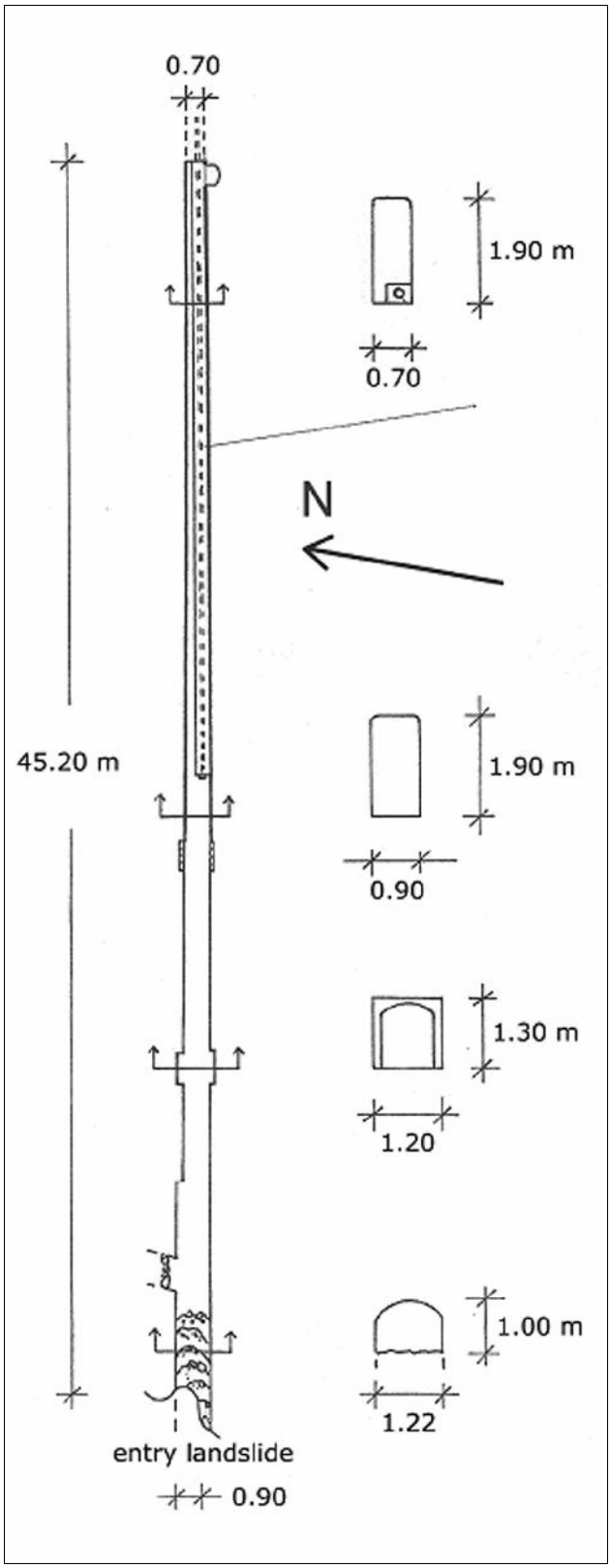

Figure 5: plan and sections of the reservoir (drawing C. Germani)

In 1850 the Borbone family, who succeeded to the Farnese family in 1700 ordered the restoration of about 6 miles of the aqueduct.

With the unification of Italy, the State acquired the property of the entire structure, but this did not prevent the progressive deterioration of the complex. Other restoration works were made in 1950, when the Farnese Palace became the summer residence of the President of the Republic.

At present, the aqueduct ends at San Rocco (at a short distance from Caprarola), from which the small amount of residual water is still canalized towards the built-up area and the Farnese Villa.

Two springs join aqueduct along its course, whereas some tracts of the same duct act as drainage galleries in the points where the aqueduct crosses suspended layers.

In addition to the initial part of Capodacqua, detected and explored by Giulio Cappa in 2010 [CAPPA, 2011], we had the possibility to go along a tract of the aqueduct at San Vito (A in Fig. 3) and another tract along the via Cimina, in a private property (B in Fig. 3).

In the first tract, previous landslides allowed us to cover a 100m-longer distance in the running tract of the aqueduct, which has undergone a number of restorations, maintenance works and modifications.

Figure 6: measuring the tank with tunnel structure (photo C. Germani)

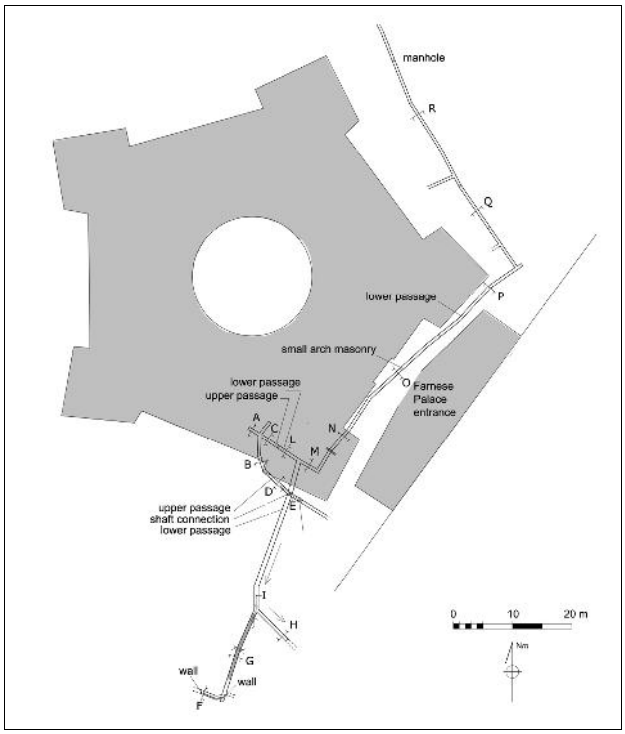

Figure 7 A: plan of the tunnel beneath the Farnese Palace in Caprarola (drawing C. Germani)

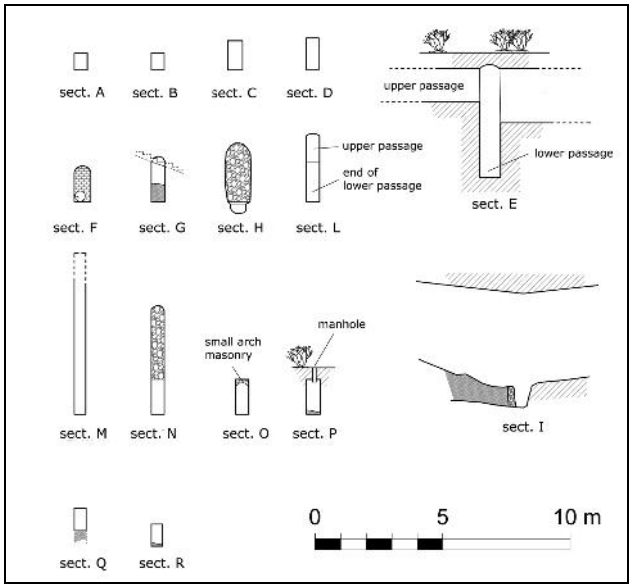

Figure 7 B: sections of the tunnel beneath the Farnese Palace in Caprarola (drawing C. Germani)

Water flows in a modest amount in the second tract of the aqueduct and is partially diverted to the Villa, where it opens up. The duct is so narrow that it can be walked along only for some meters.
This width cannot obviously be the original one and is probably due to the settlement of the tufaceous mass.

In conclusion, the major part of the duct is heavily deteriorated, has slipped down or is completely inaccessible, whereas its last tract towards Caprarola seems to have completely disappeared.

In the tracts we examined directly, the work is made of a sequence of frequently overlapping portions accomplished in different ages and with different techniques (Fig. 4).

The series of restoration interventions carried out along the centuries make it difficult if not impossible to date the work precisely, but – for some tracts – the observation of the transversal sections may lead to the hypothesis of an original Roman work.

The aqueduct is protected by the Ministry of Heritage and Culture.

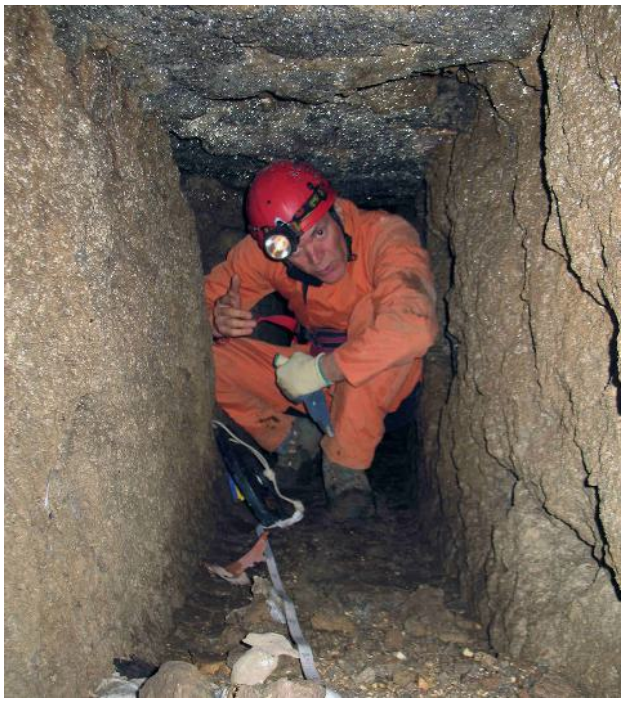

Figure 8: the very narrow duct between O–P sections in figure 7 (photo M. Vitelli)

3. THE RESERVOIR

The detected reservoir is located in the northern side of the garden at a short distance from the Villa. It is a mostly ruined structure, over 45m. long, and 70 to 90m large, with an East-West orientation (Fig. 5). The western side has partially slipped and is accessible, whereas the other ide is walled up.
The reservoir apparently has a tunnel structure, probably resulting from the partial closure of a previous tunnel, used for water transportation (Fig. 6).
From its location and altitude, it can be presumed that the reservoir belonged to the previously mentioned Farnesian aqueduct, probably being its final tract.

4. THE TUNNEL

A series of hydraulic woks for a total length of 190m have been detected and explored in the surrounding area of the Farnese Villa (Figs 7 A-B).

These works had the function to channel off from North to South the rainwater collected in the grassland between the Villa and the hill where the garden is located.

The northern side of the tunnel, until the tract located under the access to the palace, has a series of manholes located at the center of the grass corridor and at a distance of about 10 m. from each other. In this area, the duct is very narrow, but still able to carry out its original function (Fig. 8).

There are some water entries at the side of the building, probably from the roof downpipes.

The southern section of the tunnel runs under the southern rampart of the Villa, and it underwent several sub-excavations (e.g. sections MM and NN of Fig. 7 A). The waters are then conveyed to the *Fosso di S. Teresa*.

The duct, as previously mentioned, does not run perfectly around the Villa, but a tract runs under the southern side foundations, where the excavation was made deeper. This makes us believe that it was built before the Villa designed by Vignola and that it was part of the previous military fortress designed by Sangallo.

5. OTHER UNDERGROUND STRUCTURES

The long trench separating the northern part of the Villa form the large garden is characterized by the presence of some partially inaccessible hypogea. We have made some surveys but the little time available did not allow to complete the study, so we can only report their presence.

6. CONCLUSIONS

The relative stability of the Pontifical State between the end of the 16th and the 17th century allowed the building of several noble country-residences, which reminded of the ancient splendor of the Roman imperial residences.

Most of these residences had large gardens with water fountains and nymphea. The increased water needs led to the building of several aqueducts, which frequently followed the course of previous Roman or Etruscan hydraulic works, which had fallen into disuse during the Middle Ages.

The *Villa Farnese di Caprarola* is not an exception: it was built between 1559 and 1570 by Vignola upon a previous, unfinished military fortress designed by Sangallo and one of the two architects (we don't know which of the two) designed and built the aqueduct, most probably exploiting previous Roman tunnels.

We know for certain that Vignola brought the water to the garden and to the interior of the Villa, and, at the same time, he built a series of canalizations to convey rainwater.

To do this, he probably used part of the ducts designed by Sangallo for the drainage of the moat, which was supposed to surround the fortress, but which was never built.

Unfortunately, all the hydraulic structures are in a state of neglect and it is impossible to describe them more accurately, but we are sure that they could reveal unexpected aspects of the entire structure.

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Preliminary Report on the Rock-Cut and Underground Cisterns of Medieval and Post-medieval Messinia

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Abstract
Water cisterns are very common structures, but still somehow neglected by the archaeological research. They were constructed to collect water for rural, agricultural and industrial uses, taking the best possible advantage of local natural resources (i.e., water beds) and climate (i.e., rainfalls).
The relief, history and archaeology of Messinia, at the south-west edge of the Peloponnese (South Greece), leaves no doubt about its significance. It is a place where different 'ethnic' groups lived and prospered co-existing, interacting and developing their own cultural idioms: Byzantines, Franks, Venetians and Turks. In this context, numerous cisterns existed, as vital parts of the urban and rural infrastructures, offering an excellent opportunity to study their positioning, placement and structure.
The present paper focuses on these artificial water tanks through a comparative perspective. Cisterns dating to the medieval and post-medieval times are recorded. According to their typological and structural elements, they are divided into two main groups: (a) underground structures, usually rectangular in shape, and (b) rock-cut structures. They were mainly barrel-vaulted, while the roof of larger constructions would be usually supported by columns. The inner surface of the walls was lined with water-proof mortar. The positioning of a cistern, as part of a wider water supply system, was a result of careful and intentional planning that took into account the local geology and natural resources. Being crucially important for the population's daily subsistence, water collectors were built close to or within the confines of a settlement, a monastic compound or a castle.
This article is a first attempt to gather and study all information concerning water cisterns, as well as to investigate and discuss issues regarding their typology, function and positioning with an aim to create a corpus that could serve as the basis for further comparisons with non messinian counterparts. Out of the scope of the present paper and at a later stage, comparisons will be made to other similar structures in southern Mediterranean countries.

Keywords
Water; Water management; Cisterns; Messinia-Greece; Fortresses-Castles; Monasteries

Water cisterns are constructed to collect and store the water that would be distributed to settlements, castles and monasteries in order to cover the needs of daily subsistence. To be more precise, they were used to supply (examples given in medieval Greek archaeological context): a settlement [Skagkou, 2001], a castle [Dori et al., 2003], a single house [Gioles and Damoulos, 2012] a church [Gratziou, 2010] or an industrial unit [Pallis, 2011] with water; irrigate the fields and water the animals [Wilson, 2002]. They are quite popular *laic* monuments of secular architecture. Despite their very frequent occurrence as ruins of medieval and post-medieval times, especially in the Greek territory the archaeological fieldwork has barely touched issues concerning their typological variety and evolution, their technological development and their role in the formation of a settlement's space and topography [Antoniou et al., 2006; Antoniou, 2009; Mays et al., 2013]. This may be due to the fact that they are mainly simple structures of no monumental character or specific artistic value. As a result, they remained neglected and most of them are nowadays in ruins or covered by vegetation.
The province of Messinia is situated at the south-western edge of the Peloponnese (Southern Greece, Fig. 1); it is a territory where water cisterns were constructed by Byzantines or Latins (Franks and Venetians), in a period of more than ten centuries (4^{th}-17^{th} centuries). They are found scattered in various locations of the messinian hinterland, usually in rural settlements and often in regions, where intense agricultural activity was carried out. More frequently, they occur in castles – either randomly, within the enclosure wall, either at the basement of a tower; they may also be located not far from the main churches (*catholika*) of monasteries or other churches [Nikolakaki, 2004; Germanidou, 2012; Breuillot, 2013]. It seems that no effort was made to build such humble structures; however, the choice of their precise location was a result of careful planning and thorough observation of the geomorphology and environmental conditions.

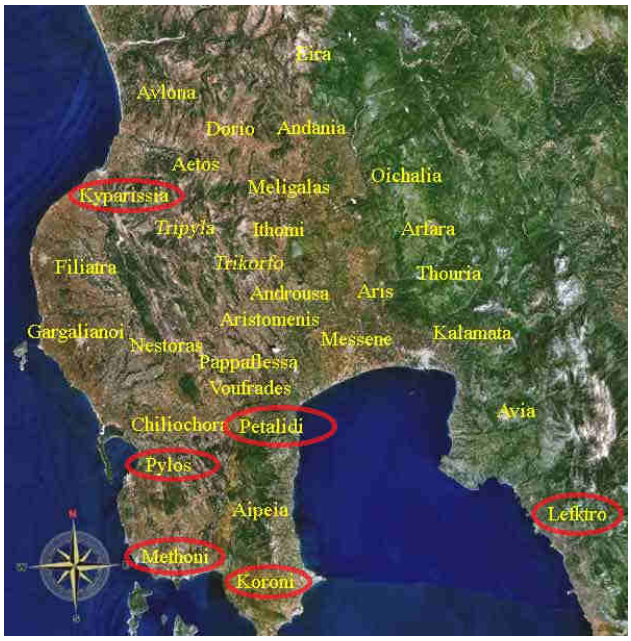

Figure 1: Map of Messinia, indicating in red the main name-places cited in the article

Figure 2: Inner coating, cistern at Lefktro castle, 13th century (Frankish)

The registration and study of the water cisterns in Messinia is in progress; hence, the present paper deals with the most representative cases and their main characteristics. These water reservoirs were built as underground structures or carved in the natural bedrock; they were either individual units or separate parts of a composite network, which would be arranged according to the way water would be collected and diffused. They can be divided into two groups, according to their construction details: they are simple small vaulted structures or more ambitious large constructions whose roof would be supported in various ways. In most cases the domes and the vaults of the roofs have partially or entirely collapsed. The collection of water was based on two main factors: the rainwater and the natural water resources that would be artificially conveyed.

Figure 3: Inner coating, cistern at Samarina church, probably 13th century (Byzantine)

Both kinds of cisterns share certain common technical characteristics, such as: the coating of the inner walls with hydraulic lime plaster to gain impermeability (Figs. 2, 3); the usually rectangular or even rounded hole that pierced the barrel-vault allowing water to fall into the cistern and – less frequently – the water pipes that would pierce the walls of a cistern conveying water to other cisterns or wells. In most cases, traces of densely and regularly disposed rafter sockets are visible on the walls. These water collectors are usually made of rubble masonry; the upper part of the walls, which hold the barrel-vault, is occasionally more carefully made using dressed blocks.

Two examples dating most probably to the Byzantine times represent the group of underground cisterns. They are large structures, both situated within two of the most important Messinian castles: the castle of Kyparissia and that of Koroni. These two cisterns are practically unknown, while that of the Koroni castle remains unexplored. In Kyparissia, a small opening at the steep west side of the castle's surrounding wall gives access to the cistern (Fig. 4 and 5). A stone staircase leads to the underground reservoir that can be described as a space, whose vaulted roof is supported by large pillars of well-carved stones. Over the lined surface of the basin one may observe the rubble masonry of the walls, which also included bricks, as well as the symmetric rectangular rafter sockets [Andrews, ²1978; Kakouris, 1978; Ioannidou, 2005]. The monumental underground cistern of Koroni castle is similar in shape [Andrews, ²1978; Nanetti, 2011]. The construction of such large and elaborate cisterns indicates the importance and prosperity of the castles, as well as the financial standards and advances architectural techniques that were developed in the adjacent settlements.

Figure 4: Inside walls at the cistern at Kyparissia castle, Byzantine period

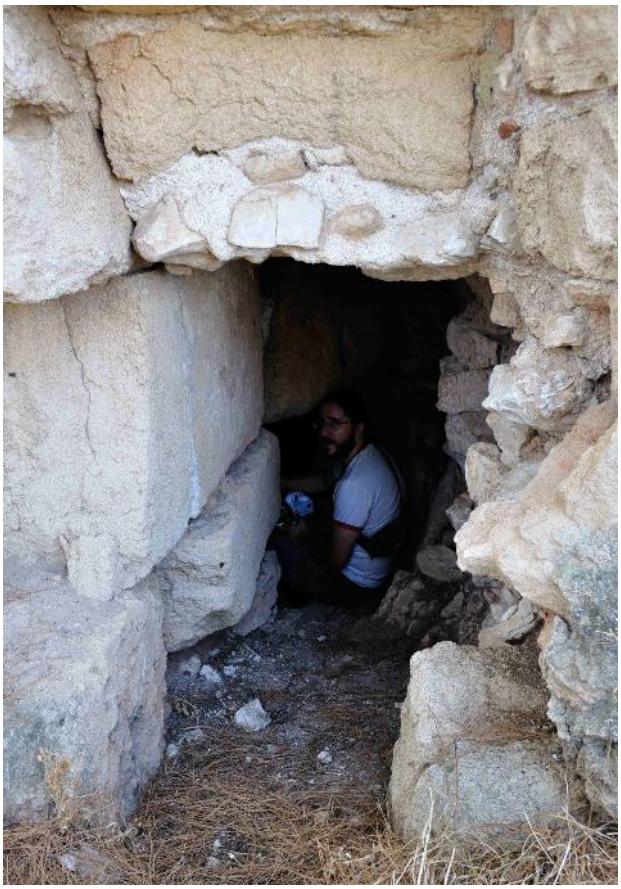

Figure 5: Access to the inside of the cistern at Kyparissia castle, Byzantine period

The group of smaller built underground cisterns is represented by numerous examples; most of them are situated in castles, as autonomous structures, while others appear integrated into the lower level of towers. Such a structure exists in the vicinity of the Byzantine church of the Virgin Life giving Spring (*Zoodochos Pege*) Samarina

Figure 6: Cistern at Samarina church, probably 13th century (Byzantine)

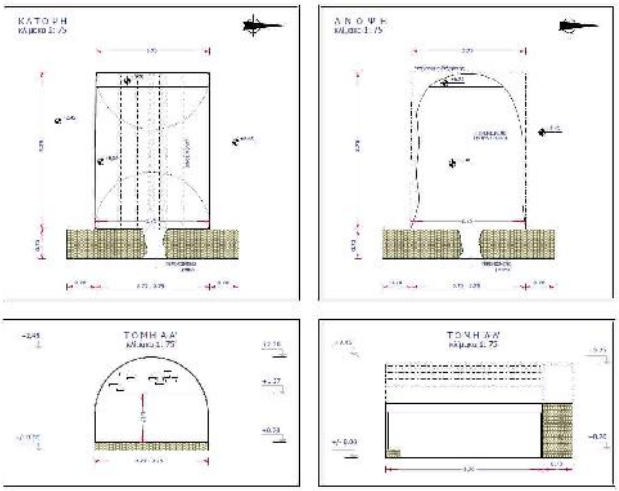

Figure 7: Ground plan and sections, cistern at Samarina church, probably dating back to the 13th century (Byzantine)

that was erected in the 12th century not far from Androussa, a village of central Messinia. This is the main church of a monastery – presumably a nunnery – and it appears that the cistern was used to cover the needs of the respective monastic community. The main compartment of the cistern is a rectangular area, whose inner walls are partially lined with hydraulic plaster. It measures 3. 76 m. by 2.72 m. and its underground part reaches a depth of 1.17 m. (+ 0.20 m. including the vaulted roof) (Fig 6 and 7).

A rectangular room made of stone masonry is attached to the east side of the cistern and incorporates a pipe that would convey water to other wells. In the neighbouring monastery of the Transfiguration of the Saviour, known as

Figure 8: Cistern at Lefktro fortress, 13th century (Frankish)

Andromonastiro, another interesting case occurs. The east part of the main church's south chapel is erected over a hydraulic installation that collected water from the adjacent natural source [Militsi-Kechagia et al., 2016].

Similar tanks for the collection of rainwater are located in castles, such as the castle of Lefktro (Beaufort, present-day Stoupa village (Fig. 8) in the messinian Mani, the castle of Peran near Petalidi village, the castle of Krempeni at Ano Melpeia village (Fig. 9 and 10) – all built by the Franks in the 13th century [Breuillot, 2005] – as well as the Palaeonovarino castle in Pylos that most probably dates to the First Period of Venetian Rule (1206-1500).

The cisterns were necessary structures in the castles, due to the fact that water should be sufficient for the subsistence of the guards, who stayed at the most remote and inaccessible places. Hence, the construction of water tanks was one of the prime concerns and a significant infrastructure included in the planning of defensive buildings.

Figure 9: The "almond-shape" cistern at Krembeni castle, 13th century (Frankish)

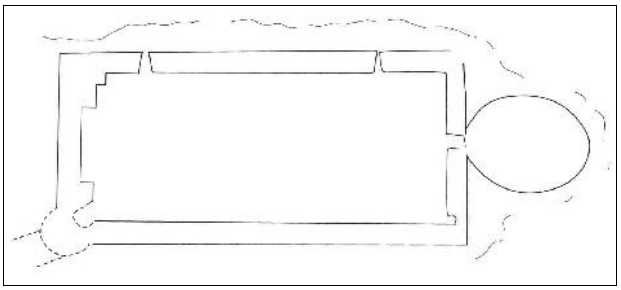

Figure 10: Ground-plan sketch of the "almond-shape" cistern at Krembeni castle, 13th century (Frankish) [after Breuillot, 2005]

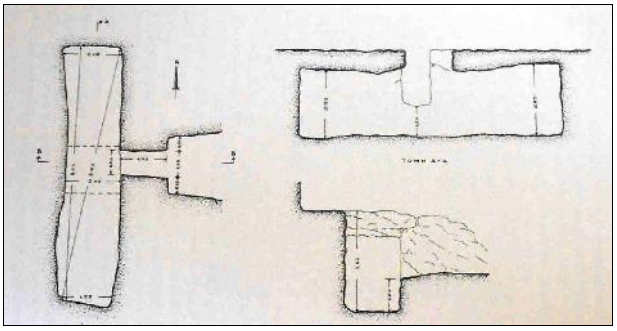

Figure 11: Ground plan and section of the Lykotomaro, Methoni, underground cistern, Byzantine period [after Pallas, 1971]

Two more Byzantine cisterns are located and excavated at sites not far from Methoni; they are both found in the uninhabited rural area, known as Lykotomaro. They are hydraulic installations that mainly served for the irrigation of the surrounding fields.

They differ considerably from the morphological point of view. The first is a group of pits carved into the bedrock; the fact that their inner surface is not lined with hydraulic plaster was interpreted as an indication that they were carved in ancient times (Fig. 11).

The above ground compartment of the Byzantine cistern is built of rubble masonry that incorporates a large number of bricks (Fig. 12).

Figure 12: The built cistern at Lykotomaro, Methoni, Byzantine period

above - Figure 14: Vault and arches, cistern at Methoni castle, 1471 (Venetian)

on the left - Figure 13: Pointed arches inside the cistern at Methoni castle, 1471 (Venetian)

Figure 15: Rock-cut cistern at Pidima castle, 13th century (Frankish)

Figure 16: Rock-cut cistern at Palaionavarino castle, probably 13-15th century (Frankish)

Its shape is trapezoid and measures 5.00 m by 3.40/3.70 m; its depth is 1.00 below the topsoil [Pallas, 1971].

The remains of the water supply system at Methoni can be compared with urban equivalents. A large number of cisterns that date to different periods are preserved outside as well as inside the castle [Andrews, 1953; Kontogiannis, 2001; 2005; Kontogiannis and Grigoropoulou, 2009; Nanetti, 2011]. The large, L-shaped cistern covered with pointed arches resting on buttress arches is the most impressive in Methoni (Fig. 13 and 14).

At the south-western corner of this monumental building the stairway leading down to the bottom of the cistern is preserved; remains of the impervious plaster cover partially the inner walls. The building is made of rubble masonry that includes irregularly inserted bricks at the vaulted parts; dressed stones are used in the construction of the buttress arches. Such a structure would exist to cover the needs of a flourishing population settled in Methoni in the First Period of Venetian Rule (1206-1500). In 1829, on the walls of the cistern, a member of the French Expedition to the Morea observed an inscription in Latin mentioning the year 1471 and the name of a Venetian inhabitant of the city.

So far, only a restricted number of large rock-cut cisterns are registered. One of them is located in the Frankish Pidima castle (13th century, (Fig. 5); another one is situated in the precinct of the Monastery of Saint Sophia (17th century) at Petrovouni – a village in the messinian Mani. The rock-cult water cistern at Palaeonavarino (Pylos) is characterised by an almond-shaped outline and seems to date to the Frankish period (Fig. 16).

The standardisation in the construction of cisterns in the Messinian territory does not differ from respective structures located in other regions. One may observe certain characteristics, such as the pillars – instead of columns – that support the vaulted roof of the large underground cisterns and a relative lack of morphological variation. The imposing cistern in the Methoni castle stands out, due to special elements, such as the buttress arches and the inscription mentioning its construction date. Building a cistern was part of an organised planning; it was never the result of an unscheduled or random initiative, because it was a major infrastructure for the vitality and subsistence of all kinds of agglomerations (castles, monasteries etc.). A cistern's mason would not care for the embellishment of the construction, which would not be costly. Only exceptions some more composite cases, such as the underground cisterns in the castles of Kyparissia and Methoni – maybe in that of Koroni as well – which should cover the needs of large populations, especially in times of long siege. The function of these water tanks is not yet thoroughly studied or fully understood; however, it is an indication of the measures taken to cover the demand for water collection and irrigation. Cisterns are buildings that stand as witnesses of the way that rural societies managed to take advantage of natural resources in order to collect and convey the most essential and vital element: water.

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Underground hydraulic works related to artificial crop areas in Cappadocia

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Abstract
In Cappadocia (Central Turkey) several valleys in ignimbrites contain large underground passages that look like natural caves. Their study shows that they are parts of old drainage galleries that were enlarged by intense weathering and floods. In the same places, on both sides of the valleys, underground aqueducts are also present. Their exploration and the observation of the surrounding topography show that these underground structures belong to ingenious agricultural systems.

Ignimbrites are very fertile if they are fragmented and irrigated but they are very sensitive to weathering and flood erosion. Former farmers had converted the valley bottoms in artificial cultivation areas, irrigated by aqueducts and protected from water erosion and floods by drainage tunnels dug to divert the surface water. These crop areas are formed by the cuttings from the aqueduct excavations, retained by massive ignimbrite walls. The wall blocks came from excavation of the drainage tunnels which therefore constituted underground quarries.

The age of these achievements is unknown but several generations of structures are visible, testifying that this practice has persisted over time. In some areas these systems are still in use.

Keywords
Aqueduct, drainage gallery, ignimbrite, crop area, flood, weathering.

1. INTRODUCTION

Cappadocia extends in Central Turkey (Fig. 1) with a mean altitude of 1200 m a.s.l. between the cities of Kaysery and Nevsehir. It is a volcanic province where Erciyes dag (elev. 3.916 m) and several other volcanoes have deposited important levels of lavas and pyroclastic formations from Neogenic to Quaternary ages [Toprak et al., 1995]. They spread on more than 10 000 km^2. The pyroclastic deposits are mainly Mio-Pliocene ignimbrites that are very sensitive to erosion. Runoff due to precipitation and snow melting has intensely shaped these volcanic formations. Differential erosion makes it possible the existence of a unique landscape of deep valleys and “Fairy chimneys”, a kind of pinnacle that forms in places where more resistant geological levels preserve soft formations that extend beneath them (Fig. 2).

The erosional products fill the bottom of the valley where they form very good land to cultivate grape, vegetables, lemon and apricot (*kayse* in Turkish), the main products of Kayseri area.

The place is also famous for its rock-cut dwellings, dovecotes and churches that were excavated, since the Antiquity, in the pinnacles (Fig. 3) and valley slopes.

In several flat areas people dug underground cities that may extend on several levels down to 40 m below the surface like in Derinkuyu.

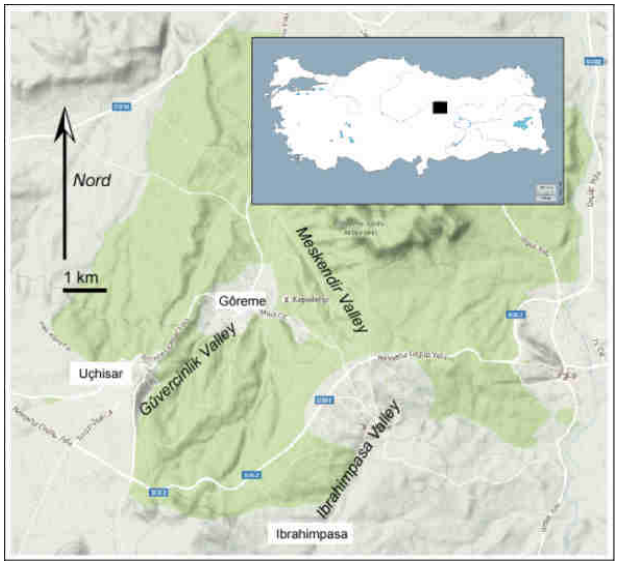

Figure 1: Location of Meskendir, Güvercinlik and Ibrahimpaşa valleys

The place was revealed to the Occident by Jerphanion [1912] who surveyed numerous Christian churches and convents in the early XXth century.

Most of the archeology studies in Cappadocia concern Byzantine and modern Greek churches [Jolivet, 2015], but

Figure 2: Fairy chimneys. Note the hard level on top that protects the softer one

older Roman and Greek graves are also known [Lamesa, 2016]. As new inhabitants used previously dug places to create their new settlements, most of cave dwellings are polyphase, thus their age is difficult to be estimated.

Due to the importance of the archeological site and the beauty of the landscape, Cappadocia quickly became a touristic place and it is now part of the UNESCO world heritage.

Since two decades important underground exploration was done by caver teams, mainly from Italy [Bixio, 2012; Andaloro et al., 2015] and Turkey [Yamaç & Tok, 2015]. They revealed the importance of non religious underground places like shelters, aqueducts, cisterns and an amazing derivation tunnel to cross the Kızılırmak, the main stream of that area [Gilli, 2013]. All of this indicate that people used underground solutions to solve hydrological problems.

In different valleys the exploration of rock-cut dwellings made it possible to discover underground narrow aqueducts that extend for several kilometers [Gilli & Yamaç, 2015], but also shorter and very large underground structures that look like natural caves.

Figure 3: Rock-cut dwellings in Göreme

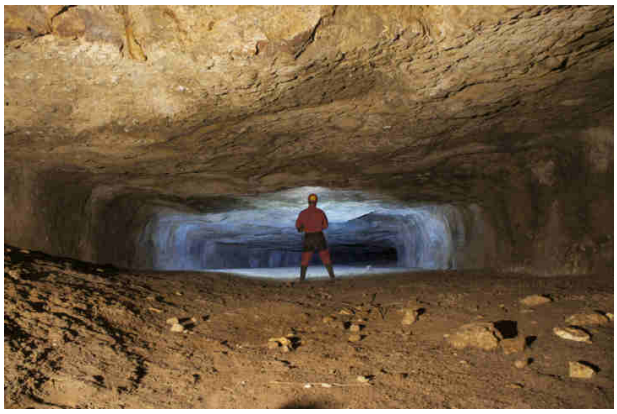

Figure 4: Derivation tunnel of Kızılırmak

It is of course impossible to have natural water caves in such pyroclastic formation and traces of rock-cut structures shows that their existence was initiated by underground artificial tunnels that were later enlarged by erosion.

The explanation is given by Castellani [2002], Bicchi et al. [1995] and Burri and Petitta [2005] that studied Meskendir valley close to Göreme and described these forms. They assume local people had created an ingenious system of hydraulic tunnels for both irrigation and drainage.

In Meskendir, a series of shallow drainage tunnels were excavated parallel to the valleys, to ensure the fast discharge of meteoric waters, avoiding erosion of the valley bottom, where agricultural crops are present.

In addition several aqueducts and cisterns could catch, drive and store water from local aquifers and rainfall. They could provide irrigation and drinking water.

These antique water works prove the good understanding of hydrological cycles and erosion processes by the ancient inhabitants of Cappadocia, and their ability to solve the problems of water supply, soil erosion and land management by using underground solutions. Similar systems are present in Güvercinlik and Ibrahimpaşa valleys.

Figure 5: Water tunnel of Güvercinlik [Gilli, Yamaç 2015]

Figure 6: Underground cistern in Uçhisar

Figure 7: Destroyed tunnel perched on the slope of Güvercinlik valley

2. FIELD OBSERVATIONS IN GÜVERCINLIK VALLEY

2.1 Underground tunnels

In Güvercinlik Valley (Fig. 1) several underground forms are present that are similar to what observed in Meskendir Valley:

- a 4 km long aqueduct (Fig. 5) that drives water to a group of cisterns in Uçhisar village (Fig.6);
- a series of short aqueducts and small cisterns in the low parts of the valley that feed crop zones;
- remains of tunnels perched on the slopes (Fig.7);
- spectacular pseudo-caves (Fig.8) and rock shelters (Fig.9) in the very bottom of the valley.

The observation of traces of rock-cut structures (Fig.10) shows that these pseudo-caves were initiated by artificial galleries, in agreement with what observed by previous authors in Meskendir Valley.

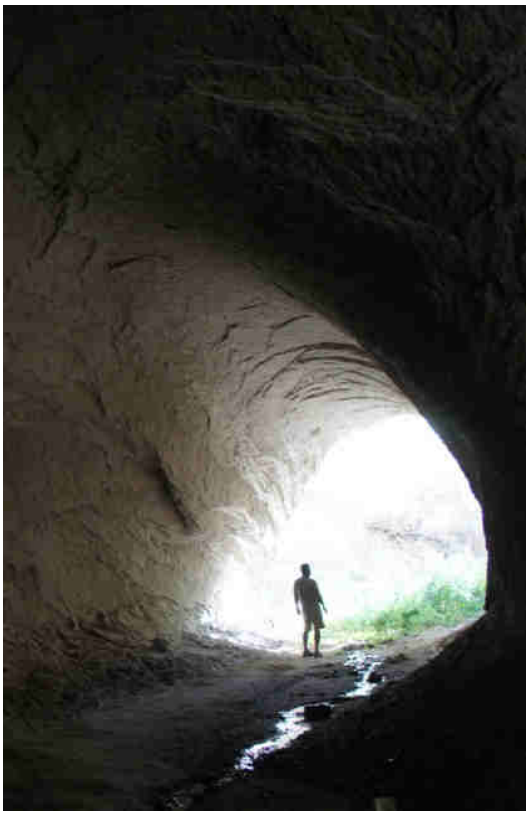

Figure 8: Pseudo cave in the bottom of Güvercinlik valley

Figure 9: Rock shelter in Güvercinlik valley

3. EXAMPLES IN IBRAHİMPAŞA VALLEY

3.1 Drainage tunnels

Ten kilometers south-east from Güvercinlik Valley, Ibrahimpaşa Valley (Fig. 1) offers good examples of well preserved drainage tunnels. As for Meskendir valley, the section becomes bigger when going downstream. Some parts are well preserved and are now used to install the sanitation pipes of the village (Fig. 11).

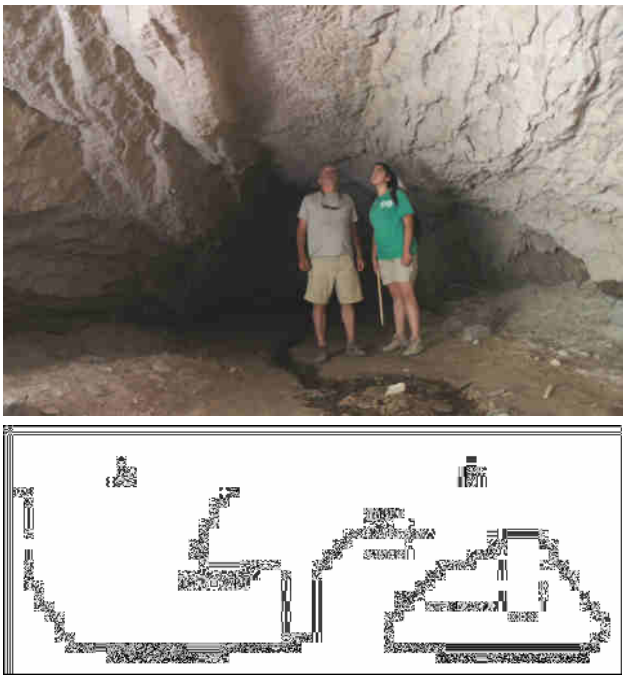

Figure 10: Remnant of artificial gallery on the ceiling of a pseudo-cave in Güvercinlik valley

3.2 Artificial crop areas

In the same valley, crop zones are well preserved and it is possible to observe side terraces (Fig. 12) and totally filled portions of valley (Fig. 13). As in Meskendir, people have created an ingenious system of artificial cultivation zones irrigated by aqueduct and protected from erosion by drainage tunnels (Fig. 14).

The soil is maintained by large blocks of ignimbrites. As no quarry is present we assume these blocks were cut underground, during the digging of the tunnels.

Figure 11: Drainage tunnel and modern sanitation pipe in Ibrahimpaşa valley

Figure 12: Crop area with a side wall made from large ignimbrite blocks

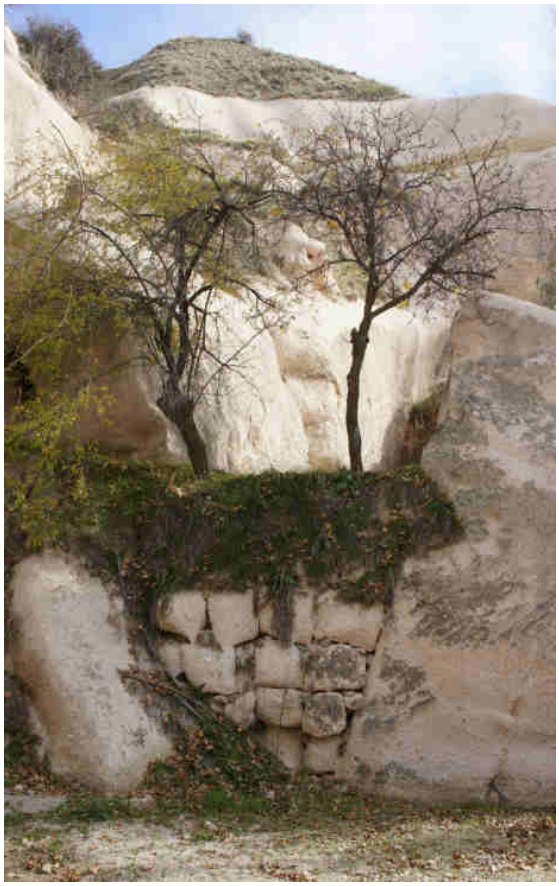

Figure 13: Tributary closed by a wall made from large blocks of ignimbrite

The observation of an unfinished grave in Sofular, a village close to Avanos, indicate that workers were cutting the walls to make ignimbrites blocks (Fig. 15). Smaller cuttings could be mixed with surface erosion products issued from the weathering of the ignimbrites slopes. This made it possible to solve both problems of evacuation of cuttings and scarcity of cultivation zones.

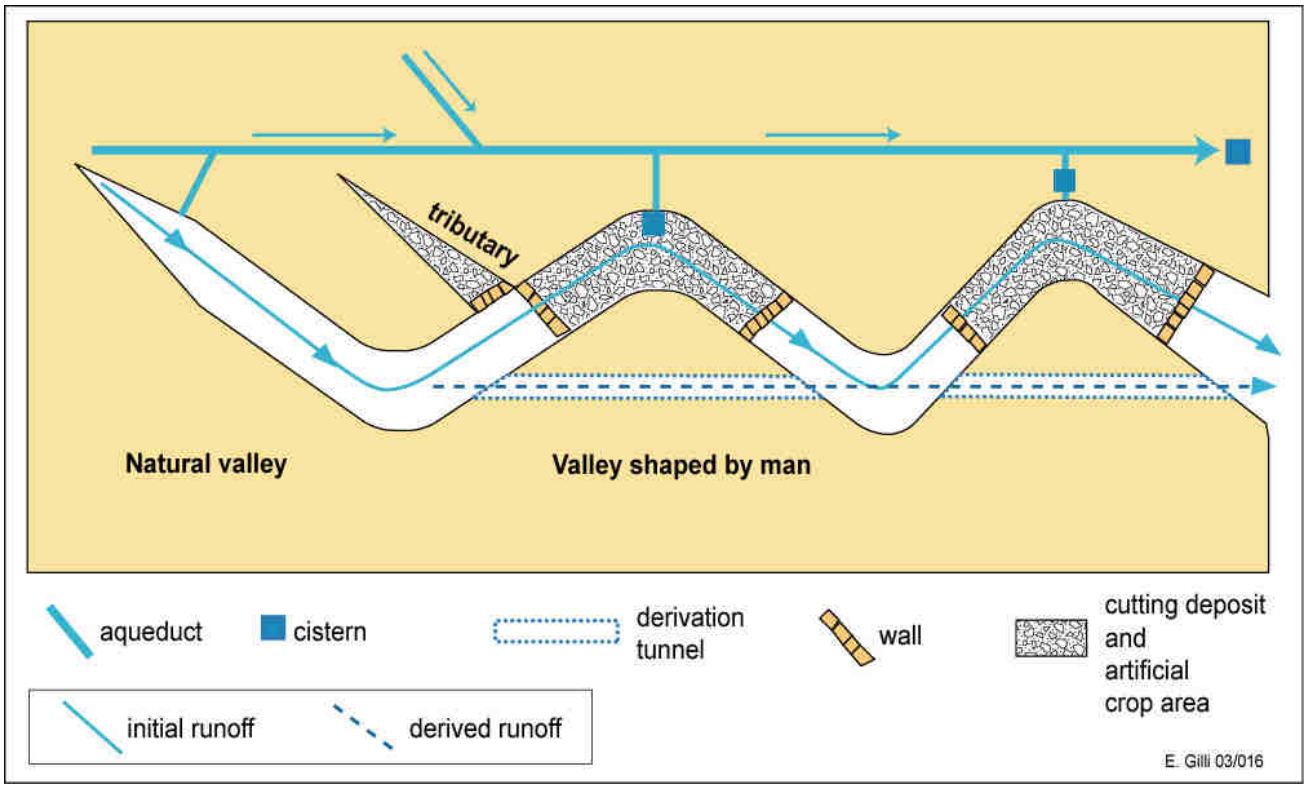

Figure 14: Sketch of the land management in Cappadocian valleys

Figure 15: Underground excavation of a block in an unfinished grave (Sofular). Left cut is around 15 cm large

4. AGE OF THE SYSTEM

As for most underground structures of Cappadocia it is difficult to know when the system was first initiated. Burri and Petitta [2005] propose a Byzantine age (VIIth to XIIIth centuries A.C.) but no one can exclude older ages as the area was inhabited by Greeks and Romans that started developing a rock-cut dwellings civilization as early as the Vth century BC [Castellani, 2002; Lamesa, 2016].

In Italy Etrurian and Roman examples are numerous that prove the ability of people to manage the flood by digging drainage channels some of these being still active after 2000-2500 years [Galeazzi et al., 2012; Parise & Sammarco, 2015; Parise et al., 2015].

5. CONCLUSION

In the three valleys the spatial organization of the cultivation areas and the tunnels shows that both problems of irrigation and protection of land were solved using underground techniques.

These examples show that the people of Cappadocia, faced with the variability in hydrological conditions, characterized by a succession of rainy periods, phases of snow melting and very dry summers, have developed irrigation and drainage techniques whose modernity must be emphasized. Indeed, they developed specific underground techniques, dictated by the lack of building stones.

These works are accompanied by a strategy to optimize the land cover and optimization of excavation techniques allowing the use of cut and fill to create artificial cultivation areas in the bottom of the valleys, a place normally subject to intense erosion.

In spite of the strong erodibility of the ignimbrites, the excavation techniques have allowed some works to remain functional for many centuries which proves their good adaptation to this difficult context.

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Tank of the Roman Villa in Tor Vergata (Rome - Italy)

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Abstract
The contribution describes a system of artificial cavities, referring to a branched cistern served by wells and at least two large tanks, inspected by A.S.S.O. speleologists who have carried out analysis and plans of the structure. The cistern is part of a Roman villa located in the southern suburbs (Tor Vergata - Rome), which has, as showed by the archaeological data, at least 3 phases of life, starting from the 4th-3th century BC. One of the owners of the villa was Caius Fonteius Agrippa, consul suffetto in 58 AD, as it can be read on a lead pipe (fistula) found during excavations.

Keywords
Tor Vergata, Rome, hypogeal branched cistern, Caius Fonteius Agrippa

1. INTRODUCTION

The parcel of land corresponding to "426a Via di Tor Vergata" has been part of a precautionary archaeological surveys from March 2013 connected to the building of a shopping centre by the "Eurospin Lazio" firm, under the scientific direction of Soprintendenza Archeologica di Roma.

The archaeological survey has dug out a complex structure of the Roman age, with multiple chronological phases (Fig. 1) and articulated functions [De Franceschini, 2005].

From the hydro-geological point of view, the area of the survey has always been characterized by a relevant presence of water since the ancient ages, like in all the South-East sector of the Roman *suburbium*.

A main freshet (perhaps in prehistorical age) flowed across the central sector of the terrain, with E-W orientation, in a riverbed whose tuff banks have been pinpointed in the northern side of the excavation. The systematic filling of the river basin created a slightly elevated hill with two secondary dikes to the sides, broken forth by the abandon of the main river.

In the historical phase, upon the river sliding layers, a complex system of water flows control has been realized, made by rectangular/circular water wells with a brim well between them, some galleries N-S orientated and a network of dispersion raceways, covered with irregular *lahar* blocks, on the S-SWO slopes of the plateau.

Upon the tuff surface that came to light near the north and south corners of the hill, there are traces of the agricultural use of the area, with NE/SW- SE/NW canals and raceways, used to prepare the terrain for vineyard cultivation.

Since the archaic ages, this site had been preferred due to elevated position upon the surrounding flat areas, insalubrious and insecure.

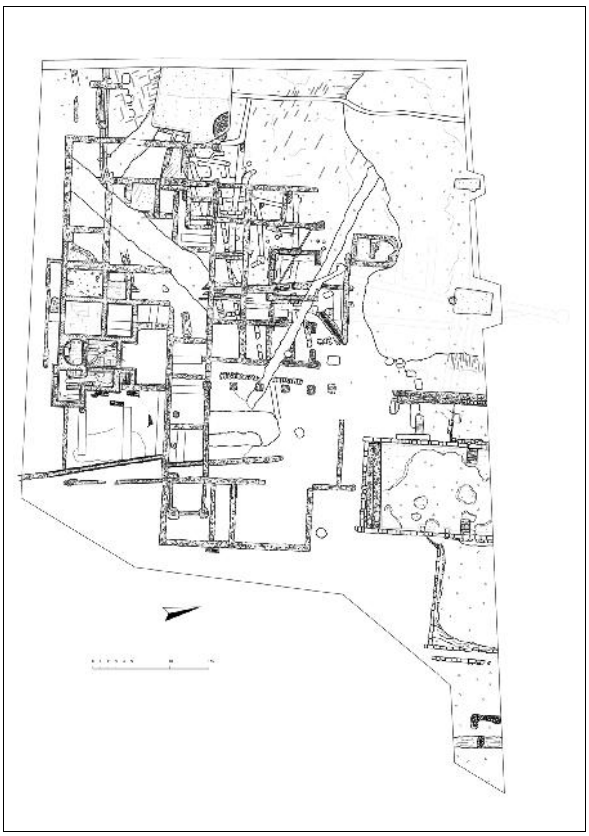

Figure 1: Main phases of "Tor Vergata Villa" (drawing D. I. Pellandra)

Figure 2: The *natatio* in the Agustan period (photo A.S.S.O. - Drone Solution: Francesco Marsala)

In continuity with the choices made in the previous period of frequentation of the site, between the end of the 4th and the beginning of the 3rd century B.C., a first settlement nucleus has been built, perhaps the first rustic villa.

The remains of the villa are an imposing structure in *opus quadratum* with rectangular blocks of gossan (*cappellaccio),* part of stone presenting alterations, infiltration or discontinuity with respect to the solid rock substantially unchanged, or delimiting a series of quadrangular rooms (Fig. 1). Of the same period is the great *natatio* found near the east corner of the plateau used as a great water collector and the coterminous, hypogeum square area, with an eight steps slip-in (for the construction characteristics of the structure, it is suggestive assuming that it is the chamber tomb of the owner of the villa, but, at the same time, it is likely that it could simply be a subterranean area built as a storage area for food or instruments and tools).

In the Augustan period, a renewed building activity began in the plateau area, consisting of abandoning of the ancient nucleus, whose structures were partly obliterated and abandoned (*natatio*) and, partly, incorporated in the new residence's foundations. The little *peristylium*, dates back to this second period, with a central area made in *opus reticulatum*, a major quadrangular delimited area and a second smaller room (with a following phase of restoration of the elevation, whit the, quite rare, usage of *cubilia* made of *latericium* in the brick-work-*cortina*). A new *natatio* was built for the new villa, smaller than the ancient one (Fig. 1).

The building of the imposing cistern with subterranean branches (better described later) dates back to this period of use of the plateau, which confirms the huge water need of the through all the I century a.C..

The findings of *Campana* slabs [Tortorella 1981; Strazzulla 1991] and of a monumental oil lamp, in association with other objects of great artistic value, support the hypothesis that the villa had belonged to an eminent personality of the Roman middle class. The owner of the villa could have been *Caius Fonteius Agrippa* of gens *Fonteia* coming from

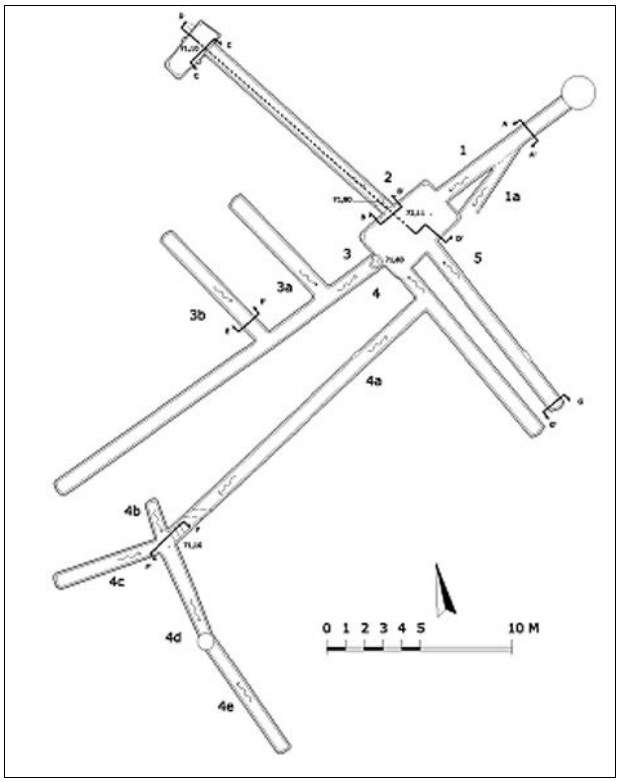

Figure 3: Hypogeal branched cistern (drawing D. I. Pellandra)

Figure 4: Tank B (photo: D.I. Pellandra)

Tusculum, whose name is written on the lead *fistula* found in the layers of filling earth in the little *peristylium* area.

In the Flavian era the main nucleus of the villa was expanded and restored, and we see the third phase of life of the complex: in the Hadrian era a little thermal system was built (trademark on the hypocaust's floor, cfr. C.I.L), and subsequently restored and restructured at the beginning of the 3rd century b.C. (212-217 B.C.).

The gradual and progressive decline of the villa starts towards the end of the same century and seven graves date

Figure 5: Tank A with *pedarole* (footholes) (photo A.S.S.O.: Mario Mazzoli)

back to this period, even though additional construction activities are documented, with the reutilization of marble elements from the previous phases inside the concrete.

2. THE HYPOGEAL BRANCHED CISTERN

Starting in the Augustan age, on the North-East side of the excavations area there is an organized system of horizontal cisterns and galleries developed under the structures of the villa, which are linked to two vertical tanks, A, smaller, and B, bigger (Fig. 4). Cisterns and galleries were inspected by A.S.S.O. speleologists who have carried out analysis and plans of the structure. All the walls of the galleries and cisterns are coated by 3 cm of *cocciopesto*, with horizontal and vertical curb at the corners,10 cm large and 10-12 cm high. On the walls, there are evident traces left by the water level (Figs. 4 - 5).

The galleries are 85 to 90 cm of width and around 180 cm of height, with barrel vault (except the gallery 1a, less than 150 cm of height). The system seems to be centred on cistern B, based on quadrangular plan (2,50 and 3 meters for the short sides and 4,5 meters for the long ones), with a little niche, which constitutes the edge of a well.

Figure 6: Gallery 2 with hydraulic duct (photo: D.I. Pellandra)

Figure 7: Gallery 4, the extrados (photo: A.S.S.O.: Mario Mazzoli)

Figure 8: Tank 4, the steps
(photo A.S.S.O.: Mario Mazzoli)

The floor is made of *cocciopesto* at an altitude of 72,11 metres above the sea level. From this cistern branch off 5 galleries: the gallery 1, from the short N-E side, is long slightly more than 10 meters and ends in a well with footholes curved in tufa (*pedarole*), of the diameter of 90 cm.

At 2,90 meters from the entrance of gallery 1 starts gallery 1a, 1,60 cm higher than the planking level, and oriented towards the N-E corner of cistern B, in which it ends up. The gallery 1a could have worked as "overflow" regulator, considering that the slope goes towards the centre of cistern B.

The gallery 2 opens in the centre of the N-W wall and is the link with the cistern A: it is 12,70 meters long and it has a little wall 75 cm high, above which probably there was a water duct stolen immediately after the abandon of the structure or afterwards (Fig. 6). Furthermore, the flooring slopes towards gallery B with a level, nearby the entrance, 30 cm lower.

Cistern A, of quadrangular plan (short sides 1,10 m S-W, 1,30 m N-W and long sides 3,10 m), has the flooring one meter deeper than the other, 71,10 m above the sea level; it has *pedarole* on the longer sides (15x12x10 cm and 30/35cm distant from each other).

The entrance to gallery 3, on the S-W side of cistern B, is preceded by a triangular decantation basin with rounded corners, completely coated in *cocciopesto* and with perimeter curbs, 50 cm deep (Fig. 2). It is likely that this was one of the point to draw waters from outside.

The gallery is 21 m. long and has – on the North side – two more parallel arms, 3 meters distant from each other. Gallery 3a is 6,90 m long and gallery 3b is 7,50 m. long; both of them have flooring gently sloping towards gallery 3, which, itself has a sloping towards cistern A.

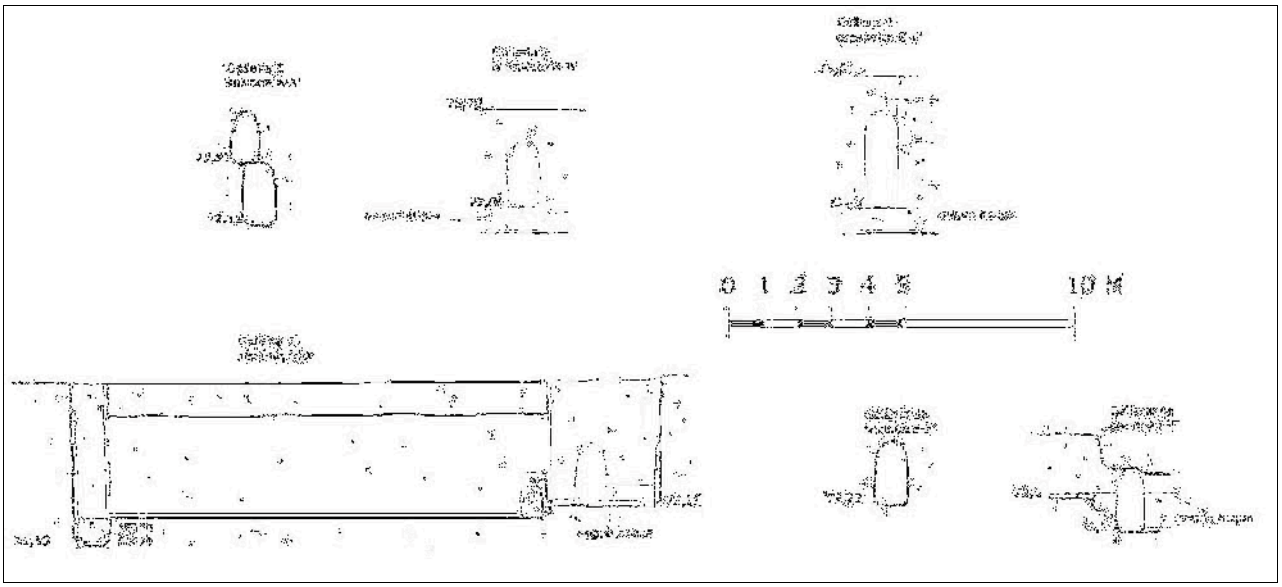

Figure 9: section of the hypogeal cistern (drawing D. I. Pellandra)

Gallery 4, the more articulated, opens in the south corner of cistern B and it is 11,09 m. long. It has a flooring sloping towards the interior; after only 1,35 m, on the west side, gallery 4**a** opens. It is 17,60 m long, and it has a flooring sloping towards the interior and then changes direction going towards three steps which connected it, with an overhang of about 1 m, with the galleries 4b, 4c e 4d, irradiating on the four sides.

The extrados (it is named extrados the upper or outer curve of an arch) of the vault, about 2 meters before the steps, has a discontinuity like a recess, 45 cm wide. It is veryinteresting to point out, that this recess is in correspondence with a water duct with a 100 cm diameter, running above the tufa surface area of the main building (Figs. 7 – 8).). The gallery 4b, only 1,80 m long, continues northbound, while the gallery 4c, 5,85 m long, goes West, as the continuation of gallery 4a. Both 4b and 4c galleries have a flooring inclined towards the interior. Gallery 4d goes South 4,30 m long, to cross a circular well 100 cm diameter with *pedarole* curved in tufa; from this point starts the last gallery, 4e, 7,10 m long, South-East oriented, still almost completely underground. The slope of the floors of galleries 4d and 4e goes towards the circular well.

Finally, parallel to gallery 4, gallery 5, 10.59 m long, opens on East wall of cistern B. It has a flooring sloping towards the centre (Fig. 9).

As it is evident by this description, the cistern developed under the villa with a precise and regular series of galleries, coated by hydraulic plaster, with slopes built depending on the wells excavated to use the stored water.

It is interesting to note the presence of decantation basin to improve the quality of the extracted water, exactly on the vertical side of the main wells.

The dating of the final phases of use of the cistern is inferable by the ceramic found during the archaeological survey, and - in particular - thanks to the finding of two oil lamps dated to the 5th century B.C. in the layers of filling earth in cistern A.

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Dating and Understanding the Underground Water Structure in Gaziantep based on *Şeriye* Records and Charter of *Wakfs*

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Abstract
Gaziantep's historical water structure comprises underground tunnels that bring water from a spring about 14 km west of the settlement. The tunnels, referred to as *livas*, provide water to many monumental buildings, including mosques, khans, baths, madrasahs and fountains, and to the wells of the privately owned houses in Gaziantep. The *livas* construction technology resembles that of the *qanat* systems that can be found in most parts of the world, from China to America, with the dates going back 2500–3000 years. The construction technique and its main elements can be identified from the existing traces and parts of the system, although putting a date to the construction of the tunnels remains an issue. The water tunnels in Gaziantep form a huge network beneath the settlement, with a main course and many subsidiary lines going in different directions. All of these subsidiary lines worked as a whole to ensure all users benefitted from the water, and as a system that provided so many with one of the fundamental needs of mankind, water, rules had to be established for its usage. It is the intention in this paper to identify the construction dates and water usage rights and rules of the entire *livas* system, for which an analysis will be made of the charter of *wakfs* and *şeriye* records. The first part of the paper describes the historical water system in Gaziantep, after which, in the second part, the *şeriye* records and charter of *wakfs*, containing information about the construction period of water system of Gaziantep, will be introduced. The final part includes evaluations and proposals for estimating the age of the underground water system in Gaziantep.

Keywords
Water system in Gaziantep, *livas*, water usage records.

1. INTRODUCTION

The earliest sign of settlement in Gaziantep, a city in southeast Turkey, dates back to the 5th century, with the first signs of settlement found within the walls of Gaziantep Castle [Özdeğer, 1996].

The settlement expanded towards the south of Gaziantep Castle over time, and gained in importance as a settlement after the 13th century [Çam, 2006]. As a result, at the beginning of 13th century the city saw significant development, with new constructions and new agricultural areas and gardens opened for cultivation [Çam, 2006], since this area has a long history of agriculture.

The Alleben River, which flows through the city in NW–SE direction, must have been an important source of water for both the agricultural areas and the settlement, but as the city's water needs were more than could be provided by Alleben River, underground water tunnels were constructed to bring spring water from outside the city.

Constructing water tunnels under the ground provides some advantages like protecting the fresh water from external threats and vaporization [Parise M., Galeazzi C., Germani C. & Sammarco M., 2013], thus underground water structures can be identified in many cultures [Parise M., Galeazzi C., Germani C. & Sammarco M., 2013; English, 1968; Wulff, 1968].

The historical water system of Gaziantep is formed around a tunnel, referred to locally as the *livas*, which brings water from a spring nearly 14 km away from the city center. The *livas* tunnels are self-supporting underground structures that work based on gravity, with two different constructions techniques observable at the site.

Some parts of the tunnels are constructed close to the surface, for which the builders dug a tunnel into the bedrock and then covered it with an arch (Fig. 1), after which the excavated hole was back filled with soil to ground level. For the parts constructed several meters below the surface, vertical shafts were dug that were then used to construct the *livas* tunnels below ground by linking the vertical shaft horizontally (Fig. 2).

This technique is similar to the qanat system that is in wide use in most parts of the world, from China to America, with systems that date back 2500–3000, bringing underground water to the surface via underground tunnels, utilizing only gravity [Qanats; English, 1968; Wulff, 1968].

Figure 1: *Livas* tunnel constructed close to the surface (photo Uçar, 2014)

Figure 2: *Livas* tunnel constructed several meters below the surface (photo Uçar, 2014)

The *livas* provided water to many structures in the city, such as khans, madrasahs, baths, mosques, fountains and private houses by way of wells. The *livas* also provided water to special structures for the public usage of water, referred to locally as kastels – underground structures at varying depths based on the level of the *livas* lines.

These structures had different functions, including pools, wells, sitting places, small mosques, toilets and bathing facilities. To date, six *kastel*s have been uncovered, but it is known that there were more. Among the uncovered *kastel*s the Kastel of Pişirici dates to the 13th century, and is believed to be the oldest in Gaziantep [Çam, 2006] (Fig. 3), while the Kastel of İhsan Bey has been dated to the 14th century; the Kastel of Kozluca to the 16th century or earlier; the Kastel of Şeyh Fethullah to the 16th century; and the Kastel of Ahmet Çelebi to the 17th century or earlier. These are not to be confused with public fountains, which are also referred to as *kastel*s in the region.

Although there are some documents that have helped researchers to date the *kastel*s, the construction period of the *livas* tunnels has yet to be ascribed. As described above, this water supply network is a huge architectural and engineering system, spread out beneath the city and serving many buildings and structures. Water is one of the basic needs of all humankind, and so it concerns everyone. In this regard, constructing a system for the supply of water is something that goes beyond the mere technological structure, as there is also a need to establish rules to ensure equality among users, and these date back to the very dawn of civilization. In Gaziantep the water tunnels bring water to many buildings and structures in the city, and so it is obvious that rules would have been needed to be in place to ensure equality and order among the different stakeholders.

Providing water is a public service and a governmental responsibility. Today, municipalities are responsible for providing water for public usage, although in the Ottoman Period, the government was not responsible for many public services, including the provision of water to its citizens. In the Ottoman Period, the provision of water and maintaining equality and order in its usage were managed within a specific administrative system of the Empire involving the *qadi* as a state organization, and *wakfs*, guilds and neighborhoods', as public organizations sharing the responsibility in public services [Ökmen & Yılmaz, 2015; Ortaylı, 2015].

In this system, *wakfs*[1] were responsible for the provision of water for public use, while it was the duty of the *şeriye* court to resolve any water related disputes that reached court. The *wakf* system, which began by serving only personal and local needs, developed over time to provide also social, economic and cultural support, and became involved also in education, healthcare, transportation, security and the provision of public service [Bilgin & Alpaslan, 2014]. In addition to khans, baths and mosques, *wakfs* also came to oversee the construction and maintenance of waterways and associated structures [Köprülü, 1938]. The *wakfs* provided water-related services independent of the state and according to its own rules, without imposing taxes or taking payments from the public. Within the overall system the administration of *wakfs* was the responsibility of the *şeriye* courts, and the *qadi*, as the arbitrator within the court.

In parallel with the general administrative system of Ottoman Empire, *wakfs* provided water for public use in Gaziantep [Yücel, 2014] under the control of the *şeriye* courts, where they played an important role in meeting the water needs of the city.

[1] *Wakf*: A permanent dedication of any movable or immovable property for charity, such as education, healthcare or social services. The person dedicates the property is known as a *"wakif"*. Once a property is dedicated, all rights over the property pass to the *wakf* board and the trustee of the *wakf*.

Figure 3: Kastel of Pişirici (photo Uçar, 2012)

The Gaziantep *şeriye* court records cover the period spanning the early 16th century to the beginning of the 20th century [Külek, 2010], and include a great deal of information about the water usage rules and construction permissions for the period.

2. WATER RELATED RECORDS IN *WAKF* CHARTERS AND *ŞERİYE* COURTS

Wakf donations for the construction of water facilities in Gaziantep came in two different forms:

1) Donations of real estate or money for the maintenance of water tunnels for purely altruistic reasons, such as:

- Local people donated real estate to the Kale Fountain in 1611, stipulating that monies raised be used for the maintenance of water tunnels running to the fountain [Kopar & Özkan, 2014].
- In 1688, a local person donated half of her estate for the waterways of Karatarla Mosque [Yücel, 2014].
- In 1707, a local person donated 10 *kuruş* to the waterway providing water to her district and the local mosque [Yücel, 2014].
- In 1755, a local person contributed 20 *kuruş* to the maintenance costs of the waterways to the pools of Tahtalı Mosque [Yücel, 2014].
- In 1886, siblings in the Tışlaki district donated their shop to supplement the general and water tunnel costs of the Kastel of Keçehane [Kıvrım, 2014].

2) Donations of estate or money in exchange for personal benefit related to water usage such as:

- In 1666, Recep Efendi, stating that the route of the water tunnel serving Handaniye Mosque passed close to his house, said he would like to benefit from the water in exchange for a 40 *kuruş* donation to the *wakf* of the mosque [Yücel, 2014].
- In 1698, Es-Seyyid Ali Çelebi offered to donate 28 *kuruş* for the maintenance costs of water tunnel and one *batman* (measure unit, corresponding to 7.692 kg) of oil each year to the Ömeriye Mosque in exchange for the benefit of water. The trustee of the Ömeriye Mosque *Wakf* agreed to supply one *masura* (measurement unit of a stream) of water in exchange for the donations [Yücel, 2014].
- In 1719, following the construction of Hüseyin Paşa Mosque, Hüseyin Paşa donated 50 *kuruş* for the maintenance cost of the water tunnel network in the city. With the participation and approval of, first of all, the trustee of the *wakf* of the water tunnel network in the city and Gavri Fountain, as well as the trustees of Kale Fountain, Mihaliye Madrasah, Tekye Mevlevihanesi, Tahtalu Mosque, İbn-i Eyyüb Mosque, Boyacı Mosque, Gergerizade Mosque and Hacı Nasr Fountain, the *qadi* gave Hüseyin Paşa Wakf permission to construct a private water tunnel branch from the main water tunnel of the city [Yücel, 2014].
- In 1850, Kenan-zade Hacı Abdo Ağa, Hacı Aba's son Arif and his son-in-law, all of whom live in the Amu District, stating that the route of the water tunnel to Molla Ahmed Ömeriye Mosque passed close to their house, said they would like to benefit from the water in exchange for a donation of one batman of oil each year [Yücel, 2014].

The records show that the growth of the city in the 17th and 18th centuries resulted new demands on the growth of the *livas* network. It is apparent in the records that in some cases, people were channeling water to their properties from an existing tunnel, probably by constructing small tunnels from the existing network to their properties, but in some cases the *wakfs* constructed new subsidiary tunnels directly from the city tunnel to certain properties. The continuity and maintenance of the tunnels were also provided by the *wakfs*, as can be understood from the following records concerning the maintenance of *livas*:

- Records from 1891 concerning the income and expenses of a *madrasah wakf* adjacent to Boyacıoğlu Mosque state that the *wakf* paid 5 *kuruş to a kanavatçı*[2] every month [Kavaklı, 2012].
- In 1895, a *wakf* recorded expenses in the form of a payment to the *kanavatçı* of the Kastel of Aslanlı [Kavaklı, 2012].

Şeriye records also provide us with data that can help in understanding the construction period of the water tunnels in Gaziantep:

- In a judicial entitlement from 1711–1712, it is stated that with the participation and approval of the trustees of Tahtalu Mosque, Alaybey Mosque, Allaüddevle Mosque, Kervan Beğ, Ferhadiye Mosque, Guru Fountain, Lala Mustafa Paşa, Hazaniye Mosque, Beğ Mosque, Falik Fountain, Gergerizade Mosque, Ağa Mosque and the clerk of the Mahir Efendi Pool, Esseyyid Ahmed is granted the right to access the water

[2] *Kanavatçı* refers to a worker employed in the maintenance and repair of *livas* tunnels.

network by constructing a tunnel branch from the existing network, following a donation of 120 *kuruş* for the maintenance cost of the tunnels. The judicial entitlement covers the construction of a new tunnel linking first to the pool of İbn-i Eyyub Mosque, then to the house of Mehmet Ağa in the Şarkiyan District, then to the small mosque constructed by Şeyh Mehmed Efendi and then to Ahmed Çelebi Mosque [Yücel, 2014].

- A case related to the watering of animals from the *livas* tunnel in 1766 was brought by the trustees of Ferhadiye Mosque, Bey Mosque, Münhaliye Madrasah, Boyacı Mosque, Alaybeyi Mosque, Koca Nakıb Madrasah, Guru Fountain, Eyyub Mosque, Beşpınar Bath, Hüseyin Paşa Bath and the trustees of additional mosques, madrasahs and fountains. They stated jointly that the old tunnel linked to the villages of Öğüm Söğüt and İsbatrın and the water flowing from the spring to all tunnels of the Sacur River waterway had long been providing water to most of the mosques, baths, wells and fountains in Gaziantep, and so they all had the right to benefit from that water. They accused the villages of illegally watering their animals from this tunnel, and petitioned the court to intervene by banning the practice [Kuzucu, 2006].
- In an 1894 case concerning the water tunnel to the Kastel of Mihenk, the trustee of the *kastel*, along with other stakeholders with the benefit of water usage Mehmed, Hasan, Hacı Şerif, Ali, Kadir, Mehmet Ali, Katip Hocazade Hafız Ahmed Efendi, Süleyman from the Bostancı District; Durdu, Seyyid, Ali, Memik, Mehmed, Mahmud, Terlik Mehmed and Ahmed from the Kastel District; and Zincirli Ali, Kasabbaşı Mehmed, Çapan Ali, Ahmed, Haydar, Bostancıoğlu Ahmed, Mehmed, Çelebi Ahmed and Neccar Yahya from the Emir Ağa District opened a court case against Hacı Hüseyin and Ali ibn Mustafa, accusing them of illegal usage of water from the tunnel of the Kastel of Mihenk, and of causing damage to the tunnel. Hacı Hüseyin and Ali ibn Mustafa proved that they had been benefiting from the water for 50 years, and that their subsidiary tunnel had not damaged the tunnel of the kastel [Babanınoğlu, 2004].

3. CONCLUSION

The purpose of the Ottoman period *wakfs* related to water usage can be summarised as overseeing the provision of water by building water structures such as tunnels, fountains and pools, and ensuring the continuity of water supply through maintenance and repair.

Şeriye records and the *wakf* charters concerning water usage rights, including liabilities and benefits, state that the construction of underground tunnels, *livas*, continued in parallel with the growth of the settlement. In their construction, *wakfs* played an important role, having the right both to use the water and to grant permission to others. As clarified in the *şeriye* records and the charter of *wakfs*, a *wakf* could obtain permission for the use of water from the *wakfs* of the main tunnel, and to provide water to the mosques, madrasahs or khans through a subdivided new tunnel through a judicial entitlement and with the approval of all stakeholders. The *wakf* then had the authority to grant permission to other people or *wakfs* to benefit from the water of its own tunnel. As can be understood from these records, the *livas* tunnels were not constructed as part of a single project, but rather were added to in line with the needs of the developing city over many years.

The construction period of the main tunnel flowing from the spring in Pancarlı is yet to be ascertained, although some local researchers date the construction of the main city tunnel to 1711–1712 in the Qadi Mahir Efendi period based on several different sources, including the poems of Nabi. There is, however, evidence that the main tunnels are somewhat older than this. Ünler, referencing to the wakf charter of the Wakf of Qadi Mahir Efendi, claims that the tunnels already existed at the time Qadi Mahir constructed the properties of the *wakf* [Ünler, 1943]. Besides, as the oldest *kastel* in the city; the Kastel of Pişirici dates back to 13th century, and it is believed that the *livas* tunnels must have been constructed at the same time or before the construction of the *kastel*.

Historical documents always identify many agricultural areas in close proximity to the settlement, and so water would have been a necessity, and must have been supplied in parallel to the development of the settlement and agricultural activities. Accordingly, a detailed study of the historical development of the city may help identify the construction date of the main tunnel.

It is clear that the water system was not designed following a holistic approach, but rather developed with additions throughout history until the end of Ottoman period. Despite this, it works as a whole and is the concerns of all its users. Another important point worth noting is that the *livas* tunnels were constructed using the same construction technologies throughout history using knowledge that was passed down from generation to generation.

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Underground Hydraulic Structures of Gaziantep (Southeast Turkey): *Livas* and *Qastels*

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Abstract

It has been long known that Gaziantep, possessing a continuous inhabitancy since 3.000 BC, has hundreds of underground structures carved in sandy limestone. Some of those underground structures were used as storage facilities or cisterns, while some others are as yarn ateliers today. Furthermore, despite forming a huge and complex system, underground water structures, only a small part of which can be researched due to destructions, are another important phase of our project. It is extremely difficult to determine the roots of this extensive, technologically advanced water distribution system. While the section that can be seen above ground is fairly limited, it is difficult not to consider this system as an important engineering achievement for its era. This water distribution system is a network of water canals carved into limestone rock layer, locally known as *"livas"*, onto which the city was built upon. This system is similar to the one first applied in Persia 2000 - 3000 years ago and used today in many countries such as Morocco, Algeria, Egypt, China and known as *"qanat"* or *"karez"* while displaying a set of unique characteristics unique to Gaziantep. The system relies on the principle of distributing water originating from a source far away from the settlement area, by using well designed underground canals with gentle slopes to distribute the water to a large settlement area and by using wells in locations of need or by clear water underground reservoirs known as *"qastel"*. As a result of our studies, limited length "*livas*" and all existing "*qastel*"s were surveyed and mapped in Gaziantep.

Keywords: Gaziantep, underground hydraulic structures, *livas, qastel*

1. INTRODUCTION

The city of Gaziantep, located in Southeastern Turkey (Fig. 1), developed around a castle built in the 11th century, during the First Crusade. Archeological excavations documented that the previous location of the city was at the Düllük Village, 9 km away from the castle. This settlement, dating back to the Paleolithic Period, was abandoned and the city developed in its current location.

The greatest problem of the city of Gaziantep is that it does not have a water table. The city that was built on a hill and that developed in time, has solved this problem by transporting the water from nearby springs through underground aqueducts. The plateau that houses the city of Gaziantep and its periphery mostly consists of limestone and chalk, Upper - Middle Eocene in age [MTA, 1997]. Although it mostly made of soft rocks, thicker layers of massive limestones can also be observed.

Argillaceous limestone consist of whitish, gray, cream, dingy yellow, loose and thin middle-layered and chalky layers. Tens of kilometers of underground aqueducts, called "*livas*" locally, were dug under the city that is situated over this easy-to-dig soft limestone. Although it is not possible to determine the date when the digging of this aqueduct system started, it is known that the system was used until mid-20th century. On the other hand, apart from this water distribution system with similar examples throughout the world [Judson & Kahane, 1963; Castellani & Dragoni, 1991; Wessels, 2000; Parise et al., 2015], there are impressive underground public areas, locally called "*qastel*", unique to Gaziantep and where the water coming through these underground channels were used publicly. During our survey in Gaziantep as the OBRUK Cave Research Group, we have conducted the first scientific study of both these underground aqueducts, and the "*qastel*" connections of these channels.

1.1 Underground Aqueducts of Gaziantep; *"Livas"*

There are numerous water resources around the plateau upon which Gaziantep is located.

Figure 1: Location map showing the area of exploration

Figure 2: 3D sketch of a *'livas'* and a well connection. (drawing M. Egrikavuk)

Figure 3: An active *'livas'* under Nadir Bey House (photo A. E. Keskin)

Despite all these resources, there is no water table under the city. Therefore, long tunnels were dug in order to bring water to Gaziantep from those springs. Length of some of these tunnels reaches a few kilometers, and they are the very image of ancient *"qanat"* or *"karez"* that were first implemented 2000-3000 years ago in Iran, and encountered in many countries such as Morocco, Persia, Algeria, Egypt and China.

Figure 4: A *'livas'* in Tutuncu Han (photo A.E. Keskin)

The essence of the system is transporting the water to the city center by channels from a main source fairly outside the settlement to wide settlement areas by well-calculated, smooth-sloped underground galleries, and distributing the water through wells dug where water was needed.

The wells almost never went down directly to the water flow in the *livas*, but reached a point nearby. The wells were dug a little deeper than the *livas* level, and connected to the *livas* through a short, horizontal connection gallery and as the water waited in this reservoir, the residues settled to the bottom and the water was purified (Fig. 2).

The dimensions of this system are very impressive in Gaziantep. The main water source that fed the old settlement was situated at the current location of the Alleben Pond. Although the distance of Alleben to the city center is around 10 km, the total distance of the interconnected *livas* system would reach hundreds of kilometers. Various water tunnels like those in Gaziantep War Museum Cave, Tutun Han Cave, Nadir Bey House and Omer Ersoy Culture Center are all connected to the same underground water system (Fig. 3 and 4). On the other hand, it is determined that many shafts investigated during the project are also connected to these water tunnels.

Apart from its scope, the engineering calculations for the system are also impressive for the period. It is obvious that obtaining the correct slope at every point to ensure a constant flow in the channels for tens of kilometers was very important in terms of the performance of the system. The scope of the labor may be better understood by considering that the work was conducted under the ground, in the dark, in very hard conditions and with limited technological means.

Another problem was meeting the *livas* below from the wells to be dug at the surface. It is difficult today to determine how this was achieved. The landscape in downtown Gaziantep is very rugged and there are serious differences between the levels of neighborhoods, or even houses in the same neighborhood. Making a well being dug from the yard of a house meet with an active *livas* through a gallery that is precisely calculated, and that is dug from the correct level in the correct direction, is not a small feat. We could determine that the work flow was in this direction, i.e. from the well to the *livas*, for certain in at least one sample.

1.2 Public Underground Water Structures; *"Qastel"*

Apart from these aqueducts, another impressive feature of the underground water structure of Gaziantep are the structures unique to this city called "*qastel*". The difference of these structures from the individual wells in the city is that these are public places created to allow access to the clean water distribution in the *livas* for a wider audience. In all known samples, wide stairs provide access to a large underground space dug inside the main block of rock. These spaces were planned to allow many people from various classes to have an easy access to clean water, provision of washing and using water, and moreover, as social spaces. In a city where it is not possible to carry the water transported through underground aqueducts to the surface through water fountains, we can think of the *qastel*s as a social area of the past [Çam, 1982].

Although these structures seem religious, because some of the six samples preserved until today are next to mosques, there are findings that suggest that the *qastel* structures date farther back in time.

As evidenced in samples such as the Ahmet Celebi Qastel (Fig. 5 and 6), Ihsaniye Qastel, Imam-ı Gazali and Pisirici Qastel there are no connections between the mosque structure and the *qastel* structure. Moreover, the fact that most of these *qastels* contain a small underground mosque suggests that they were built before the mosques above. The best example for this is the fact that the Pisirici *qastel*, built in 1283, is one of the oldest structures in the city (Fig. 7 and 8). It may be thought that, in many cases, the mosques that were built in a later period took over the existing *qastel* structures.

Although there were at least 15 *qastel*s until 60 years ago, only 6 examples remain today. Yet, even the remaining ones give us an idea about the impressive architecture of these interesting underground structures. Among those *qastel* s, only Pisirici and Ahmet Celebi fits the purpose with slight changes. The remaining 4 qastels; İhsaniye, Kozluca, Imam-ı Gazali and Şeyh Fethullah are unprotected and have been victims of wrong modifications.

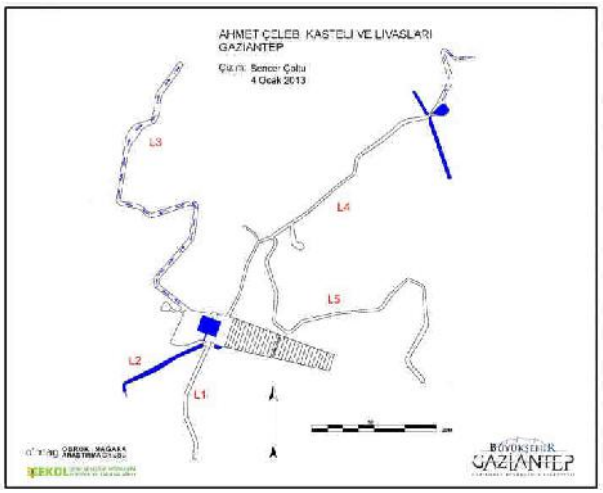

Figure 5: Map of Ahmet Celebi Qastel and adjoining *'livas'* (drawing S. Coltu)

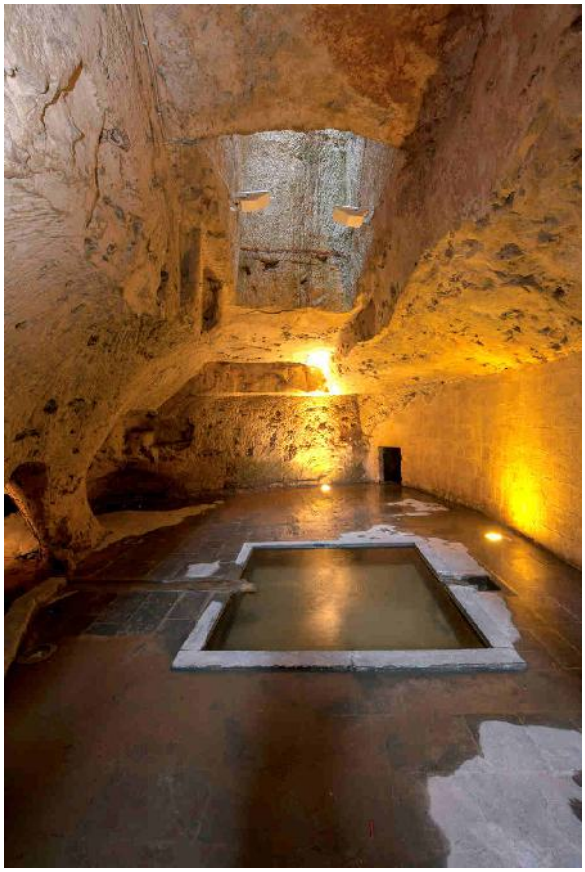

Figure 6: Ahmet Celebi Qastel (photo A. Yamac)

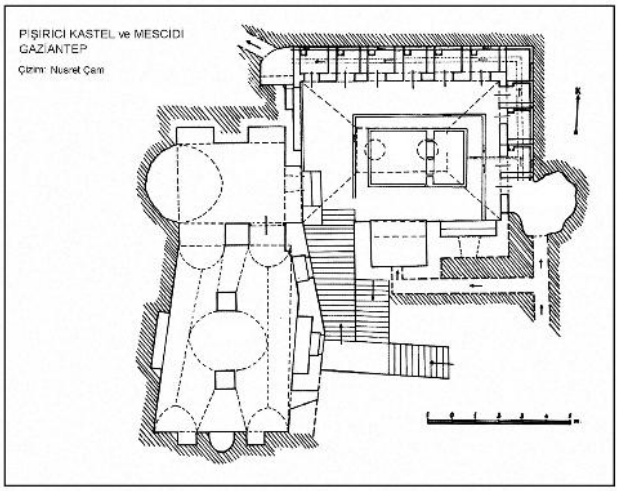

Figure 7: Map of Pisirici Qastel (drawing N. Çam 2006)

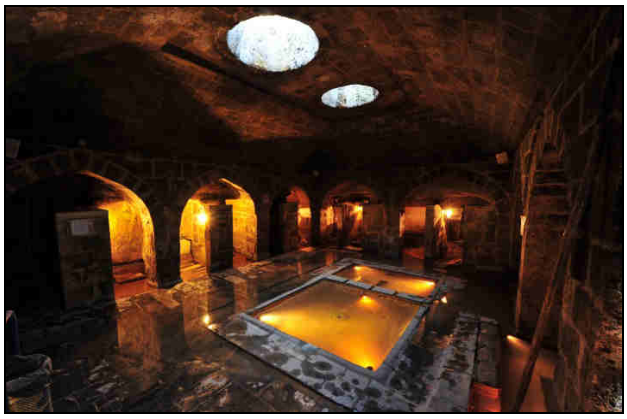

Figure 8: Pisirici Qastel (photo A. E. Keskin)

2. CONCLUSION

Modern water distribution reached the city of Gaziantep only in the 1950s. Unfortunately, two kinds of destruction and neglect have brought this ancient *livas* system that served the city for centuries near destruction. One of these two factors is individual users filling the wells that they do not need anymore, and even worse, filling them completely with mortar.

The other one is that the modern municipalities did not understand the historic value of the system and have damaged it underground beyond repair during infrastructure works for electricity, natural gas, water, etc.

As can be seen, the current level of destruction of this system is a priceless loss for the identity and historic past of the city of Gaziantep. It is particularly sad that this destruction happened in such a short time. We believe that, in order to be able to reach the future generations, these structures need to be protected immediately.

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The rock-cut sites in the basin of Şahinefendi (Ürgüp - Cappadocia)

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Summary

The investigations carried out in the large catchment of Şahinefendi, 20 km south of Ürgüp (Cappadocia, Nevşehir region - Central Turkey), in the centre of which the Byzantine church of Forty Martyrs is located, allowed us to identify a widespread presence of rock-cut sites, dispersed over an area of about 15 km^2, in which, besides residential and religious works, specific works for water supply and defence are present.

Although the explorations are still incompletes, it has been possible to draw a map which highlights a distribution of man-made cavities going from the centre of the natural amphitheatre, in which are located the Church and the Monastery, and their appliances, to the sides where two "wall rock-cut villages" have been surveyed on the opposite cliffs surrounding the basin. Both had small churches and vertical shelters with millstone-doors and trap-tunnels/shafts. Moreover, we intend to highlights the potential existence of a system of cavities and tunnels under the present residential area of Şahinefendi. The organization of water supply system is not yet clear. However, in the top part of the cliff of one of the rock-cut villages we found a number of basins and downpipes which, though cut by the collapsing of the rock, suggest a system for rain water gathering through funnels and perhaps pensile cisterns.

Some cavities, excavated into a group of pinnacles at the bottom of the valley, currently inaccessible because located high on the walls, deserve a special mention because they are likely tombs, maybe Phrygian or Roman like other archaeological evidences existing in the area. Only one cavity that could be an apiary has been localized. We detected many pigeon-lofts and grape-treading rooms, most of which around the ancient Roman settlement of *Sobesos*.

Keywords

Turkey, Şahinefendi, man-made cavities, rock-cut churches, rock-cut villages, underground refuges, water works, funnels, apiaries, grape-treading, rock-cut tombs.

1. INTRODUCTION

The site of Şahinefendi is located 20 km south of Ürgüp, in the territory of the ancient Byzantine *thema* of Cappadocia, in the centre of the present Turkey (Figs. 1, 2). The area examined is a hollow located at the head of the catchment of the Damsa stream which, retreating, created a large natural amphitheatre of about 15 km^2. The bottom of the valley is surrounded by high cliffs which frame the top of a wide plateau (*mesa*), about 1.550/1.600 m a.s.l. (Figs. 4, 5). Northwards the basin is divided in two parts by an isolated long and steep ridge, flat on its top (Orta Tepe butte).

In this impressive landscape, on 23 September 2013 the rock-cut church of Forty Martyrs (or Altı Parmak Kilisesi - flag 100 in Figs. 4, 5, 7) become a museum open to public visits. The unveiling was the culmination of important studies and restoration works, started on 2006 by the Italian mission of the University of Tuscia, Viterbo (Italy), lead by Prof. Maria Andaloro, named *"Rock painting in Cappadocia. For a project of knowledge, conservation and valorisation",* realized in collaboration with the Cultural Heritage and Museums General Direction of the Ministry of Culture and Tourism of the Republic of Turkey and supported by the Nevşehir Archaeological Museum, directed by Murat Gülyaz.

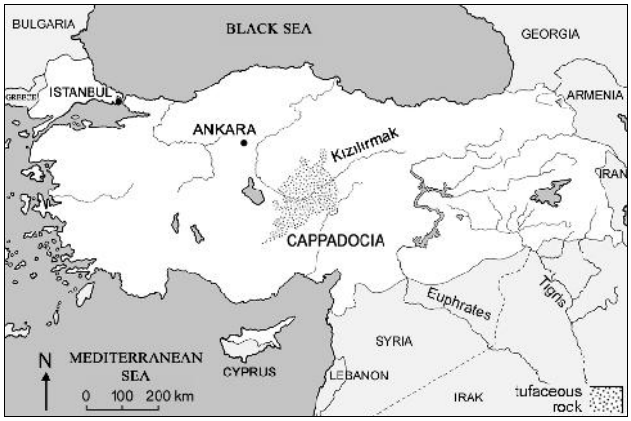

Figure 1: Area in the centre of Turkey corresponding to the ancient *thema* of Cappadocia (drawing R. Bixio)

Before the works of the University of Tuscia little was known about the church and its surroundings. The structure has been visited in 1911 by the French Jesuit, archaeologist, epigraphist and byzantinist Guillaume De Jerphanion who produced the first documentation, in the chapter given up to Souvech (and Damsa), as the village was called at his time [De Jerphanion, 1936], recently supplemented by Catherine Jolivet [Jolivet, 2015].

2. ŞAHINEFENDI AND THE CHURCH OF FORTY MARTYRS

2.1 Geographical and historical outline

The Turkish village of Şahinefendi is located 18 km S of Ürgüp, in the core of rupestrian Cappadocia, along the road leading to Niğde. The geographical context is characterized by plateaux of volcanic tuff, pumice and basalt rocks, deeply incised by the combined action of tectonics and erosion achieved by the streams flowing down to the Kızılırmak river with a N-S orientation; among these, the Damsa.

In particular, the study area is located at the opening of the valley, along the southern slope of the Orta Tepe hill (1580 m), one of the *mesas* produced by the weathering and the erosion (Fig. 1).

Volcanic deposits – the Kızılkaya ignimbrite (thick about 6 m), at the top of the hill; the Gördeles ignimbrite (about 30 m); the Tahar ignimbrite (about 5 m); the Cemilköy ignimbrite (about 10 m) – are interbedded with continental deposits, constituted by debris, paleosoils, lacustrin marls and calcrete. The lithological features of the Cemilköy ignimbrite are remarkable, since they have been produced the earth pyramids (the so called "fairy chimneys"), in which are carved many of rock-cut settlements of the area of Şahinefendi [Rovella et al., 2014].

In the Roman period (and afterwards) the Damsa valley was crossed by a secondary communication route, connecting the town of *Venasa* (Avanos) with *Nazianzos*, *Kyzistra* and *Tyana* (Kemerhisar) [Hild, 1977]. The layout of the Roman road between the village of Cemil and Şahinefendi is marked by the presence of several rock-cut tombs along the stream [Thierry, 2012]. The remains of a large late Roman and early Byzantine settlement, including a church and a cemetery, have been discovered about 1,5 km SE of Şahinefendi, not far from the church of the Forty Martyrs [Cassia, 2004; Gülyaz, 2014].

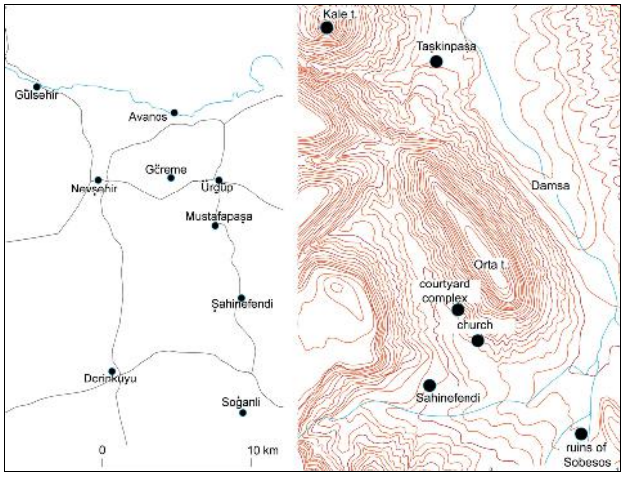

Figure 1: Map of the region (left); location of the area of Şahinefendi (right)

This site has been identified as *Sobesos*, a Byzantine settlement mentioned as a diocesan seat in a *Notitia* from the Leo VI period [Jerphanion, 1925-1942; Hild & Restle, 1981]. The old name of the village of Şahinefendi – *Söviş* or *Suveş* since the beginning of the 20th century – could be in fact a corruption of *Sobesos*. From this point, the route probably went to S intercepting after about ten kilometers, at Güzelöz, the road through the Mavrucan Valley [Turchetto, 2012].

During the Seljuk period the Damsa Valley and the related road-network retained a strategic importance. The village of Taşkınpaşa (formerly *Tamisos*, *Tamsa* or *Damsa*) preserves a *medrese,* a mosque and two *türbe* dating back to 14th century; the top of the butte shaped cone, which dominates the village and the valley (Kale Tepe, 1585 m a.s.l.), presents the remains of a late Byzantine and Seljuk fortress. A rock-cut shelter located on the southern side of Orta Tepe allowed the control of a long portion of the valley [Andaloro et al., 2015].

2.2 The settlement

The nucleus of the Byzantine settlement developed around the church of Forty Martyrs, including a number of chimneys and tuff pinnacles scattered on the southern slope of Orta Tepe, heavily subject to erosional and weathering phenomena [Rovella, Marabini & Crisci, 2014]. The location of the settlement was certainly conditioned by the presence of these rock formations as well as a by the favorable exposure to S (Fig. 2).

In the middle and late Byzantine period, a large part of the population of Cappadocia was dispersed in small rural settlements, carved in groups of cones adjacent to the stream, like in the case of Gorgoli, N of Cemil [Jolivet Levy & Kiourtzian, 2012-2013; for a regional overview, see Cooper & Decker, 2012]. This is also the case of Şahinefendi.

The south-eastern and the western boundaries of the village were defined by the presence of funerary chapels [for a similar situation, see Kalas, 2009]. Between these two points, along a length of about 400 m, about 60 caves are scattered and used as dwellings, storehouses, stables and factories [Andaloro et al., 2015]. The subsistence of the village was guaranteed by the breeding of sheep, goats and horses and by the cultivation of fields in the valley. Judging by the large number of wineries, the cultivation of vine had an important role [La Russa et al., 2016].

Two of these are very close to the church and have all the characteristics of these industrial buildings, containing a wine-press with two quadrangular tanks at different levels connected by a duct, wall housings for containers and storage niches. The engraved crosses above the main entrance and the typical invocation IC XC NIKA ("Iesoùs Christòs nikà") [Walter, 1997] painted on the tank emphasize the sacred connotation given to the production of wine.

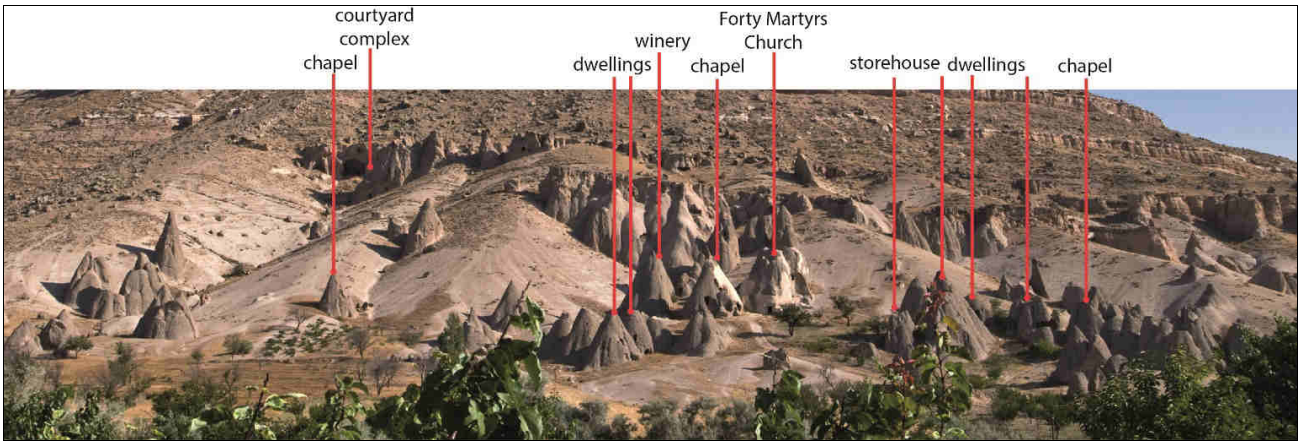

Figure 2: General view of the Byzantine settlement of Şahinefendi (photo G. Alfano)

The church of Forty Martyrs (*Kırkşehitler kilise*, or *Altı Parmak kilise*, "the Church of the Six Fingers") is located in the central part of the settlement and shows three main phases of excavation. Each of them can be linked to a different layer of painting, as the recent studies have pointed out [Andaloro, 2011, 2012; Andaloro et al., 2015]. The first church was a single aisled chapel, flanked by funerary chambers with rock-cut *arcosolia* and graves. Later, probably during the 11th century, the church was enlarged by the excavation of a second nave and entirely renewed in its painted decoration (Fig. 3).

The last renovation took place in 1216/1217 under the patronage of ieromonk *Macharios* and is commemorated by an inscription painted on the western wall of the church [Jerphanion, 1925-1942; Jolivet-Lévy, 1991].

It is very difficult to point out for how long the rock-cut village and the church were used. Between the 14th and 16th century, at least the 75% of the settlement in the region of Ürgüp was inhabited (partially or entirely) by Christian population [Vryonis, 1971; Beldiceanu, 1982]. Looking to the Damsa valley, one can observe that, while in *Tamisos*/*Damsa* (later Taskinpasa) the process of islamization seems to have been more rapid [Beldiceanu 1982], in other villages, as *Sinasos* (Mustafapaşa) and *Sobesos* (Şahinefendi), an important Christian community remained until the exchanges of population in the 1920's. This was probably also the result of a new colonization by Greeks during the Ottoman period. The ruins of the churches still existing in Cemil and in Mustafapaşa could date back to 18th or 19th century [Jerphanion 1925-1942].

As in many other rock-cut settlements in Cappadocia, during the Turkish period the church of the Forty Martyrs and the surrounding caves were reused as either dwellings or for rural activities (stables, cellars, storage areas, dovecots). Thus, they were heavily altered to exploit stone for the construction of terraces and houses in the neighboring village of Şahinefendi, which represents the latest episode in the history of this territory [Andaloro et al., 2015].

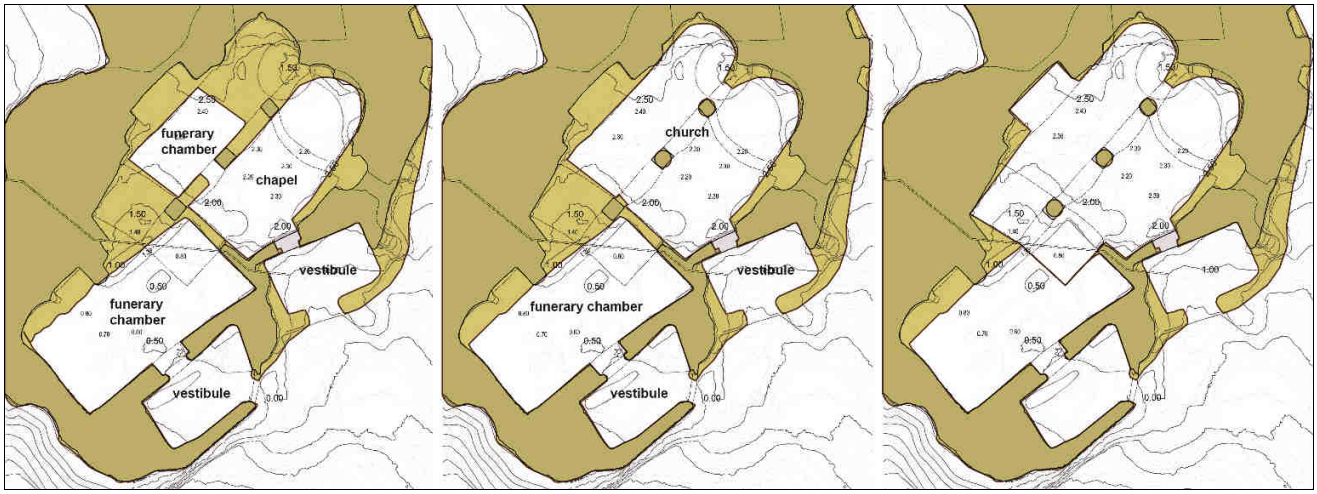

Figure 3: Church of Forty Martyrs, main phases of excavation (drawing G. Romagnoli)

Figure 4: The courtyard complex and the Orta Tepe (from S)

3. THE COURTYARD COMPLEX

3.1 Introduction

After the work of G. de Jerphanion on rock painting in Cappadocia [Jerphanion 1925-1942], many researches have focused their attention on churches with painted decorations, analyzing these monuments from a stylistic and iconographic point of view [Jolivet-Lévy, 2015]. Only in the last twenty years scholars have begun to take an interest in carved architecture of Cappadocia as a source for the reconstruction of settlement pattern and landscape in Byzantine period.

However, the most recent researches have begun to question the exclusively religious nature of most of the rock-cut settlements – many of which were often too hastily identified as monasteries or hermitages – and to challenge the traditional view of a sacred, "pan-monastic" landscape. Recent studies, in particular, have been paying attention to a number of rock monuments characterized by one (or more) central courtyard and usually associated to churches with paintings in red. Traditionally interpreted as monastery, several of these rupestrian complexes are now identified rather as secular residences belonging to the military aristocracy that emerged in Cappadocia during the middle Byzantine period [Mathews & Daskalakis Mathews, 1997; Ousterhout, 2005; Kalas, 2009; Öztürk, 2013; Cooper & Decker, 2012].

The main features of these complexes are: the position of large cliffs; a carved façade; the arrangement of the main rooms around a three-sided or quadrangular courtyard; the presence of a church and annexes. The various topography of the sites, the morphology of the different rock formations and the larger or lesser availability of volumes of rock could influence the shape, the plan and the size of these complexes, but the main types (double courtyard, pi-plan type and inverted T-plan type) show a derivation from the same model [Cooper & Decker, 2012].

Figure 5: The main façade of the courtyard

3.2 Location and general features

The so called "Şahinefendi Monastery" [Rodley, 1985; Mathews & Daskalakis Mathews, 1997; Cooper & Decker, 2012] is a rock-cut courtyard complex located about 150 m NW of the church of Forty Martyrs in the southern cliff of Orta Tepe, in a dominant position on the church and the surrounding village (Fig. 4). It is locally known as "*Beş parmak*" ("the five fingers"), due to the characteristic form of tuff pinnacles).

The location was determined by morphological and geological reasons: first of all, the availability of a large cliff and the presence of some isolated pinnacles; furthermore, the structure was carved in the soft Cemilkoy ignimbrite, at the boundary between this layer and the upper calcrete level, which protects the structure thanks to its hardness. This particular topographical and stratigraphic conditions have also influenced the greater or lesser advancement of erosion of the slope and, consequently, the conservation of the structures [Rovella et al., 2014].

The nucleus of the complex is organized around a court (Fig. 6, A), most likely of quadrangular shape, which was heavily damaged by erosion and landslides.

Figure 6: General plan of the courtyard complex (in blue, the lower level) (drawing G. Romagnoli)

According to the signs of excavation identified further E, a second smaller quadrangular court is likely to have existed (Fig. 6, B). If this hypothesis is confirmed, Şahinefendi would represent a further example of the double-court complex type. However, it is still necessary to verify whether the two courts can be dated to the same chronological phase.

Only a small portion of the larger court is preserved on the northern side. The main façade presents a carved decoration with a series of blind arches, separated by thick pillars, which probably divided the façade into seven sections with a main central entrance. This part of the façade was covered, at least in part, by white plaster representing geometric decorations in red. The top portion includes an area decorated by a motive of small and rounded blind arches (Fig. 5).

The vestibule (approximately 11.50 x 6.80 m) is divided into two sections: one area behind the façade, 3 meters wide and covered by a flat ceiling, and an internal area, about 3.90 meters wide and covered by a barrel vault (Fig. 6, C). The back wall of the vestibule presents a motive with large niches framed by rounded arches. Between every niche is a bas-relief forming a cross with long branches.

A series of rooms with a ceremonial and residential function are distributed around the main court and the vestibule, according to a quite common model for rupestrian Cappadocia. The finely cut main room (6.70 x 4.30 m) presents a flat ceiling (2.80 m height) characterized by pairs of semi-columns and semi-pillars on each side and a deep square niche (2 x 1.20 m) on the short side opposite of the entrance (Fig. 6, D). In the center of the niche is a framed Latin cross with expanded branches, inserted into an oval shape, with traces of red painting applied directly on the rock along the oval and the cross branches (Fig. 7).

Along the short sides of the vestibule are also the entrances to two rectangular spaces with a flat ceiling, possibly having a housing function and both originally lacking windows. In the left chamber (6.10 x 4 m) the only element that can be connected to the original plan of the complex is an arched niche located right of the entrance, most likely a tank (Fig. 6, E). A later reuse as stable can be identified through the presence of two mangers.

Figure 7: Main hall (from S)

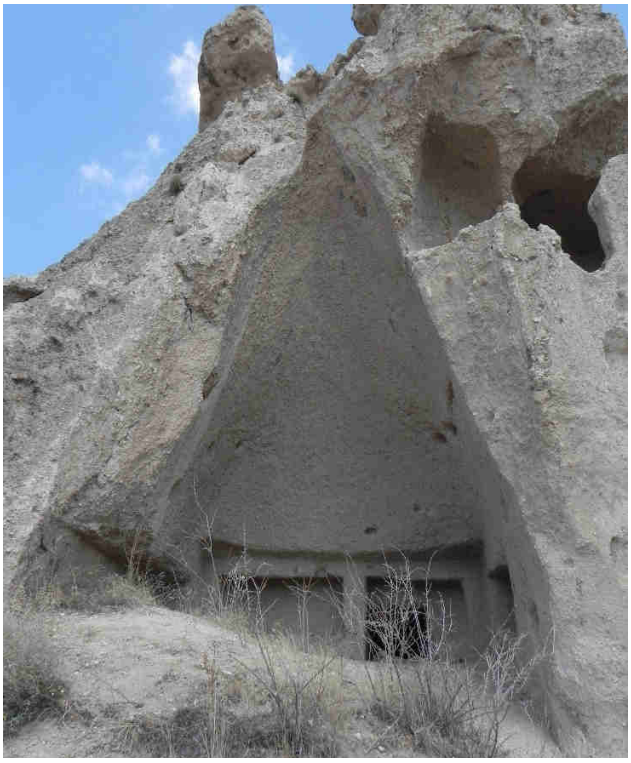

Figure 8: The kitchen (from S)

Also, the passage leading to the kitchens (always relatable to the housing phase of the complex) and a wide opening on the left wall (to provide the entrance of light) were added in a second phase when the peripheral spaces collapsed.

The room on the right of the vestibule, which is rectangular (5.95/6.20 x 3.80 m) with a tall flat ceiling (high 2.40 m approximately), received light from a single opening in the smaller court (Fig. 6, F). No element in this room seems to be related to the original function of the space.

Some small cells roughly carved along the left and right walls can be related to a late use as a dovecote.

Only a part of a kitchen (4.50 x 3.70 m approximately), which is characterized by the presence of a cone-shaped chimney and some square storage niches, survived (Fig. 8).

3.3 The church and annexes

The church, located in a cone E of the courts, is preceded by a nartex with two funerary rooms, partially buried by debris and landslides [Rodley 1985]. The right room, which can be examined in its entire perimeter, is accessible from a horse-shoe arched opening and presents an irregular square shape. The W wall presents two horse-shoe arched niches, probably positioned in relation to the underlying burial pits obliterated by the present landslide in the cave. This space (5.40 x 4.50 m) presents a cross-in-square plan or *quincunx* plan with four supports (two columns and two pillars) dividing the internal area into six square spaces. The branches of this cross are covered by a barrel vault, while the central space and the four corners present truncated cone shaped domes with spherical caps. All the domes include decorative red painting on the stone resembling a wall curtain. On the three sides towards the interior, the capitals present a simple bicolor plant motive, with parts incised and painted in red on white plaster. The church, obliterated by debris for a long time, does not present the significant alterations characterizing other rupestrian complexes in the region.

The rooms used for farming and production activities are decentered from the court and the church. The main room of this group might have been used for the storage of commodities. A stable for horses and donkeys was located in the bottom part of the complex. Just like the housing area, also this complex developed at first on one single level. This characteristic has been noticed also in several other both religious and secular rupestrian complexes of this region, like the Aynalı Kilise and the so called “Eglise de la Colombe” in Göreme. Only later, the rooms were expanded to the upper level with the excavation of dovecotes and shelters. The creation of these rooms probably took place in the Ottoman period, when the complex lost its residential function and was already partially buried and obliterated by debris and landslides.

4. SURVEY AND REPRESENTATION OF ROCK-CUT ARCHITECTURE

The campaign stage has taken place in 2014, from late August to mid-September, in a warm and dry climate with a rarefied dusty air. According to the resources and time available, the team was equipped with digital cameras and a laser scanner. In recent years, laser scan technology has been improving the precision in the acquisition of dimensional data and the reduction of costs and time. At the same time, the technics of digital visualization offer surveyors a wide range of innovative and easy-to-play-with tools for navigating three-dimensional models.

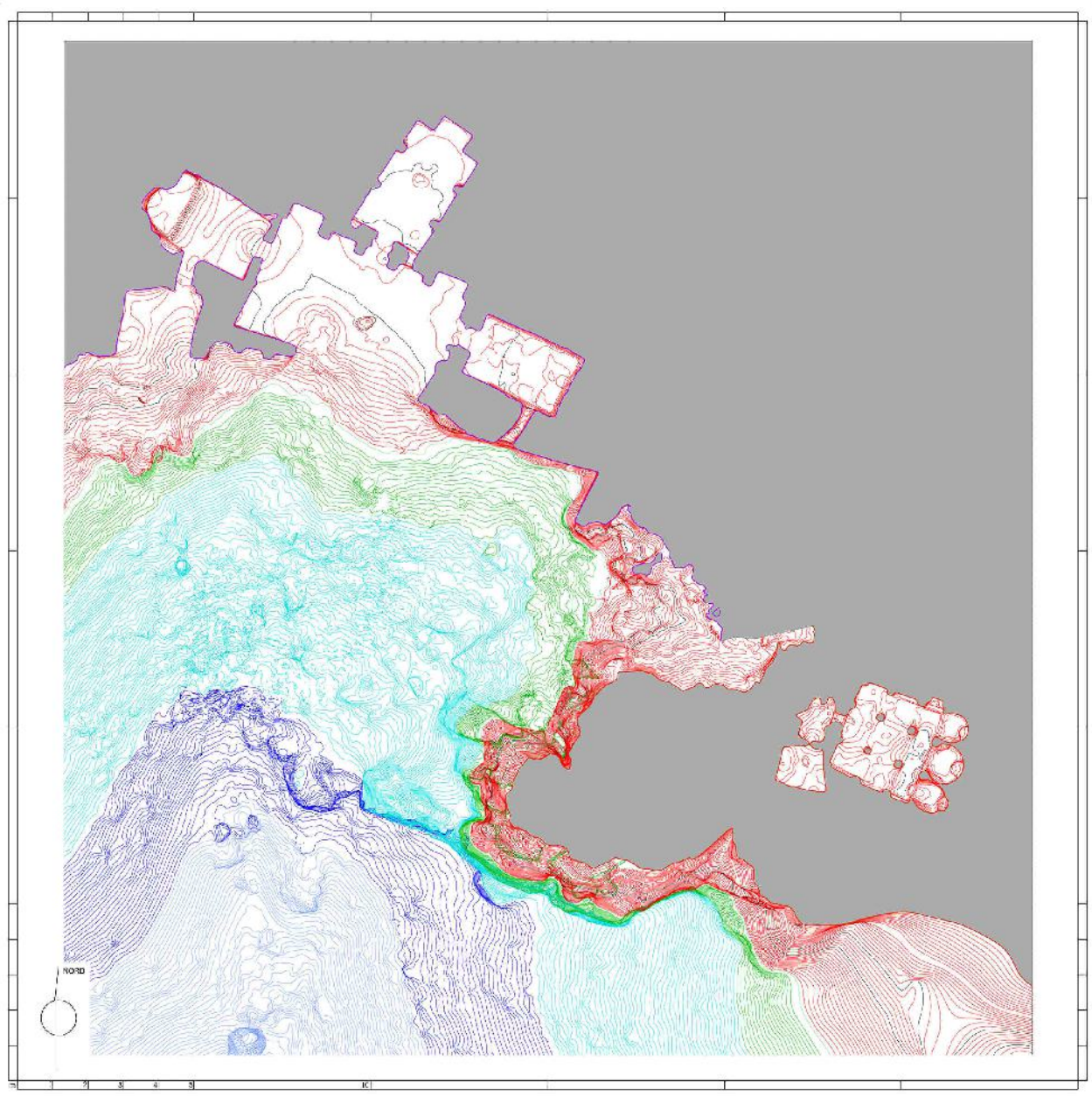

Figure 9: General plan by contour lines after scan (drawing M. Carpiceci)

A FARO Laser Scanner was preferred because of its physical properties that make it a lightweight, easy-to-use and powerful tool, compatible with the rough orographic conditions and the dark narrow caves to be explored. Moreover, this guarantees a density of collected data as good as to ensure the recording of the traces of excavation left by the ancient builders on the rock surfaces. Although on the hottest days, extended outer scanning occasionally produced overheating effects, some rest in a dark cave and the alternative use of two batteries allowed an extensive use of the laser scanner along the entire working day. Laser scanning was carried out regularly with the aid of reference spheres: at least three of them were recorded in two adjacent scans to ensure their effective welding during the production phase of the global points cloud.

The lack of a direct relationship between exterior and interior as well as serial elements, symmetry, sharp edges, and orthogonal corners prevents the surveyors from using conventional criteria not only for surveying but also for representing rock-cut architecture. In fact, as long as the campaign stage is largely delegated to laser scanner's "objective" eye, the knowledge of the site, which once was partially achieved through the direct survey approach, is somehow delayed to a successive phase.

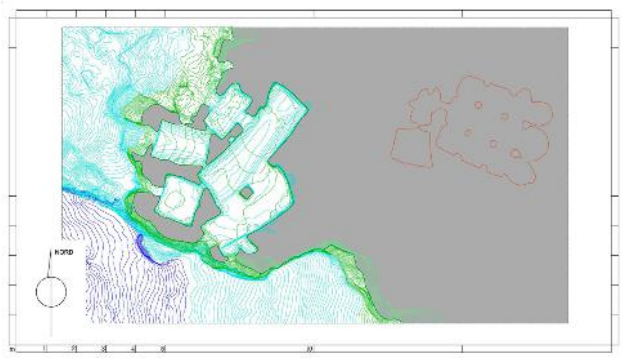

Figure 10: Plan of the lower level rooms by contour lines after scan (drawing M. Carpiceci)

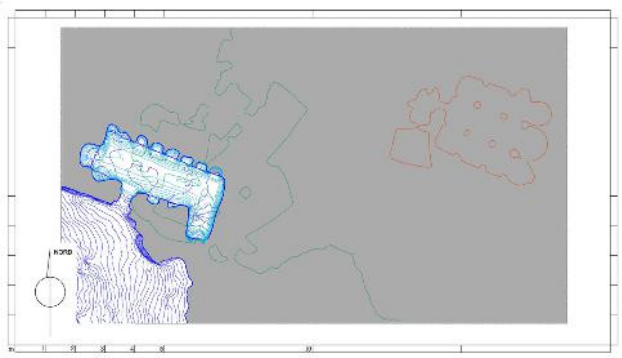

Figure 11: Plan of the lowest level room by contour lines after scan (drawing M. Carpiceci)

In this quite unedited scenario, the visual outcomes after the point cloud must be developed not only to simplify the navigation in some virtual model but also to encourage the knowledge of architecture through scale drawings.

The sculptural quality of rock-cut architecture often makes it impossible to choose which edge is to translate into a black continuous line and which one could be neglected. Every choice comports the risk of losing too many information and offering an arbitrary "image" of the site. Inspired by cartographic models, we experimented a contour line representation, which happens to be the most appropriate for a type of architecture between natural and artificial. After identifying the most significant parts for their ability to describe the complex morphology of the settlement, a number of sections has been developed by moving the section plan with a constant step.

In Cartography, this equidistance, which is the constant gap between successive contour lines plane, is usually set at 1/1000 of the denominator of the reduction scale in meters of the map. For a canonical architecture representation at 1:50 scale of reduction, contour interval (equidistance) should be 5 cm, but preliminary tests have convinced authors to adopt a 10 cm step to describe properly the architectural forms without "background noise". By identifying main levels with colors, plans and sections can demonstrate the actual form of spaces as well as the hidden relationships between extrados and intrados of monuments without the loss of geometric information.

4.1 The knowledge after the representation

The survey after the laser scanning favors some evident compositional and morphological considerations on Beş parmak complex. This is mainly distributed on a single quota according to a single plan orientation. Two horizontal section plans with contour lines showing both the floors and the vaulted ceilings (Fig. 9), demonstrate the general organization of rooms as well as their specific internal solutions. Two elements seem to underline the project uniformity of the whole complex. The former is the consistency of the orthogonal orientation of both the church and "residential" zone.

The latter is the common walking level between the two areas. It varies of only ca. 60 cm, which is a negligible amount in consideration of the distance of ca. 40 meters between the two zones.

In the protruding cone, the rooms located at three meters below (Figs. 10) just W from the upper rooms, constitute an interesting sequence of volumes. A small hall with a barrel vault introduces to a pair of rectangular rooms staggered in the longer side: one of them is covered by a barrel vault while the other one by a flat roof. Connected to these by narrow openings are two more rooms, which are respectively covered by a barrel vault and a flat roof, too. While the three smaller rooms are quite regular, the others reveal a curved geometry. Thus, their rectangular shape is rather transfigured into a circular crown sector. Moreover, both the flat and vaulted ceiling show a slight depression with respect to the median of the head areas. This apparent anomaly may derive from the desire to improve the static behavior of rocky material, weakened by the activity of excavation. Similar "twisting" effects can be seen also in the Aynalı complex where the reception rooms and the church show curved deformations.

It is quite interesting that even the rooms located 7 meters beneath these (Fig. 11), at the base of the cone, with an autonomous entrance from S, show the same orientation than not only the smaller upper rooms but also the main monumental complex.

5. CONCLUSIONS

The surveys recently conducted at Şahinefendi by a combination of historians and architects surveyors offer an advanced digital photogrammetry-based iconography and suggest a general insight on the ways and forms of settlement in the region in the Byzantine period.

The inhabitation of the Damsa Valley during the Roman and early Bizantine periods is demonstrated by certain evidence along the road network connecting the *Halys* and the area of Soğanlı. A small settlement, identified as *Sobesos*, was located at the entrance to the valley and maintained a certain degree of importance until at least the 5-6th century, as documented by the recent archaeological investigations on the site.

The reinterpretation of the pictorial layers and the phases of excavation of the Church of the Forty Martyrs highlights a continuous use of the site during the middle Byzantine period, during which both the cave settlement surrounding the church and the above courtyard complex (according to which it is possible to identify it with the house of a local élite family) developed.

The dating of this monument is still an object of debate. It is commonly identified with the 10-11th century, especially thanks to a formal and stylistic comparison with the most known rupestrian monuments in the area of Soğanlı and Göreme. A new analysis leads to identify at least two separate phases for the creation of this rupestrian complex. The significant stylistic difference between the carved decoration in the central nucleus of the complex (courtyard façade and main chamber, both characterized by the presence of thick pillars and rounded arches) and the church (with thin pillars and horse-shoe arches) is astonishing. One should also highlight the uncommonly peripheral position of the church in relation to the nucleus of the complex, perhaps explainable with a reconstruction of the residential complex, where a secondary court might have been (according to the traces found in the western section). All these elements suggest a more recent dating to the 11th century, when the cross-in-square plan became the most common type adopted in religious Cappadocian architecture. In this same period, the pictorial decoration in red on white plaster might have been added on the façade of the main court, completely similar in techniques and stylistic patterns to the ones inside the church.

In any case the connection of the residential complex - the only one definitely identified in this part of the valley - with the control of the road network is evident, as well as the close relation with the village surrounding the Church of the Forty Martyrs for the farming activities of the lands in the valley which continued for at least the entire Seljuke period.

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Our thanks to dr. Alba Serino for translation and to the photographers Gaetano Alfano and Domenico Ventura.

SESSION 4

HYPOGEAN CIVILIAN DWELLINGS

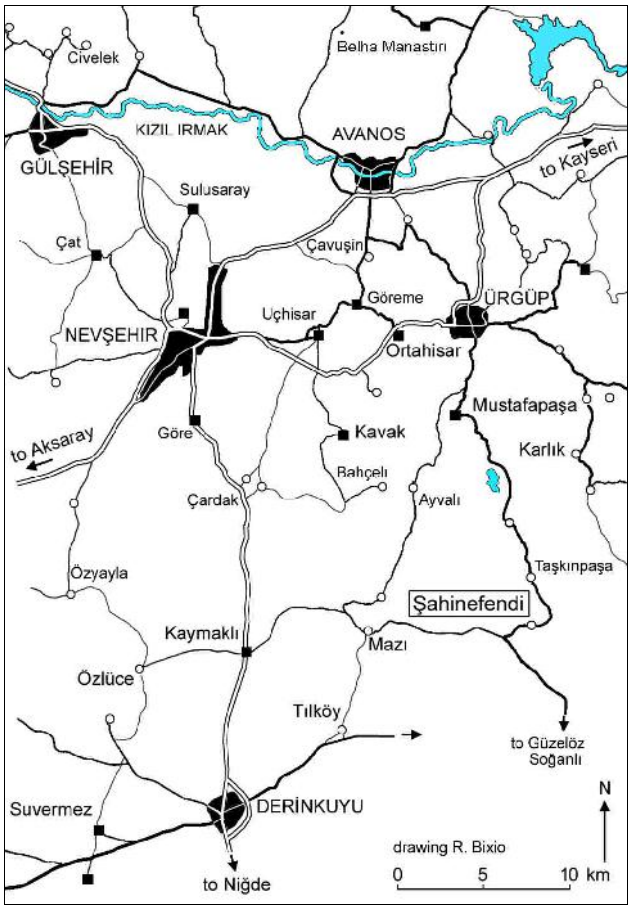

Figure 2: Location of the village of Şahinefendi in the Nevşehir region, Ürgüp province (drawing R. Bixio)

In 1981 the rock-cut complex named Monastery (or Beş Parmak Manastırı - flag 112 in Figs. 4, 5, 7), carved into a rock crag, 200 m north-northwestward and a little higher of the church site was documented [Rodley, 2010].

In 2002 the archeological excavation of the site (not rock-cut) dating back to the 4th century A.D. (thermal baths, mosaics and the remains of a masonry church) started in Örenci area (near flag 101, in Figs. 4, 5, 8), conventionally identified as the ancient Sobesos [Yenipınar, 2003]. The remains are 1,2 km south-west from the church, slightly higher (1.370 m a.s.l.) than the lower part of the basin (about 1.350 m a.s.l.), in the middle of an area still strongly cultivated, mostly with vineyard.

This was the state of the art about the man-made works before the study and the restoration works of the Church of Forty Martyrs.

1.1 Church and refuge of Forty Martyrs (GPS 100)

As said above, in 2006 the team of University of Tuscia starts to survey the area and in 2007 the restoration works of the underground structure and its paintings began. These were attributed to different phases, in a period within 9th and 13th century [De Jerphanion, 1936, pp. 158-159; Uyar, 2011, pp. 391-398; Andaloro et al., 2015, pp. 16, 19]. The church is entirely excavated inside a tuff pinnacle, at an altitude of 1.384 m a.s.l., on the slope opposite the rural village of Şahinefendi, 500 m east-north-east. The site is located at the bottom of the mentioned butte, *'... une sort de bastion naturel, en tronc de cône, couronné par une muraille trachytique'* [De Jerphanion 1925, p. 33], 1.581 m high a.s.l..

In parallel with the interventions on the ecclesial structure a survey program for the adjacent area, about 1 km^2, was prepared to document a number of related rock-cut spaces, dug in the many surrounding pinnacles. Various pigeon-lofts, stables, shelters, stores, two grape-treading rooms, two kitchens, probably a refectory and some funeral chapels have been ascertained. Moreover a defensive system, under the church, was identified and described by Benucci and Romagnoli [Andaloro et al., 2015; Benucci et al, 2017].

In short, this refuge, consists of two spaces, once defended by two millstone-doors (Md1, Md2), no more *in situ*, connected through a low tunnel to a small inner room (redoubt C) (Fig. 6). This room was intentionally raised to be accessed through a short ascending trap-shaft, originally closed with a trapdoor, protecting the last space. The irregular hole (breach) communicating with the apse of the church above certainly originates from subsequent interventions, probably accidental (Fig. 3).

In 2012 the Centro Studi Sotterranei of Genoa (Italy) was invited to join the surveys, by contributing through its specific speleological techniques and its previous experiences about the Cappadocian underground structures developed during regular investigations organized within 1991 and 2000. We recall that these researches were carried out on a wider area, drawing more than 60 plans and realizing the first cadastral list of 207 sites, over six regions [Bertucci et al. 1995; Bixio et al., 2002, 2012].

Figure 3: The trap-door in the redoubt [C] and the breach passing in the church (photo A. Bixio)

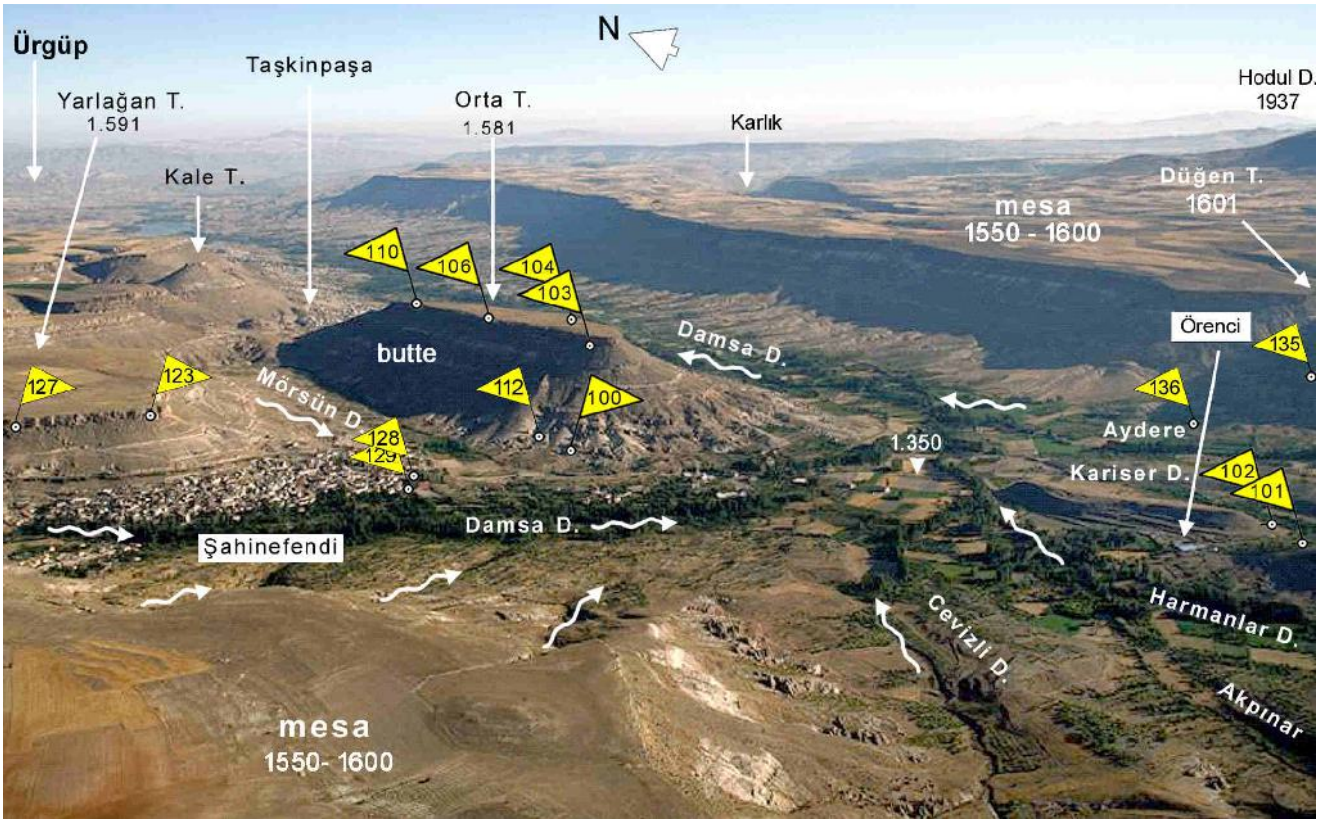

Figure 4: The catchment of Şahinefendi and the butte of Orta Tepe (photo courtesy of Murat Gülyaz, drawing Bixio)

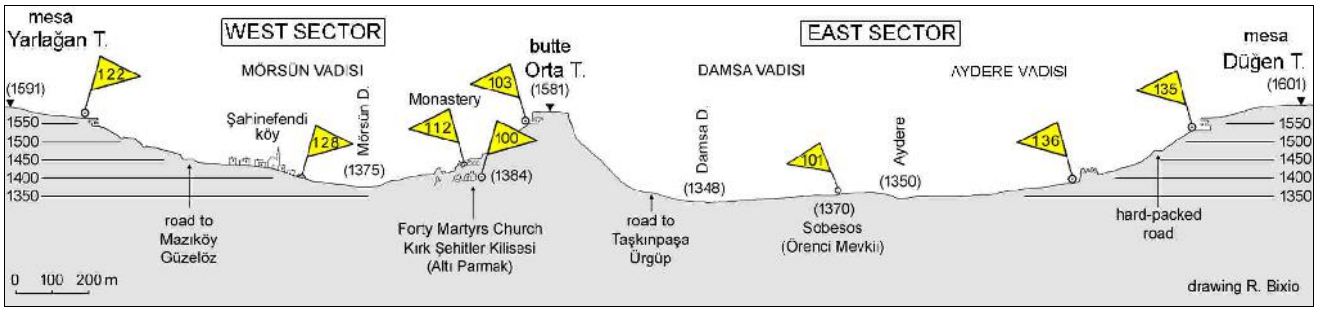

Figure 5: Schematic altimetric section of the hollow, from E to W, with a few rock-cut sites (drawing R. Bixio)

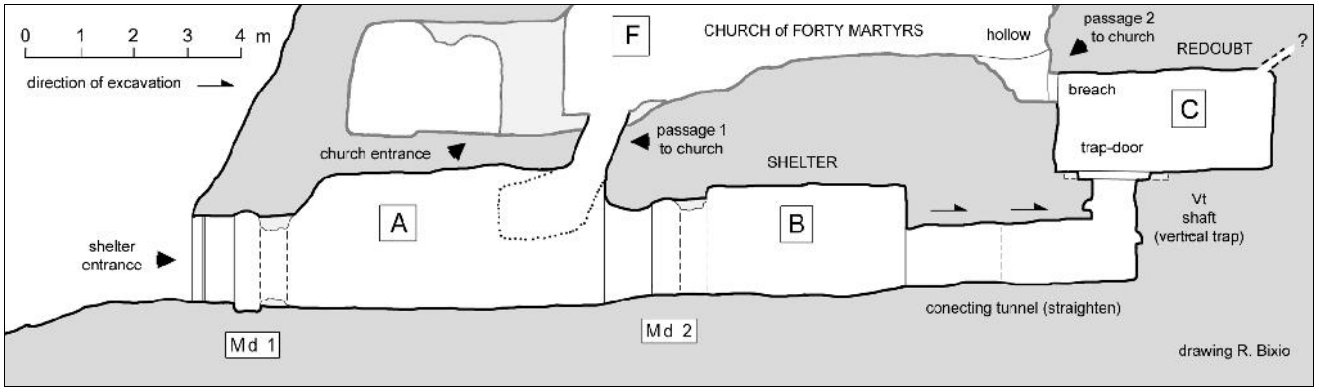

Figure 6: Schematic section of the rock-cut shelter below the Forty Martyrs Church (drawing R. Bixio)

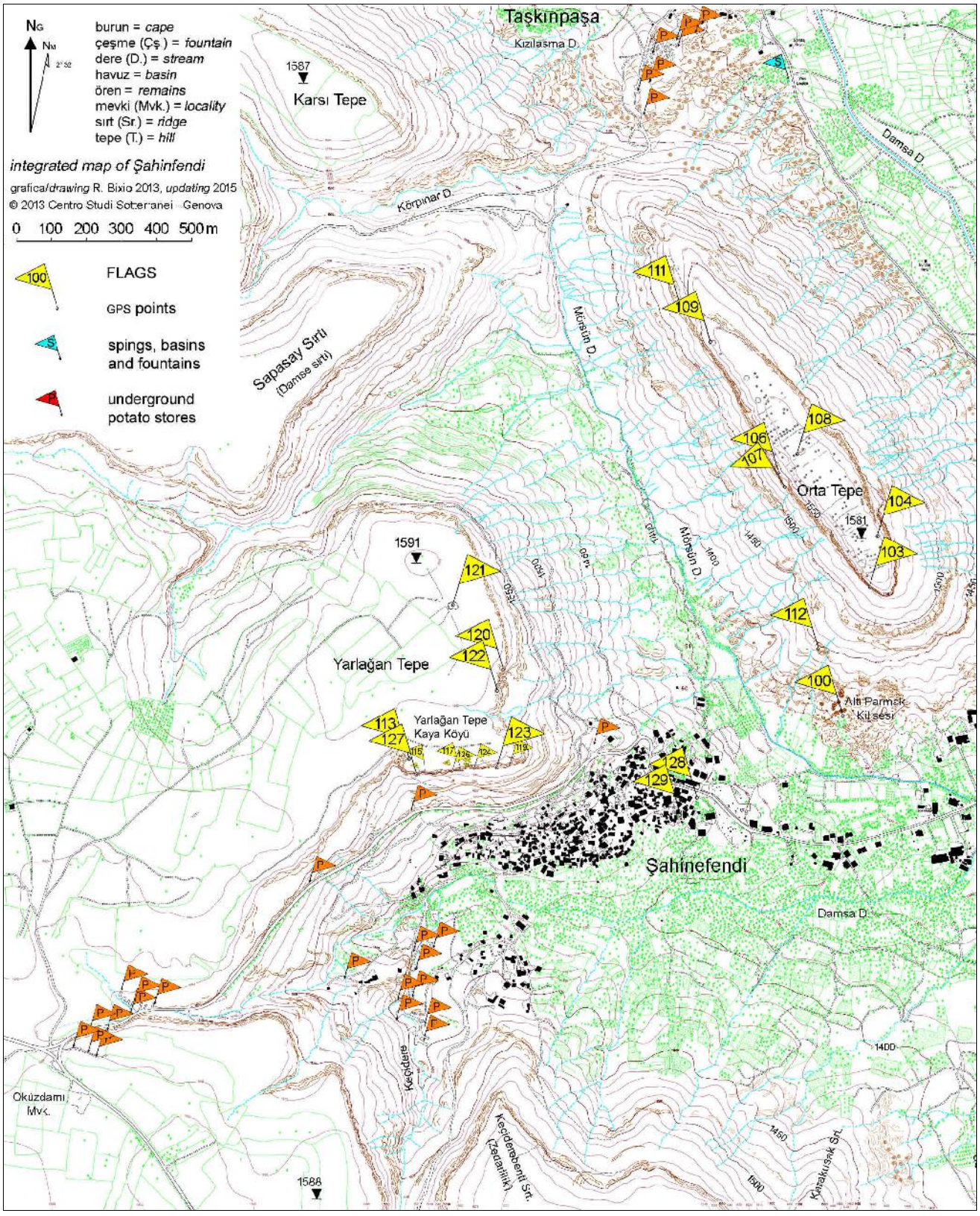

Figure 7: Şahinefendi hollow - western sector (drawing R. Bixio)

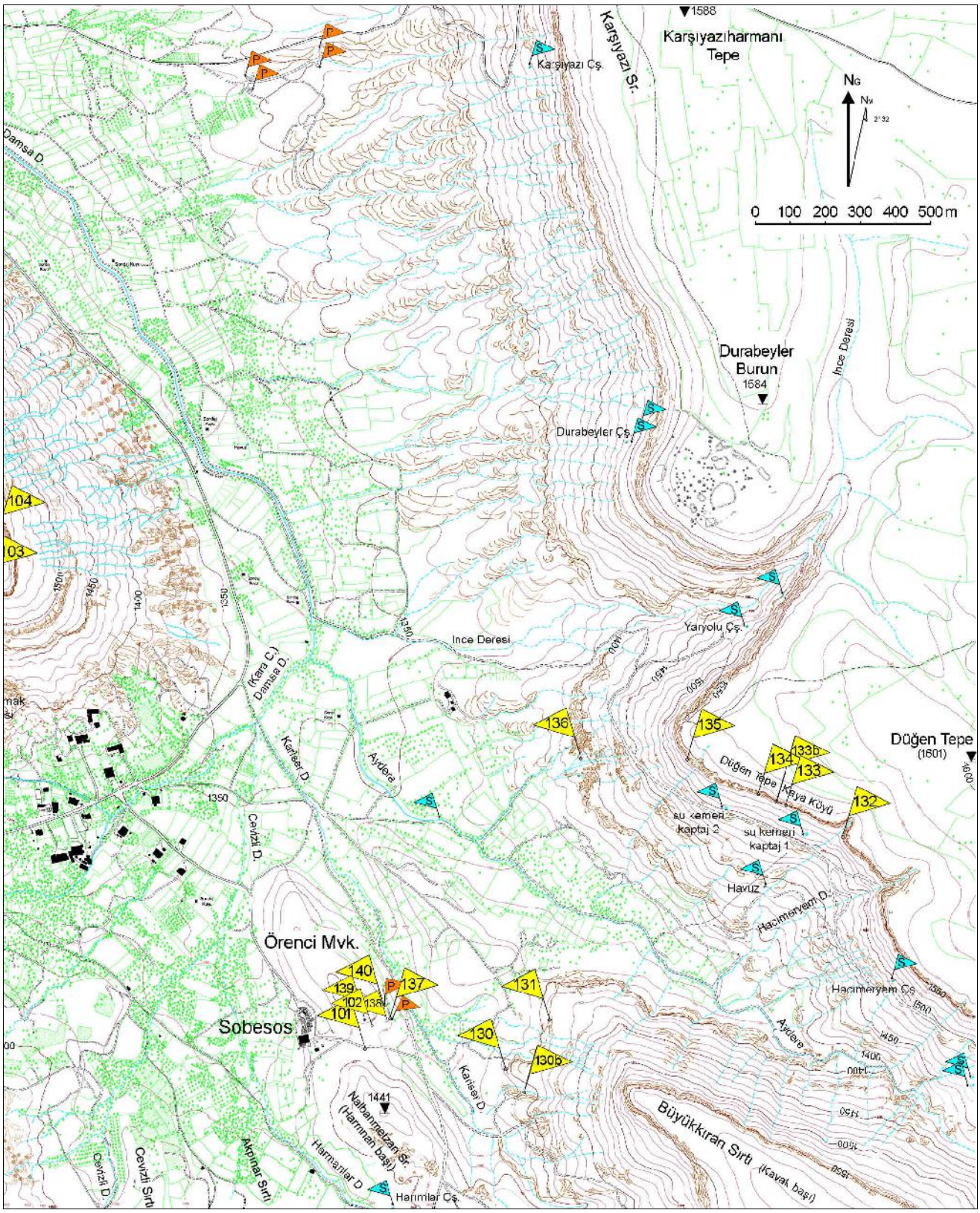

Figure 8: Şahinefendi hollow - eastern sector (drawing R. Bixio)

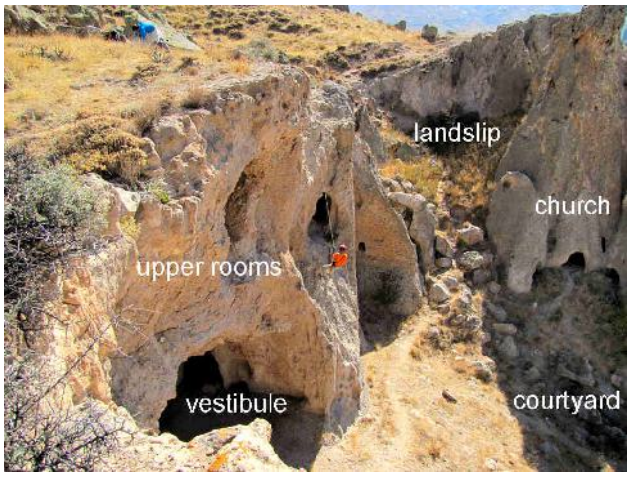

Figure 9: The Monastery (photo A. De Pascale)

2. THE PERIPHERAL ROCK-CUT SITES

The rock-cut structures around the Church of Forty Martyrs (flag 100), positioned nearly in the middle of the basin, seem to be the centre, too, of the whole Şahinefendi district. Investigations in the surrounding area have been carried out gradually, widening the range of action towards the borders of the natural amphitheatre, by locating and documenting a number of man-made cavities, shortly described below.

We marked the points, geo-referenced with the GPS (flags with number) in the resultant maps (Figs. 7, 8). For the sake of completeness, we indicate the underground potato stores too (flags with P), probably all excavated in relatively recent times, most of which are still in use today.

Furthermore, we indicate also fountains, basins and springs (flags with S), mentioned in a topographic Turk map dating 1995, but currently (at least during our investigations, in September) dried.

2.1 The Monastery (Beş Parmak Manastırı - GPS 112)

It is matter of a rock-cut complex (flag 112) excavated into a crag (altitude 1.445 m a.s.l.), on the western slope of Orta Tepe, faced by a rock mass with five (*beş*) tips which circumscribe a sort of courtyard, partly natural. The settlement consists of a large structure, with monumental façade, partly collapsed, and carefully carved.

The typical *"inverted T-plan"* [Öztürk, 2012, p. 158] consists of a transversal room (vestibule) and a long perpendicular space (hall). A lateral room is believed to be a kitchen. Opposite there are a number of interconnected rough spaces and, set apart on one side, an *"inscribed cross-plan"* church that *"should probably be assigned to the eleventh-century period"* [Rodley, 2010, pp. 38-39]. The entrance is almost entirely buried by the collapsed narthex and by land fills.

The rooms excavated about 4 m above the vestibule, partly collapsed with the façade, have been reached from above by using single-rope techniques.

They consist in small sizes cavities with traces of niches for the pigeons. So we exclude the hypothesis of the presence of an extended structure used as refuge.

However, we think such lack is surprising and we consider plausible that, as we will see in other sites documented in the basin (and also in other sites[1]), this complex too could had its own refuge, probably not yet identified due to the large amount of boulders collapsed from the crags that, for example, nearly hid the entrance of the church (Fig. 9).

2.2 The "wall" vertical refuge of Orta Tepe (GPS 103)

Unlike the Monastery, the cavity at the foot of the upper crowning cliff of the Orta Tepe butte (flag 103), 100 m higher, at an altitude of 1.546 m a.s.l., is clearly a structure conceived as defence against raids. We extensively described its characteristics in the proceedings of Hypogea 2015 [Andaloro et al., 2015].

In short, this is a structure excavated on two levels in the parallel band nearest the front of the cliff (Fig. 10). It is classifiable as “wall" vertical refuge.

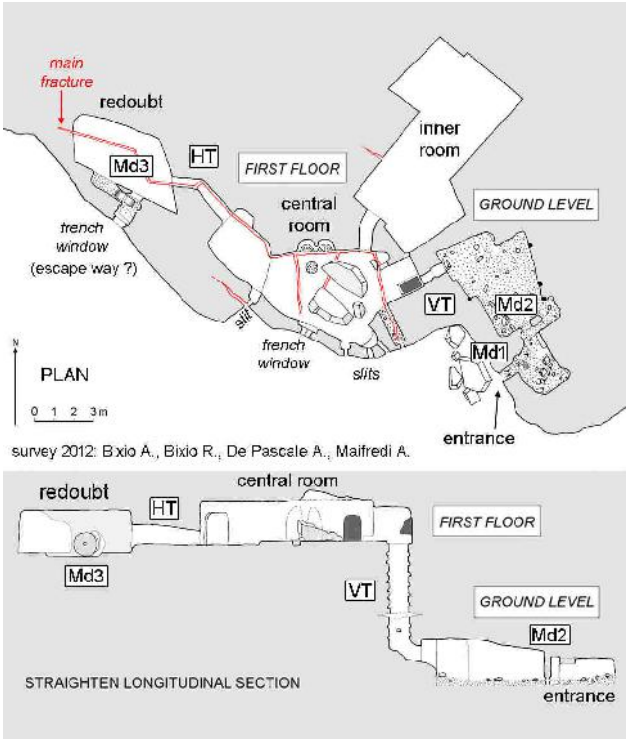

Figure 10: Plan and section of the "wall" vertical refuge (GPS 103) of Orta Tepe (drawing R. Bixio)

[1] See, for example, "The Concentric Refuge..." [Bixio A. et al., 2017a] in these same proceedings. We can also mention the site of Belha Manastırı (Fig. 2), near Özkonak (north of Avanos), very similar to the “Monastery” of Şahinefendi, which indeed has a structure designated as refuge excavated in the inner side of the perpendicular hall.

Figure 11: Orta Tepe vertical shelter. The pensile mill-stone door inside the redoubt (photo A. Bixio)

It was protected by a sequence of millstone-doors (Md) and vertical (VT) and horizontal (HT) traps, for the defence of the residential area (first floor) and a room used as last refuge (redoubt). This room has an opening, closed by a millstone-door still *in situ* (Fig. 11), which probably protected an escape route through a pensile cornice, today disappeared owing to the collapse of a large part of the cliff. In this case the site was isolated from the other settlements in the basin and was difficult to be reached (Figs. 5 and 7). So we think likely that the structure was not related with the residences at the bottom of the valley, but could serves both as dwelling and, in case of danger, refuge for a single family who, maybe, practiced farming or grazing on the near flat top of the butte. This was connected by a road cut in the side of the cliff (flags 106/107), today sheared off by the recession of the rock front which poses a serious threat to the underground rooms too. We point out that on the plateau there are evidences of a large necropolis attributed to the Phrygians era dating back between 8th and 7th century BC [pers. comm. Metin Çakar].

Figure 12: The pensile cavities in the Aydere amphitheatre (photo A. De Pascale)

2.3 The underground structures of Örenci Mevkii

In the site (*mevkii*) of Örenci, 200 m eastward of the archeological site of Sobesos, a group of six small cavities has been documented (flags 101, 102, 137, 138, 139, 140 in Fig. 8). At least four of them have been originally realized as grape-treading rooms (Fig. 24), with the typical basins (or their remains) for the treading and the gathering, recently partially used as potato stores and today abandoned. As stated above, the site is in the middle of a large plain still mainly cultivated with vineyard, at an altitude of 1.380 m a.s.l.

450 m southeast of this group the plain is bordered by the first spurs of the mesa (Büyükkıran Sırtı), on which crags (altitude 1.400 m a.s.l.) one can see the remains of ancient rock-cut pigeon-lofts (flag 131), some of which very worn. One is still used today as hut by the shepherd charged of the adjacent sheepfold (flag 130). A tunnel purposely closed with stones and traces, outside, of a rock-cut road (flag 130b) are clues of a frequentation protracted throughout the time.

2.4 The pensile cavities of Aydere (GPS 138)

From the Örenci Mevkii, moving northward, along the Aydere valley, you are flanking the cliff, about 15 m high, which define the lower part of the west slopes of Düğen Tepe. The crag is scattered with a number of artificial cavities, most of which, sheared off by erosion, show their ancient use as pigeon-loft.

A group of cavities located 700 m downstream, at an altitude of 1.400 m a.s.l., in a rock crag which form a sort of amphitheatre about fifty meters in diameter, seem to be of a different kind (flag 136 in Fig. 8). Here the erosion shaped the high walls into a number of pinnacles not completely isolated yet, leaving intact for now the spaces excavated inside (Fig. 12).

Figure 13: One of the windows opened in the rock face of Aydere amphitheatre (photo A. De Pascale)

Figure 14: The millstone-door in cavity 134 of Duğen Tepe (photo A. Bixio)

The openings, today unreachable, are all positioned above the contact line between two horizontal layers which, due to the ground gradient, are between 5 m and 15 m high. There are three rectangular entrances and five square openings, variously distributed and orientated on the vertical face. Each is inside a shallow arched niche, without decorations or bordered with just a double line, carved in the rock (Fig. 13). Footholds, small windows or flight holes are not visible, nor niches for nesting. We therefore believe these are not pigeon-lofts or apiaries, and we cannot exclude that they could be refuge-houses, but the appearance and the position suggest that, more likely, the cavities could be pensile tombs, chamber type.
We do not know if this hypothesis is correct, nor their age, especially since it was very difficult to explore them, but it would not be surprising if they would date back to the Phrygian or Roman age, owing to the archeological evidences present in the area.

2.5 The "wall" rock-cut village of Düğen Tepe

On the contrary, the cavities located at higher altitude (between 1.540 and 1.550 m a.s.l.), scattered along the cliff which ends the top of the right orographic slope of the Aydere valley, and borders the Düğen plateau (about 1.560 m a.s.l.), seem to have been realized for dwelling. The complex constituted a “wall” rock-cut village (Düğen Tepe Kaya Köyü) which seems even to extend northward of the Şahinefendi basin, toward Taşkınpaşa and beyond. We note that on the top of the large spur named Durabeyler Burun (Fig. 8), which overheads the Aydere amphitheatre, the satellite images show traces of fences and other structures, maybe of an ancient settlement about which it would be appropriate to investigate.
Due the great extent of the cliffs and the rough path along the slope at their bottom, cluttered with collapsed boulders, we have examined only a portion of the slope, about 800 m long (between flags 132 and 135 in Fig. 8).

Figure 15: Duğen Tepe. Chapel 133 (photo A. Bixio)

The real extension of the settlement is difficult to be evaluated owing to the disappearing, even more than in other sites, of large parts of rock and for the impossibility to reach many cavities, made dangerous by the precarious stability conditions resulting in the relentless natural process of degradation of the cliff.
In short, all the units generally consist of a large room at the ground floor, connected to the superimposed levels through vertical shafts. The presence of those vertical traps and the identification of a millstone-door (Fig. 14), lying down and half buried by the collapsing of the entrance (flag 134), highlight once again the need to defend the communities from the raiders. It should be noted that the only cavity documented still almost intact is a small chapel (flag 133), with niches, seats and linear decorations, very elemental, carved in the rock. A small "cross potent" is chiseled in the partition between the nave and the narrow presbytery, without altar (Fig. 15).

A cavity between the previous two (flag 133b) would deserves further investigations. It is identified by a small door excavated in the wall, 6 m height above the ground,

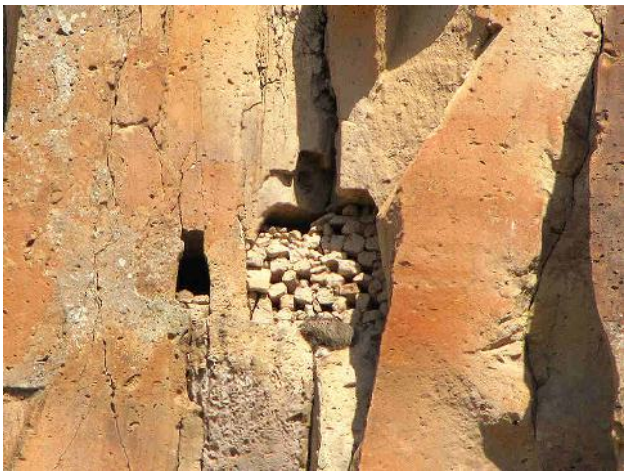

Figure 16: Opening 133b, closed with squared stones shaping several niches (photo A. de Pascale)

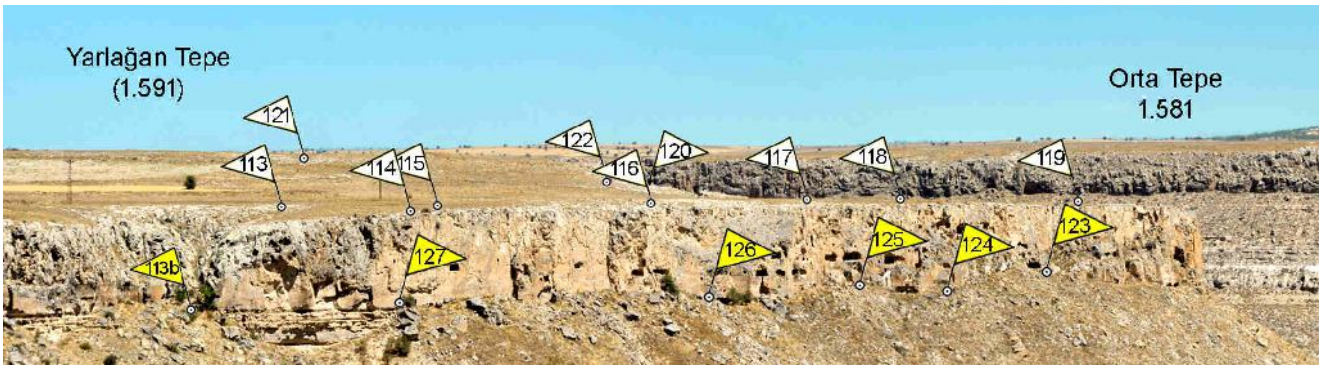

Figure 17: The "wall" rock-cut village of Yarlağan Tepe (photo A. Maifredi)

impossible to be reached without a ladder (Fig. 16). The entrance is near a larger opening closed with squared stones lying in staggered lines, thus forming at least fifteen small superimposed niches, topped with a greater window excavated into the rock.

The arrangement suggests it could be a pigeon-loft combined with an apiary as, for example, the one in the Zemi valley (Göreme). It may be the only rock-cut apiary found in Şahinefendi so far, although there are others (at least 19) in the surrounding villages, as in Karaın (6) or in Soğanlı (4) [Roussel, 2006]. However, the arrangement of perche-niches of this size is unexpected for Cappadocia, while there are similarities with the ancient apiaries of Imgiebah, in Malta [Bixio et al., 2002].

We note that, on a topographic map dated 1951 (Fig. 19, upper drawing), there are not signs of connection roads from the cliff of Duğen Tepe to the bottom of the valley, whereas there are two paths which, starting from the villages of Şahinefendi and Taşkınpaşa, climb up toward the top of the mesa. From here, undoubtedly, the rock-cut village could have been reached by descending the ravines breaking the crowning cliff. Nowadays, a dirt road climbs the slope up to the foot of the cliff (Fig. 19, lower drawing).

Figure 18: Shaft (vertical trap) in cavity 127 of Yarlağan Tepe rock-cut village (photo A. Bixio)

We believe that it was built, of course after 1951, to serve the plugs of the two buried aqueducts which feed today both the cited villages (*su kemeri kaptaj* 1 and 2 in Fig. 8). This fact confirms the presence of water tables inside the rocks, today collected, which in the past could have guaranteed the water supply for the rock-cut village by springs.

2.6 The "wall" rock-cut village of Yarlağan tepe

This rock-cut settlement (Yarlağan Tepe Kaya Köyü) is located opposite in the basin (west sector), along the cliff which borders the Yarlağan mesa (Figs. 4, 5, 7, 17). It extends for 250 m on a spur (flags 123-127) which dominates the present village of Şahinefendi, 1 km as the crow flies west of the church of Forty Martyrs. It could be reached with a long detour from the top of the mesa, or by climbing, with difficulty, the steep slope, covered with precarious scree, from the modern paved road up to the foot of the cliff.

The survey allowed to determine the features of the settlement which, as for Duğen Tepe, fall within the “wall” cliff village type, that means with the rooms excavated in the vertical face, on overlapped levels. Schematically, the settlement consists of several adjacent dwellings, each composed of a room (smaller than those in Duğen), excavated at the bottom of the crowning cliff, on the break of slope.

The ground level is communicating with the upper rooms by means of ascending shafts (Fig. 18) with their entrances on the ceiling, probably originally reachable with a ladder that could have been withdrew from above so to isolate the upper levels in case of raids. Only in one unit (flag 127) we found the presence at the ground level of a "movement room" where could have been handled a millstone-door, today disappeared, in order to achieve a first defensive line for potential attacks. In the other cases the upper levels are difficult or impossible to be reached owing to the large collapses of the rock parts.

This settlement too has a small church (flag 123) where the cubical altar is still present, leaning against the apse, and realized by saving the rock from excavation.

The site has two steep roads communicating with the top of the plateau, specifically excavated in the rock on both sides

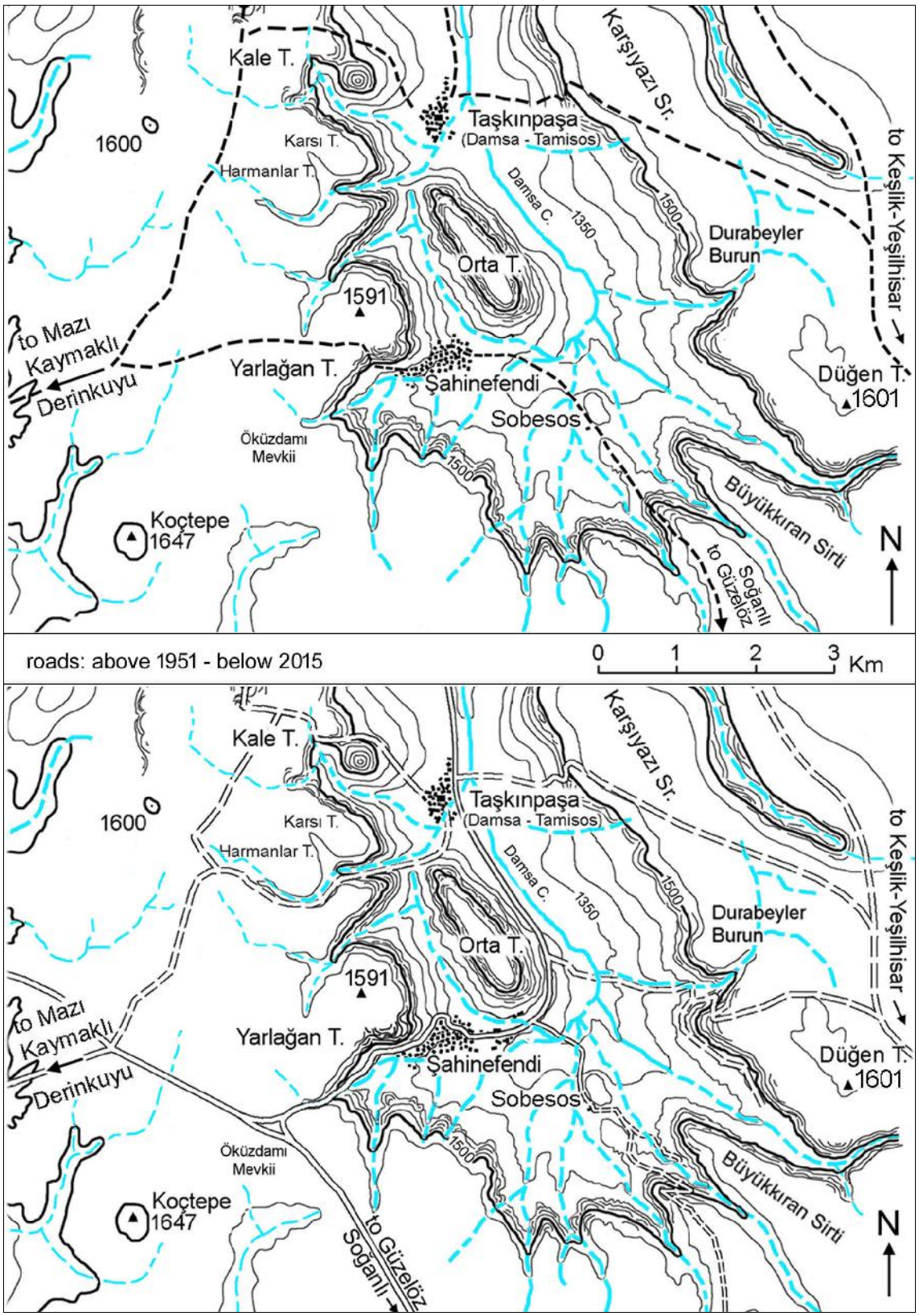

Figure 19: Road networks 1951 and 2015 compared (drawing R. Bixio)

Figure 20: Funnel, i.e. rock-cut basin (trough) and duct on the cliff edge of Yarlağan (photo A. Bixio)

of the settlement (flags 113-113b and 120-122 in Figs. 7, 17). The topographic map of 1951 (Fig. 19) mentioned above, shows that, before the construction of the modern paved road which cut the slope at a lower altitude, the rock-cut village was not so isolated as appears today, but it was directly connected with the bottom of the valley. Actually the settlement was on the main route between the basin of Şahinefendi and the valleys of Mazı, Derinkuyu and Kaymaklı, to the west, Güzelöz and Soğanlı to the south, and Taşkınpaşa to the north where, also in the past, other important rock-cut settlements were present. The old route is by now very hard to be identified under the talus which chaotically covers the slope.

2.7 Hydraulic works

Interestingly, on the top of the cliff of Yarlağan a possible water supply system has been located: it consists of a number of basins (or troughs) to gather the rainfall or the snowmelt. They are spread along the whole front of the settlement, carved on the rock surface near the edge (flags from 114 to 119 in Fig. 17).

The basins are equipped with short drainage channels which open toward the void, maybe in the past combined with downpipes, today sheared off by the cliff recession, connected with underlying spaces (fig. 20). We call these devices "funnels" [Bixio A. et al., 2017b]. Here, we believe, some pensile cisterns might be found similar to that documented in Sarıhıdır, near Avanos [Gilli et al., 2014; Bixio et al., 2016].

2.8 The underground village (*köy*) of Şahinefendi

Finally, the investigations embraced the oldest built-up area of Şahinefendi village (*köy*), between the cemetery and the old mosque. The inhabitants report a number of underground structures located under the masonry buildings. In two cases (flags 128, 129 in Figs. 22, 23) we carried out short surveys noting the existence of spaces of various sizes excavated in the rock, partly combined with the masonry works.

The rooms have passages, filled with debris or intentionally closed (Fig. 21), which the local rumors say to be in connection with the church of Forty Martyrs, 500 m far as the crow flies. There is a possibility that a sort of "overturned village" exists, maybe coeval with the rock-cut church, as the inhabitants believe, about which further investigations should be carried out.

3. CONCLUSIONS

Compared with the first investigations of the site carried out in the last century, we can now affirm that the knowledge of the settlements excavated in the rock within the basin of Şahinefendi (Sobesos), although not yet exhaustive, has been greatly increased, unveiling a widespread presence of rock-cut structures, even if scattered over an area of 15 km^2, of which the church of Forty Martyrs (flag 100) is the focal point. So, the ecclesial complex was not as isolated as, at first sight, may appear today, but was the centre of a wide community which populated, in particular, the edge of the amphitheatre, at a higher position. *"Ce fait... explique que Sobésos ait pu devenir, au dixième siècle, la siège d'un évéché"* [De Jerphanion, 1936, pp. 156].

Even the typology of the rock-cut structures, before limited to religious works, today is greatly differentiated, not only for the identification of correlated elements (kitchens, refectories, grape-treading rooms (Fig. 24), pigeon-lofts, funerary chapels), but most of all with the location of two different "wall" rock-cut villages and a possible underground system under the masonry dwellings of the modern Şahinefendi. We underline that one of the rock-cut villages (Yarlağan), although decentralised, was positioned on the original main route, today disappeared, which, climbing over the passes, reached the others valleys.

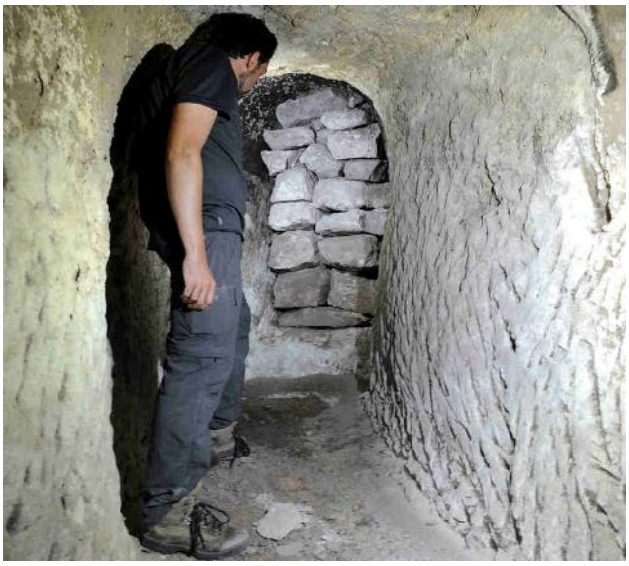

Figure 21: Village of Şahinefendi. Tunnel carved in the rock below the house 128, intentionally clogged with squared stones (photo A. Bixio)

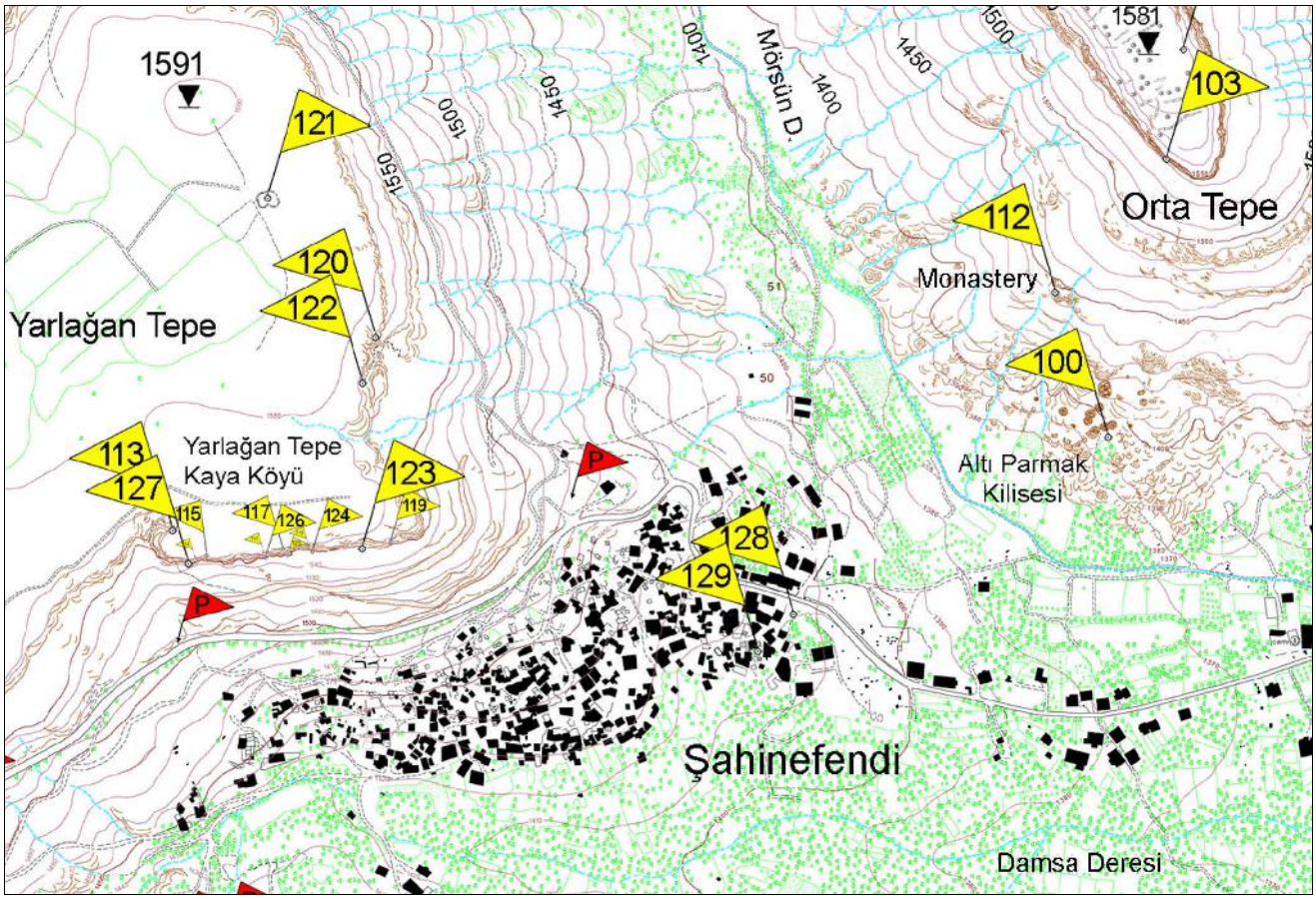

Figure 22, above / Figure 23, below: Area around the today's village of Şahinefendi (drawings R. Bixio)

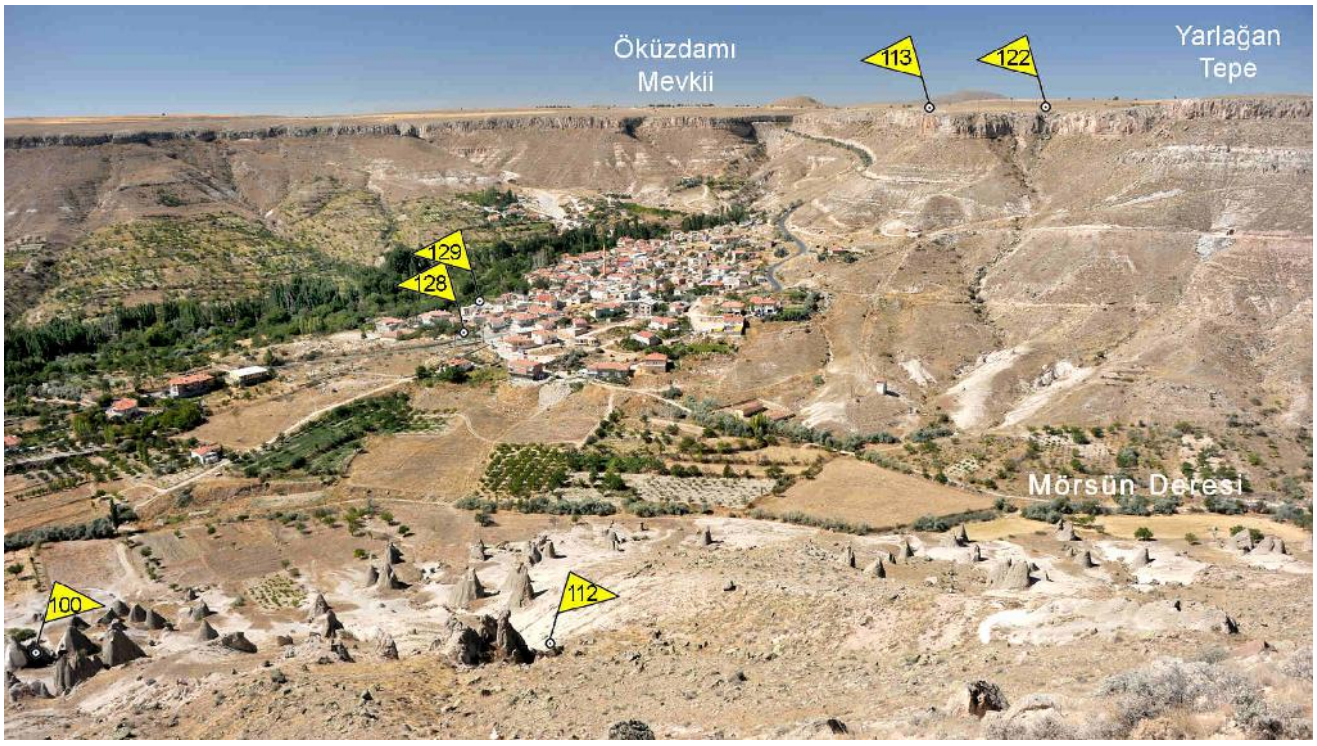

Figure 24: Örenci Mevkii. Grape-treading room (photo A. De Pascale)

Figure 25: Potatoe stores close to Şahinefendi village (photo A. De Pascale)

It is interesting to note that both the "wall" settlements had their own chapels, previously unknown, clearly used for local religious needs, which could have limited to travel toward the bottom of the valley just only for the most important celebrations. So, in total we have at least four rock-cut churches, two funeral chapels, in addition to the remains of a masonry built church (in the Örenci site).

In this area we note too, without surprise, the presence of structures clearly planned to protect the inhabitants from raids, for example *"...aux époques troublées par les incursions arabes..."* [De Jerphanion, 1932, p. 157]. Due to their conformation on overlapped levels, defended by combined devices (millstone-doors and trap-tunnels/shafts), they fall within the category of "wall vertical shelters". We located three (in addition to the one under the church of Forty Martyrs), but they should be more, today hidden by the collapses resulting from the unavoidable natural decay of the rock. We point out that this typology has comparison also in the surrounding villages, as Karlık [see Galeazzi & Germani, 2017], Golgoli [Yamaç & Gilli, 2016], or the more complex refuge of Mazı. The organization of water supply is not yet quite clear. However, on the top of the cliff of a rock-cut village (Yarlağan) a particular system has been identified with basins and downpipes which, although sheared off by the regression of the rock wall, suggest the water gathering through funnels and, perhaps, pensile cisterns. A special mention deserve some cavities on the rock wall, so far unreachable, excavated in a group of pinnacles at the bottom of the valley: they could be tombs, maybe dating to Phrygian or Roman age, of which there are archaeological evidences in the area. Finally, we point out the presence of a cavity on the rock wall of Düğen Tepe which, owing to its external appearance, could be an apiary, maybe combined with a pigeon-loft. The underground stores of potatoes are here just mentioned: no investigation has been carried out because they are nearly all still in use and we think they should be realized in recent times (Fig. 25).

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5. ACKNOWLEDGMENTS

Our thanks to the inspector of Ministry of Culture, Metin Çakar (Çorum Müzesi), for the information about the Frigian remains of Orta Tepe, and to Murat Gülyaz (Director of Nevşehir Archaeological Müzesi) for the courtesy of photo in Fig. 4, and for the explorations shared with us during the years.

Rock Shelters of the Upper Turia Valley (Spain). A testimony of a lost society

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Abstract

The Turia River and its valley has been a unifying element of the life in the central Valencia Region of Spain. The Mid-Upper Valley crosses the mountain region of La Serranía, in which the geological structure, with a sub-horizontal stratigraphic setting in many areas, has created an important number of rock and cave shelters. Many of them have been used for purposes related with agriculture and grazing, and after centuries of use and as consequence of the change in live systems, are now abandoned and in risk of total destruction.

In this paper we present the analysis, topography and review of some of them, linking their characteristics with the ancient usage, aimed at promoting this local heritage.

Keywords

Rock shelter; Cave shelter; Serranía; Spain.

1. INTRODUCTION

The district of La Serranía is an interesting area in the center of the Valencia Province (Spain). With a long history of human occupation, it is rich in archeological sites, including prehistoric paintings, Iberic settlements (Burriel and Ruiz, 2015), Roman remains (including a very well preserved aqueduct) (Cantó and Curiel, 1998) and castles from the Arab period (Glick, 1995).

The geological characteristics of the region created a relevant number of rock shelters, some of them hanged up in the cliffs with fantastic views over the valleys. These rock shelters usually have a horizontal structure that facilitated their use for different purposes related with the agricultural society that has been predominant in the region up today.

In this paper, we present a general view of the district of La Serranía, with special attention to the aspects related with existence and use of the rock shelters, and a description of some representative shelters, studied during the last years.

2. LA SERRANIA DISTRICT. SOCIO-ECONOMIC ASPECTS

La Serranía (also called Alto Turia or Los Serranos) is a district of the Region of Valencia (Spain), located in the interior of the province of Valencia and occupying the territory between latitudes 39º 58' N and 39º 32' N and longitudes 01º 12' W and 00º 38' W, with an extension of approximately 1500 km^2.

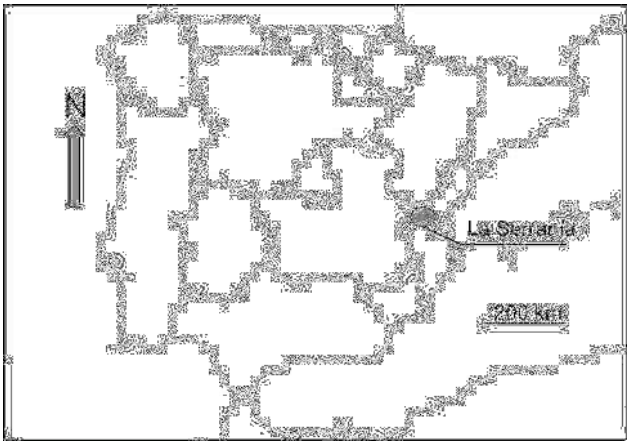

Figure 1: Location of La Serranìa district (drawing A. Carrión)

It includes almost the whole middle-upper course of the River Turia and adjacent territories, counting with very diverse landscapes, from the highlands of almost 1600 m a.s.l. of altitude to low altitude areas where orange trees are dominant (Bolos, 1967).

With low-density demography, its capital and geographic and historical center is Chelva (about 2000 inhabitants), although the most populated town is Villar del Arzobispo (barely 4000 inhabitants).

The towns in the mountains are austere yet rugged and

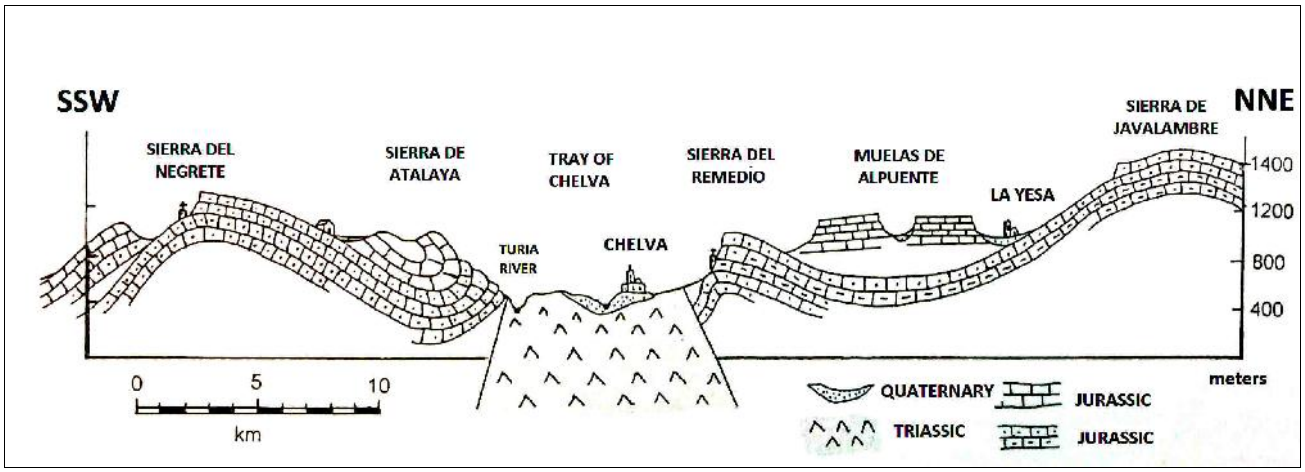

Figure 2: Topographic profile of La Serranía [after J. Piqueras, 2012]

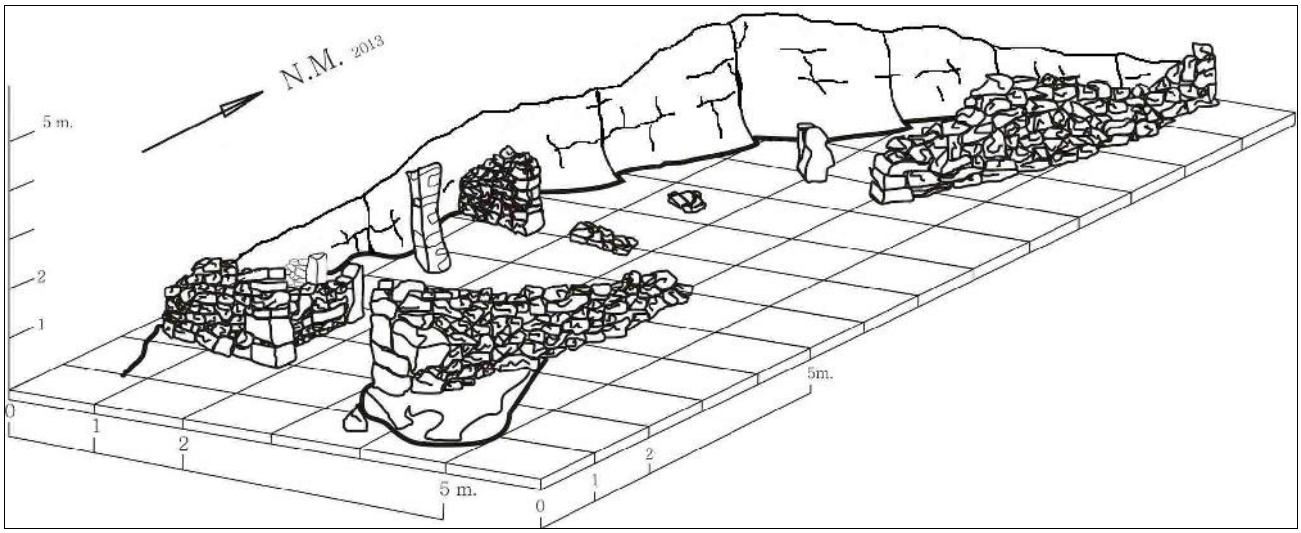

Figure 3: Mangranero Cave Shelter remains (drawing A. Fornes)

picturesque, having a continental Mediterranean climate, hot in summer and not too cold in winter, although with large changes in temperature between day and night. The lack of rainfall causes a predominantly arid landscape with pine trees, almond trees, olive trees and low brush, with abundance of aromatic plants.

The predominant mountains create a rustic landscape, with a multitude of ravines and narrow canyons with cliffs up to 200 m high, and intervening fertile plains irrigated by canals. In many hillsides we can find many terraces for cultivation, although today they are abandoned, as were liked to a subsistence economy.

The economy of la Serranía has been traditionally centered toward agriculture and sheep farming (sheep and goats). The main products are almonds, grapes, wine and oranges. Tourism has an increasingly important role, due to its natural landscapes and the proximity of the city of Valencia and the highly touristic coastline.

3. PHYSICAL AND GEOLOGICAL ASPECTS OF LA SERRANIA

From a strictly geological perspective, the middle Turia Basin corresponds to the so-called Castillian branch of the Iberian Range, south of the Calatayud-Teruel depression (Fernandez, Gran Enciclopedia Aragonesa, 1980).

La Serranía is limited to the north by the Sierra de Javalambre Mountains and to the south by the Sierra del Negrete Mountains. Both are part of the Iberian System Anticlines, with orientation NW-SE. These reliefs were originated in the Alpine Orogeny, during the Cenozoic Era, and feature numerous longitudinal and transverse faults that affect the Jurassic and Triassic materials that compose the mountains.

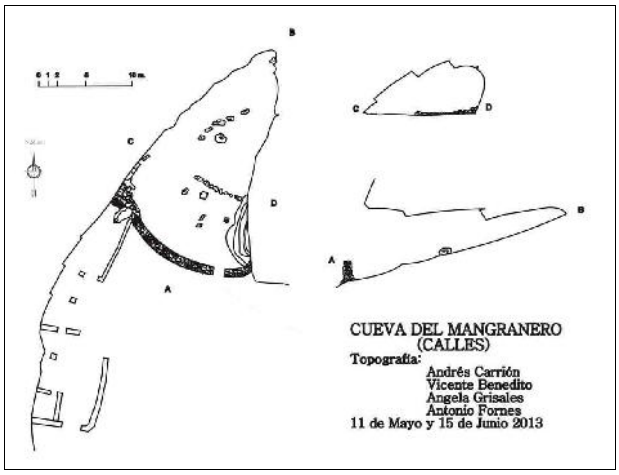

Figure 4: Mangranero Cave Shelter (drawing A. Fornes)

The intermediate space between these two sierras, despite corresponding fully to the basin of the River Turia, is not at all a relief in the form of valley, but it is a mountainous area of great geomorphological heterogeneity [Hermosilla Pla, 2010].

The topographic profile includes three major sub-units (Piqueras Haba, 2012). The first is formed by the Mountains of Alpuente (called Muelas de Alpuente), tabular reliefs of Cretaceous limestone placed over a syncline of similar lithology but of Jurassic age. The current landscape of Horst and Graben is the result of the action of the erosive and tectonic forces, which have also created (at lower levels) corridors filled with Quaternary sediments (like those of La Yesa, Titaguas, etc.).

The second unit is the Tray of Chelva. It is a depressed area, like a pit, in the Jurassic limestone coverage (see Fig. 2), drained by the river Tuejar, tributary of the Turia River on the left margin. This depression is flanked north by the Sierra del Remedio Mountains and south by the Sierra de Atalaya Mountains. The erosion of the higher strata allowed the outcrop of the Triassic Keuper, on which we found a "magnificent and complicated network of canals and ravines, which extends from Tuéjar to Calles" (Piqueras Haba, 2012).

The succession of hanging, NW-SE directed, synclines and anticlines, which begins with the already mentioned Sierra de Atalaya forms the third unit. Alternating Jurassic and Triassic folds create small valleys filled with Quaternary sediments.

Triassic deposits have thickness between 100 and 1000 meters depending on the material. They are mainly sandstones and micaceous ortoquarzite, dolomite and dolomitic marl, clays with limestone and dolomitic limestone. We can find also diapiric character structures formed by clays of different colors, plasters, sandstone and salts.

For the Jurassic period, limestone and marls are prevailing, with differences between the middle-lower Jurassic and the Upper Jurassic. In the first we find crystalline dolomites, limestone and layered limestone with chert, clays and gray limestone, with a total thickness between 310 and 480 meters. In the second the thickness ranges from 70 to 200 meters, dominated by gray massive limestone.

Cretaceous materials have a total thickness of 480 meters, in which dolomites and dolomitic limestone predominate [Hermosilla Pla, 2010].

For our study Jurassic materials are especially important, as most of the rock shelters studied are in materials from this period, mainly gray limestone.

4. ABOUT ROCK SHELTERS

Traditionally, speleological activities have ignored or at least given minimum attention to rock shelters. Only related with archeological findings we can locate some references in the speleological literature.

The complicated geography of La Serranía implied that, since ancient times, its inhabitants were looking for sizeable cavities that are present in some cliffs or under large rocks, for various and sometimes multiple purposes: residential, keeping livestock at night or in the winter chill, to be protected from the weather, monitor or defend certain strategic locations, or simply to be used as seasonal homes on support for certain agricultural or farming activities, when the distance to the place of habitual residence justifies this option.

The purpose of this study was to locate, document and describe as many of these rock shelters, without performing any study of archaeological character.

In this paper we have included only those rock or cave shelters where the rock component is sufficiently important, i.e. forming the most obvious or primitive part of the structure.

In some cases the human intervention simply closed with stone walls the access to the cavity; in other cases various dependencies were are also created (even rooms with some kind of household or facilities providing certain comfort); and in other cases people excavated to expand the cavity, or to collect and store rainwater.

5. ROCK AND CAVE SHELTERS

5.1 Mangranero Cave shelter

This rock shelter (Fig. 4), located near the village of Calles, has some differential characteristics in comparison with the rest of shelters included in this paper.

The first one is its structure, closer to a small cave than to that of a standard rock shelter. The term cave shelter is here perfectly adequate. The second differential aspect is the extent of the remains of construction located in the entrance of the shelter.

The access to the shelter is difficult, as is just down a cliff that has to be descended. There is one passage in the cliff, marked at the top by a little stone cairn.

Figure 5: Mangranero Cave Shelter (author A. Carrión)

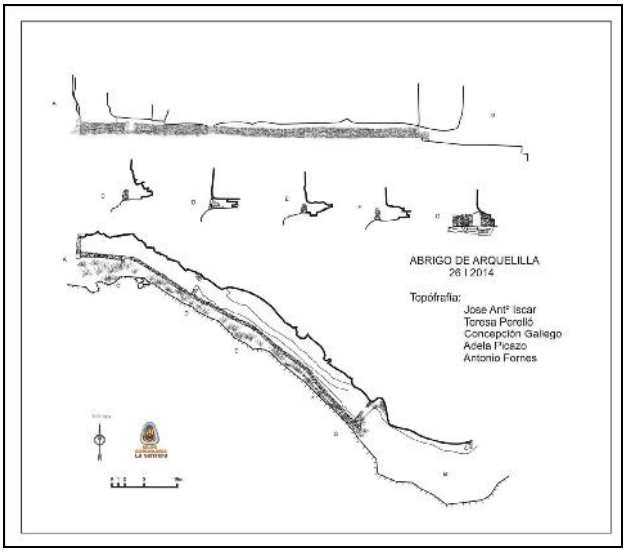

Figure 6: North Shelter of Arquelita (drawing A. Fornes)

Descending this passage, we continue with the cliff on our left hand to find, about 50 m ahead, the first remains, defining an entrance, built with irregular ashlars, to an area where we find sections of stone walls defining two or three rooms, including the rest of two rustic pillars (see Fig. 3), also built with irregular ashlars.

After this remains the entrance of the cave shelter, protected by a wall, is located. Inside the cave shelter, remains of a second wall indicate that the enclosure was divided in two areas.

5.2 Rock shelters of Arquelita

The Tuejar River valley has a narrow sector about six km up of the place named El Nacimiento. In this place, we find two rock shelters in opposite cliffs, face to face and almost symmetric (Figs. 6, 7, 8). Obviously this was due to the identical characteristics of the rock in both sides of the valley.

Figure 7: View of the South Shelter of Arquelita (author A. Carrión)

Both cave shelters are very similar: formed by differential erosion of a group of strata about 2 m thick, a narrow and long area covered from the rain has been closed partially using stone walls with irregular pieces. In past times both shelters had an entrance door, today completely disappeared in the Southern shelter and partially in that to the north.

The northern shelter has more complex structure, as after about 45 m (two thirds of its total length) a second door defines an inner enclosure, maybe reserved for the people. This second enclosure has also an independent entrance by the side of the cliff, in this place not so vertical. Also remains of one door are present in this last entrance.

While the northern shelter is easily visible and accessible, the south shelter remains almost inaccessible, as the forest has covered the possible path. The structure is similar to the other shelter, but here we only have one single enclosure, about 30 m long and between 5 and 7 m wide.

Viewed from outside, both rock shelters face to face in this narrow place, seem to control the passage, but there is no passage here, the valley is not suitable for being a path way, and river and rocks make it impracticable.

Probably we are in front of a summer and winter solution for the question of protecting and saving livestock (mainly sheep and goats).

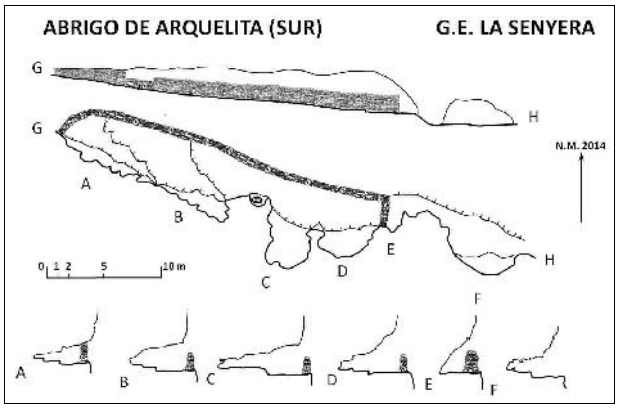

Figure 8: South Shelter of Arquelita (drawing A. Fornes)

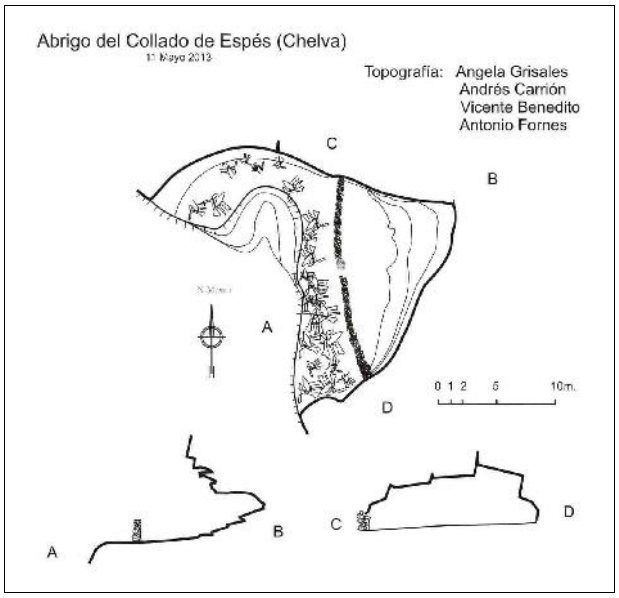

Figure 9: Rock Shelter of Espés (drawing A. Fornes)

5.3 Rock shelter of Espés

Just over the road from Valencia to Chelva, very close to the mountain pass of Espés, we find a small rock shelter, closed with a rustic stone wall to define an enclosure in the protected part of the shelter. The stone wall has an entrance, with remains of a door, more or less in the center. This enclosure has a triangular shape, about 18 m front and 10 m deep. Outside of the closure there is a plane terrace, today covered by under-growth.

5.4 Rock shelter of Corrales de Silla

This is a relevant group of pens built over nearly 100 m in cliff about 15 m high along the Tuejar River. It is located 1.5 km north of the village of Tuejar. In its lower part, a few meters above the river, we found a large sheep stone yard (about 50 m^2) made with dry stone masonry in acceptable good condition. As we ascend through the stratum (about 15° of inclination) we found another similar stone yard, although somewhat deteriorated. Important works can be seen in the rock for facilitating access and widening some areas. After continuing for 30 m, we find stone walls forming smaller dimensions enclosures. In three of these have been found prehistoric cave paintings. There is a metallic enclosure for protection.

Rock Shelter I is the higher, with dimensions of 17 m in length and 7 m maximum in depth. In the center there is a human figure and on the right a doe in good condition, although very faded by the limestone layer that almost covers the painting. Below this there is a barely noticeable deer and on the right the image of other animal difficult to identify. Paintings are dated 10,000 years B.C.

Rock Shelter II has greater dimensions, and shows remains that indicate its ancient use a sheep yard, as all the rock

Figure 10: Corrales de Silla (author A. Fornes

shelters in this cliff. Due to its dimensions (25 m long) and to the strong inclination, it was divided by a central wall. Prehistoric paintings are in the upper area. Here it is possible to recognize a complete goat and the head of other one, as well as remains of the other figures impossible to identify. These paintings are dated 5000 years B.C.

Rock shelter III has the greater number of paintings, representing archers in different attitudes, and in irregular conservation state, due to the effect of nature and the fires that during centuries have been made in this place. Five of the best preserved figures have arch and arrows, other two are incomplete and the rest are difficult to interpret.

Paintings are on the flat roof of a cavity, about 6 m-long and 3 m-deep, and are dated 6000 B.C.

Figure 11: Corrales de Silla. Surveying in the area of the paintings (author V. Benedito)

All figures are red and the deterioration of the surface of the rock effect of environmental perturbations suggests that many other paintings have disappeared.

5.5 Rock shelter of Las Buitreras

Located in the middle of a more than 100 m-high cliff, it has a morphology similar to those presented above: long but narrow, limited by the cliff wall in the inner side and by a vertical fall (the same cliff) in the other. The specificity of this shelter is related with the constructions found in it, namely the very well preserved walls with a use that do not seem to match with farmers' use. Instead, the position of a stall, surveying and closing the access to the greater part of the shelter, and with an excellent view over the valley and even a peephole oriented to the valley suggests a military use, which can be related with the Spanish Civil War (1936-39) or with the Civil Wars of the 19th century.

5.6 Other rock shelters

In the area of study, that includes about 1500 km^2, many others cave and rock shelters are present, in addition to those described above. Here we include a short list of some of them.

Village	Location	Name	Comments
Tuejar	Barranco de la Hoz	Abrigo del Barranco de la Hoz	Long shelter in the right margin cliff of Barranco de la Hoz
Tuejar	Barranco de la Hoz	Cueva de los Malditos	Group of dry stone walls conforming a big and complex shelter under and around big rock blocks
Alpuente	Arquela	Abrigos de Arquela	At least eight rock shelters, stepped in the mountain and cliff over the Arquela Fountain. One of them has a white cross painted on the cliff, just left of the cave.
Chelva	River Chelva	Cliff shelters of Chelva	A number of caves carved in the stone, in the right margin cliff on the Chelva River. In bad conservation state due to rockfalls.
Chelva	Alcotas	Abrigo de la Mora II	Long (100 m) and narrow shelter in the base of a cliff.

6. CONCLUSIONS

Our target was not to elaborate an exhaustive catalogue including all the cave and rock shelters in la Serranía District, but to give a view of this interesting patrimonial elements, abandoned in the middle of the mountains and suffering a slow destruction process.

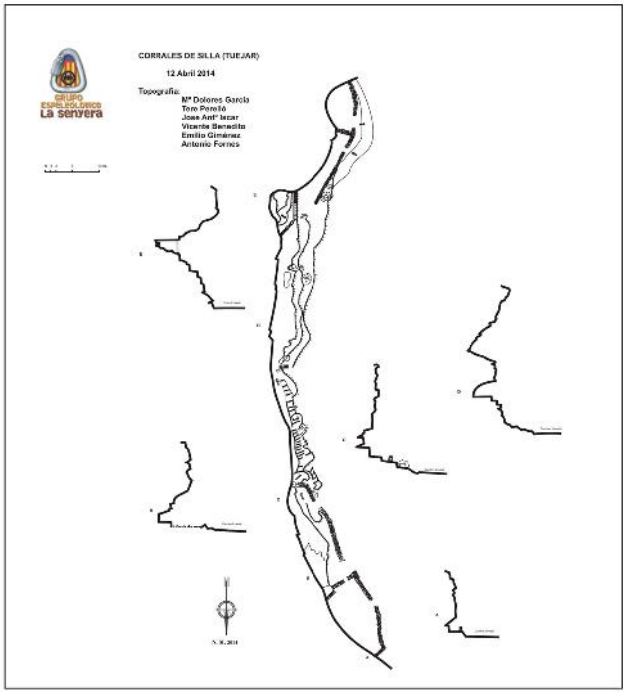

Figure 12: Plan of Corrales de Silla (drawing A. Fornes)

Almost all the shelter studied have served as sheep or goat yards, and in some cases additional construction always in dry stone show some habitational use.

Shelters are placed in the basis or in the middle of cliffs, related with structures as the Muela de Alpuente or Sierra del Remedio (see in Fig. 2) or in the cliffs of narrow valleys, like small canyons.

One aspect that raised some perplexity is the almost total lack of any type of ancient graffiti, nor textual or figurative. Only in one the rock shelters of Arquela a big white cross has been identified, and maybe is not so old. No text, no names, no religious symbols have been found after intensive search.

The conclusion is that we face the remains of a deeply illiterate society. This fact (that can be liked with historically high analphabetism rates) can justify the lack of texts and names, but not that of other symbols, including the religious ones. One interesting possibility is that the constructors and users of these shelters may be Islamic population, present in the area between 8th and 16th centuries, having also high illiteracy level and a lack of religious representations.

The studied shelters are all out of use, and the more recent traces of their usage seem to be at least 50 years old. Some were probably abandoned centuries ago. The society that constructed and used this rock and cave shelters is not the present one.

Figure 12: Rock shelter in Arquela, with white cross (author A. Carrión)

Figure 13. Rock shelter in Arquela (author A. Sisternas)

We have the aim of continuing the study of these shelters, paying attention to the possible presence of prehistoric paintings and other remains and completing the panorama of the country life in this district.

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The rock-cut settlement of Karlık (Central Turkey) Speleological investigations

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Abstract

Karlık, in the district of Urgup, is located on the left bank of the Derebağ river, a tributary of the Kızılırmak; it lies between the towns of Karain and Yeşilöz at 25 km SE of Nevşehir, along the highway 767 connecting Dörtyol to Kayseri. The interdisciplinary study conducted by the authors in 2002, together with other colleagues of speleological associations and Italian Universities, showed that the rock-cut settlement develops on four levels, with each level dedicated to a different use. The particular geology of the area could have produced substantial variations in the structures over the years. This unpublished study is presented here with the aim of documenting what acquired in 2002, which could be of some use as a basis for possible future investigations of the area.

Keywords

Artificial cavities, speleological investigations, Karlık, rock-cut settlements, Turkey.

1. INTRODUCTION

Cappadocia, in central Turkey, presents spectacular landscapes known all over the world, with characteristic deep valleys and singular geologic features into which dwellings, churches, tombs and entire undergrounds towns have been dug.

Through the ages Hittites, Persians, Alexander the Great, Romans, the Byzantine Empire, the Ottoman Empire and Turkey have ruled this region of central Anatolia.

In this paper we present the results of a short interdisciplinary investigation performed in 2002 by the authors (Egeria Underground Research Centre) with Fabio Redi (University of Pisa), Ezio Burri (University of L'Aquila), Elena Di Labio e Nerio Leonori (Association The Eccentric Stalactite). The present study aimed at investigating a little known area in Cappadocia, the Karlık area. Unfortunately, the preliminary survey was not followed by a detailed study. Anyway, we consider useful to report the data collected at that time, hoping that they can be of help for future, more detailed studies.

2. THE OLD SETTLEMENT AT KARLIK

Karlık, in the district of Ürgüp, is located at about 25 km southeast of Nevşehir on the left bank of river Derebag, tributary of river Kızılımark.

The modern settlement, placed on the valley bottom, is dominated to the west by the Avla Dağ and by various cliffs, on the sides of which are clearly visible the entrances of many hypogea. On the cliffs top a wide highland is still farmed today (Fig. 1).

The settlement at Karlık appears peculiarly open and vulnerable. Therefore, unusual protections were required, and the settlement turns out to be an uncommon case of a village with the productive sites placed at the top – and not at the bottom – of the settlement itself. The old dwelling, dated to the High Middle Ages [Burri et al., 2003] develops on four levels (Fig. 2).

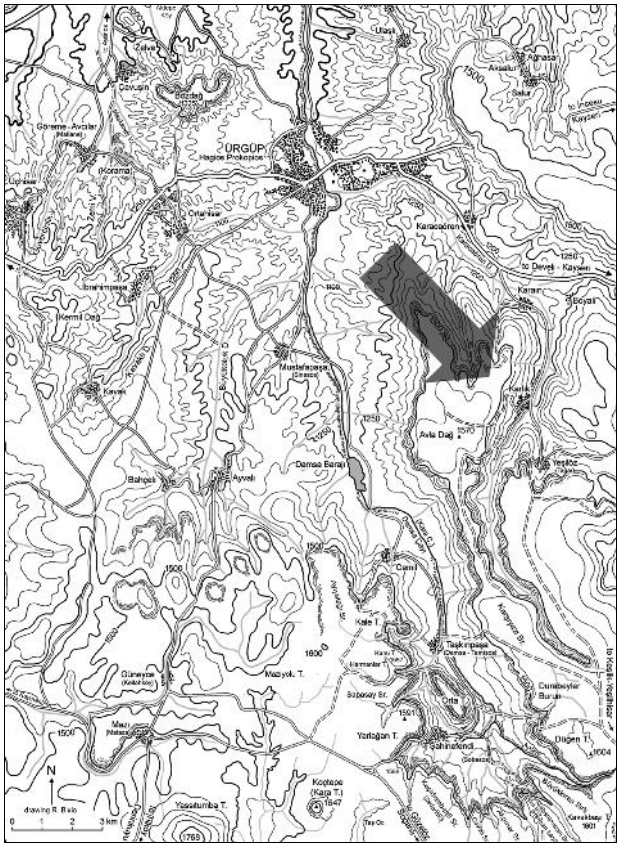

Figure 1: map of the area (drawing R. Bixio)

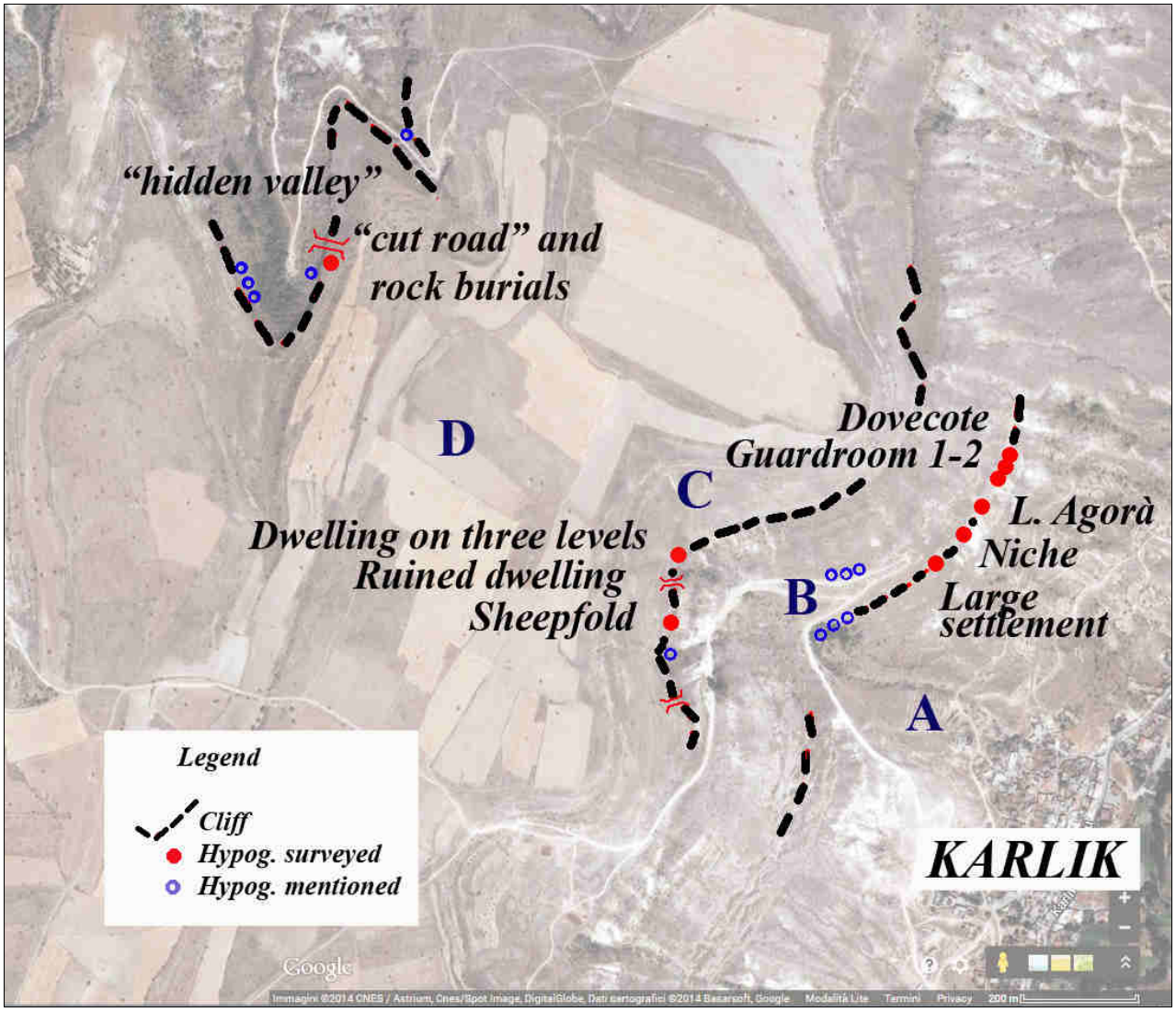

Figure 2: map of the studied area (drawing C. Germani, on Google Earth base)

From the bottom to the top, we find first the level A, which corresponds to the present settlement.
Levels B and C follow, well visible from below, which can be reached by the road going up northwest, following the tracks of the many paths departing from it.
The cliff high section can be reached along the same road until the top plateau, or from the base of level C through easy but well-hidden staircases dug into the tuff, located at about 20/30 meters to the left of the hypogeum on three levels described in the following.
The speleological campaign, though taking into consideration all the noticeable features, focused mostly on the levels B and C. Here a few underground structures have been explored and analyzed, and their use investigated (Table 1).
In the following we present in detail the various residential zones and the (unfortunately few) surveyed underground structures (Fig. 2a).

Figure 2a: The underground structures (photo C. Germani)

Hypogeum site	Place	Coordinates N	Coordinates E	Altitude m s.l.m.	Hypogeum type*	Development m
Dovecote	*B*	38° 33' 58,3"	34° 59' 4,1"	1.418	B7	2
Guardroom 1	*B*	38° 33' 54,2"	34° 59' 3,9"	1.418	B2/D1	2
Guardroom 2	*B*	38° 33' 54"	34° 59' 3,6"	1.414	B2/D1	3
Large Agorà	*B*	38° 33' 52,5"	34° 59' 2,5"	1.415	B1	approx. 15
Isolated Niche	*B*	38° 33' 51,1"	34° 59' 1,4"	1.416		
Large Northern Settlement	*B*	38° 33' 48,8"	34° 58' 58,7"	1.190	B1	approx. 100
3 Levels Dwelling	*C*	38° 33' 49,5"	34° 58' 40,2"	1.544	B1	25
Sheepfold	*C*	38° 33' 45,8"	34° 58' 40,1"	1.539	B6	14
Ruined dwelling	*C*	38° 33' 49,5"	34° 58' 40,2"	1.544	B1	8
Cut road	*Hidden valley*	38° 34' 6.3"	34° 58' 16.7"	1.156		100
Rock-cut burials	*Hidden valley*	38° 34' 6.3"	34° 58' 16.7"	1.156	C2	approx. 3

Table 1: list of the underground structures explored and analyzed.
*** Type reference by SSI - Cadastre of artificial cavities [Galeazzi, 2013]**

The four levels

Level A

It substantially coincides with the present settlement of the town of Karlık. Here one finds houses with an inner courtyard and drinking troughs to water livestock. The underground structures, at the time of the investigation, were still largely used by Karlık inhabitants, and therefore difficult to access. We noted various sheepfolds (at least one of them has been obtained in a rock-cut church) and an underground tank still connected to a series of watering channels.

Level B

The middle level B is characterized by a large number of hypogea in various conditions of preservation, and by two complex rock-cut structures. It appears divided in many overlying steps, often broken by landslides. The level ends at a large scree, located just beyond the "pigeon house" described below. In 2002, level B showed traces of recent farming on terracings. In the central and southern sections other highly ruined hypogea were found, which were not investigated in detail.

Level C

The upper level C is formed by a beautiful cliff between 15 and 25 m high (Fig. 3). Here the proper underground town developed, as shown by the many windows looking out over the valley. The access to the rooms was generally from the top plateau, but collapses make the exploration difficult; already at the time of our survey it was necessary to move down the cliff with speleological techniques. During the survey three underground structures have been explored and their plans obtained, as described in the following.
From the plateau it was possible to reach the rooms for the storage of food commodities, the dwellings, cult spaces and burial grounds, likely by means of wood staircases. The dwellings were in turn further defended from possible assaults thanks to traps and mill-windows.

Top plateau D and the Hidden Valley

The top plateau D still coincides with the farming area of the settlement. The road starting in Karlık ends near a large tank, partially collapsed. On the plateau are still well visible the tracks of the prolonged passage of carriages and the vestiges of interesting surface works, carrying water to the tank. Over the centuries, after the tank ceased its original use, it became a stable, as witnessed by the dry walls inside. On the NNW side of the plateau, a few burials, clearly violated, have been observed, as well as a wide path leading to the "hidden valley" characterized by abundant vegetation and rock-cut tombs. In ancient times the access to the valley had to be secured by a "cut" road which led from the highland to a spring. At present, a vast landslide has canceled a long section of the cliff, sweeping away also some rock-cut settlements.

Figure 3: the cliff - Level C (photo C. Germani)

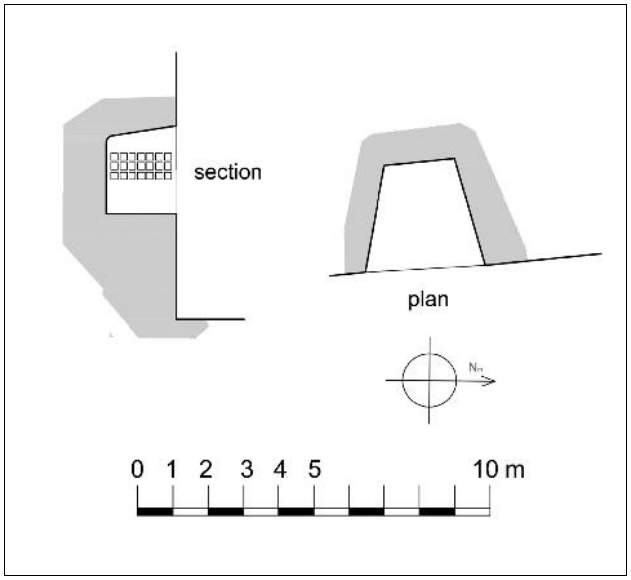

Figure 4: plan and section of the small rock-cut pigeon house (drawing C. Germani)

3. DESCRIPTION OF THE HYPOGEA

The names of the underground structures are not the local ones, since the inhabitants apparently ignore them; therefore, they have been chosen on the basis of their position and presumed use. If this study will be resumed, this subject should be better defined.

Dovecote

A small rock-cut pigeon house at the northern edge of cliff B. On all the walls small little cells 20x20 cm, well lined-up, have been obtained (Fig. 4).

Guardroom 1

It consists of two rooms, placed side by side, the larger 2x4 m, each with a very small window. On some of the walls, red lines decorations are present. It is likely that the collapse of the front section destroyed part of the hypogeum (Fig. 5).

Guardroom 2

Room 3x4 m with a very small window. Above and below the access window there are slots of uncertain use. It is likely that the collapse of the front section has destroyed the entrance to the hypogeum (Fig. 6).

Large Agorà

Large rectangular yard 14x20 m, entirely dug into a terrace in the middle cliff to the left. The floor is completely covered by collapse debris, preventing the definition of the original form of the structure. However, the back wall shows some signs of curvature which suggests the presence of a portico, by now disappeared. At the sides of the large yard, on the right, two hypogea (see later), while on the left, many niches and remains of tombs. At the center, a large "pigeon house" (Figs. 7A-7B).

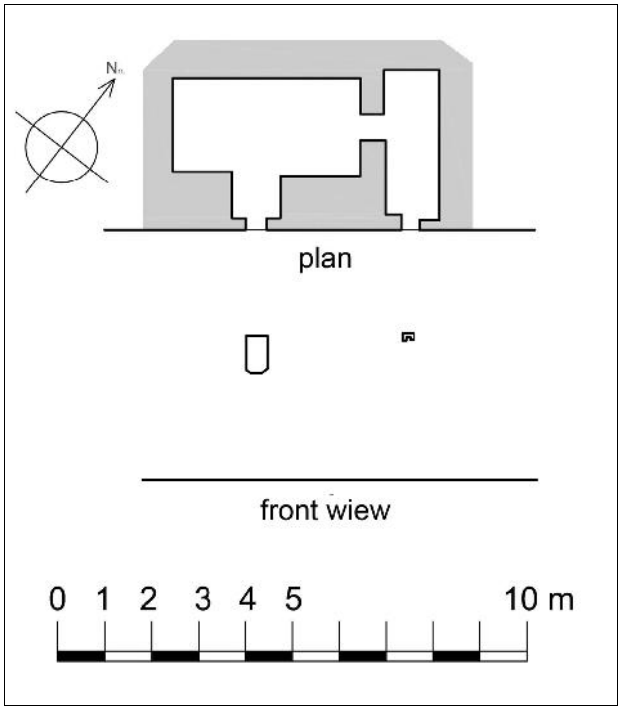

Figure 5: plan and front view of the guardroom 1 (drawing C. Germani)

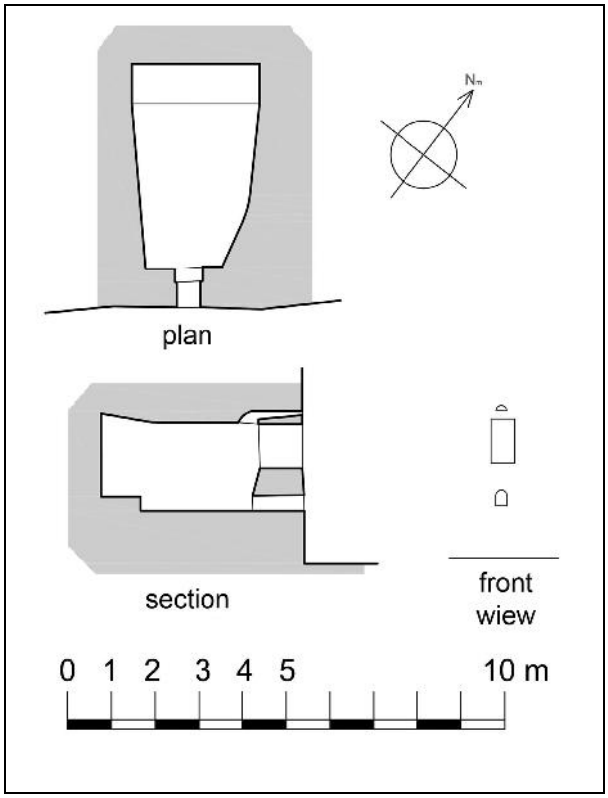

Figure 6: plan, section and front view of the guardroom 2 (drawing C. Germani)

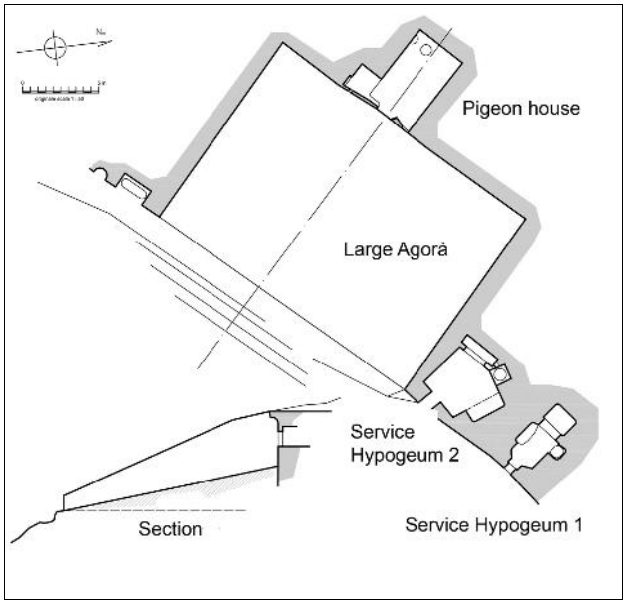

Figure 7A: plan and section of the Large Agorà (drawing C. Germani)

Large Agorà – The central Pigeon house
On the longer side of the large Agorà a wide square hypogeum is located, 5x3.5 m, 1.95 m high. Inside, many niches 20x20 cm, irregularly distributed. The digging marks and the general shape suggest that the pigeon house is the result of a reuse.

Large Agorà – Service Hypogeum 1
Service-hypogeum located to the right of the Large Agorà. It appears of rough making, with a wide trough on the back wall and a tank on the right side. On the walls, the marks of locking poles (on the outside) and remains of a floor. It looks like a violated tomb, afterwards used as stable and, at the time of our study, completely abandoned.

Large Agorà – Service Hypogeum 2
It appears less rough than the preceding one and was used as oil mill or wine-press. On the back wall there is a large trough connected, through a hole and a short duct, to a small tank dug in the floor, full of debris.

Between the wine-press and the small tank, a small window dug to better "control" the pressing and the filling of the tank. Both structures present signs of waterproof plaster. On the walls, many niches are located to place objects, and traces of red lines decorations are visible. At the door sides, there are traces of the locking pole (on the inside).

Isolated niche
In a cliff area where various mining holes are found, to be noted on the wall a niche 60x105 cm, 80 cm deep, a clear remain of a more complex structure, by now completely destroyed by mining works.

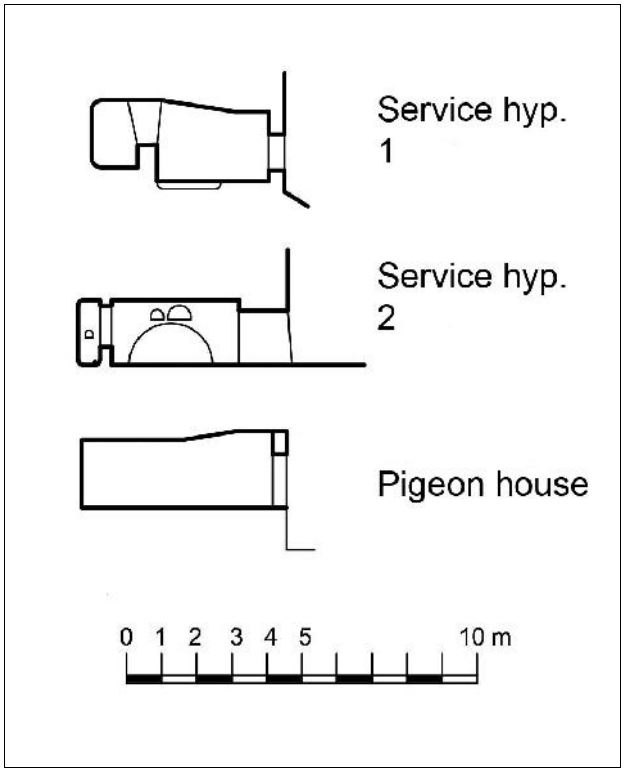

Figure 7B: sections of the Large Agorà (drawing C. Germani)

Large Northern settlement
This is a series of large dimension hypogea, located at short distance from one another, so to suggest a single structure, similar to the Large Agorà described before (Figs. 8-9). It comprises a church with frescoes (so called "with the broken columns"), a few service-rooms and a large common oil mill. Countless collapses of the overhanging cliff have partially canceled the original structure, which appears poorly defined. The reuse of the rooms as sheepfold or stable, likely in recent times, has required many operations of cleaning and reinforcement which, if on one side have made again accessible the rooms, on the other have largely damaged the structure and the frescoes. It is likely that the landslides hide other hypogea.

Large Northern settlement - Service room 1
Small hypogeum in very bad conditions, largely occupied by landslides and collapses. It is connected to the church "with the broken columns" through two holes: the first
(A) due to a collapse, the second (B) not accidental and well finished by a series of concentric frames.

Large Northern settlement – Church with the broken columns
Underground church changed into a sheepfold, abandoned in recent times. The back wall is subject to landslides; in an unknown time works of cleaning and reinforcement have divided the space in two with a high dry wall.

Figure 8: Large Northern settlement (photo C. Germani)

The four (or six?) columns have been broken to increase the available space in order to house sheep, and their stumps are left hanging from the ceiling. This intervention (it is not clear if made before or after the building of the reinforcement wall) has seriously prejudiced the possibility of understanding the structure, as well as its stability, since it presents many cracks. Instead, the floor is still well leveled.

On the vault some frescoes and inscriptions are still visible:

A – dedication to Archangel Gabriel

B – vertical writing: ιγλιτιceti

C – Peter and Niceta (?) to the left

D – Agapione (?) or Agapito

E – JOJOB … I?P.. TY

F – Helen and Costantin

Large Northern settlement – Service room 2

Located next to the church, it is almost completely filled with earth. It was connected to the church through an opening, now closed with a dry wall. In it, a few *arcosolio* tombs and large niches. The landfill, which prevents the visit to a large part of the hypogeum, is not due to collapses, but comes from the outside. On the dome vault, a few crosses.

Large Northern settlement – Service room 3 (storeroom?)

Large hypogeum about 10x6 m. On the back, an *arcosolio* and on the walls many niches dug at different times. It was connected with other rooms located to the left and to the right, by now collapsed and not accessible. On the right a dry wall prevents the collapse of the wall and of part of the ceiling.

Large Northern settlement - Common oil mill

Large hypogeum devoted to store and oil mill. The front presents a series of monumental arches in bas-relief, but collapses and landslides from the overhanging cliff prevent the reconstruction of the original structure. The inside is formed by two communicating rooms: the first, 10x5 m, more than 4 m high, presents collapses on the right stopped up by a dry wall, beyond which the debris have been piled up. The walls are completely blackened, testifying the long human use.

The second room, 7x5m about 2.5 m high, is characterized by three tanks communicating with each other by means of a masonry duct.

Grapes (or olives?) were collected and pressed in the first tank and, by means of a short channel, the liquid was carried into a small decantation area, and from here to the large collecting tank placed at the left of the entrance, On the walls, small niches of various sizes.

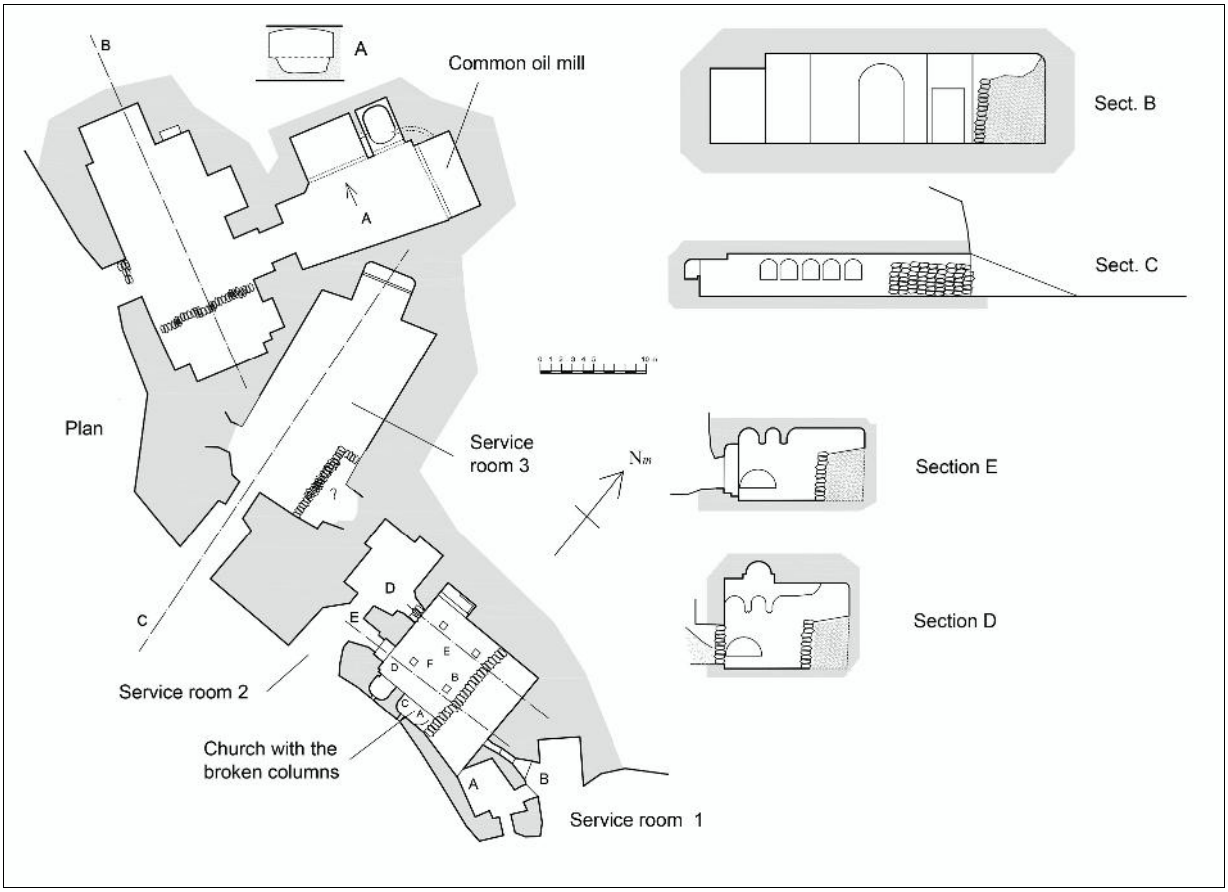

Figure 9: plan and sections of the Large Northern Settlement (drawing C. Germani)

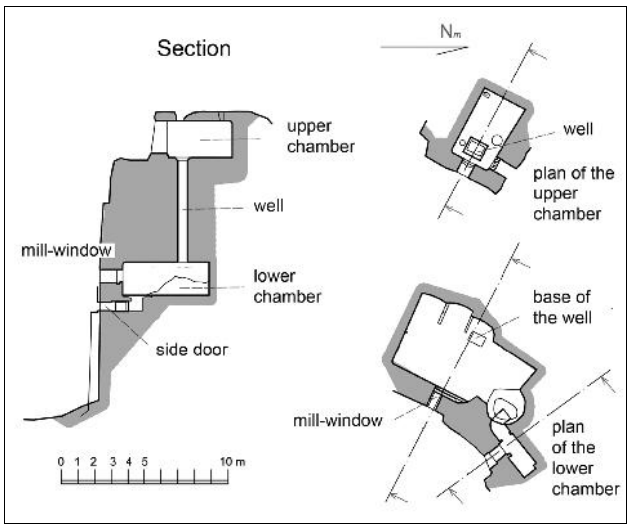

Figure 10: plan and sections of the 3-levels Dwelling (drawing C. Germani)

3-Levels Dwelling

The dwelling is formed by two main levels. The first is at the height of the highland overhanging Karlık, and the second at about half-way to the top. A second access is at a slightly lower level. The upper room, rectangular, has two openings towards the cliff, one of which closed by a dry wall. A shaft of about six meters, with the opening next to the entrance door, suggesting a "trap" passage, allows the access to the lower level.

The lower room has an irregular shape, a "window" open on the cliff, and a lateral shaft jutting out on a short and low tunnel and a second window of small size. The larger window presents a lateral cross hollow, which appears to have held a mill-window, that is, a round lock stone (Fig. 10). [For details see Burri et al. 2003].

Sheepfold

The entrance to this hypogeum is located almost at the center of the arch formed by the Karlık cliffs and is well visible from below. The gate opens on a large room about 10x4 m, a couple of meters high on average. To the right of the entrance a chimney leads to an upper room. To the left a secondary room, of about 2.5x2 m and about 2 m high. Along the walls of the larger room and along part of the secondary room we find a series of niches dug at a height of 110 cm; on average, they are 70 cm large, 50 cm high and 70/80 cm deep.

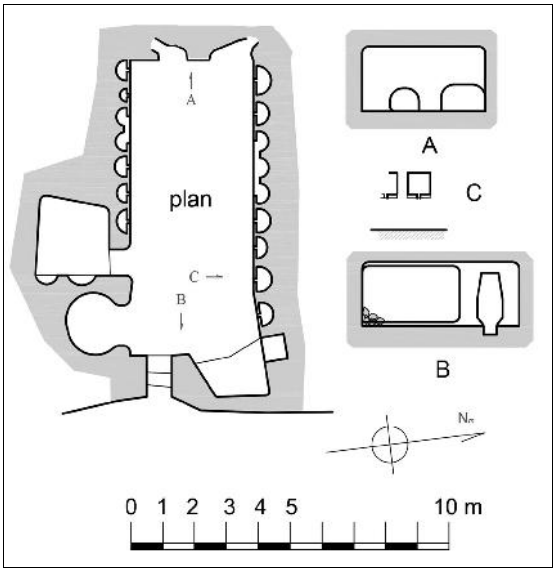

Figure 11: plan and sections of the Sheepfold (drawing C. Germani)

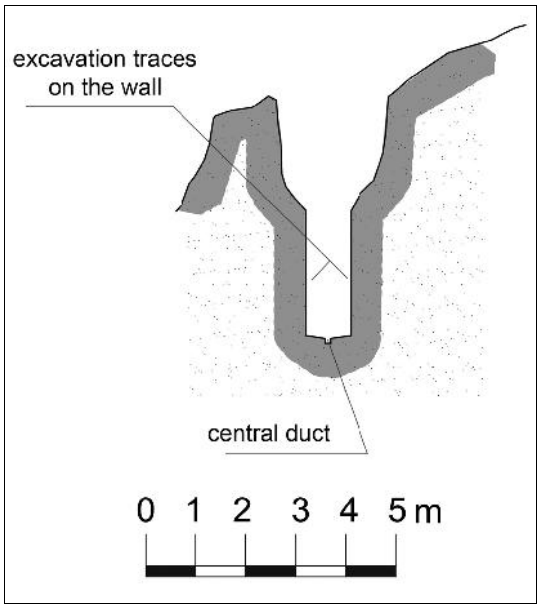

Figure 12: section of the "cut" road (drawing C. Germani)

All present a rim about 10 cm high and 10 cm deep, with a break at the center, likely in order to drain the niche itself. The hypogeum is still used as shelter for sheep and goats (Fig. 11).

Ruined dwelling

Dwelling in bad state, of difficult access, located to the left of the three-level dwelling. It consists of two rooms largely filled up by debris, the collapse of the front section has canceled any access from below or from above. The access is possible only with speleological techniques.

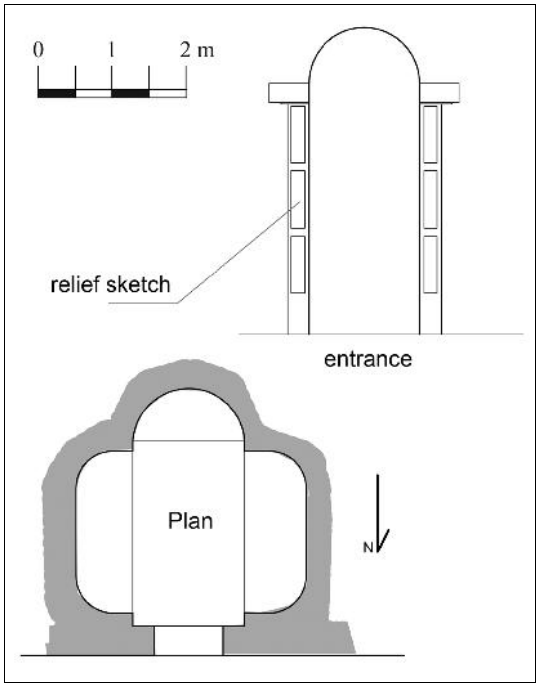

Figure 13: plan and front view of one Rock-cut Burial in the Hidden Valley (drawing C. Germani)

Level D hidden valley

Cut road

"Cut" road, dug parallel to the plateau wall, which led to the settlement in the "hidden valley". A section about hundred meters long is left, while the missing part has been destroyed by a large landslide, which has touched also some rock-cut tombs. The best remaining part shows clear digging marks and is 80/90 cm wide (Fig. 12). On the bottom, a small channel, which was likely part of a rain water collecting system.

Rock-cut burials in the hidden valley

Close to the cut road many rock-cut burials are found: few well preserved, most of them more or less ruined. The burials appear all of the same type: an entrance 1.5/1.8 high and 50/60 cm wide, on the sides two small columns in bas-relief with ornamental drawings. On the inside, from two to four *arcosolio* tombs, all violated long ago (Fig. 13).

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Caves settlement in Peristrema (Ihlara) Valley, Turkey

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Abstract

During three expeditions of the Russian Geographical Society to Ihlara valley, Turkey, we have surveyed and described three large rock-cut residential complexes. Two of them are located near the temple of St. George and the third to the north of them. In the article we make some conclusions about purpose of such rock-cut dwellings, their appearance and functionality.

Keywords

Ihlara valley, rock-cut complexes.

1. INTRODUCTION

Ihlara (Peristrema) valley is located not far from a large ancient city Gersavra (Aksaray), in Turkey. This was a very good place for human settlement in ancient times, due to outcropping of soft rocks in which it is convenient to cut down the rooms. Further, availability of water supply and the good natural shelter provided by the rocks were other favorable features.

The gorge is narrow, 15 km long, was eroded by Potamus Kapadukus river (formerly known as river Melindiz). Its entrance is difficult and is possible only on the northern side, where also, there is a large complex of underground buildings and the Turkish village of Selime, or from the south, where is now the Turkish village of Ihlara.

Today, a large number of underground structures are located in the valley: temples, halls, household premises, shelters.

2. DESCRIPTION OF COMPLEX A.

The complex A is located 150 meters to the north-west of the church "KIRKDAMALTI KİLİSESİ"

This complex has five levels. Now, the accesses to all five levels are separated because of the collapse of the cliff.

On the upper floor there are living rooms hall with windows, lavatory (Fig. 1, point 4, the entrance - 1). In addition, there is a water well (Fig. 1, point 5).

The two living rooms are well preserved and a part of third room destroyed (Fig. 1, point 10).

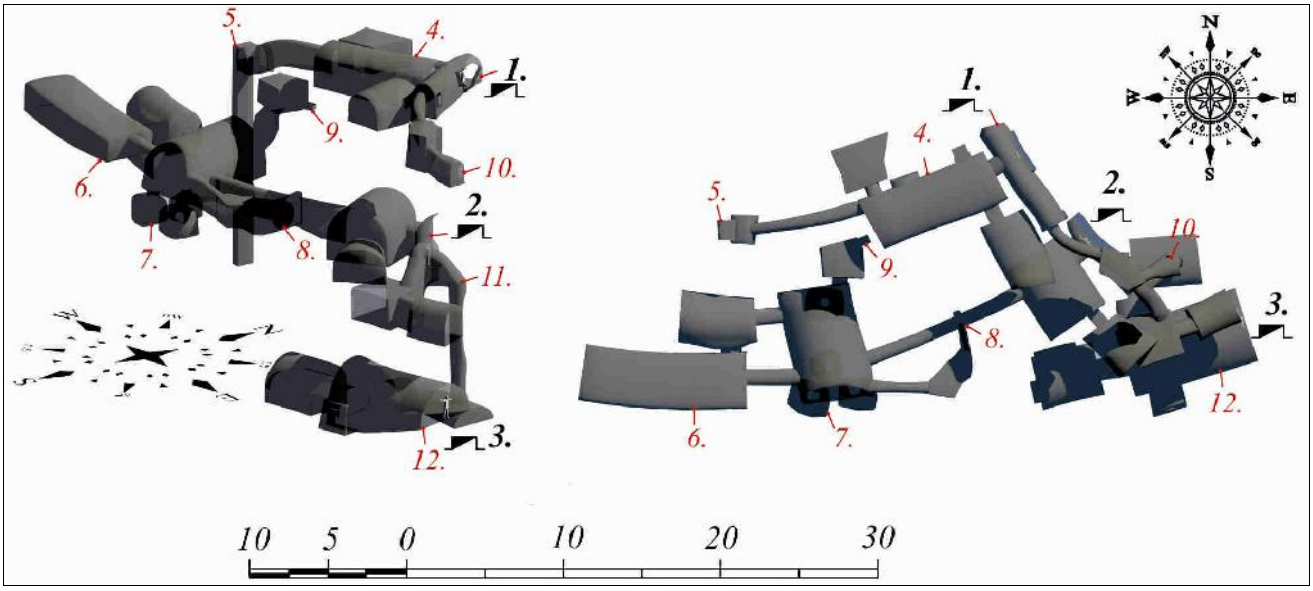

Figure 1: Complex A (drawing Michael Leontev)

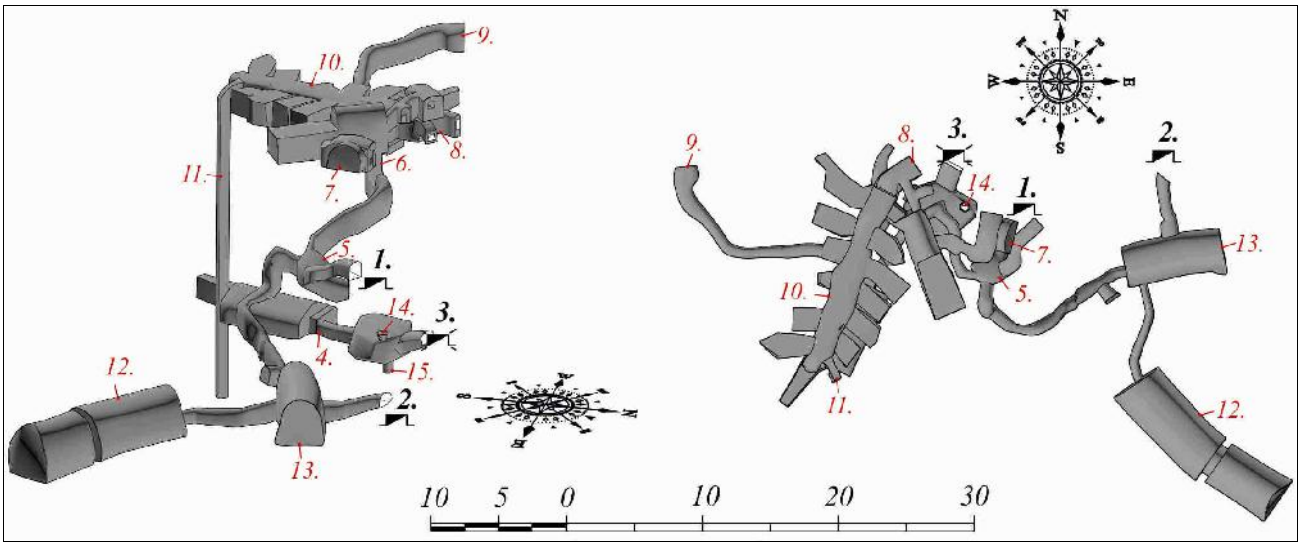

Figure 1: Complex B (drawing Michael Leontev)

The well is located in the northwestern part of the top floor (Fig. 1, point 5). Today, the depth of the well is 14.8 m. Further, the well is filled with stones. A wall protects the mouth of the well.

The middle floor of the complex is the shelter (Fig. 5, the entrance number 2). A narrow corridor overlaps the circular stone door (Fig. 1, point 8). Behind the door are the four available rooms. One of them is the grain storage (Fig. 1, point 7), and the other two are likely animal rooms or storage rooms (Fig. 1, point 6). In the corner of the room, there is a small central pit. This well rises by 3 meters. Upstairs there is a small room, with a plate to block the top of the well. From this room there is a small hole in the side of the slope. This hole is filled up with stones (Fig. 5, point 9).

The size of the shelter is sufficient to cover a small group of people and a certain number of animals.

3. DESCRIPTION OF COMPLEX B.

This complex is located 100 meters southeast of the church "KIRKDAMALTI KİLİSESİ".

The rooms of this complex, like the previous one, consist of residential, housewifely and shelter rooms. Internal underground passageways connect the rooms (Fig. 2).

The lower level has a separate entrance. Today it is lower hole (Fig. 2, entrance - 2). Behind it, there is a large hall with arched ceiling 5 meters high (Fig. 2, point 13). In this big room, we can see a decorative horizontal stripe. From the hall, there are two narrow passages: the first leading up to the main part of the complex; the second goes deeper into another large hall (Fig. 3, point 12).

This room has a size 13x3.5 meters and height of 3.5 meters. On the walls, there are several niches and holes to tie animals. In the floor, there is a hole into an underground storeroom; today it is filled with earth.

The middle level also has an entrance (Fig. 2, the entrance - 1). Just beyond the entrance there is a room with a stone door (Fig. 3, point 5). Next, the passage divides into two, one connecting with the bottom level, the second way rising up and in the end leads to a vertical well with steps at the edges. The well height is 4 meters (Fig. 2, point 6). The well leads to the rooms on the upper level. This well had a cover with a lock system. We can see the signs of this mechanism on the walls of the room. From this room you can go through a wide passage in the central corridor of the upper level (Fig. 2, point 10), and from the other side through a narrow passage to the room with a window and shelves, possibly a kitchen (Fig. 2, point 7).

In the middle of the upper level a large wide corridor, with length of 16 meters and an average width of 2 meters, is located (Fig. 2, point 10). On both sides of this corridor are nine small rooms, with size from 4 to 8 square meters. On the one hand, a corridor ends with three windows located at two levels (Fig. 2, point 8). On the other hand, there is a well (Fig. 2, point 11).

The well is filled by rocks at a depth of 22.5 meters. At a depth of 16 meters from the top there is a connection with an ancient part of this complex. As we can see this connection was created by chance. From the well we enter in a large room 7x3.5 meters. This is a more ancient level.

The original entrance into this part was closed by earthquake. At the exit, there are traces of installation of a round stone door (Fig. 2, point 4). This room is connected to another through a narrow corridor. Next room has a size 4x5 meters. The room partially littered with rocks and soil from the collapsed entrance.

In the eastern part of the room on the floor there is a well laid out circular masonry, well filled by soil (Fig. 2, point 15). The ceiling above the well has a hole covered with stones to the top (Fig. 2, point 14).

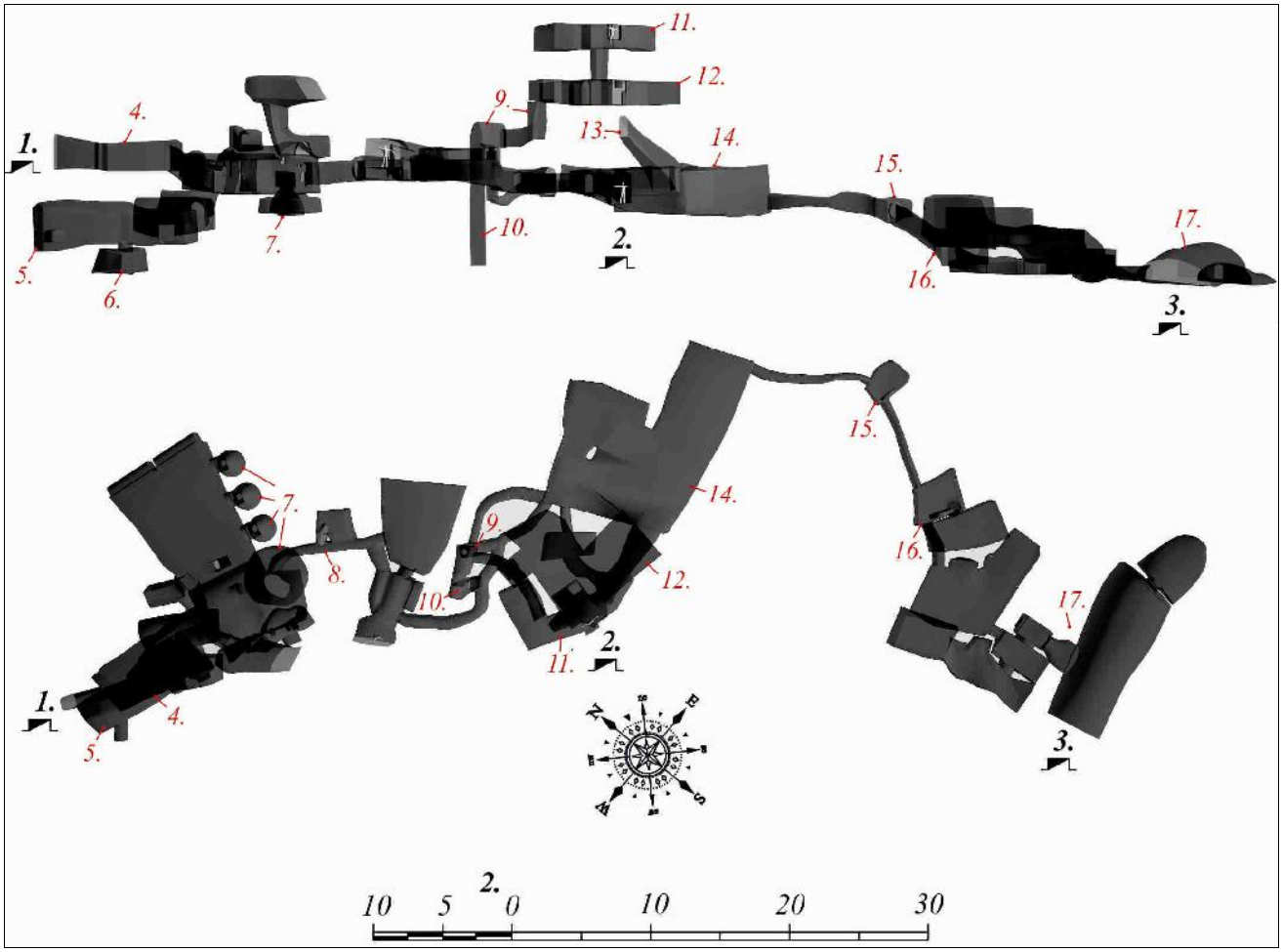

Figure 3: Complex C (drawing Michael Leontev)

4. DESCRIPTION OF THE COMPLEX C.

Complex C (Fig. 3) is located at the north part of Ihlara valley. The historical entrances into this complex were destroyed by earthquake. Because of this, today we can enter directly into its central part. (Fig. 3, entrance - 2), Before the earthquake the stone doors blocked passages into this rooms (Fig. 3, points 8, 15, 16).

The bottom rooms are partly destroyed and partly filled by earth. (Fig. 3, point 17). No cult elements is present in these rooms, so we cannot determine their functions.

A narrow passage leads to the central part. In this passage two rooms with stone doors were constructed. (Fig 3, points 15, 16). Above the first room, there is a little one connected to the passage below by a little hole (long about 0.5 meter). This hole was used to attack enemies by spear.

Finally, the passage entered into a big hall with a pillar in the center (Fig. 3, point 14).

In this hall we can see on the walls of the northeast part the elements to place the wooden partition to organize second floor. On the south part a window was plased to provide light and ventilation. The window is located very high on a cliff and unattainable for the enemies.

On the west side of the hall are two passages. In the center of the main passage, we can see two wells. The first well leads up to the upper floors. The second leads up and down.

The way down ended 6 meters below (Fig. 3, point 10), ans is filled with stones. Exit of the first well is decorated with a smooth circular hole with a diameter of 50 cm (Fig. 3, point 9). The second well also leads to this little room.

This strange room connected through short narrow passage to the bottom of the next well (4 meters high). At the top of this well is the exit into the upper floors of the complex. On the top level, we have two floors (Fig. 3, points 11, 12), one with have an area of about 34 square meters and a window. The entrance to the upper floor is located at the ceiling.

To achieve it you should use a ladder. Obviously, this is the most protected part of the complex. The upper floor has two little rooms and a little window. There are no niches or architectural elements (Fig. 3, point 11). The area of these rooms is about 16 square meters.

At the center of the middle level two rooms are plased. From the east part, they are connected to the passage from the big hall. From the west, there is next passage to the west hall. On the way to this hall, there is a room for stone door. This door can block the central part from the western side. (Fig. 3, point 8).

After this door, we get into another big hall. Definitely, this hall looks like a storage (Fig. 3, point 7). There are three niches on the east wall. Each niche has an accurate round hole into the bottom through which we can see a little spherical tank for store. The approximate volume of the tank is 4 m³. In addition, there is a big cellar.

The center of the hall is strengthened by pillar. There are several windows on the southern wall.

From the hall, a wide passage leads to the 'kitchen' (Fig. 3, point 4). There are three windows and several holes on the floor for draining water. The ceiling in this room much blackened. Close to the kitchen, there is a little room, which looks like a toilet.

5. CONCLUSION

We examined the complexes of underground facilities and discover that these complexes contain the elements household for a group of people. It can be considered as a separate family household. Many similar households are present in Ihlara valley.

Thus, we have a conclusion that this was a large settlement in ancient times. In addition, there are facilities for general meetings, churches, catacombs. There is more than one hundred religious cave settlements. However, as we can see, more of them looks like households. Moreover, from this point of view, we can look on Ihlara valley like a large ancient underground settlement.

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Rock cut dwellings in Syunik, Armenia

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Abstract

Rock cut villages and towns have been indivisible part of the Armenian culture throughout the entire history of the Armenian people. Rock cut villages and towns were addressed by Xenophon in the 5th century B.C. Reports and data from Khorenatsi, Draskhanakerttsi, Davrizhetsi and other medieval Armenian historians indicate that caves have continuously been inhabited. The last cave dwellers were forced out of their dwellings and resettled in other places in 1965. The article considers the rock cut dwellings in the *Syunik* province of Historic Armenia.

Key words

rock cut dwellings, Armenia, Syunik

1. INTRODUCTION

Several cave settlements are situated in the south-eastern part of the Republic of Armenia, in Syunik. They were carved in the Neogene pyroclastic rocks known as the *Goderdz-Voghjaberd* volcanogenic-sedimentary suite (Fig. 1). The thickness of the suite is a few hundreds of meters and its individual rock types are represented by ignimbrite tuffs, tuff breccias, tuff conglomerates and other formations related to volcanic activity [Balyan, S.P. et al., 1986].

Figure 1: Volcanogenic-sedimentary strata of Neogene period (photo S. Davtyan)

The cave settlements of *Syunik* are not populated nowadays. The population moved to the settlements built over the plain areas located in the vicinity of their former rock dwellings in the 1950s (Figure 2).

Conventionally, to distinguish the present-day populated areas from the cave settlements, the latter are given a complex name with an adjective "*Hin*" (which means "old"), such as *Hin Goris*, *Hin Kh'n'dzoresk*, etc. Currently, the cave settlements are in dilapidated state, and only some of their caves are in use as auxiliary structures serving wine cellars, enclosures for animals, closets, and other [Papukhyan, 1972].

Cave settlements consisted of several dozens to several hundreds of caves in hard-access areas, carved inside the slopes of deep gorges, but also in isolated natural "*pyramids*" or their groups (pyramid-like and conical rock massifs). The hard accessibility warranted their survival and safety as the cave settlement turned to be a kind of fortress. Some of the caves represented not deep natural voids that formed as a consequence of suffosion and were later deepened and expanded by humans.

The cave settlements have irregular layout with caves located along the gorges. Each family excavated its cave considering the nature of the rock and the household needs. Each cave-apartment had a door and a smoke duct; sometimes windows were also available. The dwellings did not have any regular geometric design in terms of both

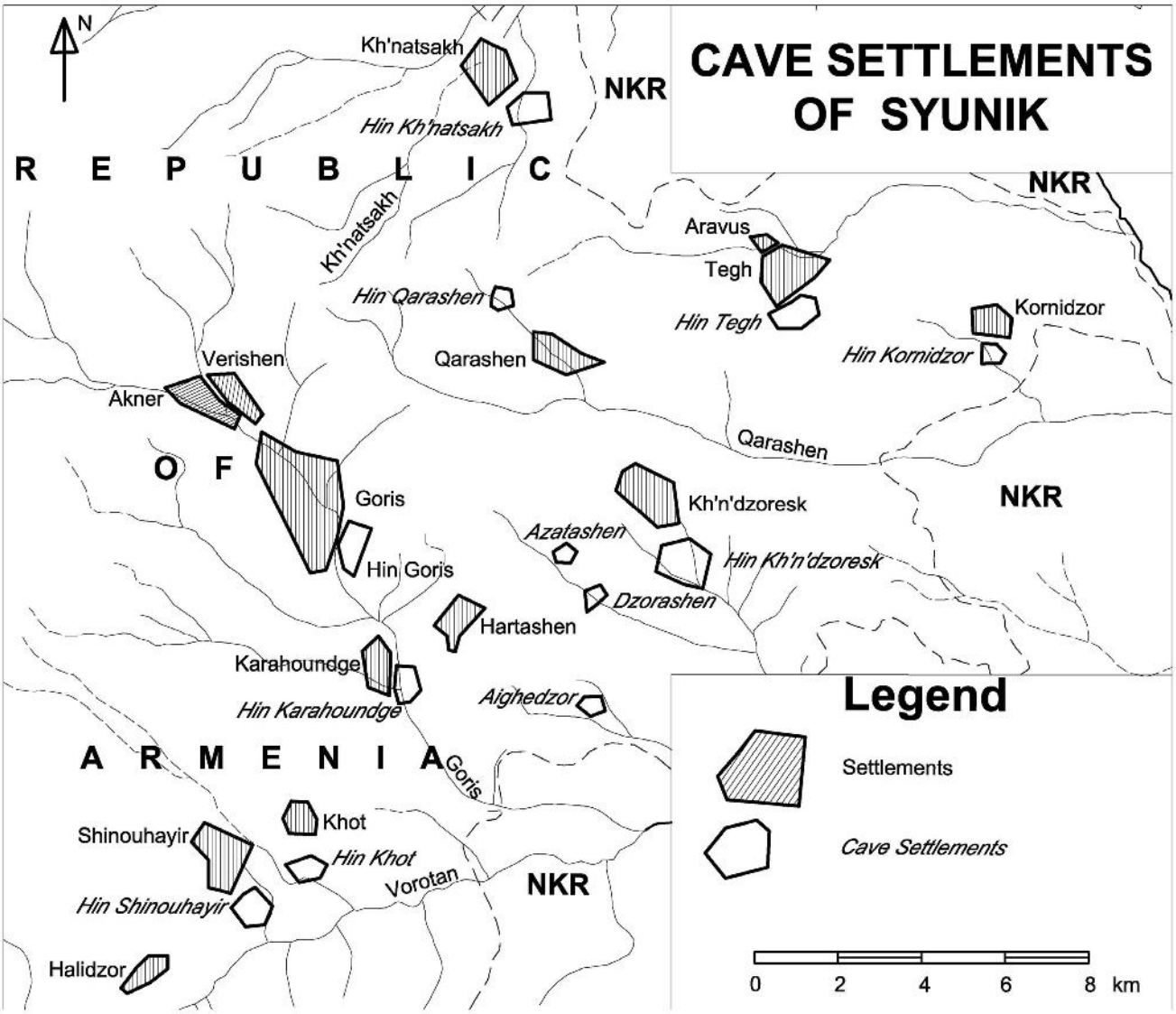

Figure 2: Cave settlements of Syunik

space and layout. Their areas varied in the range from a few square meters to several tens of square meters. Different tools, such as chisel, axe, pick and shovel were used for excavation of the cavities. The walls were processed without smoothening and the signs left by application of rock carving tools are clearly visible. Floor areas were inclined toward the entrance, and an open yard located in front of it accommodated also rock-carved household structures (cellars, animal sheds, wine press, etc.).

In some cases, cavities had several storeys connected with internal stairs, but the door was built for the lower storey only. The entry to the second floor served as a balcony and was not heated in winter; the ground floor was heated only with an open hearth burning in the centre or within *tonir*, a hole excavated in the floor. The hearth or *tonir* was placed closer to the door. Smoke was coming out through the smoke duct, which also served sometimes as a light window. Small cavities excavated within the walls served as cases for kitchenware or small items, the larger ones were used for beds. Some of the cavities were excavated in elevated places and had doors located several meters above the ground level.

To enter such dwellings people used rope ladders. Cavities not having a yard were used to store both the house property and the household utensils and agricultural implements. To expand the space of their cave dwellings, people built balcony structures in front of the entrances, which sometimes rested on a support wall erected from the base level. These balconies were in some cases built of wood and masked the cavity entrances completely.

2. CAVE SETTLEMENTS

Cave settlements of *Syunik* include *Hin Goris*, *Hin Kh'n'dzoresk*, *Hin Kornidzor*, *Hin Khot*, *Hin Shinouhayir*, *Hin Kh'natsakh* and other [Lalayan, Y. 1899].

The area of *Hin Goris* represents a large-size natural amphitheatre (about 1 km in diameter) opened toward the northwest, with the fortress of *Dzaghedzor* standing on a gigantic rock in its central part.

The main prerequisites of the economical development of *Goris* included its position protected by the natural landscape, springs, the *Vararakn River*, sun-exposed slopes, easily excavated rocks and connection to the trade routes.

The settlement had 10 districts. The natural environment had determined the irregularly structured layout of *Goris*. A trade route running along its western margin along the *Vararakn River* branched into secondary roads connecting to individual districts.

Within the settlement area, cavities were excavated inside gorge slopes and conical or pyramidal earth mounds; these cavities were used as dwellings up to as late as the 18th century.

After the 18th century, one or two-storey apartments had been built opposite to the cavities and the caves earlier used as dwellings were thereafter used as auxiliary structures (wine cellars, bake-house).

By their spatial design, the residential houses were neatly fit to and harmonic with the surrounding natural environment (Figure 2). The spatial design of the settlement followed the spatial landscape forms.

In the middle of the 19th century, *Goris* had 150 houses (about 1500 residents). The population worked mostly in crafts (pottery, vegetable oil production, silk warm breeding, tanneries, and other).

Some acting churches were built underground, but most of them were on-ground constructed structures. Since the 1850s until the 1950s, population had been abandoning *Hin Goris*. As a consequence, there is no resident population now and just few cavities are used of those remained of *Hin Goris*.

Figure3; Cavities of *Old Goris* (photo S. Davtyan)

Hin Kh'n'dzoresk is situated south of the present-day *Kh'n'dzoresk* village on the slopes of an up to 150 m-deep gorge stretching over 2 km from the north to the south. The slopes are also cut with deep gullies and in places rocks protrude to heights ranging up to a few tens of meters. Hundreds of cavities were excavated in the slopes and in the rocks. The village had 11 districts and was the biggest one in Eastern Armenia in 1913. It had 1800 houses, a population of 8300, 7 schools, many stores and workshops.

The population of *Kh'n'dzoresk* was engaged in land cultivation, cattle-breeding, and crafts (carpet weaving, armory, tailoring, blacksmithing, and other). *Kh'n'dzoresk* is mentioned by Stepanos Orbelyan, an Armenian historian of the 13th-14th centuries, in his "History of *Syunik*". The list of taxation provided in the end of his work indicates that the village of *Kh'n'dzoresk* paid a tax of 10 units to the *Tatev* Monastery [Orbelyan, 1986].

The size of the tax suggests that *Kh'n'dzoresk* was a medium-size settlement. In the early medieval period, all dwellings in the settlement were in cavities; later, stone houses were also built in front of the cave dwellings. They were arranged in terraces: roof of a house within the lower tier served as a yard for the house built above, so that the village looked as a big multi-storey building spreading up over the slope. Armenian *Catholikos* Abraham Cretatsi visited *Kh'n'dzoresk* in 1735 and described the village.

According to his account, residents of *Kh'n'dzoresk* used the cavities carved in rock as nests located sometimes 20 to 30 m high above the ground level. [Cretatsi, 1870] Cretatsi was surprised to see how a mother used a rope to climb up to the cavity with her child bound to her back. The fortress of *Kh'n'dzoresk* is located in the central part of the village and represents a hardly accessible complex of cavities in stone. In 1728-1730, the fortress was the military camp of Mkhitar Sparapet.

Four churches were built in the area of the village in the 9th-18th centuries; one of them was carved in rock and built in the 9th-10th centuries. Springs available in all districts of the village supplied drinking water to the village residents. A water reservoir carved in rock has been preserved near the Saint Tadevos Church. The present-day village of *Kh'n'dzoresk* was actually built at the cost of the old one: abandoning the village, residents demolished old houses and used the stone material for construction of new apartments, which had actually led to the destruction of the village that had been preserved until the 1950s.

Hin Kornidzor is situated on the left-side mountain slope of the gorge of the *Kornidzor River*, which is a right-hand tributary to the *Hagari River*. The gorge is an 80 to 100 m-deep valley. Cavities were excavated at different height within the valley. In 1939, the village had a population of 1049 residents living all in the cavities. In 1957, the village was abandoned and the population was moved to the newly built *Kornidzor* village. Presently, there are about 50 cavities in *Hin Kornidzor*, each having an area from 25 to 40 m^2.

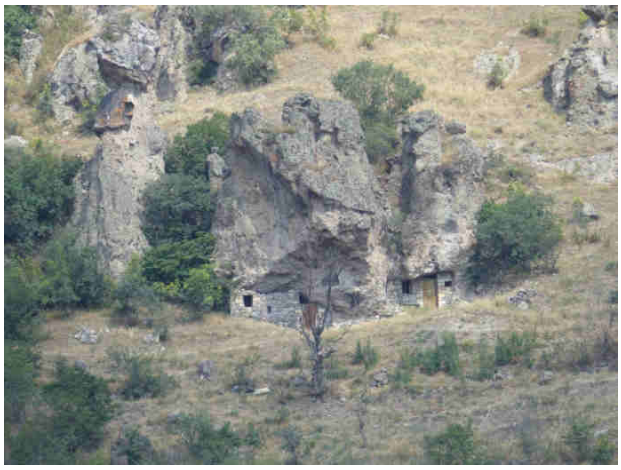

Figure 4: Cavities still in use today in the village of *Karahoundge* (photo S. Davtyan)

The *Hin Qarashen* village was placed on the slopes of the gorge of *Qarashen*, a right-hand tributary to the *Hagari River*. The gorge is about 100 m deep, and the caves located on its right-side slope have natural origin, while those present on the left-side slopes are man-made. They served as apartments. The new *Qarashen Village* was built in the 1960s and the villagers left their cave settlement. The cavities are not used nowadays.

Kh'natsakh is situated on the banks of the *Kh'natsakh*, a small right-hand tributary to the *Hagari River*. Several caves have been preserved in the village area and are used now for domestic purposes (as cattle shed or barn). The gorge of *Anapati Dzor* stretches at the distance of 1 km to the southeast of the village; the slopes of this gorge have tens of natural and man-made caves. The area of one of the natural caves is about 600 m^2. One of the man-made cavities is 14.2 m long and 9.2 m wide and served as a church. The church has a sanctuary and 2 vestries with a basin caved inside the southern one.

The caves of the *Tegh Village* were located mostly over the slopes adjacent to the village's Church of St. Gevorg (the 4^{th}-18^{th} centuries). Currently, they are all in damaged condition. Judging by the preserved ruins it is suggested that they served as cave dwellings.

The cavities of the ruined *Dzorashen Village* were carved in the slopes of the middle- course gorge of the *Dzorashen*, a small left-hand tributary of the *Vorotan River*. The caves had been populated until the 1970s, but are not used presently.

The caves of the ruined *Azatashen Village* are located on the upstream slopes of the *Dzorashen*, a small left-hand tributary of the *Vorotan River*. The cavities had been populated until the 1970s, but are not used presently.

The caves of the ruined *Aighedzor Village* are situated on the slopes of the gorge of *Aighedzor*, a small left-hand tributary of the *Vorotan River*. The cavities had been populated until the 1960s, but are not used presently.

The caves of *Karahoundge* are arranged in groups in the vicinity of the village being located to the northwest, south and southwest of it (Figure 3). In total, there are about thirty cavities in the area; all represented cave dwellings and had been excavated since the medieval times up to the 19^{th} century. Most of the cavities have one room, but there are also residential complexes consisting of two or more rooms arranged in the same yard. Most of them are not in use today, while the rest are utilized for domestic purposes, mainly as barns or cattle-sheds.

Cavities excavated in rock are present also in other settlements of Syunik, such as *Hin Khot*, *Hin Shinouhayir* and other, but in each they are fewer than 10 and are all in ruined condition.

3. CONCLUSIONS

1. Since old times, the hard sections of the Neogene volcanogenic-sedimentary suite in *Syunik* were used as construction material excavated with metal tools. The created cavities were used for housing, domestic or industrial purposes and did not have any regular dimensions, smoothened walls or roofs. Careful stone processing and hewing was applied to religious (worship) structures only.

2. There are about ten rock-carved settlements in Syunik: they were created on the slopes of river valleys, gorges and canyons. The reasons behind this approach were two-fold: a) climate in valleys was milder, and b) flat land areas were used for agricultural purposes only.

3. Construction of rock-carved dwellings in Syunik evolved in two stages. The first stage of purely cave dwellings lasted until the 18^{th} century, and during the second stage, which had started since the 18^{th} century, stone or wooden apartments and balconies were constructed in front of the cavities.

4. The rock-carved settlements represented entire urban complexes. Each settlement was supplied with water from springs, water canals and waterways. Industrial and household structures met the population's needs in the products of agriculture and crafts.

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Cave Dwellings of Euphrates River (Southeast Turkey)

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Abstract

As OBRUK Cave Research Group, we began to search cave dwellings on the bank of Euphrates River, in south-eastern Turkey, during April 2013. Our research is between Halfeti and Gumuskaya villages. There are two dams on Euphrates on the region: Ataturk Dam, 145 km north of Halfeti, and Birecik Dam, 55 km south of Halfeti. Because of this second dam, the water level of Euphrates raised 20 meters, with a width up to 500 meters in some areas. In this region the river is flowing through the Eocene limestones, and there are hundreds of dwellings carved in those soft limestone walls. Those structures are mostly to the north of Halfeti, reaching up to Gumuskaya Village, near Ataturk Dam. Especially 2 km north of Halfeti, on both banks of Euphrates there are tens of artificial cavities around Rum Kale. Rum Kale, also known as "Hromgla", was mentioned in Assyrian scripts and was the capital of Armenian Church for 90 years until 1293, when conquered by the Mamluks. We are planning to survey the whole rock settlements within this 35 km stretch of Euphrates, from Halfeti up to Gumuskaya Village. In addition to cave dwelling villages, we had explored and surveyed several underground churches in this area. During our survey project, each artificial cavity has been marked by GPS, photographed and surveyed. Till today, four explorations have been realized and a total of 73 rock settlements in 64 different points, three of which are church or monasteries have been found, 33 of which have been surveyed and mapped. In this presentation, in addition to the surveys of previously unknown cave dwellings and underground churches, the major aim of this project will be explained in detail.

Keywords: Euphrates, Halfeti, cave dwellings, Turkey.

1. INTRODUCTION

Urfa Province of south-eastern Turkey (Fig. 1) has a worldwide importance due to its long history. Urfa (antique name Edessa) is a settlement frequented since the prehistoric times.

The Euphrates River, flowing in the west borders of this province, is historically probably one of the most important rivers in the world. However, five dams have been built on this river since 1975.

Today, the lake of every dam on the river extends nearly to the previous dam wall upvalley. Only one third of Euphrates, which length is 1.260 km in Turkey, is in natural flow, the rest consist nowadays of dam lakes.

Figure 1: Location map showing the general area of exploration

The five dam lakes built on the Euphrates River submerged hundreds of villages and ancient settlements. Despite several rescue excavations in many ancient settlements before the constructions, there is an incredibly huge loss in historical heritage.

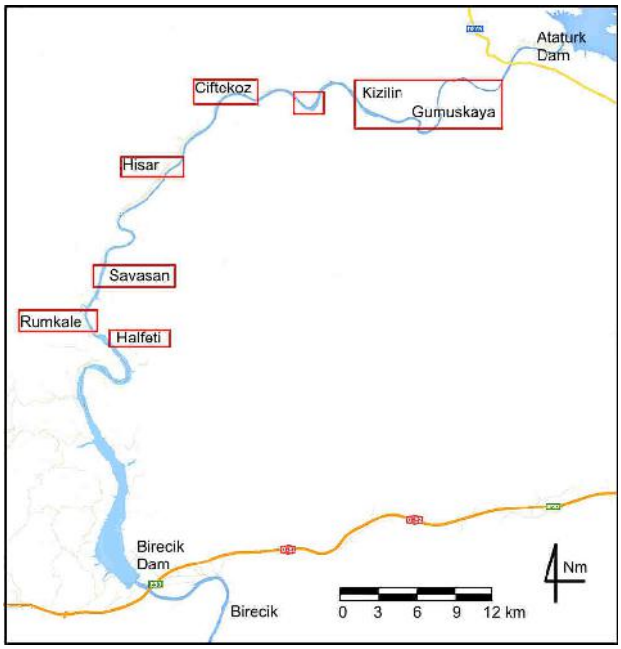

Figure 2: Various rock dwelling localities in the working area

After the construction of the Birecik Dam in 2000, the level of the river in this region raised about 20 meters and countless rock settlements in the area were submerged. The ancient sites that were going to be under water had been explored, dug or, at least inventoried previously by big projects such as ODTU-TADCAM, but the cave dwellings of this area were not searched before the construction of the Birecik Dam.

As OBRUK Cave Research Group, we began this new inventory project of the rock dwellings north of Birecik Dam Lake, in March 2013 (Fig. 2).

Following this first reconnaissance trip, two other research surveys were made in April 2013 and June 2015. There are hundreds of dwellings carved into the rocks of this region, where the River Euphrates flows between locally very steep limestone walls. Unfortunately, these structures were not comprehensively studied or inventoried until today. As OBRUK Cave Research Group, we have begun a long-term project to identify and inventory these ancient cave dwellings with ÇEKUL Foundation. The work planned for this study consists of marking through GPS all the cave dwellings on the walls of the River Euphrates from Halfeti northwards, until the Atatürk Dam, inventorying them by means of photographs and maps, and to map all the important buildings.

2. GEOLOGY OF THE REGION

The whole area extending to the northwest of Urfa consists of horizontally bedded, neritic, Eocene limestones, more than 400 m thick. Miocene - Lower Miocene neritic limestones unconformably overlie this formation, and are observed on the northern and southern parts of the region. All of these thick limestones have been settled on the shelf parts of Neo Tethys. The southern part of Neo Tethys, which started to close in late Cretaceous, caused compression between the Arabian and Anatolian plates. This compressive tectonic lasting intensively from Cretaceous to Late Miocene has been the main factor for the current formation of the region and the faults observed in the area. Digging and working this soft stone, locally strongly fractured, is easy [Ulu, 2002; Yesilnacar et al., 1998].

3. FINDINGS AND RESULTS

We carried out three different explorations in the area and, as a preliminary result, a total of 97 different rock dwellings were identified and inventoried, with 42 of them surveyed and mapped. In the following, the area of study is decribed in four different sectors, starting from the south.

3.1 Between Birecik Dam and Halfeti

Only a few small cave dwellings have been identified in this area mostly due to the lack of vertical limestone cliffs, which are the only landscape formations where rock settlements were excavated. Nevertheless, towards the south of Halfeti three small cave dwellings were found and surveyed.

Figure 3: Figures on the wall of an Armenian Church at Savasan Village (Photo A. Yamac)

Figure 4: Rumkale (Hromgla) Peninsula, with the Euphrates flowing on the left of the photo (Photo A. Yamac)

3.2 Around Halfeti

During the first and third seasons' of work we identified 22 cave dwellings in and around Halfeti. At Degirmen Pass inside Halfeti, in addition to 2-3 small rock dwellings, we surveyed a 159 m long water tunnel and a natural cave that is currently being used as an animal shelter. A small dwelling, located on the western shore of Halfeti, was also mapped during the first study. The next cave dwelling in this area was named "The King's Daughter Cave" in the legends, on the western shore of River Euphrates. This complex, which consists of three stories and five separate caves, is one of the most important rock dwellings in the area. 17 cave dwellings have been surveyed and mapped on the southern shore of Savasan Village, situated 2 km north of Halfeti. The forms and locations of those structures seem to outline its use as a small cave village.

The most important structure among these rock dwellings was a small Armenian church carved in the rock. This structure, the walls of which were covered with crosses (Fig. 3) and Armenian writings, may probably be dated to the 13th century, when Rumkale (Hromgla), located on the eastern shore of Euphrates River, was the seat of the reunified Armenian Church from 1203 until its capture by

Figure 5: Rock dwelling localities between the villages of Gumuskaya and Kizilin (Google Earth)

Mamluks in 1293 [Stewart, 2006] (Fig. 4). Rumkale, named as "Hromgla" in ancient scripts, is now on a peninsula. The remaining structures of this castle, the name of which is mentioned even in Assyrian scripts, are mostly dated to Roman and Byzantium periods. There are tens of other rock dwellings around this structure, not yet surveyed and inventoried due to continuing archaeological excavations and restorations in the area.

3.3 South of Çiftekoz Village

There are tens of rock dwellings on both rocky walls of the River Euphrates in this region, which lies inside the city of Gaziantep. The only mode of transport to the area is by the river. A reconnaissance trip was organized to this region during the third study. Twenty-eight different rock dwellings, many of them multi-storied, were identified and marked with GPS during this study. This region will be further investigated.

3.4 Between the villages of Kızılin and Gümüskaya

The first season of work began in this region, with the rationale that this 1.5 km-long part has the densest population of rock dwellings (Fig. 5). Rock dwellings were identified at 30 different locations. Although some of these were single dwellings, in many other cases tens of dwellings are clustered together. Multi-story, multi-chamber structures that were all church/monastery complexes were identified and surveyed at three different locations. No significant rock structure was found under water during the divings in various points.

The most important rock complex in the area is a structure located on the southern shore of the River Euphrates. Named as Kizilin Monastery (F 11 in Fig. 5) this structure has tens of rooms spread over six stories, consists of a large church at the top floor, and many rooms and common areas in the others (Figs. 6 and 8). Another rock structure complex on the River Goksu, which meets the Euphrates, consists of tens of structures dug side by side. These old rock dwellings are situated on a E-W direction and lined up on a rocky cliff; they are probably Roman tombs (EK 3 in Fig. 5). Gelin Cave (F 21 in Fig. 5), on the northern shore of the River Euphrates, near Kizilin Village is another important church / monastery complex with several rooms

Figure 6: Kizilin Monastery F 11 (Photo A. Yamac)

Figure 7: Gelin Cave on the shores of Kizilin Village (F21 in Fig. 5) (Photo A. Yamac)

on two stories (Fig. 7). The old, rock dwelling village of Kızılin lies below the new houses of the village. A small part of this 18 different single-room rock structures within the Euphrates coast was mapped to constitute an example for an ancient cave dwelling village (F 22 in Fig. 5).

4. PLANNED SURVEYS

We had been informed that between Halfeti and Gümüskaya villages there are more areas with rock dwellings, not yet investigated. The caves in the Karasu Canyon and the dwellings in Yenikoy are the fairly important ones among these. We are planning to investigate all the cave dwellings on the River Euphrates from Halfeti to the village of Killik. An inventory book that includes all the cave dwellings in this region will be published after this project.

5. CONCLUSION

In our opinion, a study that will reveal the cultural and historical value of the Halfeti region, in addition to its touristic value, will make a significant economic contribution to the region. These historical structures, with various rock dwelling churches or monasteries are an important part of the historical heritage of the Gaziantep, Urfa and Adiyaman provinces which reach beyond ages.

Figure 8: Kizilin Monastery plan and profile of level 6 (Survey L. Makrostergios)

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7. ACKNOWLEDGEMENT

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Kırkmerdiven Underground Site at Doganli Village, Kayseri (Southeast Turkey)

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Abstract
Although the region known as "Cappadocia" is located in the Nevsehir-Urgup-Goreme triangle of Anatolia (Turkey), the capital of Cappadocia in ancient times was the antique Caesarea city, today known as Kayseri. Kayseri, located 75 km east of the present Cappadocia, has been affected by intensive volcanic activities which began 10 million years ago. Beside some small vents, a total number of 68 volcanoes around Kayseri had been erupting in Pliocene-Pleistocene times. That eruption phase, which continued even until historical times, piled up more than 100 m of thick ignimbrite around Kayseri. As in the Nevsehir-Urgup-Goreme area, in antique Caesarea this volcanic tuff was dug by the local people, and houses, churches, and underground settlements were built into the rocks.
Different from the known touristic places of Cappadocia, the rock dwellings and underground cities of Kayseri have not been investigated. Nevertheless, underground structures of that region have such an architectural quality to compete with the dwellings in other parts of Cappadocia. Underground settlements of the region are rather different from those around Goreme. Apart from the architectural differences, at least some of them were not used after the first construction period. When appreciated in this context, the underground settlements of Kayseri have features to shed light on the beginning of this type of architecture, which is different from Goreme, where most examples were continuously enlarged and new passages added during the history. There is an underground site known as Kırkmerdiven (Forty Steps), 2 km southwest of Doganli Village in Kayseri Province, in a flat and empty prairie. While it is strange that this large underground site, with three different surface connections and most of its galleries blocked, is located so far from Doganli village, in the middle of a forsaken plain, it is certain that an ancient settlement was located in this plain, despite almost none of its ruins survive today. Unlike most of the other examples that can be found around the area, Kırkmerdiven Underground site must have not seen any use after the period when it was first built.

Keywords: Doganli Village, underground settlements, Kayseri, Turkey

1. INTRODUCTION

As OBRUK Cave Research Group, we are conducting the "Kayseri Underground Settlements Inventory" project in the city of Kayseri since two years. During these studies, we have identified, investigated and mapped a total of 23 underground settlements, not previously mentioned in any sources [Yamac et al, 2015; Yamac, 2014]. Only short notes were found in two sources about the Doganli Underground site that was investigated as part of this project [Gülyaz et al, nd.; Yörükoglu, 1990]. Apart from these notes, the first comprehensive investigation was conducted by our group, and the location was surveyed and mapped for the first time. We are planning to organize these studies, which were previously announced in two different preliminary reports, in a book at the end of the project.

The village of Doganli is located south of the city of Kayseri (Fig. 1), in front of a rocky cliff. There are countless cave dwellings and graves on the rocky walls near the village. On the other hand, no comprehensive studies were conducted concerning the history of the village.

Figure 1: Location map showing the area of exploration

The underground site known as Doganli (or 'Forty Steps', due to the stairs carved into the rock at the village entrance), is above the rocky plateau that houses the Doganlı Village on its cliff, about 2 km southeast of the village (Fig. 3). Two of the three different depressions on the level plateau, on which the underground settlement is located and that is used for agriculture today, are the rooms of the underground village that are closest to the surface, while the third and largest depression is the original entry door to the Doganli Underground City.

Figure 2: Plan of the Doganli Underground Site

Figure 3: General view of the village of Doganli

Figure 4: Main hall of the Doganli Underground site: with a total area of 500 m^2 it is one of the largest hall in Cappadocia

This original entrance starts with wide stairs carved into the rock with a 38-degree slope (Fig. 2). Farther down the corridor, there is a narrow tunnel protected by a millstone door. The main gallery beyond this tunnel is very impressive. This hall supported by 15 gigantic pillars is much larger than similar underground halls (Fig. 4), showing an area of about 500 m^2. In addition to its size, some architectural details of the gallery are also fairly interesting.

There are 11 divisions carved on the north and east walls of the hall. The reason we call these structures 'divisions' is because they have the characteristics of sections separated from each other by thin walls. The fact that we have found clean water with a depth of 2 meters in a 3x2 m cistern (Fig. 5) at the wall of the hall during our survey provides an evidence of the high architectural quality of this centuries-old structure.

One of the two tunnels located at two different parts of this hall is blocked by debris after a short distance. The other tunnel branches out and continues for 74 m, and then it, too, is blocked. A branch from this main gallery reaches the upper level, and reaches the surface with a fairly large room. All the tunnel connections to the surface are protected by millstone doors. Although some of the stone doors are not in place today, the door shafts on the gallery walls demonstrate the presence of these doors.
The third branch reaching the surface is at the beginning of the main entrance stairs, and a part of the gallery turning south.

This gallery also houses four rooms that are carved in fairly large dimensions, different than the small chambers on the hall. A cross carved into the rock, and the remainders of wall paintings in one of the rooms, suggest that it was a small chapel. The northern connection of this shunt consists of the collapsed roof of a room. Although this last accessible room has a second door, it was not possible to investigate this part because of the collapse.

Although the fact that this large underground structure that has three different connections to the surface, and many galleries of which are blocked, is located on a desolate flatland 2 km away from the Doganli Village, it may be thought that an ancient dwelling that left no trace of its existence was located on this flatland.

In contrast to many other samples in the cities of Kayseri and Nevşehir, the Doganli Underground settlement was probably not used after its construction.

Figure 5: The cistern in the main hall

2. CONCLUSION

Today, the Doganli Underground site is vulnerable against all kinds of natural and illegal digger damages. On the other hand, although it has a very impressive and original architecture, it is not certain how such an important building, which is far from any touristic settlements, [Comert, 2008]. and even its own village, might be protected.

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Underground Settlements and Cave Dwellings of Agirnas Village, Kayseri (Southeast Turkey)

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Abstract

Central Anatolia had been affected by the intensive volcanic activities which began 10 million years ago. That eruption phase, which continued even until historical times, piled up more than 100 m of tuff and ignimbrite around Cappadocia. The volcanic rocks were dug by the local people and a great variety of underground settlements were built into the rocks. Antique Caesarea which is known as Kayseri today was the capital of ancient Cappadocia; its underground structures, churches, cave dwellings of Kayseri have not been extensively investigated yet. Around Caesarea, which had been the cradle of Christianity in Anatolia, there is an immense amount of cave dwellings and underground structures. Agirnas is a small village, 15 km east of Caesarea. Establishment date of the village, which is the birthplace of Sinan, the most important architect of the Ottoman Empire during the 16 century, is unknown. Underground of this village is like a cobweb, nearly all the underground shelters below the old houses are interconnected to each other. In addition to this gigantic underground structural system of Agirnas Village, there are tens of cave dwellings in Akbin Valley, 700 meters west of the village. It is thought that some of these structures, dug in the walls of the valley which continues from Agirnas to Dimitri Village for 3 km, were built as Roman rock graves. It is not possible to determine the date and aim of the original dwellings due to their continuous usage for centuries by re-designing, and the destruction caused by the erosions on the valley walls.

As OBRUK Cave Research Group, our research within the framework of "Kayseri Underground Structures Inventory Project" started with the underground settlements in the village. Even though it is not possible to determine the first construction date, it is obvious that this structural complex is more than 500 years old and it shows us that the village has a gigantic underground structure dug below the houses with a purpose of defense. Then we continue with Akbin Valley Cave Dwellings survey. We present here a brief conclusion about the hypogea of this village, describing the underground sites and cave dwellings of Agirnas Village and their historical transformation of usage during the centuries.

Keywords: Kayseri, Agirnas Village, underground settlements, cave dwellings.

1. INTRODUCTION

Following the signing of the protocol concerning the surveying, mapping and inventorying of the underground structures of Kayseri between the Kayseri Municipality, ÇEKUL Foundation and OBRUK Cave Research Group, we have started our study in this region in January 2014. The results of the first six studies conducted until June 2014 were announced through the "First Preliminary Report", which included 14 different underground sites and cave dwelling settlements that were identified, investigated and mapped in Kayseri. Many underground settlements that were never mentioned in any sources and some old rock dwellings located in the valleys near Kayseri that were not previously investigated were discovered, investigated and mapped during these studies. The other five studies in June 2014 completely focused on the Agirnas Village (Fig. 1). There was a veritable underground complex under this settlement. In addition to these underground structures located under and near Agirnas Village, the walls of the Akbin Valley that reached from 500 m southeast of this settlement to the Turan Village were full of rock dwellings.

Figure 1: Location map showing the general area of exploration

Figure 2: Surveying in the second underground structure of Mimar Sinan Underground City

The results of these five studies were published as the "Second Preliminary Report". In this study that only includes Agirnas Village and its surroundings, we describe the four underground settlements and the cave dwelling village.

2. AGIRNAS VILLAGE EXPLORATIONS:

2.1 Mimar Sinan Underground City

In Agirnas, a very large underground structure exists under the house in which Sinan, the most important architect of the Ottoman Empire, was born, and which serves as a museum today [Necipoglu, 2010].

The restoration of the house was conducted between 2006 and 2008 [Sozen, 2004]. Some of the underground structures under the house were also cleaned, organized and opened to visitors during these works. This organization work showed that the underground city did not only encompass the space below Mimar Sinan's (Sinan the Architect) house, but all the houses in Agirnas were connected through an underground network of structures. In time, many homeowners nearby have walled the connection tunnels with stones, to prevent access to their houses from underground.

The underground structure complex under Sinan's house is spread over a total area of 1.850 m^2. It is definite that this whole structure was a single underground settlement but, due to recent blockings, it becomes four separate structures (Fig. 2). On the other hand, the fact that even today, the first and fourth of these structures continues under the neighboring houses and have many exit points to the surface is almost the proof of the very complicated underground network that existed in Agirnas many centuries ago.

The presence of four millstone doors, three of them *in situ* (Fig. 3) in the fourth underground structure suggests that the structure was built, at least for some time, for defensive purposes. However, these underground structures have lost their defensive purposes in time, and underwent major structural changes.

The first underground structure adjacent to the museum-house is reached through a large room supported by stone arches. This underground room with a barrel vault roof, frequently encountered in many places of this structure and under some houses nearby, is probably one of the oldest structures of this part of the village. These first underground settlements continue to the east through different rooms and some of them reach the neighboring houses through tunnels, partly closed by stones.

The largest and most important of the underground structures located under Mimar Sinan's house is the fourth structure. South of this entrance, in a chamber with a barrel vault roof, there are furnaces which are thought to be an iron foundry.

The structure continues eastward behind the foundry and reaches the front street, through another house. The structure was built in two stories up to this point, and opened up for tourism. Beyond this point, it continues below the houses nearby through a small connection. These parts of the underground city are not cleaned, and more interestingly, some underground structures are still being used by those living in nearby houses. The last gallery to the east is filled with mortar and another millstone door here emphasizes the initial purpose of this structure (Fig. 4).

Figure 3: One of the *in situ* stone mill doors of Mimar Sinan Underground City

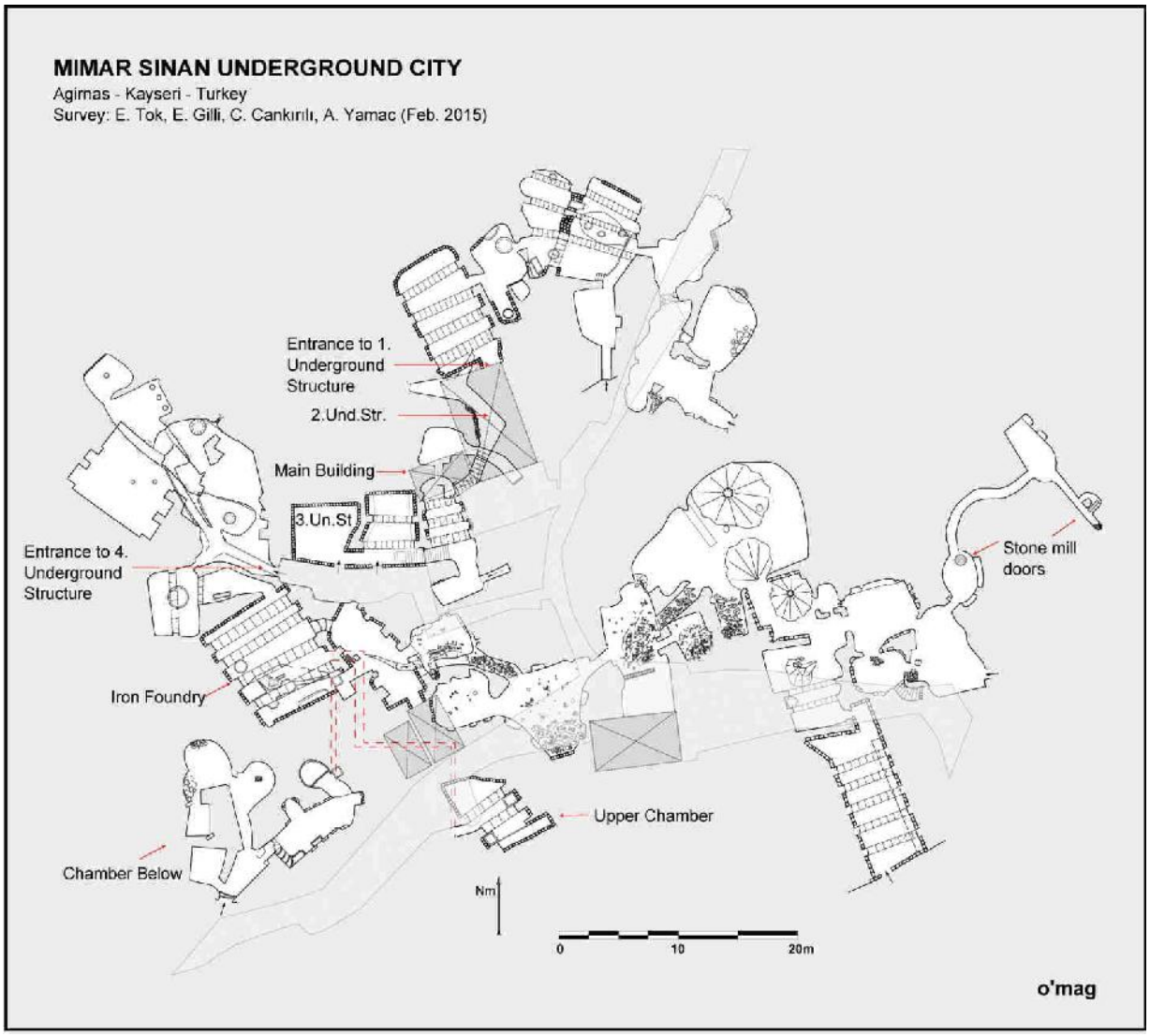

Figure 4: Mimar Sinan Underground site Complex. Note four different underground structures

Figure 5: One of the large chambers in the southernmost part of Agirnas Underground site

2.2 Agirnas Underground Site

We have conducted the detailed survey and mapping of this structure, which is located on the eastern cliff, at the entry to Agirnas, and that is open to tourism.

Agirnas Underground Site is carved in a rocky cliff located about 200 m to the south of Agirnas. It has the typical Cappadocian-style defense structure architecture, complete with its small church at the entrance, its supply stores, millstone doors and living quarters [Yorukoglu, 1990].

The millstone doors in the tunnels right behind the church show that the church was also being used in normal times. The 24 meters long and sometimes 4 meters high large hall reached from the eastern side of the church, exhibits very impressive craftsmanship.

Another entry to the northeast of the hall was closed, but the millstone used to defend the entrance is still in place. The main tunnel that continues for 60 meters toward the southeast of the hall contains a total of 11 living quarters / storage rooms. All of these rooms are so large and spacious that they cannot be compared to other Cappadocian underground sites (Fig. 5).

Another door located almost in the middle of the tunnel and that opened to the surface, is closed by a stone wall. Although the millstone door used to defend the entrance, 5 meters inside this entrance is not in place, the operation room containing the door is evident. Another entry/exit point and millstone door is present in the southeast of the underground site (Fig. 6).

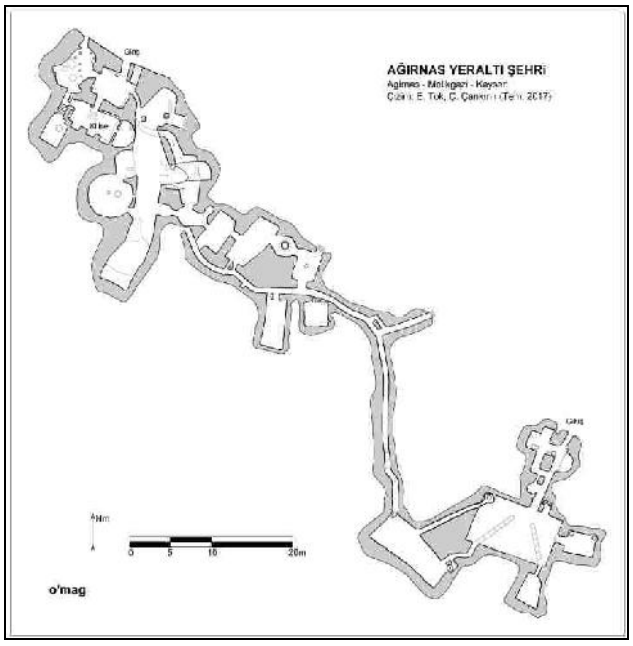

Figure 6: Agirnas Underground Site

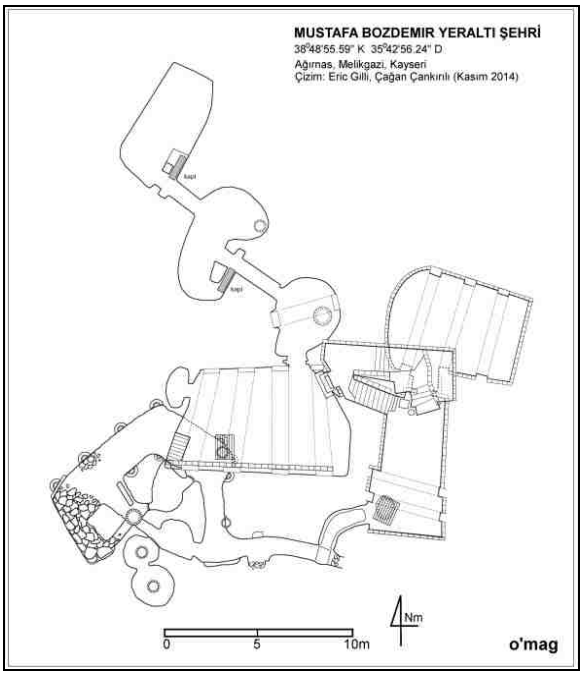

Figure 7: Mustafa Bozdemir Underground Site

2.3 Mustafa Bozdemir Underground Site

This structure which is located only 100 m from the Sinan the Architect's House in Agirnas, is located below Mustafa Bozdemir's house. This structure (Fig. 7), cleaned and opened for tourism by the house's owner, has been measured and mapped by our group. As explained above, Mustafa Bozdemir Underground Site is a small part of the defensive structures complex that extensively develops below Agirnas. This defensive structure probably lost its initial purpose after the 12th-13th centuries, and was used as a warehouse, barn, etc. in the following period.

During these re-adaptation works, the connection tunnels that reached under the neighboring houses were walled with stones. As we have seen in Sinan, the Architect's Underground Site, this structure also contains large halls that underwent serious architectural changes in time. The three-barrel vaulted, high ceiling halls at the main entrance and to the west of this entrance are very similar to those previously described. The large halls located over the defensive, stone-doored lower parts of the structure may be thought to be used for daily life.

2.4 Subasi Underground Site

This structure is located in the Subasi Neighborhood of Agirnas, and is one of the most interesting and different underground settlements in the region. The structure is located in a desolate plain that rises towards the Koramaz Mountain, about 2 km to the northeast of Subasi Neighborhood. It can be stated that this defensive structure is very similar to the Doganli Underground Site, which is also located on a desolate plain 2 km outside the Doganli Village.

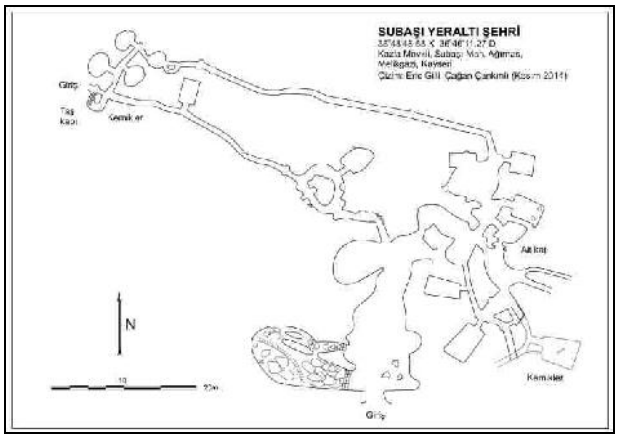

Figure 8: Subasi Underground Site

On the other hand, architecturally, the Subasi Underground Site is very different from the defensive underground structures that were investigated by our group until now. This underground settlement carved inside ignimbrite, and that is revealed as a small hill over ground, has three entrances, one of which was opened by a collapse.

Although the main entrance does not resemble the entrance of an underground settlement, but rather the entrance to a house or a barn, it might have been used to hide the defensive structure. Although it looks very simple on the map (Fig. 8), the low-ceiling, interconnected rooms give this structure the characteristics of a real labyrinth.

The underground site has a 4 room lower floor that is accessed by a short staircase in the eastern part, but all the tunnels in this lower floor are filled with earth. Although a defensive millstone door is in place at the northwest entrance, the millstone doors of the northern and southern tunnels are not, even though their shafts are apparent. It is possible that there was an old settlement, which has left no trace of its existence, near the Subasi Underground Site.

2.5 Akbin Cave Dwellings

Akbin Valley starts about 500 m to the west of Agirnas, and reaches the Turan (Dimitri) village [Comert, 2008]. It was formed as a result of the erosion of the Pliocene pyroclastic and tuffaeous deposits by the River Akbin. A very large settlement carved into the rocks of the western wall of this valley was investigated, measured and mapped by our group. Similar rock dwellings are encountered all over Cappadocia.

Such rock dwellings exist in valleys such as Degirmendere, Belagası, Erdemli, Derevenk, Turan and Güneşli near Kayseri. On the other hand, the rock dwellings of Agirnas/Akbin Valley are different from all the other structures mentioned above.

The first and most important difference is the date of these rock dwellings in Akbin Valley. All of the front row of houses that are under protection in Agirnas today are dated to 1500s, and even before.

The Kayseri Cadastral Records Book dated 1500, states that there are 56 houses in this village. In the Akbin Valley, 97 structures have been identified, 4 of them churches. We do not think that it is possible that two large settlements, 500 m apart were simultaneously settled. In this case, the rock dwellings in Akbin Valley should have been abandoned much earlier than the 15th, or even the 14th century.

However, it is known that the other rock dwellings in Kayseri, for example Belagasi or Turan, were in use until the 19th and 20th centuries. Another important difference that sets the Akbin Valley structures apart from the other rock structures in Kayseri, is the fact that there are Roman graves that are very obviously carved. Most of these structures are currently only identifiable through the carving style of their entrance doors (Fig. 9). While the internal structures of the tomb rooms were changed through time, some rooms still contain klines. Although most of the structures in Akbin Valley are residences or barns/cowsheds, at least 4 churches and 4 defensive tunnels/underground cities were identified.

Figure 9: One of the 97 cave dwellings of Akbin Valley, possibly a Roman grave previously

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4. ACKNOWLEDGEMENT

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SESSION 5

MILITARY AND DEFENSIVE WORKS

The concentric refuge of Kılıçlar Kilisesi complex (Göreme - Cappadocia)

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Abstract

A peculiar element of Cappadocia (central Turkey) is represented by the "underground refuges" (or shelters), an ancient defensive system, widespread on the whole territory, consisting of underground and rock-cut structures. These structures were organized in modules composed by residential rooms, excavated in the rock belt nearer the outside, connected through a small tunnel to an inner space named "redoubt". Here the inhabitants could retreat in case of danger, protected by millstone-doors and traps, with food supplies and escape routes. This scheme is repeated, with some differences, on the whole Cappadocian territory, and the various units on each site are often connected so as to constitute elaborated "underground networks" (or systems), mainly of two types: horizontal refuges, on a single level; vertical refuges, spread on more than one level.

During the latest expeditions in the area of Göreme, a vertical refuge has been identified which, owing to its special structure, was designated as "concentric refuge". In this communication we analyze the structural elements here summarized: 1) the entrance of the shelter, unlike the usual scheme, is separated from the adjacent rock-cut residential complex; 2) the work is exclusively located inside a single pinnacle; 3) the morphology of the rock envelope obliged to cut the different rooms on overlaid and staggered levels, around a vertical central axis, on which apex the redoubt stands; 4) the shelter is equipped with three sequential defence levels, both active and passive; 5) the various internal ways ensuring the passage on a circular path, were completed, realistically, in a second phase. As a consequence of re-use interventions and the collapse of considerable amount of rock parts, some doubts remains about the timeline and the purpose of some rooms and their entrances, as well as for the real role of the "escape route".

Keywords

Turkey, Cappadocia, Göreme, Kılıçlar Kilisesi, rock-cut works, underground refuge, vertical refuge, shelter, redoubt.

1. INTRODUCTION

The Cappadocian underground refuges

Cappadocia was an important *théma* of the Byzantine empire, located in the Anatolian Central Plateau, crossed by the Kızılırmak river, in the heart of the present Turkey (Fig. 1). Today we consider the historical territory of Cappadocia included in the six regions of Aksaray, Kayseri, Kırşehir, Nevşehir, Niğde, Yozgat. However, we point out an important underground refuge in the sinkhole area (Obruk Yaylası), of Konya region [Dolotov, 2014], and rock-cut churches near Karaman, west of Cappadocia.

One of the most important element of this territory, mainly composed of soft volcanic rocks, is an ancient defensive system, less known than the amply documented rock-cut churches, but nevertheless widespread, consisting of structures dug in the subsoil by men, named "underground refuges" (or "shelters"), today abandoned and often ignored, except a few fitted for tourism. For example, in the limited area of Göreme churches (Nevşehir), only 4 underground refuges were barely mentioned by De Jerphanion in three short points [1925, pp. 45, 46, 50] and by Pierre Lucas [2003].

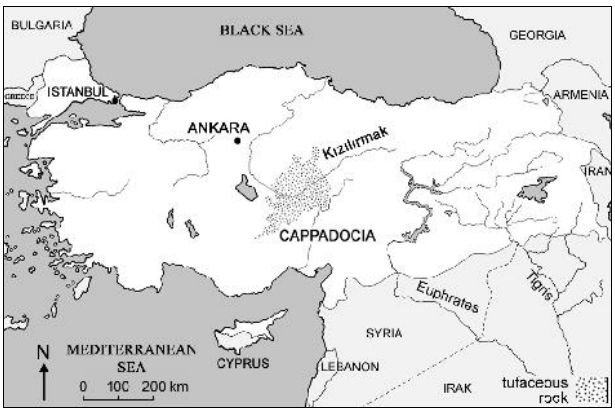

Figure 1: Dotted area corresponding to the volcanic tuffs of Cappadocia where the underground refuges are located (drawing R. Bixio)

After our surveys we found and mostly documented at least 14 defended rock-cut structures. It is matter of spaces concealed inside the cliffs or under the ground level which, originally, were intended to house, for short time and in emergencies, small groups or whole communities to be protected from temporary attacks and raids.

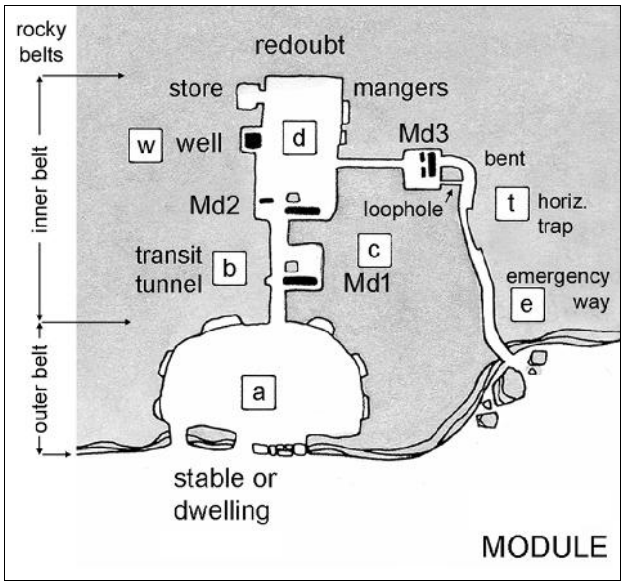

Figure 2: Sketch of a typical underground refuge (drawing R. Bixio)

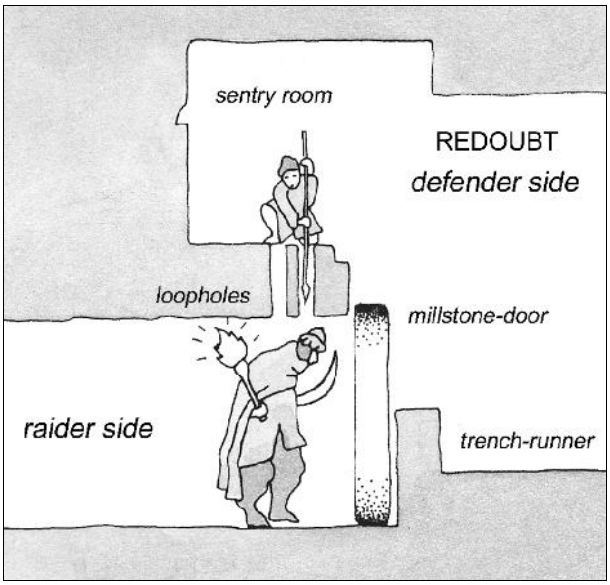

Figure 3: Devices for passive and active defence (drawing R. Bixio)

The plans reveal that these structures were organized as "modules" (Fig. 2), schematically consisting of residential and service rooms [a], carved in the rock part near the outside, followed by an innermost space [d], called "redoubt", where the inhabitants could have retreated in case of danger. The two parts where connected by a short, small tunnel [b] guarded by multiple closing systems, simple but effective, consisting of heavy circular monoliths, which can be compared to "millstone-doors" [Md], sometimes preceded by bends, and housed inside specific "operations rooms" [c].

The defences were supplemented by shafts or bottlenecks [t] which worked like traps, and by loopholes, disguised on the tunnel, to hit the attackers by surprise (Fig. 3). Each refuge was generally complemented with an "emergence route" [e], allowing to escape or turn on the enemy [Bixio & De Pascale, 2015].

This scheme occurs, with due specificity, in the whole Cappadocian territory, in an area of around 20.000 km^2, in connection with almost all the surface villages. The different units in every site are often connected so as to constitute broad and intricate "underground grids" (Fig. 4), with both "isolating rooms" and "isolated rooms" [Triolet, 2002], organised in such a way as to guarantee the mutual defence of various groups of refugees, or the progressive retreat inside sectors not yet conquered by the attackers.

We observe that modular structures reiterated in a wide region seem to suggest a strategic design co-ordinated by a central authority, by means, too, of *"un corps spécialisé...les expélatores..."* [Triolet, 1993, p. 23], rather than spontaneous and independent interventions carried out by local communities.

Two types of refuges are mainly detected: horizontal refuges, extending on a single level, towards the inner part of the rock; vertical refuges, in which the elements of the scheme described above were carved on superimposed levels, in the outermost part of the rock (Fig. 10). Sometimes the grid extends in both directions, and can be considered a real "underground city" [Bixio & Castellani, 2002; Yamaç & Tok, 2015].

In the redoubt or in the isolated partitions were identified storages for food and water, wells [w] reaching the water-table below, so to ensure the survival inside for the short time of a raid or the passage of an army. Obviously these refuges would be totally ineffective in case of a permanent occupation of the territory.

The epoch that most of all seems to correspond to such requirements is the Byzantine period known for the incursions of Arab *"dès les années 640...jusqu'à la mort de Sayf ad-Dawla (967)"* [Kaplan, 1981, pp. 149, 155], and continued until at least the strategist Nikephoros *"Ouranos' protracted campaigns... between 1005 and 1007..."* [Mc Geer, 1991, p. 133].

Art historians, according to the analysis of the paintings inside the rock-cut churches, have actually determined *"the settlement of Göreme developed through the centuries (from the 7th to the 11th century)."* [Andaloro et al., 2015, p. 17]. During this period the Cappadocian territory, while still remaining inside the Byzantine Empire, was subject to constant raids, *"twice, sometimes three times a year"*, as reported by Qāduma, a Muslim chronicler at that time [Canard, 1983, p. 274]. The attacks were mostly carried from the near Cilicia conquered by the Arab army to the Byzantines since 703. But we cannot exclude that these refuges were used in troubled times after or before [Bixio,

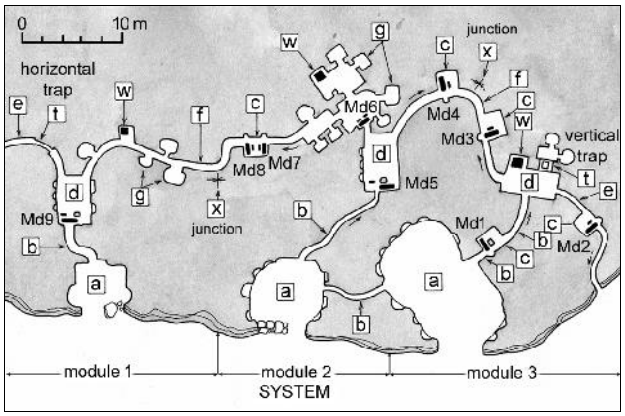

Figure 4: Complex system consisting of multiple interconnected modules (drawing R. Bixio)

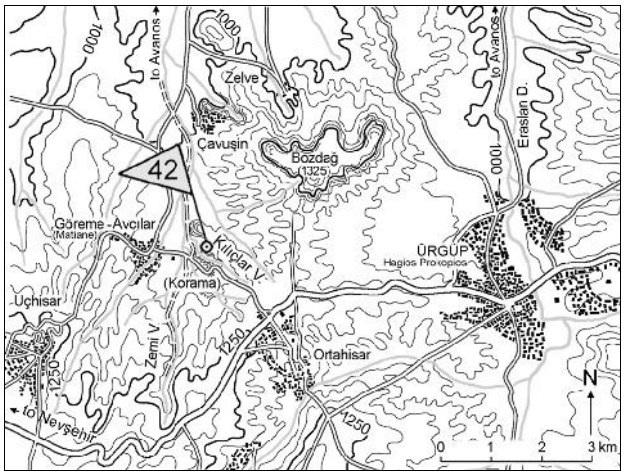

Figure 5: Location of the "concentric refuge" (flag 42) of Kılıçlar Kilisesi (drawing R. Bixio)

2002; Bixio & Caloi, 2002], as the Seljuk approaching (from the middle of the 11th century), or the Mongols (between 1243 and 1402), or for the relatively recent case of Misli or Misti (today Konaklı), in the district of Niğde, during the temporary occupation of the Egyptian army of Ibrahim Pasha, in 1832, when *"the villlagers fled below ground, cutting off their rear by stone doors like mill stones, which they rolled across the passageways."* [White, 1904, p. 68].

Martin Urban, instead, supposes that the underground refuges could be dated back to the time of contrasts between Phrygians and Assyrian (8th – 7th century B.C.), or even to the neo-Hittite kingdom of Tabal (1200-750 B.C.) [Urban, 1973/7, 1973/8, 1986], but these assumptions are, for now, just evocative hypotheses not supported by specific evidences [see also Mora et al., 2017, in this volume].

2. THE SITE OF KILIÇLAR KİLİSESİ

During recent expeditions in the area of Göreme (province of Nevşehir), a vertical refuge has been found which, for its distinctive plan configuration, was named "concentric refuge". The structure is located at the end of the narrow and deep gorge called Valley of Swords (Kılıçlar Vadisi), adjacent to the many rock-cut churches of the Open Air Museum (Açık Ava Müzesi) in the area of ancient Korama, 1 km eastward of today's village of Göreme (formerly called Avcılar) (Fig. 5).

At this site (altitude 1.100 m a.s.l.) there is a rock-cut settlement (Figs. 7, 8), consisting of an important painted church (flag/GPS 12), the Kılıçlar Kilisesi, which *"Décor archaïque"* is ascribed to the *"second quart (ou milieu?) du X^e siècle."* [Jolivet, 2015, p. 61], surrounded by chapels and other underground spaces, including one (point 12a) with the characteristic "*inverted T-plan"* [Öztürk, 2012, p. 158] on which recent interventions (dated between 1911 and 1981) to convert it as pigeon loft are visible. All the structures, although today partially dismembered by the erosion, are carved inside the tuff of a group of pinnacles surrounding a sort of natural courtyard, on a terraced slope, in front of the stream-bed.

The complex is widely reported by Guillame De Jerphanion, who defines it as "*monastique*" [De Jerphanion, 1925, p. 26, 199-242, 254-258], even if it might be a more generic civil residence. We agree with Ousterhout that, speaking about Cappadocian rock-cut courtyard units, says that *"...the presence of a chapel...not necessarily identify the complex as a monastery."* [Ousterhout, 2005, p. 179]. But, we add, the distinction is not so easy: *"La question de la fonction - civile ou monastique - des établissement dans la région...est depuis les années 1990 l'object de débats...cette intérpretation [est] contestable dans bien de cas..."* [Jolivet, 2015, p. 16].

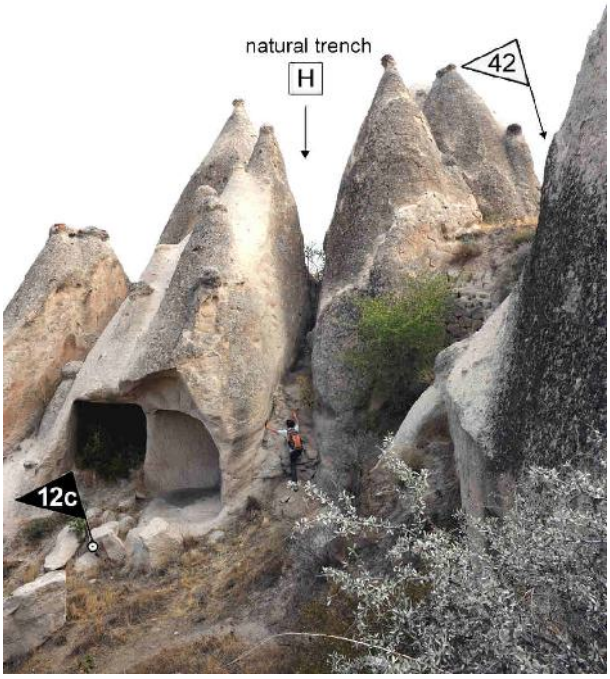

Figure 6: The natural trench cleared of bushes after recent inspections (photo A. Bixio)

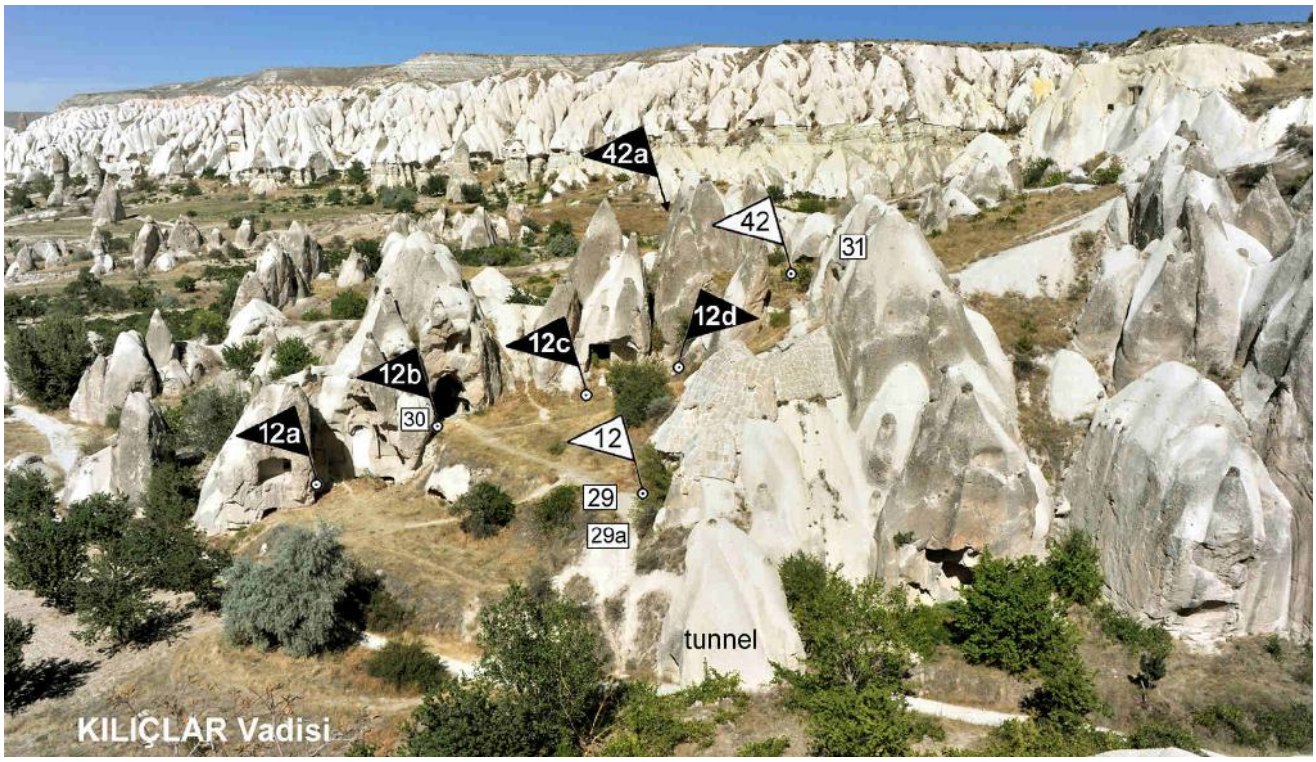

Figure 7: The area of Kılıçlar Kilisesi with rock-cut structures position (photo A. Maifredi)

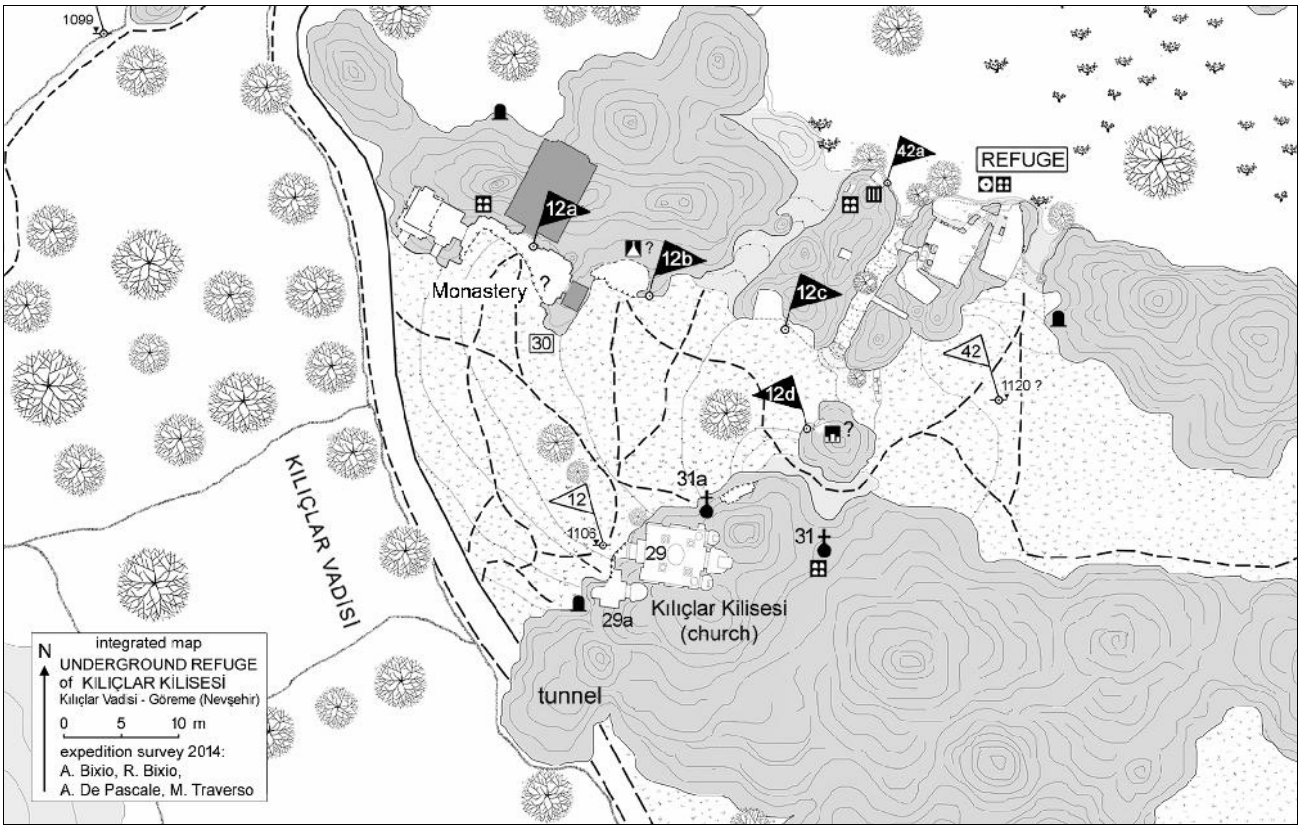

Figure 8: The rock-cut settlement of Kılıçlar Kilisesi and the related refuge, flag 42 (drawing R. Bixio)

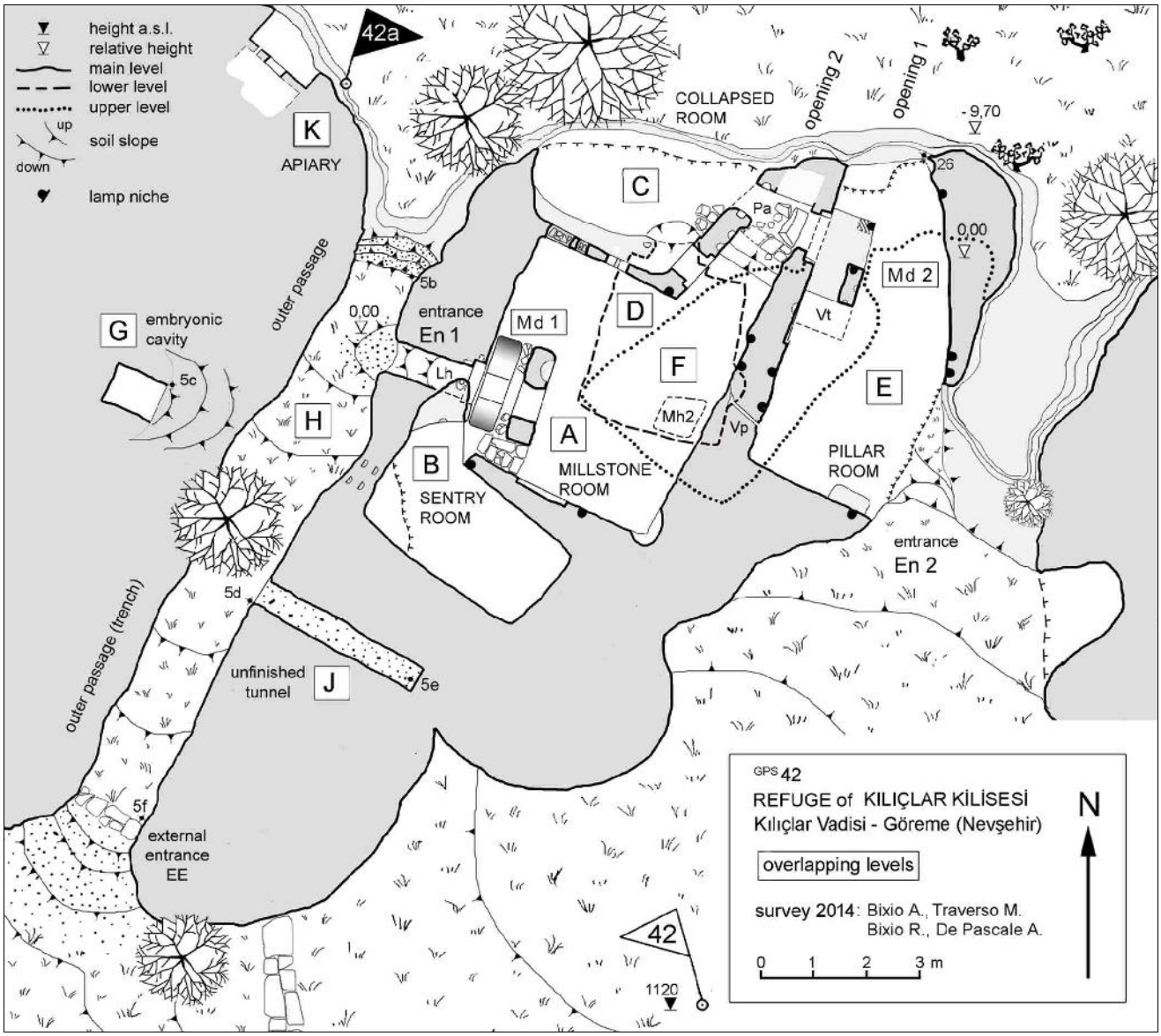

Figure 9: Integrated plan of Kılıçlar Kilisesi refuge, with the overlapping levels (drawing R. Bixio)

In any case, we note that neither De Jerphanion, or other subsequently sources concerning the complex of Kılıçlar [see e.g.: Jolivet, 1991; Jolivet, 2015; Rodley, 2010], report about a structure important for the safety of this settlement, characterised by distinctive features which, no doubt, identify it as an "underground refuge".

The reason of this unintentional omission depends on the occurance that, unusually, the entrance of the refuge is independent from the adjacent rock-cut complex, and is concealed inside a narrow natural trench [H], between two pinnacles, today closed by a rough and unstable occlusion of stones and soil, and camouflaged with trees and spiny bushes (Fig. 6).

This unusual location, with an entrance external to the others structures of the settlement, is the first difference which distinguishes this refuge from the others found until now in the area of Göreme, as, for example, in the Aynalı Kilise, in the Karanlık Kilise, in the Kızlar Manastırı, or in the complex of Saint Eustache, whose defensive structures are located inside the underground rooms related with every rock-cut settlement.

Concerning the site of the Kılıçlar Kilisesi, surprisingly, the refuge was carved inside an isolated pinnacle (see also note 1), located backwards and higher than the settlement, without direct communication with the other cavities around the rock-cut courtyard. The entrance is therefore outside, although in a hidden location (Fig. 9). Indeed the entrance of the underground structure [En1] is not visible from any point of the area around, being located on the side wall and in the final part of the narrow rocky channel [H] mentioned before.

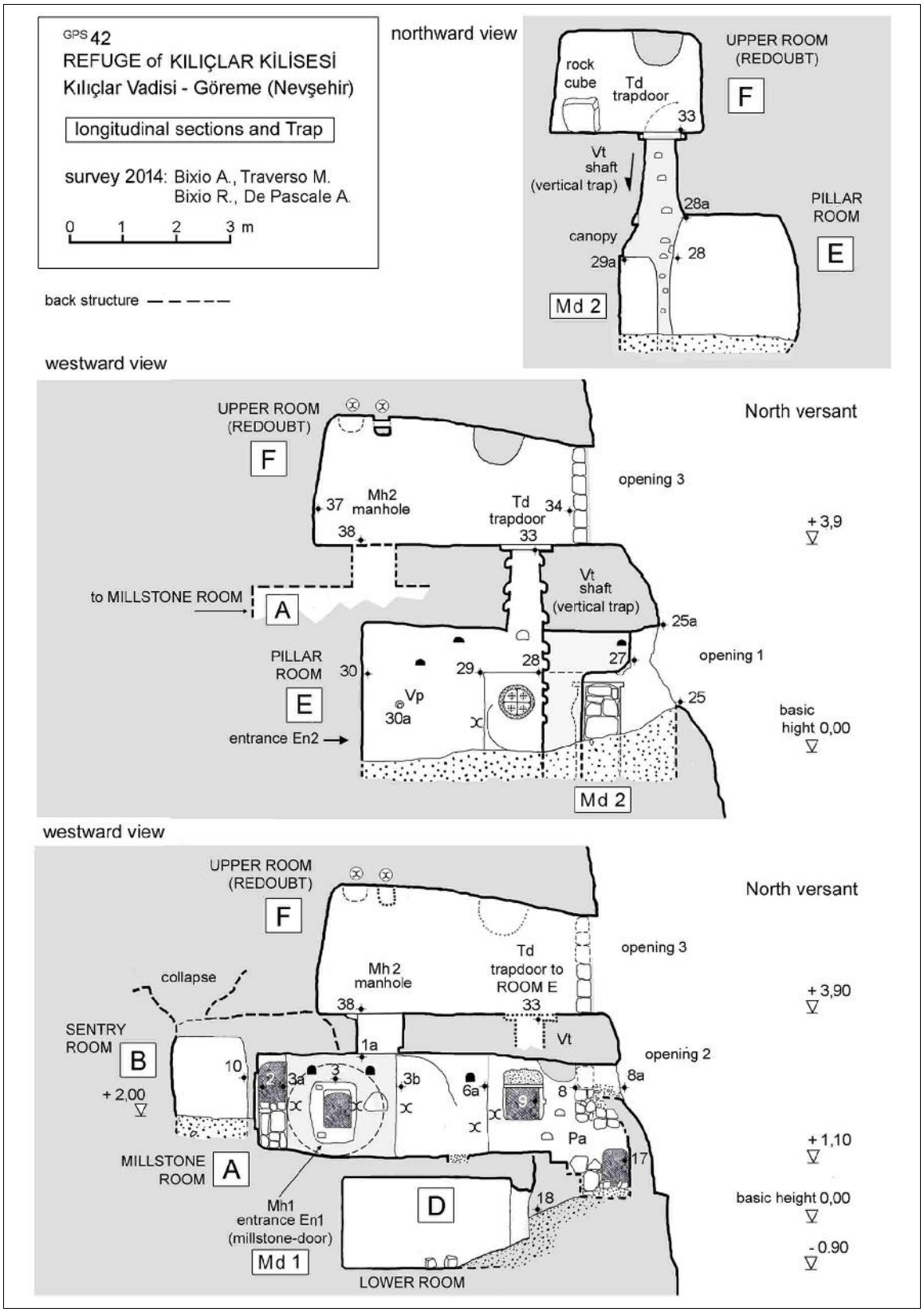

Figure 10: Sections of the Concentric Refuge (drawing R. Bixio)

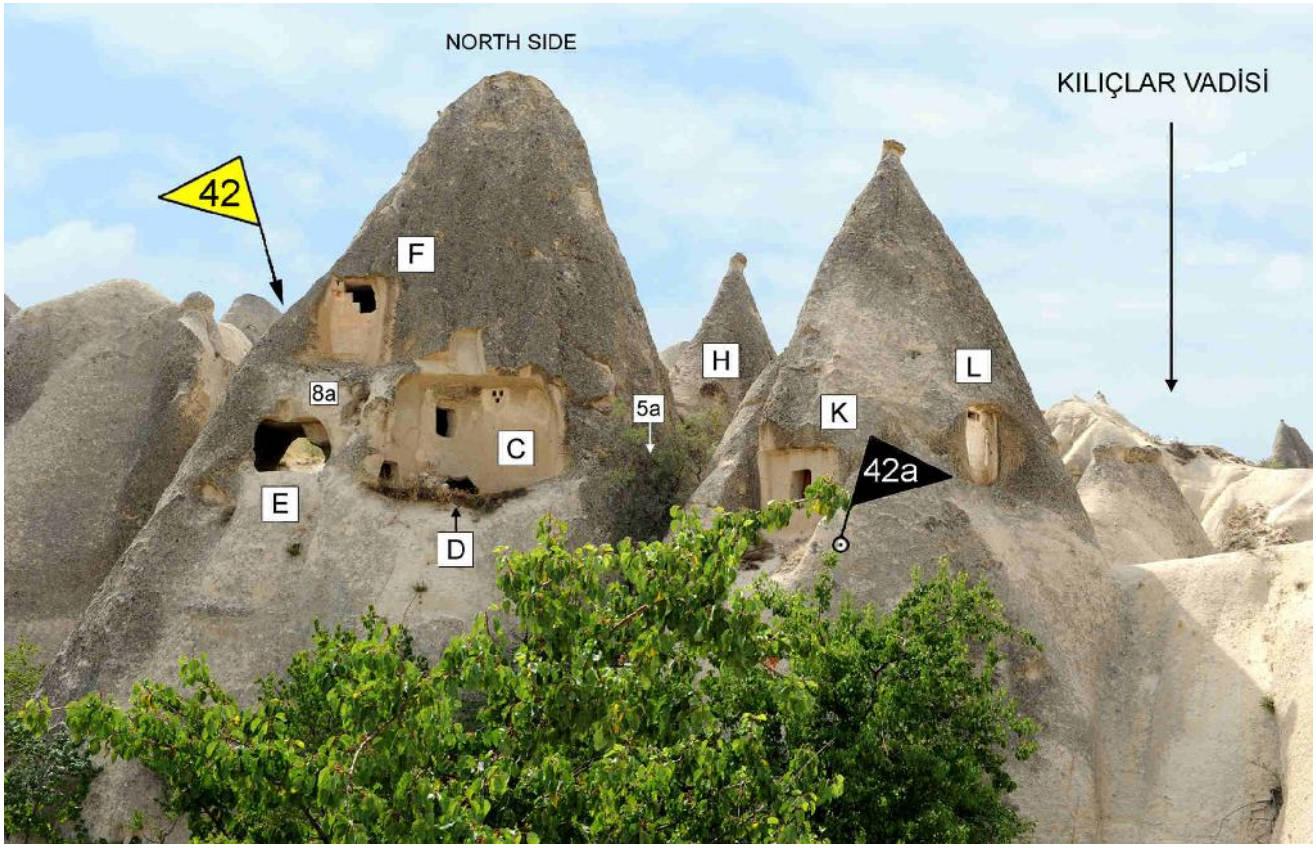

Figure 11: Openings of the refuge (flag 42) on the north side of the pinnacle (photo A. Bixio)

As we said, the natural corridor is difficult to be climbed. Obviously, originally the passage should have been easiest than today to ensure the quick access of the inhabitants in case of danger.

But even if the raiders had the intuition to climb the insignificant passage, they finally would have to face an insurmountable obstacle, consisting of a low and narrow tunnel, to be walked on all fours with restriction for the movements, and to stop, after few metres, in front of a mighty millstone-door [Md1] which still block the small passage.

In this position they should have been under the fire of a loophole [Lh] concealed on the ceiling. In fact, the original passage through the natural corridor (En1) will be searched, located and unblocked after our inspection of the refuge carried out by another way (entrance En2), resulting from the collapsing of the wall of the inner chamber [E] on the opposite (eastern) side of the pinnacle.

3. THE CONCENTRIC REFUGE

The exploration of the underground complex, as we said above, has been carried out, for objective reasons caused by transformations and obstructions, following a route almost contrary to that originally conceived for the structure. In short we will list the main changes incurred by the refuge during the centuries.

3.1 Collapses and re-use interventions.

The changes of the underground structure most oblivious from the outside (Fig. 11), are those resulting from erosion caused by the meteoric agents which, acting upon the soft tuff, have produced the detachment of large parts of rock, partially highlighting rooms originally invisible, carved in the heart of the pinnacle, endangering their initial function and, maybe, causing the abandonment of the site.

The room E, in addition to the collapse of the back wall (En2), mentioned above, suffered also a breakthrough on the north side of the pinnacle which created a large rectangular opening and the sectioning of the corridor Pa (openings 1 and 2 - Figs. 9, 11).

The adjoining room C (Collapsed Room) is almost totally disappeared, so that a small balcony united with the others room of the complex just remains. Instead, it is not entirely clear if the opening 3 in the Upper Room [F] is consequence of a breakthrough, then rectified and closed with ashlars, or if it was intentionally opened to convert it as a pigeon loft.
We point out that the wall still has remains of painted plaster with geometric patterns.

The collapse of a corner in the Sentry Room [B], quite invisible from the outside, obviously nullified the original function of this station designed to strike the attackers (see paragraph 3.2).

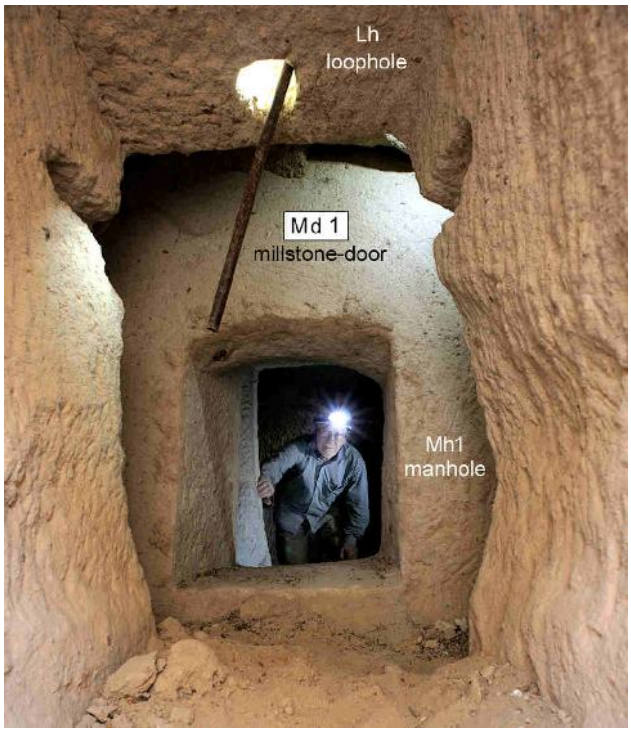

Figure 12: The tunnel corresponding to the entrance En1 with the manhole excavated through the millstone-door (Mh1) at a later phase (photo A. Bixio)

However, after the abandonment, several phases of re-use followed, proven by many occlusive interventions obtained raising stone walls, reinforced with wooden wedges and mud. The passage between the Sentry Room [B] and the Millstone Room [A] was closed with this system, and the passage Pa, both towards the Collapsed Room [C] and the Pillar Room [E], was sealed.

It is obvious that, as a consequence of this interventions, the Room A was transformed in pigeon loft with the contextual opening of three fly-windows in the back wall of the Collapsed Room [C] after the collapse of the outer wall which closed the room before (Fig. 11). The opening of the manhole Mh2, between the Room A and the Upper Room F, is instead difficult to be understood: it might have served, once the other passages were closed, to obtain an unique access to the two pigeon lofts through the entrance En2 in the room E and the shaft Vt.

However, it cannot be excluded that the manhole was contemporary to the original excavation of the refuge and may have been used as escaping route (see chapter 3.2). Perhaps more surprisingly, and not easily explainable, is the millstone-door (Md1) inside the room A, still in closing position in the housing device with two pillars, defending the short and low entrance En1 coming from the outer passage [H]. In the middle of the big monolith a rectangular passage in communication with the outside was carved, then closed with stones. Most strange of all is that it does not seem an emergency intervention, but a regular opening, well squared and finished with a door-frame. The sequence evidences at least three phases of use for the structure that we will try to analyse in the next chapter.

3.2 Organization of the refuge

According to available data and observations, and with the support of topographic survey, we can now propose a hypothesis about the excavation sequence and the strategy that inspired it. Synthesizing the plans we realized a schematic section (Fig. 16) which enlights the ways of moving and defending the people inside the refuge in case of an attack. Obviously we have to imagine the structure in its original state, still intact, with the parts today collapsed still in place, and without the changes resulting from the re-use interventions.

From the layout of the rooms it seems quite clear that this refuge differs from the others shelters in the area around Göreme, mentioned above, especially from the system of four refuges in Saint Eustache [we reported in Andaloro et al., 2015], not more than 300 m away, which extend linearly on a single level and are integrated each other.

The refuge of Kılıçlar Kilisesi complex, instead, has an unusual configuration, independent, as we said, from the residential complex, with a development prevalently concentric and vertical, intended to keep the excavated volumes inside the rock of a single pinnacle[1] (Fig. 11).

However we point out that the sequence of closing devices fits the general scheme of defensive systems for the Cappadocian underground refuges (explained in section 1) consisting of multiple installations for passive defence, supplemented by devices for the active defence, which allowed the progressive retreat inside the structure up to the "redoubt", with its own "escaping route".

As we already said, the access to the underground refuge of Kılıçlar took place through the external passage H consisting of the natural channel hidden between two pinnacles, and fast reachable from all the places of the adjacent rock-cut courtyard. The structure is entirely included inside the eastern pinnacle and the real entrance [En1] consists of a short tunnel that opens on the steep rocky side, at the north end of the channel (Fig. 9).

Even if the passage was identified by the attackers, here they would have found the first mighty obstacle to penetrate inside the refuge, consisting of three concomitant factors: the small size of the tunnel, the barrage of a solid millstone-door [Md1], and the presence of a loophole disguised on the ceiling [Lh] (Fig. 12). Thus the attackers would immediately have been in distress, they had to move

[1] A similar refuge, located inside an isolated pinnacle and developed on superimposed levels has been recently documented in the site of Golgoli, near the village of Mustafapaşa, 17 km south of Ürgüp [Yamaç & Gilli, 2016]. Another one is located upstream from Zemi Vadisi.

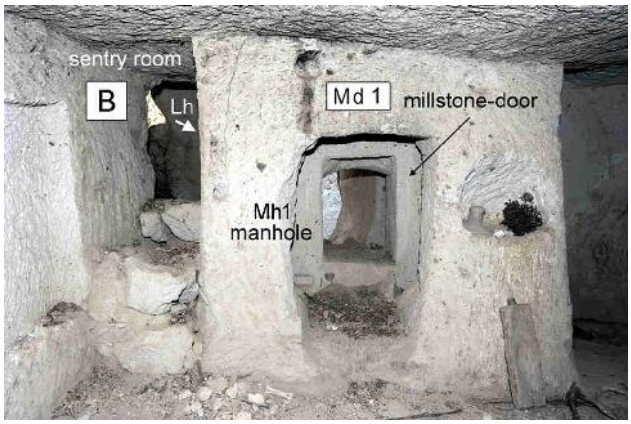

Figure 13: Chamber A. Operations room of millstone-door Md1, hidden by the pillars, with the passage Mh1 already cleared of the stone wall (photo A. Bixio)

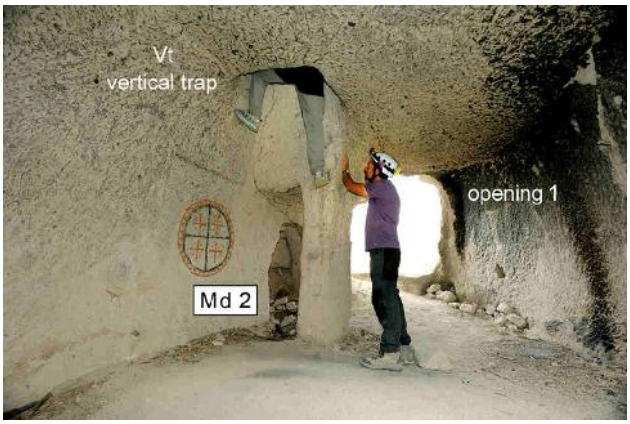

Figure 14: The trapdoor Td at the top of the vertical shaft Vt in the Upper Room [F]. The closing leaf is missing (photo A. Bixio)

one at a time, on all fours, restricted in the movements, blocked by the millstone and prevented from take it down or remove it from the outside, under the blows shot by the defenders through the hole located right above the area in front of the monolith. Obviously the passage Mh1 originally did not exist and the millstone was a solid rock!

On the other hand, the defenders, inside the wide room A had freedom of movement, the door could have been easily rolled and blocked with a simple wedge. The adjacent sentry room B was connected with the tunnel only throughout the hole of 10 cm in diameter, so unassailable from the outside, but from which it was easy to hit the attackers below, in front of the millstone (Fig. 13). Furthermore, the defenders could enter the others rooms (black arrows), unimaginable by the attackers, where undoubtedly stocks of food and water were stored. The rooms C, D, E, surrounding the room A in the middle, placed on different levels, were reachable through a corridor and a short flight of steps [Pa], excavated, inside a sort of hollow space, into the rock.

In the unfortunate event that the assailants could overcome the first barrage, the refugees arranged a second defence consisting of another monolith [Md2] located in the room E, close to the passage Pa, not by chance designed (small size, orthogonal position) to minimize the impact of an attack to the millstone-door. Even though to be spared, the defenders would retreat in this room, abandoning the others to the plundering which, probably, was the main purpose of the raid[2] and, consequently, considering the difficulties to continue the attack, they hope it would ended. However, the sense of insecurity had to be very high if the defence was reinforced by a last device consisting of the vertical shaft Vt (Fig. 14), carved next to the operations room, and connected with the room [F] above.

The room would serve as “redoubt”, i.e. as last refuge in the case of the second door had fallen too, protected by the shaft itself which would become a trap for the attackers.

Indeed, the ladder, or the rope to reach the lowest footholds was surely hoisted up, putting immediately in trouble the assailants who would be exposed, under the vertical axis of the shaft, to the throws of the defenders, even simple stones[3], which would had prevented the climbing. In case the defenders had finished the ammunitions, an extra measure would had been the trap-door on the top of the shaft, which leaf, today disappeared, could have been blocked by means of bolts on the sides (Fig. 15), perhaps also by superimposing the rock cube still present in the room (Fig. 10), which seems suitable for the purpose.

In addition it would not had been surprising if the refugees used even bees for their defence, especially since not far from the refuge there is an apiary carved inside the adjacent pinnacle (flag 42a in Fig. 8), almost certainly easily accessible from the refuge before the collapse of part of the rock. We can imagine that the defenders, after having transported in advance in the redoubt some beehives (probably of tubular type, used in the area [Bixio et al., 2004; Bixio & De Pascale, 2013]), would had been able to throw them in the shaft, immediately closing the trapdoor. The bee swarm, coming out from the hive, could attack the assailants with even deadly consequence! This conjecture is suggested by an article of Sophia Germanidou, according to whom: "*The use of animals as a military weapon, particularly the sting of bees, doesn’t consist an invention of the Middle Ages. It is traced as early as the Biblical times.*

[2] Actually, the capture of prisoners was practiced too, e.g. in 776 during the seizure of *"speluncam Causim"* [Theophanis, ed. Classen, 1839, p. 694], and mentioned in the "Treatise about skirmishing" (Περί παραδρομης = Peri paradromes) attributed to Nikephoro Phocas [Dennis, 1985, p. 138]. There are others proofs of prisoner exchanges [Canard, 1983, pp. 293, 294, 298].

[3] *"The defenders...operated stone- or arrow-shooting..."* from the walls during the sieges, is mentioned in the Byzantine military manuals [Mc Geer, 1991, pp 137-138].

Figure 15: The trapdoor Td at the top of the vertical shaft Vt in the Upper Room [F]. The closing leaf is missing (photo A. Bixio)

First references are recorded during the Roman campaigns in the region of Pontus, while the lethal biological weapon of bees was further developed as a method of defense and attack mainly in the West, and especially during the Crusaders' sieges. In all probability, Byzantium employed biological weapons, including bees, following Roman practices." [Germanidou, 2013, p. 104].

We also need to say that we do not know if the redoubt was originally planned, or it was added in a second phase, or even the Upper Room was never used as last refuge. However, the presence of the rock cube, if used to block the trapdoor, as well as the round holes aligned on the floor, which might have housed amphorae to constitute a reserve of water, might favour one of the first two hypotheses. In any case, as the shaft seems dug from top to bottom, the Upper Room must necessarily have been independently excavated, and later connected with the lower level.

From this perspective it is likely that the second passage (Mh2), located on the floor of room F (Fig. 10), was opened at a later time, after the end of raids in this region. In our opinion this manhole, although not easily reachable from below without a ladder or a rope, could have been a weakness for the defence of the refuge, making useless the second millstone-door without to supply, in the meantime, a suitable escaping route – a preventive measure usually found inside the redoubts of Cappadocian refuges – because it would have led the refugees back inside the room A when already occupied by the assailants.

We add that also the entrance En2, on the eastern part of the pinnacle, from which today one can enter directly inside the room E, in our opinion, originally did not exist. Undoubtedly the opening, with its present shape and dimensions, was the result of the collapse of the back wall of the pinnacle. If an outwards passage had been there, since it would have represent another weakness point for the defensive structure, it would have been protected by devices such that, despite the instability processes, should had left evidences which, instead, have not been found.

We are inclined to think that also the opening 1 in the Room E, noticeable in Fig. 11, is consequence of a natural collapse before which the wall was completely closed. Indeed an opening so big and visible would have been another weakness point for the defensive strategy of the refuge.

This opening would have forced the attackers to try to climb the pinnacle, bypassing both the closing devices, and leaving to the defenders, as last solution, the retreat in the upper redoubt F through the ascending trap-shaft Vt. However, it cannot be excluded that the present opening might results from a pre-existing smaller window. We recall that elsewhere refuges with superimposed levels and still intact windows exist: for example in the nearby complex of Aynalı Kilise, or in the redoubt annexed to the Karşı Kilise, near Gülşehir (Bixio et al., 2012).
Clearly those openings, located at a certain height, were considered adequately defensible from attacks. In the case of the vertical refuge of Orta Tepe, near Şahinefendi, the window on the wall of the upper level is still protected by a millstone-door (as we wrote in Andaloro et al., 2015).

It is also possible that the window of the Kılıçlar refuge has been opened (and then widened by the erosion) at a later stage, with the re-use of the structure, in a time when the inhabitants believed the danger of raids definitively ended. In this context, it is not clear the role of the tunnel in point 8a of Fig. 11, today stopped up, above the passage Pa (opening 2 in Figs. 9, 10), whose external outlet is located between room C and room E (not depicted in the scheme).

Anyway, probably the attackers never penetrate the refuge. Indeed, while the signs of abrasion made manoeuvring the first millstone-door (Md1) inside Room A show that one or more times the settlement was attacked, the absence of this signs on the wall of the second operations room (Md2), although the millstone today is missing, suggests that the defenders never needed to retreat in the room E, so they never closed it.

Moreover, the fact that the entrances in front of both millstone-doors (and also that of the Lower Room) have frames and joints capable of lodging wooden doors could be explained with the needs of a daily, or at least frequent, use of the underground spaces: for example to renew, integrate, collect the food supplies and even to regularly reside in. In this case a window for enlightenment and ventilation would be useful.

The presence of the doors would have avoided to repeatedly move the heavy millstone-doors, difficult to be shifted and manoeuvrable only from the inside, so not to be used unless in case of emergency and by several persons who instead, after walking out, could have closed the doors but not the monoliths.

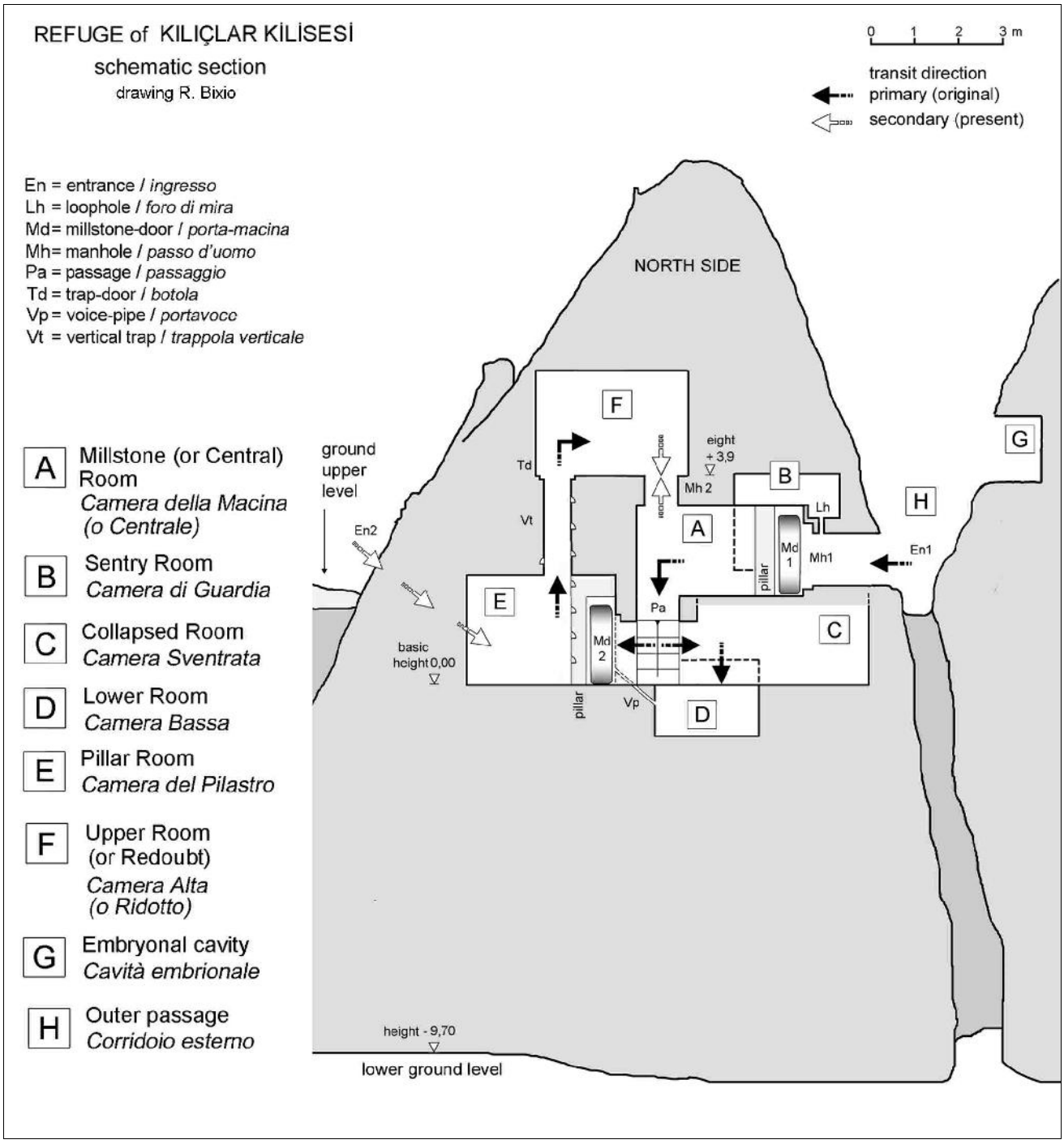

Figura 1 Figure 16: Schematic section of the refuge with the internal transit directions (drawing R. Bixio)

We also point out that, given the rotation direction of the wooden shutters, inward, when the millstones were closed, they had to be closed too, remaining between the entrance and the stone door, providing a camouflage and an additional protection for the monolith. This circumstance is still visible in the site of Yaprakhisar, at the end of Ihlara Valley (Aksaray).

3.3 Speculations about the re-use of millstone-door Md1

It is difficult to interpret the fact that, at the time of our investigations, the millstone-door in front of the entrance En1, besides of being in closing position, was even carved in the middle to realize a passage (Mh1 in Figs. 12, 13) fitting, for dimension and position, with the opposite entrance tunnel and, finally, was again accurately closed

with squared stones. Undoubtedly the various interventions are the result of interactions over many years, probably even chronologically far. However, some doubts remain about the sequence and the reasons of the events that generated them.

Reiterating that from the outside the millstone-door was impossible, or very difficult to be rolled, at the time of the structure re-use the options, of course, could only be two: the millstone was open or closed. If it was in closed position it means that the people inside had left the refuge through another way. Besides the fact that we could not identify this route (perhaps, descending the opening 1 using a ladder or a rope?), it is not clear why, after the attack, they did not return through the same way to reopen the rocky door. The only possible reason seems the fact that the first users, after that event, never come back to the refuge, permanently abandoning it because, for example, they were finally captured or killed by the attackers.

We assume that those who reused the structure at a later time, when they found the millstone-door closed and not being able to open it from the outside, decided to dig an opening right in the monolith, considering this passage more suitable, after perfecting it from the inner side too, than to move the heavy millstone. Then on the new entrance they would have placed a closing door simple to be handled, or some ashlars which, indeed, we found at the time of our first inspection, in any case easy to be removed and relocated at each access[4].

Alternatively, it is possible that the re-use of the underground structure has occurred after the partial collapse of the Sentry Room [B], as a result of natural erosion, which allowed entering inside the refuge bypassing the closed millstone-door. Then, the newcomers, in order to re-use the inner chamber, would think to close with a stone wall the passage from room B to room A, and to open a smaller one in the middle of the monolith itself, without to move it from its position.

If, however, the millstone-door was in open position, it means that, after the raid, the refugees were regularly come out from the entrance simply by removing the monolith from the access tunnel. In this case, however, it is disconcerting to think that the subsequent users would considered advantageous to close the millstone after entering the refuge, and then to perforate it.

It seems meaningless the goal to have a narrow passage, since the pre-existing tunnel, in front of the millstone, has almost the same section and was already fitted to house a door. Unless, at the time of the raids, the assailants have actually succeeded in penetrating the refuge, despite the defences, by carving a breach into the closed millstone: this hole, certainly irregular, carried out in a disturbed situation, would be used by the subsequent users, after having rectified and perfected the profile easily from the inside, avoiding to re-open the heavy door, or better by carefully sealing every split with stones, wooden wedges and mud.

4. CONCLUSIONS

We conclude observing that, as a consequence of overlapping interventions for the re-use of the structure, and the collapse of large portions of rock, every hypothesis about chronology and the real function of some rooms and their access is open to objections and additional opposite conclusions which, if excluding some contradictions, rise new ones. Probably, the original sequence and the purpose of the interventions will never be totally explained owing to the complexity of natural and human interventions that come in succession and mix over a very long period of time, at least a thousand years, which left feeble traces in the historical sources concerning Cappadocia.

However, we can summarize the features of this atypical rock-cut structure that we called “concentric refuge”.

1) Unlike the usual configuration of Cappadocian defensive modules, the entrance of this refuge, concealed inside a natural trench, is independent from the adjacent residential complex, but anyway quickly reachable;

2) the work is totally excavated inside a single pinnacle;

3) the conic morphology of the rock shell has led to dig the different rooms of the refuge on overlapped and staggered levels, around a vertical central axis, on which vertex is located the room designate for the last defence (redoubt);

4) the refuge has three levels of progressive defence, passive and active, consisting of two millstone-doors, with sentry room and loophole, and one vertical trap;

5) the various inner passages guaranteed a circular transit, although some doubts remain about the real role of the “escaping route”, probably realized at a later stage.

We consider appropriate to stress that we are not surprised by such a commitment to plan and excavate this structure, as the others around Göreme and in the whole Cappadocia. In fact, we must consider that from the "Treatise about skirmishing" of the 10th century (Περί παραδρομης = Peri paradromēs), attributed to the *strategos* and imperator Nikephoros Phokas, emerges that the preferred defence method against the Arab raids *"...which must have been hard on the inhabitants of the region, was to allow the raiders to ravage and pillage Byzantine territory and then, as they were making their way home loaded with captives and plunders, all worn out from the expedition, to ambush them in the mountain passes. If they were hit hard enough, it was hoped, they would not dare even think of invading imperial territory egain."* [Dennis, 1985, p. 138].

[4] According to the director of the Archaeological Museum of Nevşehir, describing the pigeon-lofts of the region, *"les fermiers ne visitaient ces constructions que une fois l'an, ils détruisaient un pan de mur et retiraient tout l'engrais puis reconstruisaient celui-ci jusq'à l'année suivante."* (Gülyaz, 1997, p. 166).

Clearly this hope was vain, at least until 1007, when ended the campaigns against the Arab bands still out of control by the following stategos Nikephoros Ouranos [Mc Geer, 1991]. It is also clear why the underground refuges of Cappadocia, although would require a long and difficult work for the excavation, were so widespread, well organized and defended!

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Common Traits of Artificial Caves and Rock-Cut Constructions in Ancient Armenia

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Abstract
This paper approaches the issue of organization of rock-cut environment, the process of its transformation in late pre-historical (Bronze and Early Iron Ages, ca. mid 4th – end 2nd millennia BC) and especially historical (Middle Iron Age/Urartu, ca. first half of the 1st millennium BC, and later) period history of Armenia. The mountainous character of the landscape of Armenia conditioned the dependence of all cultures developing within its territory from mountains/rocks/artificial cavities, which is reflected in architectural principles, worldview and generally in development of various cultures of the region.

Cave dwellings/burials/sanctuaries, rock-cut sacred paths, rock stairs, rock inscriptions, rock-cut tunnels, stone doors are the main forms of expression of corresponding units. Research of rock-cut structures and their environments in the Armenian Highland allows considering them and levels of their abstract perception in general cultural developments of the region as an invariant feature.

Keywords
Armenia, artificial caves, rock-cut constructions, spiritual perceptions, Bronze Age, Urartu, Medieval period

1. INTRODUCTION

Paper explores the issue of organization of rock-cut environment, the process of its transformation in late pre-historical (Bronze and Early Iron Ages, ca. mid 4th – end of 2nd millennia BC) and especially historical (Middle Iron Age/Urartu, ca. first half of the 1st millennium BC, and later) periods in Armenia. Before we turn to our core topic, we need to define the category rock-cut structure, under which we include any horizontal or vertical rock, worked by human, meanwhile the rocky environment is the geographical and cultural surrounding of the structure, its landscape. The first manifestations of use of such kind structures were caves, known since the Stone Age. During the Bronze Age rocks begin to be treated on horizontal and since the Iron Age also in vertical levels.

Discussions of these problems are based on the written and archaeological sources. Written sources are known since the 9th century BC, when the Urartian state appeared and cuneiform inscriptions were used. The Hittite-Hurrian cuneiform inscriptions of the 2nd millennium BC could also be interesting for us. For the later periods, Graeco-Roman and Armenian sources are useful. Archaeological data provide great opportunities to study the problem allowing to discuss the relationship between the human and the cave/rock since the Stone Age until the Medieval times.

It is important here to refer to the history of research of caves and rock structures in Armenia. Among ancient authors Xenophon, Strabo, Movses Khorenatsi and Arakel Davrizhetsi are to be mentioned here. The problem was reflected in the works of the 19th century authors, among which the Armenian traveller Artemiy Araratski (Harutyun Astvatsatryan), the French authors M. Brose, V. Langlua, and the German scientists H. Abikh, K. Lehmann-Haupt should be underlined.

During the late 19th century the archaeological works were systematic in Armenia, to be carried out mainly by the Russian school. The prominent scholars N. Mar, H. Orbeli, T. Toramanyan, G. Hovsepyan, D. Ghipshidze, and later on, N. Tokarski, B. Piotrovskiy, et al., put the problem of the study of rock structures on new level. Here the name of N. Marr is of particular importance, as he conducted several expeditions to Van and Ani, where the best examples of Urartian and Armenian rock architecture were measured and described. In the second half of the 19th century active research was carried out by the Armenian scholars who studied caves (S. Shahinyan, R. Vanyan, S. Davtyan), pre-Urartian (P. Avetisyan, B. Gasparyan), Urartian (B. Piotrovskiy, K. Hovhannisyan, M. Melkonyan, S. Hmayakyan, A. Piliposyan) and Medieval (H. Petrosyan, Zh. Khachatryan) rock structures.

2. LANDSCAPE TRAITS

The Armenian Highland takes central place among three highlands of the Near East bordering with the Asia Minor Highland on the west and the Iranian Highland on the east. Plateaus in the central part of the three highlands are surrounded by high mountain ranges. The uniqueness of geological-geomorphological structure, as well as speleological-spelestological specifics of each highland, can be observed in general background. In this case the Armenian Highland is noteworthy, the central part of which is divided by the Armenian Taurus Mountains. It is represented by elevated tectonic-volcanic and structural-denudative plateaus, known as the Armenian volcanic upland. Representation of the Armenian Highland as a separate geological-geomorphological and speleological-spelestological unit is conditioned by intensive tectonic shifts and Neogen-Quaternary volcanism, which created complicated folded-block and volcanic landscapes. The caves of the Armenian Highland morpho-genetically are divided into the following types: 1. Karstic caves, 2. Caves formed in Neogene pyroclastic formations, 3. Caves formed in Quaternary lavas [for details cf. Balyan, 1969; Balyan and Vanyan, 1986; Davtyan, 2013].

2.1 Karstic caves

Karstic caves are located in the mountain ranges bordering the volcanic upland: Lesser Caucasus, Armenian Highland and Inner Taurus, and the caves in Neogen pyroclastic formations and Quaternary formations – in the Armenian volcanic Highland. In addition to the natural caves, there are also artificial caves in the abovementioned region, which have been created as a result of human activities. These are located mainly in volcanic rocks of the Neogene-Quaternary period.

2.2 Volcanoclastic Deposits of the Neogene Age

They consist of tuff breccias, agglomerate tuffs, tuff sandstones, and are known by the name Goderdz-Voghjaberd. The thickness of the deposit reaches 600 m, on average it is 50-100 m. It is spread not only in the Armenian Highland, but also beyond its limits, in Cappadocia and Iranian Highland, etc. In these deposits natural and artificial voids are widespread. The natural voids were formed in tuffaceous rocks as a result of the dissolution of cementing material by ground waters and denudation of the degraded material. These spaces were enlarged later by humans. Artificial caves were completely formed by humans. The three main phases of artificial cave creation within this deposit can be separated: Bronze Age, Urartian and Hellenistic-Medieval periods.

2.3 Quaternary lavas

Such lavas are spread approximately on one-third of the territory of the Armenian Highland. The caves in this region illustrate the range and extent of the rock geology and only a small portion of the geographic landscape has been formed by humans. Two subtypes of built environment are represented: lava-contact and lava tunnels. Lava-contact caves are found on the outcrop on the slopes of the river canyons and were formed in the contact zones with neighboring lava flows, as a result of removal of the mellow materials (lithomarge) in these lava flows. Lava tunnels were formed in result of the irregular cooling of lava flow, as fluid lava flows beneath the cooled crust. The major portions of these natural hollows were utilized by humans without any physical changes. Caves with partial changes are also present in the landscape. Lava flows are mainly represented by andesitic and basalt rocks, their prominence due to natural hardness. For this reason artificial cave structures are relatively less common. Constructed caves were mainly created in the Urartian period and designed to symbolize the strength and power of the Urartian kings. The rock-cut structures of that period are cultic, burial and hydro-technical constructions (underground reservoirs and hydro-technical tunnels).

3. TEMPORAL DISTRIBUTIONS

Three main phases of artificial cave creation can be defined in the Armenian Highland: Pre-Urartian, Urartian and Hellenistic/Medieval.

3.1 Pre-Urartian Period

First solid rock-cut structures in Armenia appear with the Urartian state. A complicated problem ist the question of formation of Urartian rock-cut structures. In this regards the specialists look for in three directions – local, Hittite and Mesopotamian traditions.

So, partly worked caves/rocks are known in Armenia since the Chalcolithic period [for Areni cf. Petrosyan and Gasparyan 2014] and rock-cut structures since Early Bronze to Iron Ages in system of “cyclopean” fortresses, settlements, cemeteries or separate sanctuaries. Among them rock-cut platforms making sacred landscapes of Metsamor [Khanzadyan et al., 1973], Armavir [Karapetyan, et al. 2004], Agarak [Avetisyan, 2003], as well as stepped rock cult structure of Byurakan [Gevorgyan and Petrosyan 1993], rock-cut roads (Byurakn, Shamiram) [Areshyan, 1980; Hakobyan and Gnuni, 2007] are noteworthy. All these structures are worked mainly on horizontal level (Fig. 1, 2).

The Hittite rock architecture is also essential, although the chronological gap make comparisons to Urartu questionable. Discussing the structural specifics of Urartian burials and possible Hittite influences the following outcomes are pointed out: a) Some architectural solutions could reach Urartu through Phrygian and the Northern Syrian intermediation; b) the presence of cremation ossuaries, buried between the rocks is of Hittite origin; c) the cremation ritual, evidenced also in rock-cut tombs, infiltrated in Urartu possibly from the Hittite world, d) there are some common traits in the manner the bas-reliefs were organized (position, height, style).

Another probable foreign source of origin of Urartian tombs is Assyria. Urartu and Assyria interacted for several centuries both in political and cultural spheres.

Figure 1: Byurakn, rock-cut horizontal platforms, Bronze Age (photo of the authors)

Figure 2: Byurakan, rock-cut platform with staircases, Bronze and Iron Ages (photo of the authors)

In Urartian art many Mesopotamian borrowings can be found, but these are so changed that it could be truly stated that their local development resulted in another, unique, Urartian art. In particular, it is supposed that the Urartians borrowed from Assyria the habit of luxurious burials. Before the 9th century BC, within the territory of future Urartian state the earlier structures similar to the described burials have not been found yet.

The oldest Urartian burials date back to the reigning period of King Menua (end of the 9th century BC). By that time the Urartians already had an experience of building rock-cut burials. If the Urartian experience of building burials in the rocks has Assyrian roots, then it is necessary to assume that the cultural interactions between these two states existed previously, from the first years of formation of Urartian kingdom.

The main factor of origin and development of Urartian rock-cut tombs must be sought in a particular geographical environment. In this process, Hittite and less Mesopotamian influences are evident. However, specific features of Urartian rock-cut tombs, various methods of rock treatment and the main trends of the Urartian architecture minimize the factor of foreign element influence. From this point of view, it could be stated that Urartian rock structures elaborated considerably the level of organization of cultural environment of the Armenian Highland, developing further the principles of rock-cut architecture of the Bronze and Iron Age Armenia.

3.2 Urartian Period

Rock-cut structures are especially widespread within the territory of the Urartian state [cf. Piotrovskiy, 1959; Melkonyan, 1995; Işık, 1995]. In these structures the Urartians mastered the rock, and processed it as architectural manifestations of geometrically distinct forms. These structures were so prominent in Urartu that the Urartians had their own patron deity, named Airaini [Hmayakyan, 1990]. The importance of a rock is also proved by the fact that the Urartians sometimes formed their cultural environment around it.

The rock-cut stairs, niches, artificial caves for worship and burial purposes, tunnels etc. are included among these kinds of structures. The considerable part of rock-cut structures was located near the citadel of capital Tushpa. These structures had probably various functions, however worship was the most important.

The simplest forms of Urartian rock structures are stairs, which are connected to the cult and secular structures. The most remarkable examples of the ground stairs can be found in the citadels of Tushpa, Upper Anzaf, Bostankaya, etc. Interesting examples of underground stairs are known from Toprak Kale, Miandoab and Kale Aydar.

Other simple rock structures are niches. The most processed forms of the niches had cultic function and are called “doors” or “gates”, among which are those of Ashrut or Bostankaya. The most prominent among them is the niche on the slope of the Zym-Zym Dagh rock that stretches to the north of Van (Fig. 3). This niche is called by the locals “Mher’s door”, and the inscription of Urartian kings Ishpuini and Menua on the Urartian pantheon is preserved on its surface [Hmayakyan, 1990].

“The gates” are the most often mentioned cult structures in Urartian inscriptions. These were dedicated to the gods Khaldi, Teisheba, Shivini. There are various opinions about the form of the gates. Some authors suppose that these are rock-cut niches, which could have adjacent cult structures. The abovementioned Mher’s door was, for example, of that type. The stairs led up to it, and at its foot there was a rock cut room (as in case of Ashotakert niche) to which seven stairs led, and which also bears an inscription of cultic content. Most probably, the notion of gates included both separate structures – niches and also complete complexes with various temples, adjacent structures, economic (household) and corresponding area [Tarhan, Sevin, 1975; Hmayakyan 1990].

The majority of rock-cut structures in Urartu were burial complexes. Thus, only in Van eight different rock structures were built.

Figure 3: Van ("Door of Mher"), rock-cut vertical niche with cuneiform inscription, Urartian period (photo of the authors)

The famous Khorkhorian caves (Argishti I's rooms) are on the south-western side of the rock, which consist of two large rock-cut separated complexes and a smaller cave. One blank niche and eight cuneiform columns of Khorkhorian Annals are also located near this cave. The second one is the larger Khorkhor cave, the entrance of which is bordered by the mentioned inscription. The cave consists of a large main hall, surrounded by four small rooms. Three walls of the large hall are decorated by window-like niches, two niches on each wall, and the forth wall - with four niches. In the front left corner there are carved stairs.

The most remarkable feature of the Van rock-cut structure is that a rectangular composition was applied here. Square rooms with oblique angles in plan have been found only in Ichkala, Navt-köyü, Great Khorkhorian, Lesser Khorkhorian and Northern caves. The next remarkable occurrence is the presence of niches [Piotrovskiy, 1959].

On the bank of Araxes river, in front of the Alishar watch point, territory of present Iran, an Urartian tomb was discovered. It consisted of two rooms, connected to each other, a vestibule with an arched ceiling, and a burial chamber-hall, covered with three flat, worked slab stones. It had also seven rectangular niches [Piotrovskiy, 1959].

Another Urartian tomb was found to the west of Van Lake, near Manazkert. Its entrance starts from the arch-shaped dromos, carved in the rock. On the surface of the same rock, in the rectangular niche, an inscription of the king Rusa II is inscribed [Burney, Lang, 1971].

Not far from Manazkert, in a place called Kayali Dere another Urartian rock tomb was opened. Ch. Burney was inclined to date this burial to the years of reigning of Sarduri II or Rusa I. The tomb has a vestibule and six rooms. The walls of two rooms have vaulted niches. The tomb itself was cut in a huge tuff rock [Burney, 1966].

An Urartian necropolis is located in Artske (Adiljevaz), at a distance of 300 km from Van Lake's northern shore. Here the burials carved in rock were excavated, which usually have one hall and an arched dromos. The floor of the tombs is usually placed two steps lower from the entrance [Öğün, 1967]. Tombs with the same kind of structure were also found in Sarisu plain, by Patnos, near the road leading from Adilcevaz to Yukari Goshmegh. The burials built in natural rock fissures were discovered here, which remind us of the Urartian necropolis burials in Igdır [Barnett, 1963].

A rock tomb with three halls was found not far from Maku, in Sangar. A stairway dug in the northern side of the rock leads to the entrance of the tomb [Kleiss, 1976].

One of the latter discoveries of rock-cut structures is the Geghhovit tomb, on the left bank of the river that flows through Geghhovit village (southeastern shore of Sevan Lake). The research revealed that natural niches, located 15-20 m above the river level, were partially modified and two communicating artificial cave-tombs were built. The tomb, most probably, had also a third hall, which is evidenced by the traces of a narrow corridor in the northern side of the hall. A rich collection of archaeological material was found in the burial. It included objects of armament, ceramics, separate furniture details and adornment. The burial is dated back to the late 8th century BC [Piliposyan, Mkrtchyan, 2001].

Another rock-cut tomb was unearthed near the Armenian village Agarak. The complex consists of stone and rock cut structures, with multi-layer settlements and cemetery spread around. The rock-cut tomb was found on the southern edge of the first platform. The complex consists of a vestibule, entrance and a man-made hall. A vaulted burial-chamber has rectangular plan, oriented from the north to the south. Small and large rectangular niches are carved on three walls of the chamber hall, and eight plate-shaped dimples (hollows) on the edges. Unfortunately, it was completely plundered [Avetisyan, 2003; Kalantaryan, 2005].

There are great similarities between Urartian rock-cut burials. Thus, the burial chamber is a rectangular parallelepiped in plan, the presence of niches is common for almost all rock burials, the main hall is typical for the most of the burials, around which the other rooms are grouped together. This hall was used to enter the other rooms or to exit the tomb [cf. Melkonyan, 1995]. According to B. Piotrovskiy, many details of burial structure are comparable to the ground ones. Judging by the two types of ceiling, he made a suggestion that ground structures could also have both flat and vaulted coverings [Piotrovskiy, 1959].

3.3 Hellenistic and Medieval Period

Urartian traditions continued also later, into the Hellenistic and Medieval periods. The rock-cut structures of those periods demonstrate new solutions that are observable also among corresponding structures of neighboring countries and especially in Asia Minor. During the Hellenistic and

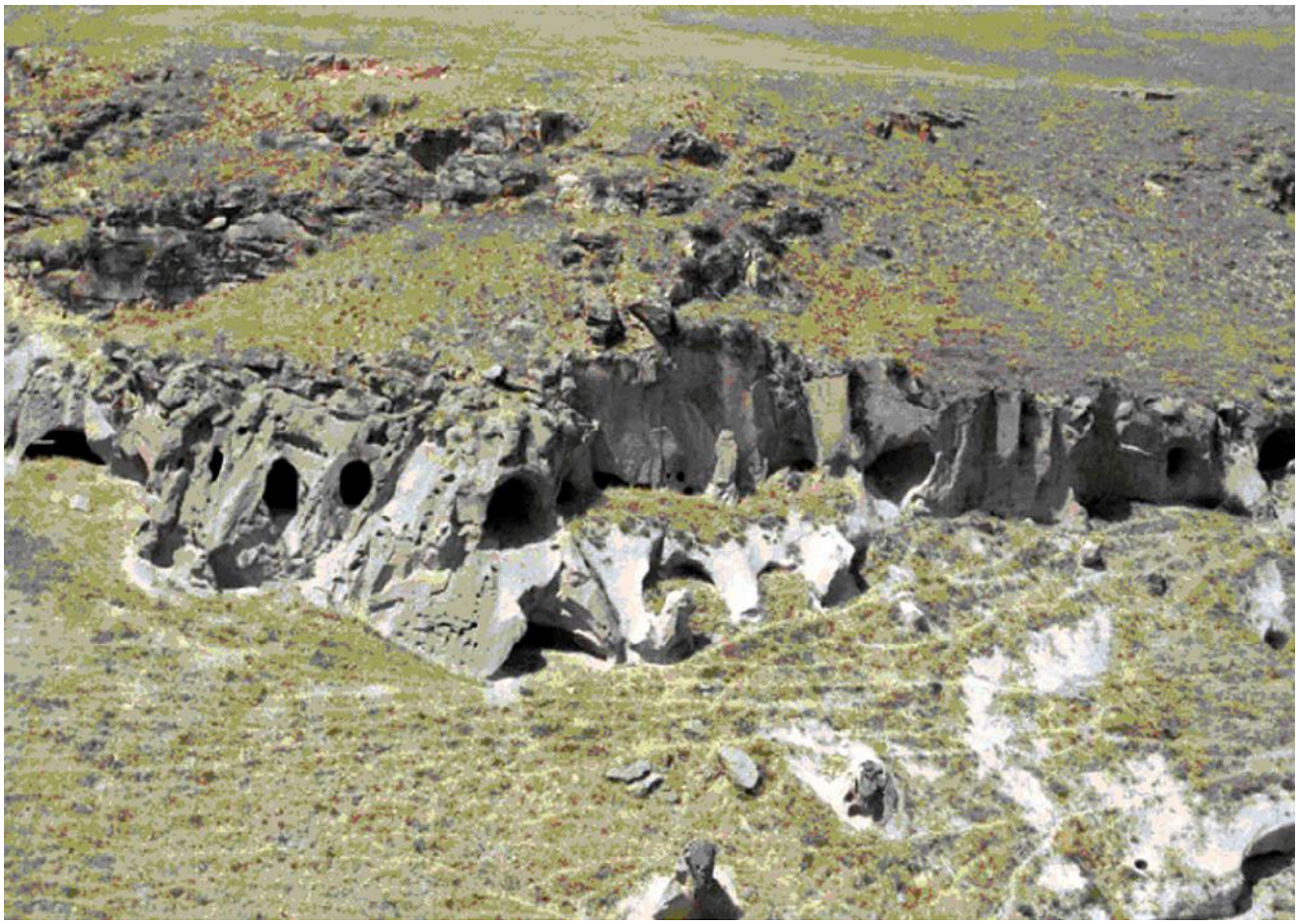

Figure 4: Ani, a view towards the rock-cut suburb, High Medieval period (photo of the authors)

especially Early Medieval period rock-cut settlements were widespread in the neighbourhood of Armenia (the most vivid example is Göreme in Cappadocia) [on Armenian-Cappadocian architectural relations cf. Kazaryan, 2000; Bixio, De Pascale, 2015]. With Christianity new elements appear in rock-treatment, as for example, catacomb burials.

The latter were not typical of Armenia, although in Armenia during the Hellenistic (Sisian) and Early Medieval (Aghtsk, Talin, Amaras, Yereruik, Tsghuk's Tanahat) periods underground burial structures were widespread, which can be observed in the context of rock-cut structures [Arakelyan, Mazmanyan, 1964].

If we compare rock-cut structures of Hellenistic and Medieval periods of Armenia, it would be evident, that there is no enough evidence on Hellenistic period. Separate data exist on the Early Medieval period (cf. the Early Christian complex, consisting of a rock-cut church, vestibule and a gravestone yard by Tigranakert of Artsakh [Petrosyan, Kirakosyan 2009]. Meanwhile the main material belongs to the High Medieval period, when rock-cut settlements and churches were abundant in Armenia [many of Medieval caves should have been used also in pagan times, as it was the case in Ani: Kipshidze, 1972]. The apogee of development could be considered the 11-13th centuries with such rock-cut sites as Ani (Kipshidze, 1972), Geghard (Hovsepyan, 1928), Martiros (Barkhudaryan, 1967), Spitak (Kalantaryan, Sargsyan, 1980) (cf. Fig. 4, 5).

For the High Medieval period the caves of Ani are of particular interest, which were studied by the expedition of N. Marr in 1915. There were ca. 1000 caves during the period of prosperity of Ani that had different functions (churches/chapels, burials, dwellings, tunnels and stairs) [Kipshidze, 1972].

During 2000-2001 a cave settlement was excavated in suburbs of Ani, within the administrative territory of Haykadzor village of Armenia. The works were conducted in two areas: in Haykadzor village and Akhuryan river gorge, in the caves in front of Horomos monastery [excavations by H. Khachatryan].

Sacralization of rocks was characteristic of High Medieval period, in form of rock-cut churches and rocks with depictions of cross-stones (Ayrivank, Havuts Tar, Mankunk, Mets Gilanlar, Ali Mardan, etc.).

This phenomenon is especially evident in area of Azat rivergorge [Khachatryan et al., 2003].

Especially noteworthy is the site called Khuts, situated in the territory of Khosrov reserve, 34 km north-east of town Artashat, in the upper Azat river. The site includes the village Khuts and rock church complex, which is carved in a piece of rock fallen down from the main rock. The complex consists of a rock church, rock platform, two rock chapels or side-chapels and a semi rock-cut grave house. It has numerous parallels in the 12-13th centuries' sites of Armenia [Hovsepyan, 1928; Khachatryan et al., 2003].

In the context of Medieval rock structures, the so-called stone doors are particularly noteworthy, a typical phenomenon for Armenia (Fig. 6, 7, 8). These devices have various appearances and functions, starting with the common amorphous rocks, which covered the cave narrow entrances, and finishing with stone doors and the doors that look like a millstone [Shahinyan, 2005; Manukyan, 2011]. In the Republic of Armenia, the stone doors are mainly spread in Gegharkunik, Shirak and Aragatsotn regions. In Aragatsotn region they are especially well researched. In general, n more than 160 corresponding rock structures were discovered between Talin and Ashtarak. All stone doors are made of basalt. Their maximum size is 160 x 130 x 42 cm, and the minimum - 60 x 40 x 16 cm, the weight is more than three tons [Shahinyan, 2005].

The caves with stone doors in Armenia consist mainly of three parts: cave-hall or halls, stone door or doors and secret passage, which is an artificial tunnel with unique masonry, quite difficult to traverse and well disguised. They are not big in size, averagely occupy an area of 40-45 m^2, but there are sometimes caves with multi-rooms and a large hall. The secret passages leading to the cave are quite long, narrow and difficult to pass. Sixty meters long passages could be seen. In some cases, these passages are wide and high, as for example, the Amberd passage, which begins beneath the cyclopean masonry of the fortress and reaches the river. The architectural design of the secret passages built between Amberd fortress and the Amberd river are identical to tunnels of the caves with stone doors.

Though the issue of dating of the caves with stone doors is uncertain, it could be stated, that in the 18th century these caves were not used for a specific purpose. The main way to define the building period of the caves with stone doors is comparative analysis. The data reveal that the majority of stone doors with projected general planning are accumulated in Aragatsotn region. These are spread at an altitude of 1000-1900 m a.s.l., from the southwestern slopes of Aragats mount to the southeastern slopes, and are mainly dug in the rocks of canyons, gorges and ravines. Separate details, like tunnels, stone doors and the caves, inside which there is a masonry parallel to the walls, as well as pithos-shaped pits could be seen in various regions of Armenia, as component part of any historical-architectural complex.

Additionally here must be noted that in the region of the accumulation of caves with stone doors there are no rock-cut, build in classical way churches, as well as cells that could be met, for example, in Ani, Khosrov reserve, Goris, Kashatagh, Lori etc. It makes us wonder, as Ararat valley and Aragatsotn were a citadel of the Christian faith. The reason of this phenomenon must be sought in absolute intolerance regarding paganism during initial stage of spreading of Christianity, as well as regarding the stone doors (the application of stone doors is not recorded in church architecture). Thus, in case of the caves with stone doors, we deal with a layer of pre-Christian way of thinking which lived on also later.

Various elements of the caves with stone doors are seen in Medieval fortress complexes (Amberd secret passages) and in Bronze Age cyclopean fortresses (Sangyar, Kare Dur, Paravi Ilikya). The caves with stone doors could refer to the ancient periods. There are at least two rock-cut secret passages and two stone doors in the foundation of cyclopean fortresses invaded by Urartian kings Argishti I and Sarduri II, as a part of the structure.

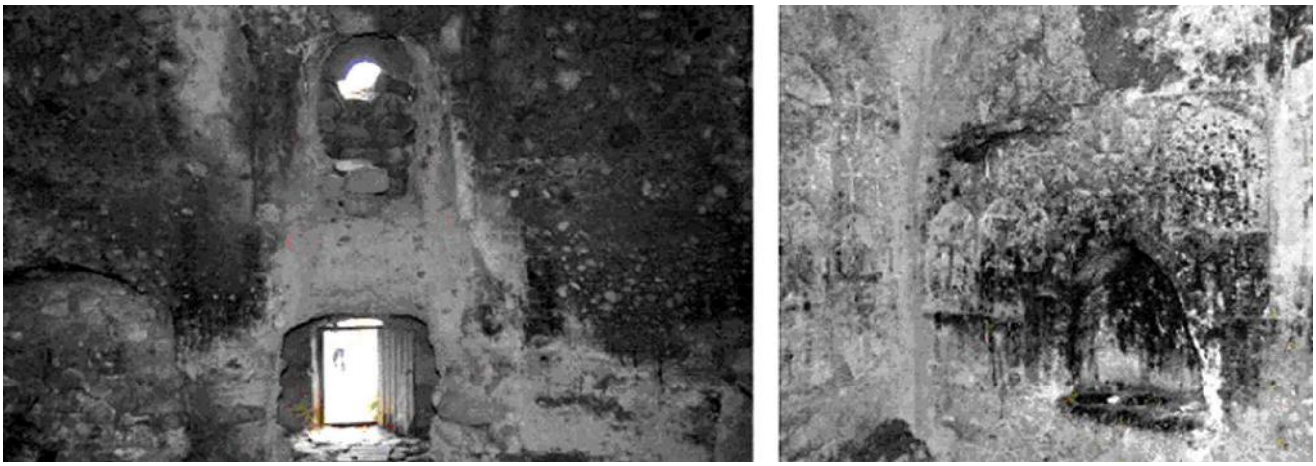

Figure 5: Martiros, rock-cut church and detail from a niche, High Medieval period (photo of the authors)

Figure 6: Karchaghbyur, rock-cut stone door, Urartian period and later (photo of the authors)

Thus, the beginning of mass building of the caves with stone doors could be dated to the Urartian or even maybe an earlier period [Shahinyan, 2005].

In this case the cyclopean fortress called Kare Dur at the north-eastern edge of Karchaghbyur village near Vardenis is noteworthy (Fig. 6). The St. Astvatsatsin and St. Sargis chapels on south-western side of this fortress are joined to each other with one general vestibule. St. Astvatsatsin chapel consists of a rectangular shaped hall and a corridor-like section, adjacent to the southern side.

On this side of the corridor, in the longitudinal walls, there are rectangular niches in each wall. It has a low entrance in its southern side. The entrance consists of stone frame and a door of an entire piece of stone. The St. Sargis chapel is a structure with irregularly rectangular plan. The entrance is on the western side, it was built later, also had a stone frame and door, which is now replaced and is located on the southern side of the chapel.

The roofing has not been preserved, but judging by the upper parts of the walls it could be assumed that it had been made of huge stone slabs, which later were replaced by a tinplate conical roof. Like the previous one, this structure is also completely underground and in the western entrance side, in the vertical section of the slope, it has an outer façade. These chapels differ from the Medieval Armenian examples by their planning and three-dimensional solutions and find parallels with Urartian burials (Chermes, Yerevan, Badnots). Judging by these specifics and comparative analysis and taking into account the fact that this building is located near the fortress Kare Dur and was inhabited also in Urartian period, it could be assumed that it was initially an Urartian burial.

The stepped covering (*hazarashen*) of the burial hall, most probably, is a result of reconstruction, and previously had been covered by the slabs put on the transversal walls in parallel, which rested on the longitudinal walls, like the preserved covering of dromos.

The massive niche of the northern wall of the hall and the second underground hall in the south-eastern side form a basis to conclude that it consisted of three burials interconnected with corridors and could had a vertical pit-like entrance.

As the cross-stones were incrusted in the walls are dated back to the 10-14th centuries by their stylistic features, it could be concluded that these burials were transformed into the Christian chapels in ca. 14th century [Hmayakyan, Sanamyan, 2001].

Thus, we can conclude that the phenomenon of stone doors arises from the ancient times and exists up to the present day in the Armenian culture.

Figure 7: Aghtsk, rock-cut stone door, Urartian period and later (photo of the authors)

Figure 8: Lernarot, rock-cut stone door, Urartian period and later (photo of the authors)

4. SPIRITUAL PERCEPTIONS

It is clear that the rocky environment was one of the main cores, around which the cultural environment of the Armenian Highland developed. In this regard it is not accidental that mountains, rocks and caves as sacred places played considerable role in the spiritual perceptions both of տիե inhabitants of the Highland [Petrosyan, 2003; Karapetyan et al., 2004; Abrahamyan 2006] and in perceptions of neighbouring peoples of Armenia [cf. Avetisyan, Bobokhyan, 2005]. Answering the question, why the Highland in particular became an object of such notions in Hittite-Hurrian and Mesopotamian legends, it must be taken into account that besides the circumstance of being rich in mountains, rocks, caves, water sources this territory was also volcanic zone. The hills and rocks were formed by the activities of volcanoes, which were active not only in prehistoric periods, but also during the Bronze Age and influenced the worldview of the people. The data about volcanoes and their surrounding is preserved in Sumerian and Hurrian-Hittite sources: the areas described there are located between the Lakes Van and Urmia and in the neighbourhood of mountains Ararat, Tondrak and Nemrut being characterized by minerals like granite, basalt, hematite, obsidian [Haas, 1982; Foster, 2000; Gadjimuradov, 2004]. An iconographic manifestation of this volcanic landscape seems to be depicted on the famous golden goblet from Hasanlu (mid 2nd millennium BC) [Foster, 2000].

5. CONCLUSIONS

The mountainous character of the landscape of Armenia conditioned the dependence of all cultures developing within its territory from mountains/rocks/artificial cavities. It is reflected in architectural principles, worldview and generally in development of cultures of the region. Diachronic analysis of existing data allows the following conclusions:

1. The dialogue between the man and the rock/cave in the Armenian Highland as everywhere begins in Stone Age. During the Stone Age the human being is passive regarding the rock, he is only a cave inhabitant. Beginning with the Bronze Age, and even a bit earlier, humans have started to change actively the rock environment in Armenia and in the period of the Urartian state (Middle Iron Age) they considerably transformed it, a process which continued in the Hellenistic and Medieval periods. There were both active and passive periods of rock treatment. In this case the Urartian and High Medieval periods are marked by extreme activity. If before the Urartian period the inhabitants of the Armenian Highland processed the horizontal rock, then with creation of Urartian state the rock is worked also vertically. That fact was connected to the inner demand to demonstrate the power of the elite.

Before the creation of Urartian rock structures, more or less elaborated cave structures were absent in the territory of the Armenian Highland, though there are numerous examples of rock treatment. In pre-Urartian period these artificial caves were not widespread and had a predominately local character. Meanwhile Urartian structures were cultic, memorial, hydro-technical and were mainly cut in tuffs and basalts. The structures of the Armenian period were cut as a rule in tuff and represented cult, fortification, hydro-technical structures, underground settlements. Some examples demonstrate that there is possibly a hereditary link between the Bronze Age, Urartian and Armenian rock-cut structures. The Armenian rock-cut structures repeat some features of the Urartian ones, and the latter ones – of the Bronze Age. It is apparent that the earlier underground architectural forms made up the basis for creation and application of ground architectural forms in Medieval Armenia (Aghtsk, Ani).

2. The rock structures of the Armenian Highland have their peculiarities: they are mainly sacred, merged with the local

landscape and traditional. However they have affined territory, in which similar structures exist – the Asia Minor. Since the Hittite period, Asia Minor has been an important cradle of rock-cut structures. Similarities between Hittite, Phrygian, Lycian, Lydian, Cappadocian and Armenian rock-cut structures are evident. And this is not accidental, as Central Asia Minor and the Armenian Highland were neighboring cultural worlds, often demonstrating similar trends in cultural developments.

3. Research of rock-cut structures and their environments in the Armenian Highland allows considering this kind of structures and levels of their abstract perception in general cultural developments of the Highland as an invariant feature.

Cave dwellings/burials/sanctuaries (from the Stone Age to the Medieval times), rock-cut sacred paths (Bronze Age - Medieval Period), rock-cut stairs (Bronze Age - Medieval Period), rock-cut inscriptions (Iron Age - Medieval Period), rock-cut tunnels (Bronze Age - Medieval Period), stone doors (Urartian - Medieval Period) are the forms of expression of that permanence.

Regardless of the fact, what kind of people inhabited the Highland, the studied region appears as a cultural environment, where similar patterns of development function at least since the Bronze Age.

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Underground Herodium: Guerrilla Warfare during the Bar Kokhba War (132–136 CE) under Herod's Royal Palace Fortress

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Abstract

Herodium, King Herod's Palace-Fortress, even though partly in ruins, served as a headquarter of the rebels' administration during the Second Jewish Revolt against the Romans (known also as the Bar-Kokhba War - 132–136 CE). Herodium was used not only as a fortress, but also as a base for guerilla warfare against the Roman units in the surroundings.

The heart of the guerilla warfare was an extensive network of tunnels hewn into the bedrock, and cut into the earthen fill of the artificial mountain and the dirt-covered structures on the slopes. The tunnels were hewn out starting from the palace fortress at the summit and dropped down the slopes in multiple levels towards camouflaged sally ports, intended for launching surprise attacks and for escape. In contrast to refuge systems in Judea, in which fighters had to crawl on hand and knees, the tunnels at Herodium were tall enough to permit a person to stand up and move fast. To conceal the existence of the tunnels the builders piled the debris into the large Herodian cisterns, into chambers and passageways in the foundations of the palace fortress, so that observers at a distance would not discern the heaps of dirt.

Digging through the fill of the artificial mountain involved a serious danger of collapse, forcing the rebels to shore up the tunnel walls and ceiling. To support the walls and ceiling of these tunnels, the rebels used wooden beams, stripped from the roofs of the Herodian palaces and structures.

Keywords: Herodium, Roman Judea, Bar Kokhba Revolt, Second Jewish Revolt, Underground Chambers, Tunnels, Cisterns

1. INTRODUCTION

The Herodium, King Herod's Palace-Fortress (Fig. 1), even though partly in ruins, served as a headquarter of the Bar-Kokhba's administration during the Second Jewish Revolt against the Romans (132–136 CE). Herodium, conveniently located at the edge of the Judean Desert, 13 km SE of Jerusalem, was used not only as a fortress, but also as a base for guerilla warfare against the Roman units in the surroundings. We learn about it not only from the accumulated archaeological data, but also from the documents revealed in the caves of Wadi Murabaʿat (Fig. 2), which served at the end of the revolt as a retreat for refugees from Herodium and adjacent Judean villages.

Figure 1: Herodium: The palace-fortress looking south, from Lower Herodium (photo B. Zissu)

Figure 2: Wadi Murabaʿat, caves 1 and 2 (photo B. Zissu)

Herodium and adjacent Judean villages. In these documents, the camp at Herodium ("מחנה שיושב בהרדיס") and its commander Yeshua son of Galgula are mentioned.

The impressive Herodian-era finds at Herodium have attracted most of the attention, shunting aside significant evidence from the Bar Kokhba War.

The archaeological data unearthed during over fifty years of excavations and the information provided by the documents found at Wadi Murraba'at allow us to reconstruct a fairly reliable picture of the events at Herodium during the war. This picture is different from what we find elsewhere in Judea and points to the unique nature of this site.

The famous description of the rebels' deployment during the Bar Kokhba Revolt provided by the Roman historian Cassius Dio fits the events at Herodium:

> To be sure, they [the Jews] did not dare try conclusions with the Romans in the open field, but they occupied the advantageous positions in the country and strengthened them with mines and walls, in order that they might have places of refuge whenever they should be hard pressed, and might meet together unobserved under ground; and they pierced these subterranean passages from above at intervals to let in air and light.

In conclusion Cassius Dio adds: "Fifty of their most important outposts and nine hundred and eighty-five of their most famous villages were razed to the ground" [*Historia Romana* 69.12.3–14.1, trans. Cary].

Herodium seems to be one of the "fifty most important fortresses" mentioned by Cassius Dio. His description of the defensive and offensive complex, which includes walls and an underground system, accurately reflects the situation at Herodium, as evidenced by the archaeological record. However, it appears that, in contrast to the popular guerrilla tactics employed by the rebels throughout Judea, with fighters emerging from the villages and rock-cut hiding places, which was primarily defensive in nature, at Herodium they conducted a coordinated offensive guerrilla warfare.

2. THE ARCHITECTURAL AND CHRONOLOGICAL CONTEXT

Greater Herodium, a construction project that engaged Herod for most of his reign, was a complex of palaces that included a fortress, an administrative center, recreational facilities and gardens, and a royal tomb compound (Fig. 3).

Three major complexes were built at Herodium during Herod's reign: the palace fortress at the summit; lower Herodium; and the structures on the northern slope, which include the royal theater and the burial site [Netzer 1981, 1999, 2006; Porat et al. 2015c].

The excavations of the past decade have revealed that, during his final years, Herod turned Herodium as a whole into a monumental burial site, with an enormous grave marker (the cone-shaped artificial mountain), a mausoleum on the northern slope, a palace fortress at the summit and a new monumental staircase running from the base to the summit, connecting all these structures [Netzer et al. 2009, 2010, 2013; Porat et al. 2015c].

The creation of the artificial mountain required dumping hundreds of thousands of cubic meters of rockfill on the slopes surrounding the fortress walls, which covered all the Herodian structures, except for the tomb compound which remained exposed. When the main opening to the palace fortress and the vaulted corridor leading to it were sealed, what was left resembled the vent of a volcano, closed in and fortified on every side.

During the decades between Herod's death and the Jewish War, the palace fortress was remodeled. The exact nature of its use remains unclear. It may have been garrisoned from time to time, without any significant rebuilding.

When the Jewish War broke out, the site became a rebels' stronghold until the Romans overran it in 71 CE. The insurgents divided the palace into residential and activity areas.

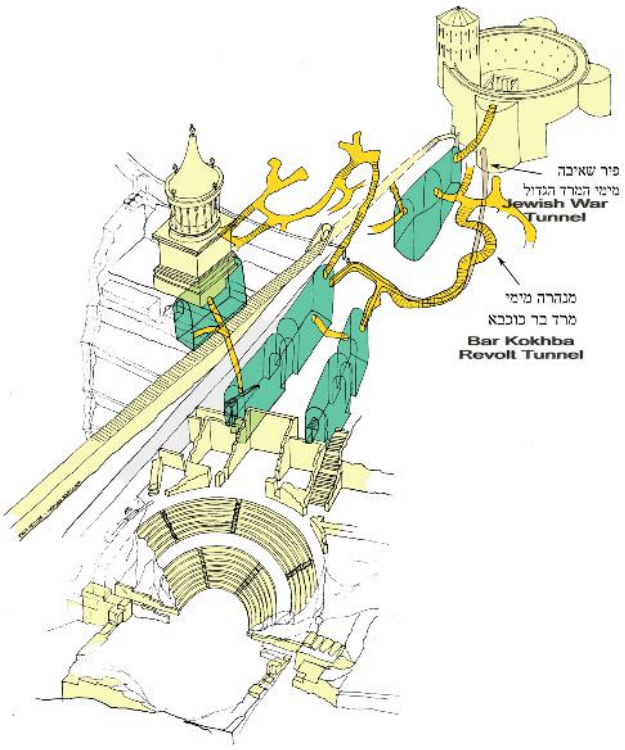

Figure 3: Artist's three-dimensional view of the tunnels, the cisterns, the monumental flight of steps, the royal mausoleum and the palace fortress (drawing R. Chachy)

They built various structures, such as ritual immersion baths (*mikvaot*), and dug a shaft and a tunnel into the mountain to create direct access to the cisterns on the slope [Netzer et al. 2011; Porat et al. 2015b].

The archaeological record suggests that a Roman garrison was briefly stationed on the spot, apparently during Trajan's reign or slightly thereafter.

After the Bar Kokhba War, the palace fortress remained in ruins for two and a half centuries, until the construction of a Byzantine monastery.

3. STUDIES OF THE BAR KOKHBA–ERA RUINS AT HERODIUM: A BRIEF REVIEW

The four seasons of excavation of the palace fortress by the Franciscans, directed by Virgilio Corbo (1962–1967), uncovered buildings and features dating to the Bar Kokhba Revolt (Fig. 4). The picture provided by these excavations is of extensive rebels' activity. However, technical and methodological limitations, notably the difficulty in clearly distinguishing remains from the Jewish War from those of the Bar Kokhba Revolt (in areas where no coins were found), made it difficult to present a well-founded picture of the site during the Second Revolt [Corbo 1963, 1967, 1989].

It seems that the rebels took advantage of the Herodian structures and built thin stone walls against them to divide the rooms into smaller units. These new walls were usually fashioned out of reused stones and architectural elements. The ceiling borne by these walls was generally light construction, supported by wooden beams.

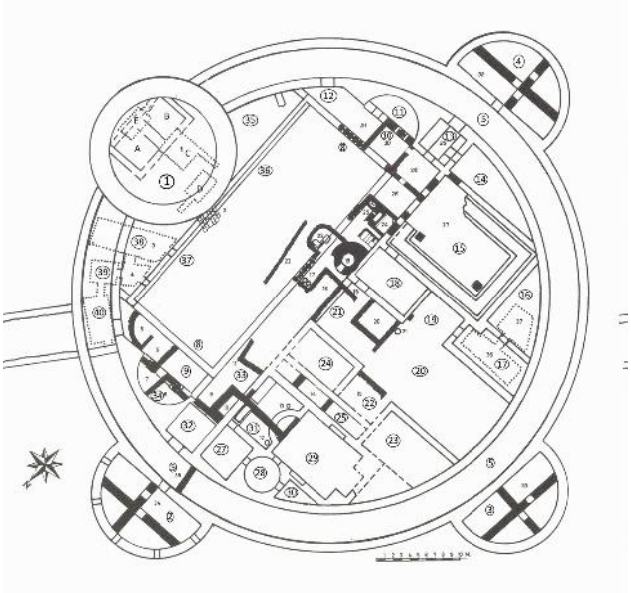

Figure 4: Map of the remains from the two revolts against the Romans, as published by Corbo [1989, Map 2]. The circled numbers refer to the Herodian buildings shown on Corbo's Map 1

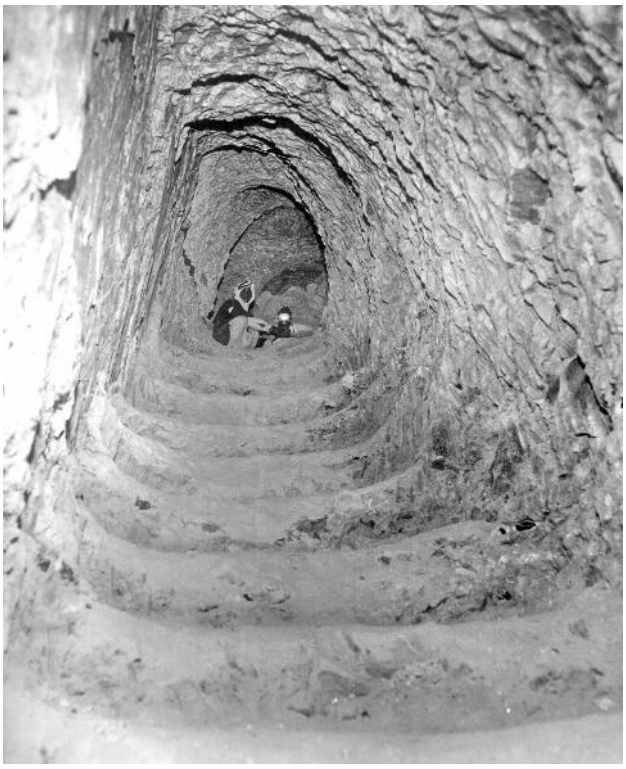

Figure 5: One of the stepped tunnels, during Foerster's excavation (courtesy G. Foerster)

The rebels used these structures mainly as living quarters, but also for storage, assembly, and worship. They include water installlations, weapons forges, and cooking and baking facilities.

Corbo's excavations in the southern exedra unearthed a series of buildings of this type. A large hoard, comprising 822 bronze coins restruck by the Bar Kokhba administration, was found under one of the floors [Spijkerman 1972]. Three human skulls were also found in this room.

Other walls built by the rebels served to stabilize debris from earlier periods in order to make it possible to use the adjacent areas. These include walls built of debris and re-used architectural elements near the main gate between the entrance hall of Herod's palace and the peristyle courtyard.

Study of the tunnel system began in 1968, under the direction of Gideon Foerster (Fig. 5) [1969, 1970, 1973]. The underground system was partly excavated by Ehud Netzer and Shimon Arazi between 1973 and 1975 (Fig. 6) [Netzer 1988].

From the 1970s until nowadays, the Herodium excavations team conducted extensive excavations of upper and Herodium, where they uncovered varied artifacts, elements of the guerrilla system as well as dramatic evidence of the battles that took place in the dying days of the revolt.

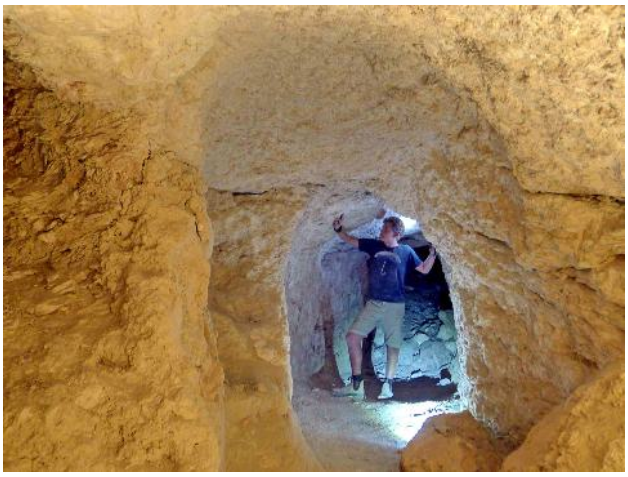

Figure 6: Typical portion of tunnel excavated by Netzer, Arazi, and the Kfar Etzion Field School (photo B. Zissu)

4. THE ARCHAEOLOGICAL RECORD

The main archaeological findings include (Fig. 7):

(1) Built and hewn-out remains; this category falls into two related and overlapping groups:

(a) an extensive system of offensive and defensive tunnels dug out and constructed below the surface of the mountain, with sally ports on the slopes. This system of tunnels stands at the center of this paper.

(b) structures that were adapted and re-used by the rebels within the ruins of the palace fortress, as explained above.

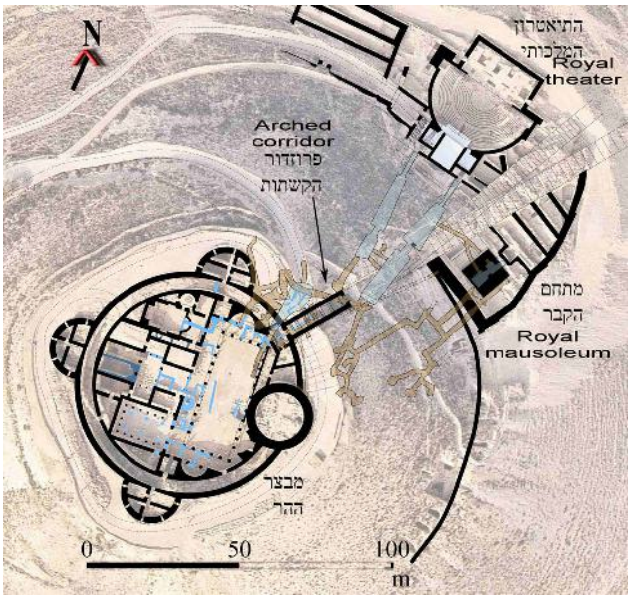

Figure 7: Plan of the Bar Kokhba revolt structures and tunnels, superimposed on an aerial photograph and the plan of the Herodian structures (photo Tatzpit; processing: M. Edelkop and R. Chachy).

(2) Various (portable) archaeological artifacts;

(3) The archaeological context: evidence of battles and associated destruction.

4.1. The Underground Tunnels

An extensive network of tunnels was hewn into the chalk of the mountain (gutting the cisterns of the Herodian palace), and cut into the earthen fill of the artificial mountain and the dirt-covered structures on the slopes. The tunnels in the interior of the mountain were hewn out starting from the palace fortress at the summit and dropped down the slopes in multiple levels towards camouflaged sally ports, intended for launching surprise attacks and for escape if necessary [Netzer and Arazi 1985; see Fig. 7]. The tunnel system was meant for both offensive and defensive purposes and was a local improvement of guerrilla tactics that permitted strategic control of the slopes. Implementation of this offensive and defensive strategy required rapid movement within the tunnels. So, in contrast to refuge systems in Judea, in which fighters had to crawl on hand and knees, the tunnels at Herodium were tall enough to permit a person to stand up, equipped with steps where they sloped, and had no tight passages. To conceal the existence of the tunnels and sally ports from the Romans, the builders piled the debris from their excavations in earlier chambers inside the mountain or in the building at the summit, so that observers at a distance would not discern the heaps of dirt. Most of the material that was excavated was dumped into the large Herodian cisterns and into the northern section of the vaulted passageways in the foundations of the palace fortress. The four Herodian cisterns were breached by tunnels (Fig. 8) and taken out of service when they were filled with hewing debris. However, there were four other cisterns under the palace fortress. It appears that only two cisterns, with a total volume of about 200 m^3, were in use during the Bar Kokhba revolt.

In a number of places where the tunnel-diggers encountered flint bands that were too hard to bore through they were forced to abandon a tunnel midway and take an alternate route.

Figure 8: The largest cistern, looking north. Note the tunnel that breaches its wall on the right hand side (photo B. Zissu)

This is why, for example, the tunnel system that extended eastward was never completed. By the opposite token, digging through the fill of the artificial mountain and through creviced and crumbling rock involved a serious danger of collapse, forcing the rebels to take steps to shore up the tunnel walls and ceiling. Approximately one-third of the total length of the tunnels currently known was dug through such fill. To support the walls and ceiling of these sections, the rebels used stone or mud walls and wooden beams. Many of these beams were found in an excellent state of preservation. They were frequently set in notches cut into the rock or at regular intervals in the stone or mud walls, creating a pi-shaped (Π) support structure for the tunnel ceiling. In other cases, the ceiling itself was made of closely spaced wooden beams. Sometimes beams were placed close together in the supporting walls. Such beams were also used to build stairs and facilitate passage between levels. To supply the many wooden beams needed to support the tunnels, Bar Kokhba's men stripped the roofs of the Herodian-era structures in the palace fortress.

There were entrances to the tunnels from inside several levels of the palace fortress, near the structure's original entrance area. One of the openings to the upper level of the tunnels (dug out of the earthen fill) broke through the wall

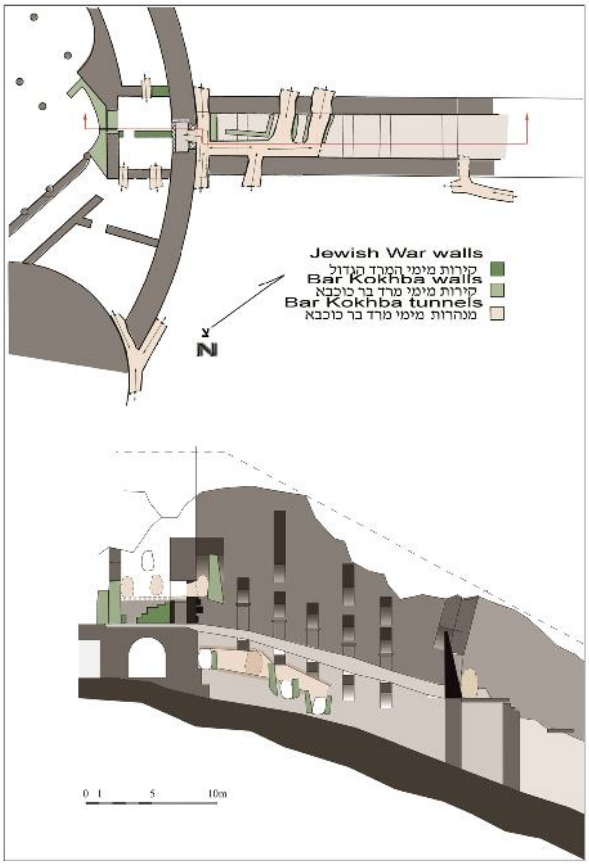

Figure 9: Plan and cross-section of the entrance hall to the palace fortress during the Bar Kokhba Revolt

Figure 10: Breaches in the eastern wall of the fortress entrance hall. Burned wooden beams in a collapsed wall. The soot-covered remains of the tunnels that pierced the walls of the vaulted corridor and the supporting wall that protected the tunnels from the earth fill in the sealed-off portion of the corridor are visible on either side of the blocked entranceway

that had been built to seal the main gate of the fortress near the end of Herod's life. Two tunnels extend from here—one going west and the other east—and pierce the walls of the vaulted corridor (Fig. 9). The entrance hall (whose opening to the courtyard was sealed, as noted above) was apparently penetrated through holes in its eastern and western walls (Fig. 10). Another opening to this section of the tunnel system was discovered just north of the eastern tower, cutting through the palace fortress's thick retaining wall. Right inside the opening, the excavation (during 2014–2015 season) turned up two Bar Kokhba coins as well as arrowheads and ballista projectiles. The main access to the lower parts of this tunnel system seems to have been via a staircase leading from the northern part of the palace courtyard at the foot of the round eastern tower down to the "middle cistern," from which tunnels extended in every direction [Netzer and Arazi 1985].

The top of this staircase, built in part of ashlars, architectural members and sections of the cornices of Herod's building, extended far above the original level of the garden and apparently reached the level of the rebels' activity above the cellars north of the eastern tower, which was recently excavated [Corbo 1967, 1989]. Other entrances to the tunnel system were located in the northern part of the vaulted cellars in the foundations of the outer walls of the palace fortress. These included passages (supported by wooden beams) between the two levels of vaults (Fig. 11) and an opening that led to the deeper underground tunnel system [Netzer and Arazi 1985].

4.2. Sally Ports Emerging from the Tunnels onto the Slopes

To date, sally port openings have been documented only on the northern slope, on several levels (Fig. 12).

Figure 11: A passageway supported by wooden beams, which linked the two vaulted cellars in the foundations of the northern section of the outer walls of the fortress. The upper vault is covered with soot from a major fire

The builders occasionally took advantage of the remnants of old structures and walls on the slope and integrated them into a sally port or used them to hide the opening. For example, three of the four original mouths of the four known cisterns that were hewn out of the mountain during Herod's time were used as sally ports; significant labor was invested to open an additional sally port through the eastern cistern (see below). The old walls and the rockfall on the upper section of the tomb compound on the slope were also used to build and hide the sally ports. One of them was discovered in the 1970s, just south of the destroyed mausoleum; another was recently found along the eastern wall of the structure's foundation. The ports were hewn into the rock and the older accumulated strata, with walls alongside to conceal the exit. Additional sally ports, all of them in a state of collapse, were discovered above the "slanted wall" above the mausoleum [Porat et al. 2015a].

Inside the eastern cistern, beneath the mausoleum, evidence was found of the rebels' attempts to break through to the surface through the mouth of the cistern (Fig. 13). They were frustrated, it seems, by the massive rocks from the destroyed mausoleum that had fallen and totally blocked the mouth of the cistern. As part of their efforts, the rebels

Figure 12: The layout of the sally ports on the eastern slope, superimposed on a diagonal aerial photograph (photo Tatzpit)

Figure 13: A tunnel that ran out from the main cistern, at the point where it breached the western wall of the eastern cistern

removed various architectural elements of the mausoleum from the inside the cistern and must have hauled them out towards the west through one of the tunnels leading to the central cistern, which is where they were discovered.

4.3. The Tunnels Uncovered During the 2014–2015 Excavations

During the course of the excavations conducted in 2014-2015, which focused on the area at the entrance to the palace fortress and its entrance hall, many segments of attack tunnels that pierce the walls of the structures and the earth fill inside and outside them were discovered (Fig. 9). Tunnels ran through the retaining wall between the eastern tower and the entrance hall of the palace fortress; they seem to have been the direct or indirect cause of the total collapse of this segment of the wall.

By the entrance to the palace fortress we found two tunnels that cut through the walls of the arched corridor that led to the gate. Under the southernmost arch of the corridor, we found a tall support wall, which ran the length of the corridor to the height of the arch and served to hold back the fill that blocked off the corridor so it would not collapse into the tunnels dug in the fill between the supporting wall and the gate (Fig. 10, above). The upper section of the Herodian blockage at the entrance to the palace fortress was apparently breached at this stage to permit access to the tunnels. The support wall was built of dozens of crosshatched wooden beams, mixed with mud and small rocks (Fig. 14). The wall was topped by a large wooden plank (3 m × 0.6 m and 4 cm thick), carefully fashioned of Jerusalem pine (*Pinus halepensis*), as identified by Dafna Langgut. We assume that the Bar Kokhba rebels took this impressive piece of lumber, like most of the other beams used in the tunnel system (most of them of cypress wood—*Cupressus sempervirens*), from various Herodian-era buildings within the palace fortress.

We obtained indirect evidence for the removal of the wooden beams from the Herodian fortress during our 2007 excavation in the perimeter corridor south of the synagogue. Under rockfall in this area, we excavated layers of dirt that appear to have resulted from a landslide and contained floors and ceilings of the upper stories, one atop the other. Judging by these finds, it is likely that some of the floors that collapsed contained coins from the Jewish War and others had coins from the Bar Kokhba revolt. At the time of the collapse, which presumably occurred because of the removal of the wooden beams from the ceiling of the corridor (or perhaps in a later earthquake), the floors collapsed in a heap, which resulted in a mix of layers because the rebels in both revolts worked on top of the floors of the rooms that had collapsed. These layers of dirt contained, *inter alia*, a Year One Bar Kokhba coin with a palm branch and lyre. Another Bar Kokhba coin, this one from the undated series, was found in situ in the upper layers [Porat, Netzer, Kalman, and Chachy 2010: 100–102].

Figure 15: A tunnel that was dug on the lower level of the arched corridor below the level of the lower arches, which was filled with earth. This section of tunnel had rough stone walls and broke through the corridor wall towards the upper cistern—the "middle cistern" (photo S. Tiram)

Similar evidence was found at the base of the northern open tower. In the large cellar, on the level of the vaulted cellars below the outer walls of the fortress, we surveyed a close-packed pile of pilaster drums that must have fallen from the top of the tower (about 20 m above) through all the tower's stories, without being stopped by the ceilings that had been dismantled. Even the narrow interior walls inside the tower had shifted and sunk slightly, apparently in part due to the removal of the wooden beams that had fastened them to the structural walls of the tower.

On the lower level of the arched corridor, under the level of the lower arches, we found stretches of tunnels breaking off a central tunnel that ran the length of the corridor and cut through its walls at four different points (Fig. 9). The fact that the tunnels ran through the corridor, which had been blocked with dirt, forced Bar Kokhba's men to employ many supports, which consisted of relatively thin stone walls and many wooden beams (Fig. 15). We make special note of a tunnel discovered below the entry to the palace fortress, whose ceiling was made entirely of horizontal beams that were placed one next to another and rested on wooden uprights (Fig. 16).

While digging in the artificial mountain east of the corridor, we discovered another tunnel that ran the length of the eastern wall of the corridor and of the "later staircase" and apparently led to the sally ports found on the slopes above the tomb compound. Note, however, that most of the sally ports of the tunnels discovered during the recent excavation seasons have yet to be located.

4.4. The Distribution of the Tunnels

Several noteworthy points emerge from the updated three-dimensional map of the distribution of the underground tunnels known as of today (Fig. 7). First, they are con-centrated on the northeastern slope, alongside the path up

Figure 16: A section of tunnel roofed with wooden beams on the lower level of the arched corridor, below the fortress gate. View from the north (photo S. Tiram)

the mountain on the monumental staircase. Second, many of the tunnels open out of the old system of cisterns on the northern slope; the detritus from their excavation was dumped into the cisterns, the hewn-out sections were used for passage, and the openings on the north were used as sally ports. Third, there is a phenomenon of parallel tunnels that open onto the slope in close proximity. This is apparently meant to allow a concentrated attack, in which many fighters can converge on a point quickly and then withdraw into the fortress. In addition to the tunnels integrated with the cisterns, another group of tunnels emerge near the destroyed royal burial ground (Fig. 12). The area of the mausoleum is the only section of the slope that was not covered by the dirt fill that created the artificial mountain, so here the rebels did not have shore up the tunnels against the fill. As Netzer and Arazi [1985] demonstrated, the tunnel diggers were unable to break through to the eastern slope because of the high layer of flint in this sector [Ilani et al. 2015].

4.5. The Date of the Underground Tunnel System

The dating of the tunnels to the Bar Kokhba period is based on their stratigraphic relationship with earlier (mostly from the Jewish War) and later (Byzantine) finds. In several places, however, Bar Kokhba coins and additional artifacts from the second revolt make it possible to date the tunnels directly. In light of the new excavations, which have provided a better knowledge of the characteristics of the Bar Kokhba–period tunnels, it is also possible to date tunnel segments on the basis of typological considerations, such as the method of hewing and supports. In general, it seems that all the tunnels of this type at Herodium can be dated to the Bar Kokhba period with a high degree of probability.

As an example of the stratigraphic relationship between the tunnels and earlier remains, Netzer and Arazi [1985] emphasized that many of the tunnels cut through the steep shaft that descended from the palace fortress to the lower level of cisterns and has been dated to the days of the Jewish War. This shaft was meant to make it possible to draw water from inside the fortress without having to go outside.

Another shaft, in the northern section of the fortress courtyard near the entrance, was apparently cut during the Jewish War and used to draw water from the "middle cistern." These shafts permitted access to the water source without the need to leave the fortress to access the cistern openings on the slopes, which would have entailed exposure to the enemy.

Another example relates to the remains of the staircase that descended from the fortress courtyard to the upper section of the tunnel system (through the "middle cistern"). The head of this staircase, which Corbo excavated (Fig. 4), was built inside a layer of rockfall from the end of the Jewish War, which covered the palace courtyard, as well as an adjacent *mikveh* constructed during the the Jewish War (see below). A Bar Kokhba coin discovered in the debris above the staircase corroborates the dating to the Bar Kokhba period [Porat et al. 2010; see also discussion in Grossberg et al. 2011, and Corbo 1967]. When Bar Kokhba's men were building the staircase, they damaged a water system that had been built in the northeastern section of the palace courtyard inside the fill of the garden.

That system was apparently connected to the nearby cistern installed in one of the rooms of the palace, just the north of the base of the eastern tower [Corbo 1967: 95–97, Map 1, No. 38; all room numbers in the text are based on Corbo's numbering on this map, unless stated otherwise. See also Fig. 4]. The construction of this cistern, which altered the original purpose of this room and eliminated the doorway to the next room on the north (No. 39), was undertaken at a later stage in the history of the Herodian palace—apparently when the entrance was sealed at the end of Herod's reign.

The water system may also be related to the drainage channel, also from late in Herod's life, which was recently discovered near the entrance to the palace and led through the arched corridor to one of the cisterns on the slope. Corbo assumed that the mouth of this cistern (No. 38, which was completely clean) was sealed during the Rebellion [Corbo 1989: Figs. 53–54]. If so, it was part of the steps taken by the rebels when they created the

aforementioned staircase in order to descend into the tunnel system [Corbo 1967]

The dating of the sally ports near the tomb complex on the northern slope is also based on stratigraphy. The sally ports cut through remains from the Jewish War and the garbage dumped there afterwards. Moreover, they are clearly part of the layer, dated to the second revolt, that covered the tomb compound and included hundreds of ballista stones.[1]

The excavation allowed us to accurately date the two openings from the palace fortress into the upper section of the tunnel system. Two Bar Kokhba coins were found next to the breach alongside the eastern tower (and north of it). In addition, the opening into the tunnels cut through the material blocking the main gate (above) is on the same level as the activity area in the entrance hall that was fixed up over the debris and the archaeological layer that was formed there during the interbellum period (this follows from the coins found in it; see Fig. 10). A burnt layer in the entrance hall, beneath scorched and collapsed wooden beams and building stones, is the result of the Roman capture and destruction of the fortress at the end of the war.

4.6. The Tunnels in the Built-Up Area of the Palace Fortress and their Date

The excavations in the palace fortress have uncovered a number of short tunnels that were cut through walls; these linked the rebels' activity areas to one another and to the system of underground tunnels (Fig. 17). One tunnel of this type ran eastward from Room 13, in the southern part of the fortress, into a storage room from the same period that was located in a barrel vault in the southeastern foundations of the outer walls of the fortress (Fig. 18). This tunnel is entered from a room southeast of the synagogue (No. 14) and descends through an opening in its eastern wall to Room 13. The packed earth floor of this tunnel yielded a Bar Kokhba coin (from the undated series decorated with a lyre and a palm frond; see Porat et al. 2010), and another from Hadrian's reign (119/120 CE). The continuation of this level of activity, dated to the Bar Kokhba period, was discovered by Corbo in Room 13 (Locus 29). Corbo reported finding layers of ash and Bar Kokhba coins here [Corbo 1967; Spijkerman 1972]. Another opening down to the storerooms in the vaulted cellar was pierced from the courtyard level, through the lower section of the Herodian gate in the southeast of the large peristyle courtyard (No. 12) and adjacent to Room 31, which Corbo dated to the revolt.[2] An attempt was apparently to dig a tunnel leading

Figure 17: The locations of the breaches in the walls and the short tunnels within the palace fortress (photo Tatzpit)

Figure 18: A tunnel that ran from Room 13 to the vaulted cellar in the foundations of the southern section of the outer walls of the fortress. Right: view eastward; center: in the passage adjacent to the original wall of Room 13, which is decorated with a fresco (photo Z. Radovan); left: view from within the cellar to the north

south from the storeroom in the vaulted cellar to outside the fortress. However, a cave-in in this area forced the rebels to shore up the section of wall that collapsed and abandon this initiative (Fig. 19).

Another short tunnel was discovered in the cruciform courtyard (Room 20, in the western section of the palace), emerging northward from a room the rebels built in the northern arm of the courtyard [Corbo 1967]. The tunnel was cut through the courtyard's Herodian wall towards the bathhouse to its north (Room 25). The floor of the tunnel is approximately one meter lower than that of the room, which it may have cut through at some point during the revolt. A Year 2 Bar Kokhba coin and an intact chalk vessel were found on top of the Bar Kokhba stratum southwest of this room, which the rebels created on top of a

[1] For more on the remains from the Bar Kokhba Rebellion in the tomb compound, see Porat et al. 2015. For more on the pottery finds, see Gärtner 2015; for more on the weapons, see Stiebel 2015.

[2] This opening was exposed by antiquities looters during the 1980s, when the wall that blocked off the opening against the fallen rock and dirt in the outer wall of the fortress was breached. These remains were documented by Netzer and Radovan.

Figure 19. Inside the vaulted cellar on the southern side of the outside walls of the fortress. The supporting walls are of stone, mud, and wood were apparently required by a collapse of part of the double perimeter wall caused by the opening of a tunnel.

thick layer of rockfall [Porat et al. 2010]. A chapel was built atop and within this layer during the Byzantine period [Corbo 1967].

Several more attempts to dig short tunnels of this type were discovered in the surviving upper section of the eastern round tower, but none of them was finished. These tunnels were hewn out of the tower's massive core and may have been intended to lead to the eastern slope. One of the tunnels cut through the Herodian floor that survived at the top of the tower in its northern section.[3]

Another attempted breach can be seen in the southeastern cellar, which was built in Herod's time in the sealed upper section of the tower. Corbo's excavations turned up significant remains of activity from the Bar Kokhba period in the large cistern in the tower's stone core, evidenced by coins restruck by the rebels and several burials from the days of the revolt. Several attempts to hew out tunnels of the aforementioned type are visible in the cistern's walls and floor [Corbo 1967].

Based on the height of the eastern tower relative to its surroundings, we assume that it served the rebels as a dominant position from which it was possible to observe the advance by the enemy forces and direct the guerrilla fighters, who then launched attacks through the tunnels (see below). This assumption explains the attempts to dig tunnels from the eastern tower.

A hole in the western wall of the synagogue led to the room on its west (No. 16). During the Byzantine period, this opening was sealed and supported by a wide wall so that the monks could use the former synagogue.[4] A doorway was cut from rebel living quarters established in the northern portico of the palace (No. 7) towards the perimeter corridor that runs around the ground floor of the outer wall of the fortress; this made it possible to reach the entrance hall through a breach in its western wall.[5] Two additional holes were cut in the southern wall of the western arm of the cruciform Herodian courtyard (between Rooms 20 and 17); at least the easternmost of them was cut before the chapel was built there during the Byzantine period.

5. EVIDENCE OF BATTLE AND DESTRUCTION: THE END OF THE REVOLT

Various finds reveal that the offensive and defensive system described above was also actively used throughout the rebellion. Ultimately, the fortress was captured by the Romans and destroyed.

Noteworthy among the evidence attesting to the events, are the distribution of weapons and ammunition, the many signs of fire, and the massive collapse and destruction evident throughout the fortress. The skeletal remains, as well as evidence for refugees from Herodium in the refuge caves of Wadi Murabba'at, attest to the rebels' final fate.

The distribution of the ballista stones, as studied by Stiebel [2003, 2005, 2015] suggests a massive bombardment of the rebels at the summit and around the exits of sally ports on the slopes. It is reasonable to assume that the Roman forces held dominant artillery positions surrounding the mountain, such as on the flat hill to the east.

When the Romans penetrated the fortress, they deliberately destroyed walls and tunnels. The concentration of rolling stones at the foot of the mountain may indicate the direction of the Roman attack. It appears that the caches of rolling stones found at the top of the slope, outside the walls near the west, north, and east towers, attest to preparations to turn back attacks from those directions.

Signs of a major conflagration—including charred wooden beams and a great deal of ash and soot—were found throughout the entrance to the palace fortress and the area where the rebels were active. These finds are apparently evidence of the Roman capture of the fortress. The fire in the entrance hall was so strong that some of the stones turned to lime. There is evidence of the effects of another huge blaze in the cellars of the northern section of the outer walls, and near the fortress entry.

Fragmentary skeletons were found in several parts of the fortress. Corbo's team found three human skulls in the rebels' rooms next to the southern exedra, near the location

[3] This opening was sealed during the Byzantine period, when a new mosaic floor was laid down; the floor was uncovered by Corbo and again during our 2012 excavation [Corbo 1967].

[4] For more on the Byzantine wall, see Corbo 1989: Map 3, No. 16 and Fig. 95; see also Fig. 21 in the present article. This wall was removed in the late 1960s.

[5] The breach was made above an opening in this wall, which was sealed during the Jewish War. The perimeter wall later collapsed into this breach (Fig. 22).

of the large coin hoard. Human remains were found in the large cistern in the eastern tower, alongside Bar Kokhba coins. Several graves, which also apparently date to this revolt, were found in several locations.

The artifacts and documents found in the Murabaʿat caves indicate that a large group of fighters and rebels managed to escape Herodium. The finds at Wadi Murabaʿat caves [de Vaux 1961; Benoit et al. 1961; Porat 2015] and at al-Mazia cave [Krispil 1983; Patrich 1986; Frumkin 2015] suggest that the escape had been prepared in advance.

6. DISCUSSION AND CONCLUSIONS

The archaeological record at Herodium suggests that an advanced and unique system of guerrilla warfare, which integrated a well-fortified and visible fortress, was prepared. It appears that Herod's palace fortress stood empty before the war; The rebels occupied the site and reestablished it as a military headquarter and an administrative center.

The integrated system established at Herodium differs from the typical Judean hiding systems, prepared underneath existing villages [Kloner and Zissu 2002; Zissu and Kloner 2014; Eshel and Zissu 2015].

The overall picture that emerges from the Judean sites suggests that the rebels had learned the lessons of the Jewish War. Unlike the first revolt, when the rebels tended to barricade themselves in settlements and fortresses, the Bar Kokhba rebels generally avoided prominent strong-holds. They opted for guerrilla warfare in the open field and hiding in caves, avoiding direct confrontation.

The guerrilla warfare in Judea seems to have been based on popular enlistment and fighting from within villages. In other words, the revolt in Judea was a popular war that used guerrilla tactics primarily for defensive purposes and sought to wear down the enemy rather than defeat him. Cassius Dio provides support for this reading of the rebels' strategy.

The activity within the Herodium fortress during the Bar Kokhba revolt, which combined massive fortifications with a tunnels system that was clearly offensive in nature is outstanding. It is also distinguished by its scale and sophistication. In contrast to the strategy of defensive guerrilla operations followed in most of Judea, here Bar Kokhba apparently developed offensive guerrilla tactics intended to hurt the enemy and wear them down. In other words, Bar Kokhba and his fighters prepared Herodium as a base for regional guerrilla warfare.

As noted, the tunnels at Herodium permitted the fighters to make surprise exits from the hidden openings on the slopes. The guerrilla tactics apparently gave the rebels effective control of the steep slopes. Lookouts could direct the fighters to the exits that lay near the Romans' ascent routes. By taking advantage of the element of surprise and the advantage of elevation, a few fighters could engage a much larger Roman unit.

Effective use of this defensive-offensive strategy required that the tunnels be constructed in a way that permitted rapid movement. The short tunnels that were dug within the built-up area were meant to be used for fighting in the built-up area; they also permitted escape from the fortress should the enemy gain the upper hand.

To sum up, the archaeological assemblage attests to fierce resistance and to the bitter end of the fortress. The finds found in the Murabbaʿat caves suggest that a large group of rebels managed to escape Herodium and escape to the desert. Finally, the Roman army overran them, too, thereby bringing the war in Judea to an end.

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SESSION 6

MINING WORKS

The rediscovery of the Formignano Sulphur mine (Forlì-Cesena, Italy)

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Abstract
During the development of the research project: "Eastern Romagna Gypsum and Sulphur", the Emilia-Romagna Regional Speleological Federation rediscovered the entrance of the Sulphur mine Formignano, the biggest mine of Savio Valley (Forlì-Cesena province). The Formignano mine had a big industrial archeology, historic and social value. Next to the mine it is a mining village, built in the 19th century. The mine quarried Sulphur from a part of the Gessoso-Solfifera Group, precisely in the Sapigno Member.

The project developed with the territorial organizations: Emilia-Romagna Region, Bologna University and Modena and Reggio-Emilia University, the Romagna Mining Research Society, the Sulphur Museum and the Romagna Parks and Biodiversity Organization. The Formignano mine that worked surely from Renaissance was the most important economic reality in the area. The mine worked until the 1962 year. After the closure the main entrance was closed: the big winze (500 meter long and 50° grade) was covered with a big concrete sheet. The speleologists searched for the old worker entrance in the abandoned village and found it. The speleologists found also other entrances of the mine system. The inside exploration is underway and it is quite problematic, because there are problems for the dangerous gases in the air: oxygen deficiency and high values of carbon dioxide. The exploration of the winze and the pits are played also trough unconventional techniques.

Keywords
Formignano Mine; Eastern Romagna Gypsum and Sulphur; Emilia-Romagna regional speleological Federation; artificial cavities speleology; Historical – geographical; mining activity; Cesena.

1. INTRODUCTION

The Emilia-Romagna Regional Speleological Federation (FSRER) has recently launched a complex research project: "Eastern Romagna Gypsum and Sulphur" aimed at surveying and studying the artificial and natural cavities in Eastern Romagna (Northern Italy). The area of analysis stretches from the Savio Valley (in the Forlì-Cesena province) to the new administrative border with the Marche Region. Many important artificial cavities exist in the area, which holds impressive industrial archaeology, historical and social values. The mines quarried Sulphur from the Gessoso-Solfifera Formation. The project will be developed in cooperation with the following organizations: the Authority of the Emilia-Romagna Region, the University of Bologna, the University of Modena and Reggio-Emilia, the Romagna Mining Research Society, the Sulphur Museum and the Authority for the Management of Parks and Biodiversity - Romagna. The numerous mines, which have undoubtedly existed since the Renaissance, were an important economic sector in the area. Moreover, the research program is determined to recover historical cartography and old mining maps; these maps will be digitized and georeferred.

The project provides for the possible mines' re-exploration and their photographic documentation.

This paper presents results of the rediscovery of the Formignano Mine and the first tunnels re-exploration.

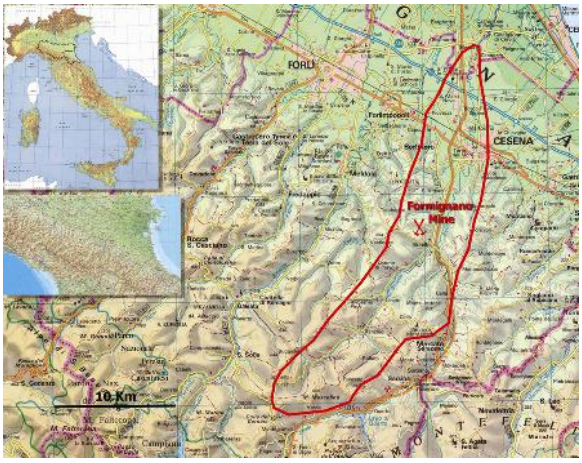


Figure 1: Position of Formignano Mine in the Savio Valley (from Emilia-Romagna Region maps)

2. GEOGRAPHYCAL SKETCH

The Formignano Mine opens in the hills in the left orographic bank of the Savio River (Fig. 1), in the province of Forlì –Cesena. The mining site is located approximately 3 km SW of the village Borello, in the territory of Cesena municipality.

3. GEOLOGICAL FRAMEWORK

The Romagna area (Northern Italy) is an excellent natural laboratory for understanding the first phase of the salinity crisis, the dramatic geological event that has turned the Mediterranean Sea into a giant salina, inhospitable to most life forms during the Messinian (Upper Miocene), between 5.97 million and 5.6 million years ago. The Messinian salinity crisis has produced the Gessoso-Solfifera Group. The Group is divided in Emilia-Romagna region, in two geological formations: the Vena del Gesso (Gypsum Vein), which is shaped from 16 layers of selenite (primary gypsum with crystals up to two meters tall containing fossilized filaments of cyanobacteria) and the Sapigno Formation that is shaped from clastic gypsum [Roveri, 2007]. As soon as the deposition of primary gypsum finished, the area has been affected by tectonic events that have triggered massive submarine landslides causing the dismantlement of the gypsum and the deposition of the re-sedimented Lower Gypsum with clastic habit [Lugli, 2015]. The Formignano Mine is in the Sapigno Formation.

The formation is characterized by clays and bituminous marls with middle layers until very thin layers. Sometimes it is possible to find sandstone intercalations (Fig. 2) [Regione Emilia-Romagna, 2012].

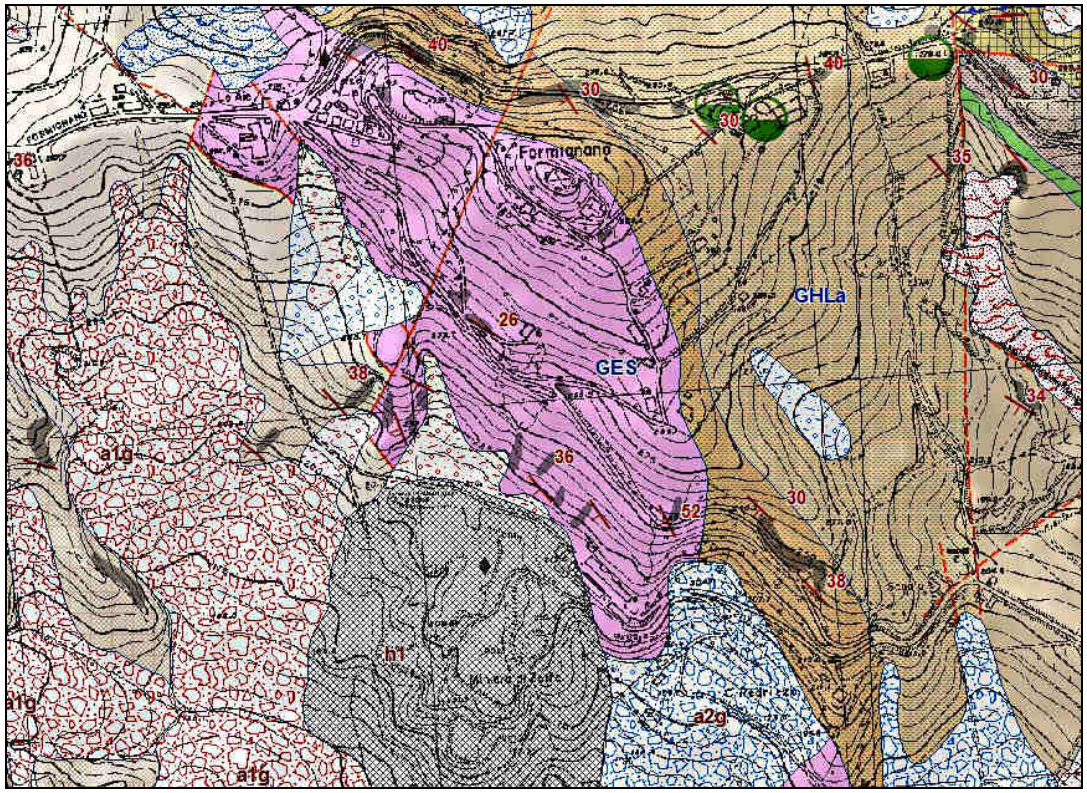


Figure 2: Geological map of the area (after Emilia-Romagna Region Geological Service)

4. HYSTORICAL FRAMEWORK

In the Roman period are documented mining activities in the Savio Valley: a mine called “Solfaranaccia” was the work place of “Damnata ad metalla”. In the year 1047 existed a parish church, dedicated to St. Peter in Sulferino, localized in the actual village of Borello. This toponym is explicitly linked to Sulphur extraction. The discovery of gunpowder in the year 1320 make the Sulphur play a lead role; Sulphur, wood coal and Potassium were the main ingredients [Magalotti, 1998].

The first excavation in the Formignano Mine certainly dates back to 1556 [Magalotti, 1986]. The scientist Luigi Ferdinando Marsili, born in Bologna, visited the Formignano Mine in the first years of the 18th century [Lipparini, 1930]. Vincenzo Masini in his poem "Il Zolfo" cited Formignano Mine several times [Masini, 1759]. The earl Fantuzzi, in his memories, wrote about the Romagna mines in activities in the year 1788 and cited Formignano with nine mouths to extract the ore [Fantuzzi, 1788]. In 1801 Natale Dellamore bought the claims to dig the

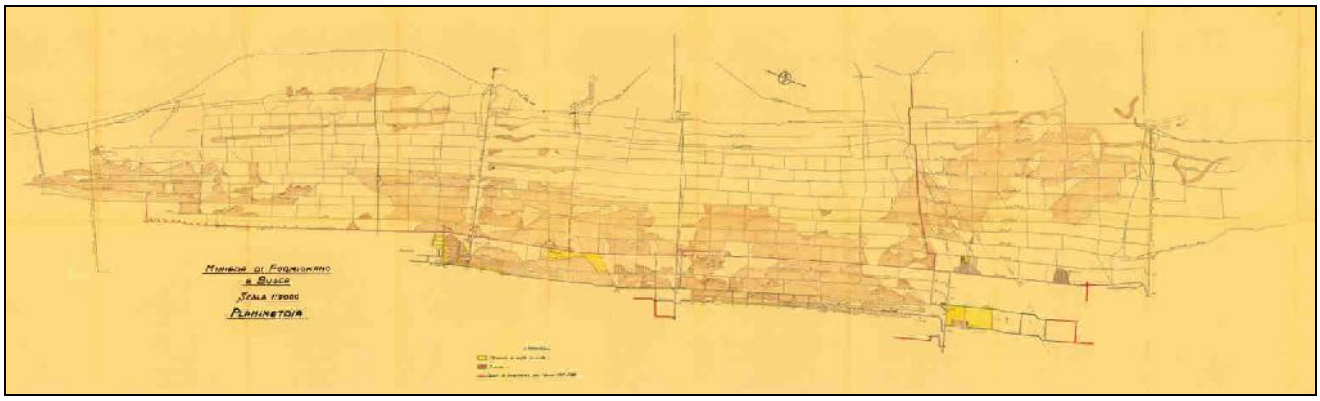


Figure 3: Map of the complex of Formignano in the year 1931 (after Museo Sulphur)

sulfurous rock in tunnels in his plot of land. This property was set in Pedrizzo, parish of Formignano [Riva, 2006]. The earl Giovanni Cisterni, born in Rimini, bought almost all mines in Savio Valley, then also Formignano. Giovanni Cisterni was the first modern owner of Sulphur mines in this area. He modernized the mines, with the last technologies of those years. He dug two pits (Alessandro and Nuovo) and built the water drainages. Several economic problems forced Cisterni to associate with two French businessmen Picard and Pothier. After bankruptcy was born the society "Nuova Società delle Miniere Solfuree di Romagna", just formed in Bologna in 1843 [Scicli, 1972]. Later on, during the 19th century the mine changed ownership several times; in 1899 it was sold to a newly formed company, the "Miniere Solfuree Trezza-Albani Romagna". This society sold all her mines to chemical company Montecatini in 1917. The Montecatini took advantage until 1962, year of definitive closure.

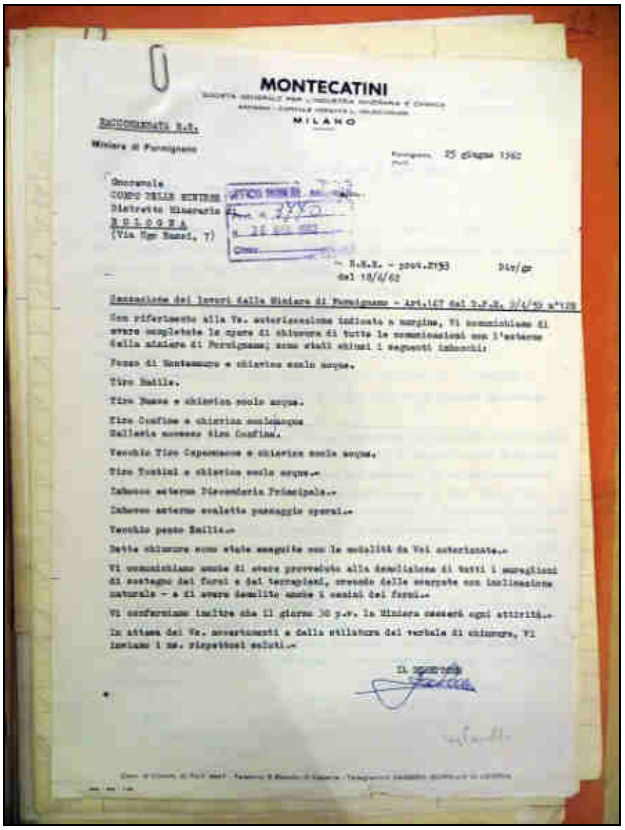
5. CLAIM OF FORMIGNANO

Under the name Claim of Formignano was included many fields of research and excavation; "Polenta--Montepennino", "Busca-Montemauro", "Luzzena-Fosso", "Formignano" and "Borello-Tana" originally separated. The Montecatini interconnected later these mines by galleries, pits and outside cableway. The Formignano Mine was the main of the complex, and also the more productive, because the thickness of the Sulphur layer in this site was the highest, reaching two meters. In figure 3 it is possible to see almost all the complex.

6. HEYDAY SITUATION

In the year 1962 the company Montecatini closed the Formignano Mine according to the precepts of the Mining District of Bologna: all the entrances were closed by walls and the Gill oven was destroyed [Distretto Minerario, 1962] (Fig. 4). Around the entrance of Formignano mine it is a mining village, built with functional use: mining (laboratories, workshops, offices) and residential for director and foreigner employers. The village is present already in the 1878 map (Fig. 5) [Società delle Miniere Zolfuree di Romagna, 1878]. It was abandoned permanently from more or less forty years. The heyday situation of the village is much damaged from the last big snowfalls. The majority of the roof fallen and also some buildings collapsed.

This destruction is a very shame, because the village was an important example of the industrial heritage of the Sulphur mines activity. During the years the institution thought to restore the village for touristic scope, but nothing was actually made.


MONTECATINI

MILANO

Raccomandata R.R.

Miniera di Formignano

Onorevole
CORPO DELLE MINIERE
Distretto Minerario
BOLOGNA
(Via Ugo Bassi, 7)

Sistemazione dei lavori della Miniera di Formignano - Art.167 del D.P.R.

Con riferimento alla Vs. autorizzazione indicata a margine, Vi comunichiamo di avere completato le opere di chiusura di tutte le comunicazioni con l'esterno della miniera di Formignano; sono stati chiusi i seguenti imbocchi:

Pozzo di Montemauro e chiavica sacca acque.

Tiro Emilia.

Tiro Busca e chiavica sacca acque.

Tiro Confine e chiavica sacca acque
Galleria accesso tiro Confine.

Vecchio Tiro Capannacce e chiavica sacca acque.

Tiro Tunisi e chiavica sacca acque.

Imbocco esterno Discenderia Principale.

Imbocco esterno scaletta passaggio operai.

Vecchio pozzo Emilia.

Detta chiusura sono state eseguite con le modalità da Voi autorizzate.

Vi comunichiamo anche di avere provveduto alla demolizione di tutti i muraglioni di sostegno dei forni e dei terrapieni, creando delle scarpate con inclinazione naturale - e di avere demolito anche i camini dei forni.

Vi confermiamo inoltre che il giorno 30 p.v. la Miniera cesserà ogni attività.

In attesa del Vs. avvertimento a Colla stilatura del verbale di chiusura, Vi inviamo i ns. rispettosi saluti.

Figure 4: The letter from Montecatini to Mining District (from Archive of State Bologna)

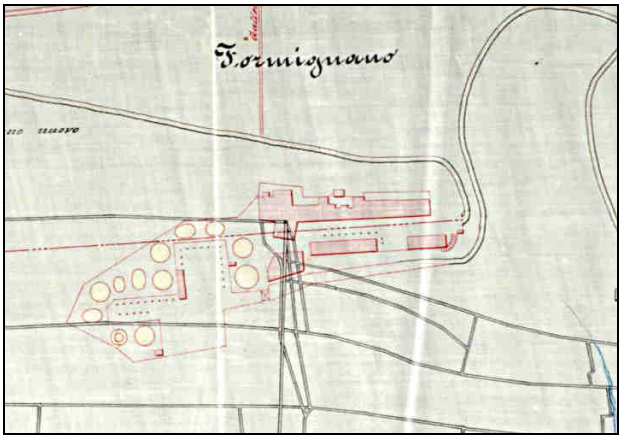


Figure 5: Plant village in the 1878 map (from Archive of State Bologna)

7. REDISCOVERY

When the speleologists of the FSRER decided to try the re-exploration of Formignano mine, it was very important to know the location of the possible entrances. The first step was the visit at the village to know the territory and to understand the problems. Simultaneously it was necessary to find descriptions and maps of the mine.

The main entrance of Formignano Mine was a big winze, 500 meters long and 300 meters deep; usually the miners entered through the winze with undercarriage, but a workers entrance on the side of winze also existed. The scale (1:2.000) of the only found complete map (Fig. 3) did not permit to localize the miners' staircase. An important clue was found in a description of a project of the village restore [Aloisi, 1989]. In this paper the author wrote about the position of a workers staircase under the little loggia of the lamp room (Fig. 6). The loggia it is much damaged and the ground was obstructed with ruins, when the mine was closed; also the big winze was obstructed from ruins, boulder and terrain. The speleologist decided to dig in the ground to find the staircase. On October 10, 2015, the digging in the Formignano village began. The information was correct and the staircase was found.

Figure 6: The little loggia (photo P. Lucci)

Figure 7: The digging began (photo M. L. Garberi)

The staircase was replenished from ruins and the work was hard and strenuous. The air in the mine could be with Oxygen lack; therefore it was necessary to enter with breathing apparatus. Moreover the speleologists needed to void the entrance of the big winze.

The tunnels of Formignano mine were dug mainly in gypsum and bituminous marl. They can present a large lack of oxygen for of a series of reasons: the marls kerogene oxidation; the flooded copious wood oxidation; the sulfates and hydrogen sulphide oxidation-reduction. Moreover there can be explosive gases, such as methane and carbon dioxide.

FSRER speleologists are quite expert about this type of explorations, because they carried out an hard re-exploration of the Perticara Mine, where the tunnel habitat is characterized by an acute lack of breathable air, sometimes until to 0% of Oxygen [Belvederi, 2015].

FSRER speleologists were provided with four breathing apparatus Dräger PSS 3000 with steel tanks. They have a capacity of 6 liters, while the operating pressure is 300 bars, total air 1,800 liters.

Figure 8: The digging and the removed ruins (photo G. Belvederi)

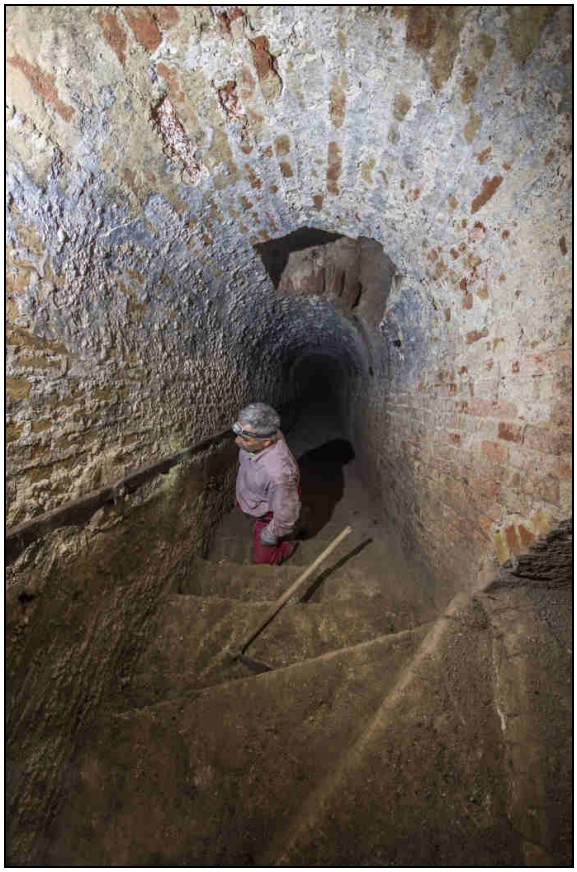


Figure 9: The workers staircase (photo P. Lucci)

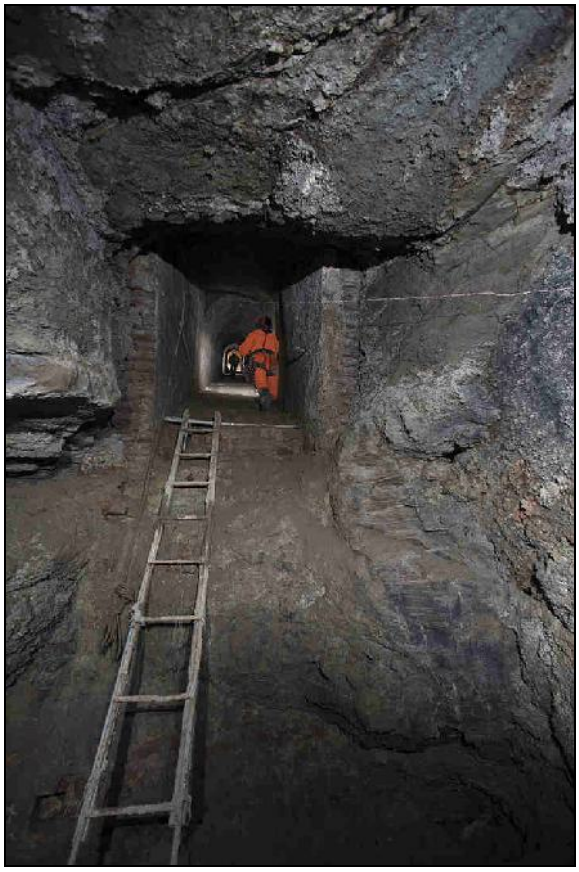


Figure 10: The collapse of the staircase (photo G. Belvederi)

The breathing apparatus are compatible with the full face masks and pressurized nozzle, because the tunnels are overfilled with gases. These gases do not contact with the explorers' respiratory system and eyes [Draegerwerk, 2013]. To integrate the equipment, FSRER also bought 2 MSA gas detectors: multigas and Altair Pro single-gas. The Altair-4x tests the presence of Hydrogen sulphide (H2S), Carbon monoxide (CO), explosive gases (Comb/EX) and oxygen in the atmosphere [Msa Auer Gmbh, 2012]. The single-gas detector tests only the Oxygen percentage [Msa Auer Gmbh, 2006].
The air in the staircase, during the first entrance, had an Oxygen level of 17 %. The staircase is long 85 steps (25 cm high) with a slope of 45% (Fig.9).
The staircase steps was covered from a layer of terrain; it was necessary to clean the steps, to make the descend safe.

8. RE-EXPLORATION

The staircase disrupts with a collapse after 85 steps (Fig. 10) and you descend in a cluttered room from a lot of ruins. The placement of the room is under the big winze and removing the detritus was necessary to reach the tunnel. The air in the room, during the first visit, had a Oxygen percentage of 17. To remove the detritus it is very hard in this condition, because of the difficult breathing conditions.

Figure 11: The big winze (photo M. L. Garberi)

After removal of the debris, the speleologists could enter in the big winze, inserting the head between the railway sleepers. The image was very impressive, with the tunnel absorbed in the dark (Fig. 11).

The winze slope is more or less 50° and the floor is covered from large amount of mud. The descend must be carried out by means of rope and speleological technique. The tunnel is covered from bricks; in a section the bricks have fallen and the rocks collapsed, creating a big dome. The fallen material glided along the winze creating an obstruction.

Figure 12: The mouth with the opened gate (photo G. Belvederi)

Figure 13: The hoists (photo M. L. Garberi)

To clean the air, it was necessary to open the mouth of the winze in the main square in the mining village of Formignano. After a hard work the speleologists removed the ruins from the square and opened a little part of the mouth (Fig. 12), now closed with an iron gate.

The air in the winze cleaned in a week and the air left from bottom in cold day in the winter. The Oxygen was stable at 20.8 %.

9. THE FIRST DESCEND

The speleologist decided to descend by means of hoists, in order to facilitate recovering of the explorers in case of air problems.

A group of speleologists worked in the hoists, while another one in the mouth of the winze to control the flow of the ropes in a roller. A third group was working in the winze at the departure of the two explorers (Fig. 14), to help and film the operations. One explorer was shooting with an action-cam on the helmet. The speleologist decided to descend without breathing apparatus.

The winze had descended for 80 linear meters and around 90 meters in deep. During the descend, the speleologists found two place without bricks and with collapses. At 80 linear meters, there is a rock, mud and bricks obstruction.

Figure 14: The departure (photo P. Lucci)

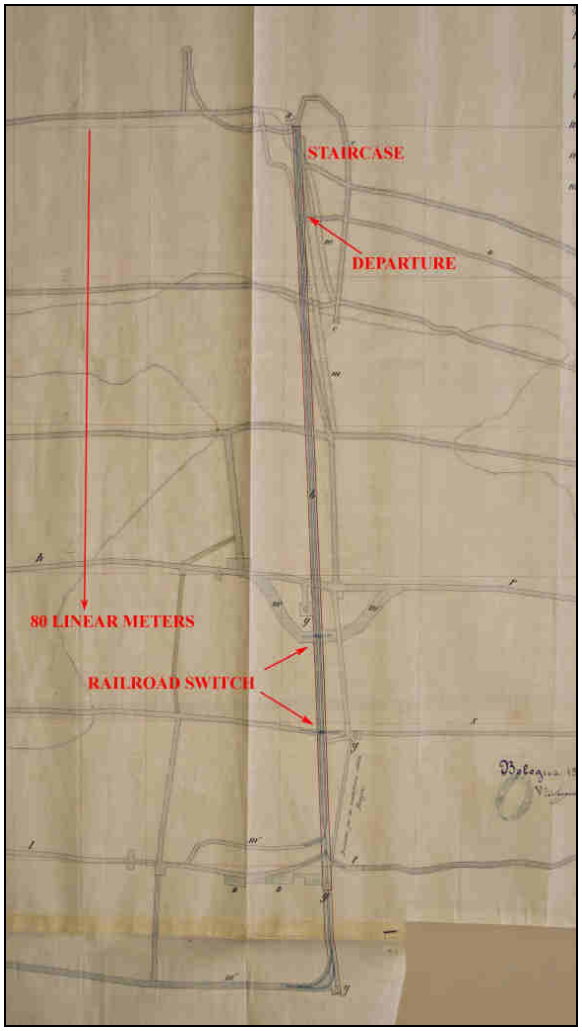


Figure 15: The old map of winze (from Archive of State Bologna)

This material slides probably until a place where the slope of the winze changes. In an old map [Società delle Miniere Zolfuree di Romagna, 1879] very detailed it is possible to see that at around 80 meter there was a cross between the winze and a gallery with a railroad switch (Fig. 15).

Figure 16: The big winze, equipped with ropes (photo G. Belvederi)

After the first descend with hoists, the winze was equipped with Multi-Monti nails and ropes (Fig. 16). The next steps will be the digging in the accumulated material to pass and reach the side galleries.

The realization could be important to run in other parts of the mines, because the winzes descend to mine portion below the phreatic aquifer and it is impossible at the moment to go on with further exploration.

10. OTHER ENTRANCES

Simultaneously the speleologists searched for the other entrances of the mining complex: the ventilation, extraction and drainage galleries and pits. In this area the ventilation systems consisted of one or two service galleries and a linked little pit, named "Tiro".

Many of these elements have been found through the geo-referenced of the old maps and the field research:

- Tiro Tontini, a ventilation pit, 30 meters deep, with the bottom closed; the service galleries are disappeared;
- Tiro Capannacce, a ventilation pit, very short and the service gallery, very steep in good conditions but obstructed of mud; it needs to be object of digging;
- Tiro Busca: only the service gallery, but very damaged and collapsed;

Figure 17: Tiro Confine: the service gallery (photo G. Belvederi)

- Tiro Confine, a ventilation pit, very short and the service gallery (Fig. 17), in good conditions in the first part, and farther on obstructed by gypsum blocks; it needs to be dug, but it is hard and dangerous;
- Pozzo Montemauro, an old extraction pit, 73 meters deep; inspected by video recording, it presents two galleries (respectively, 15 and 25 meters deep), but the wall treatment is seriously damaged and very dangerous to descend.

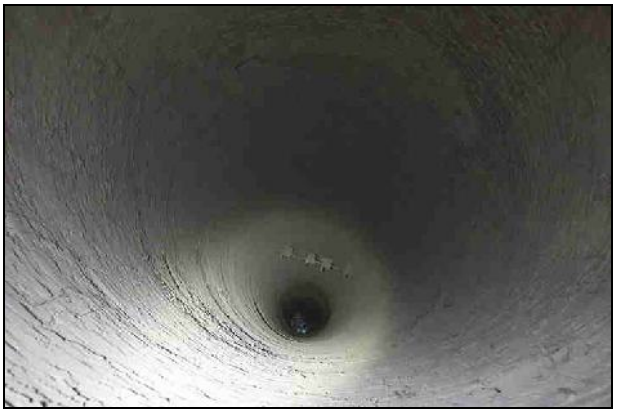


Figure 18: The Montemauro pit (photo M.L. Garberi)

11. CONCLUSIONS

The exploration perspectives of Formignano Mine are addressed toward different directions:

- the digging in the big winze to search the passage to the side galleries. It needs to be carried out in a dry period, without rain, because usually large amounts of water flows alon the winze;
- the search for the last other entrance of the complex, especially the ventilation gallery Tiro Badile. This gallery was modernized in the year 1947, when the mining district ordered to Montecatini Company to transform the ventilation gallery in emergency gallery [Distretto Minerario, 1947]. It is likely that the gallery could be better preserved.

This research is very important, because the results shaped another time the mine and his memory, which it was going to be lost. During all the works the speleologists documented with video and photographs the places outside and underground to show the situation inside the mine.

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Società delle Miniere Zolfuree di Romagna 1879 - *Planimetria Formignano- Busca, Scala 1:200.*

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The redevelopment of abandoned underground mines to mining museum and hypogeum walkway: a case from Gambatesa Mine, Aveto Natural Park (Italy)

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Abstract

The redevelopment project devoted to the underground mining museum of the Gambatesa mine is described in this research. The manganese mine is located in the Upper Graveglia valley (Aveto Natural Park, Liguria, Italy) and represents a significative example of Mn-ore exploitation from metacherts of the Jurassic ophiolitic sequences.

Ligurian Mn-deposits in Upper Graveglia valley and surroundings represented the European largest mining district for the manganese exploitation. Today the Mining Museum includes a visitor center with educational facilities, underground paths, outdoor tracks and mineral and rock collections. The first phase of the mine redevelopment project was devoted to security issues of particular interest in mining engineering and underground works: an highly specialized workplace mining into an underground museum site accessible to the general public has to adapt for cultural, economic and scientific values.

Keywords

Gambatesa mine, underground museum, Liguria, Italy.

1. INTRODUCTION AND GEOLOGICAL SETTING

Gambatesa mine is located in Upper Graveglia valley (Liguria, Italy), at a short distance (less than 15 km) from Lavagna and Chiavari cities, along the Eastern Liguria coast (Fig. 1).

The mine complex belongs to the Aveto Natural Park, internationally well known for its geological features, above all the ophiolitic rock masses and the related sedimentary covers (Fig. 2).

Gambatesa represents the biggest underground manganese mine in Italy related to SEDEX (Sedimentary-Exhalative) deposits. The so-called "Gambatesa District" in the period between 1940s and 1950s produced up to 100.000 metric tons per year of high-grade mineral (almost 35-40% Mn).

The manganese ores are embedded in the cherts ("Diaspri di M. Alpe") belonging to the Northern Apennine ophiolites. These cherts overlie the oceanic crust of the Jurassic- Ligurian-Piedmontese basin and belong to the Bracco-Val Graveglia Unit (Decandia & Elter 1972; Bortolotti et al., 2014, and references therein).

Figure 1: Location of Gambatesa mine in Eastern Liguria, Italy

The stratigraphic sequence is represented by serpentinites and gabbros overlain by a volcano-sedimentary sequence constituted by breccias, massive and pillow basalts, cherts, limestones and shales. Cherts and manganese deposits are related to the hydrothermal events on the ocean floor responsible for sedimentary-exhalative processes which

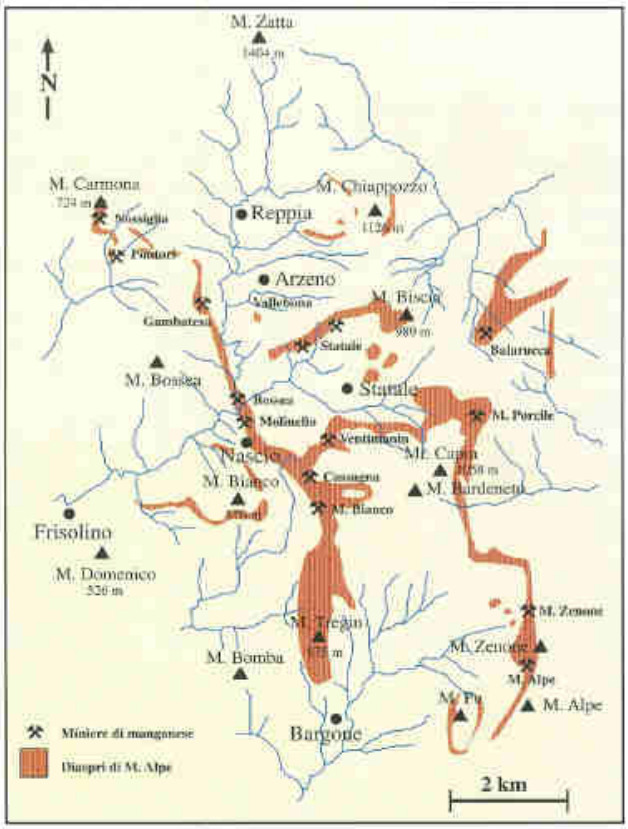

Figure 2: Location of main manganese mines and outcrops of "Diaspri di M. Alpe" (cherts) in Upper Graveglia valley and surroundings (Faccini et al., 2000)

Figure 3: Historic panoramic photo of Gambatesa mine complex (ca. half of the XX century) (Source: archive SILMA, D. Vercellotti)

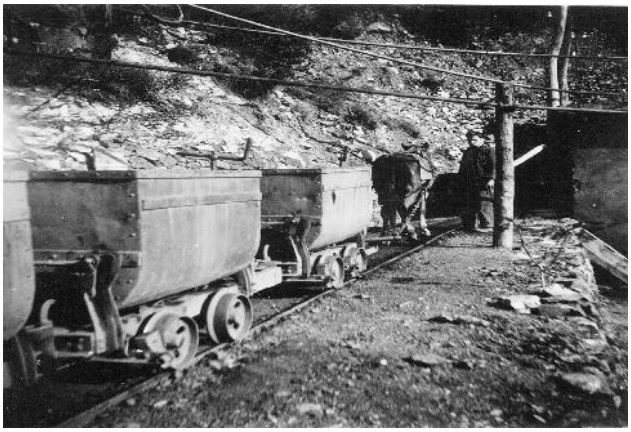

Figure 4: Historic photos of Gambatesa mine complex (ca. half of the XX century): animal traction and mine entrance (Source: archive SILMA, D. Vercellotti)

generated hydrothermal supplies of silica and manganese (Cabella et al., 1994; Marescotti & Cabella, 1996). Tectono-metamorphic re-equilibration under prehnite-pumpellyite facies conditions affected ophiolites and their sedimentary covers producing complex veining processes (Cortesogno et al. 1979; Lucchetti et al. 1990).

As a consequence, the manganese mineralizations occur as layers or massive lenses and boudins. In addition, diagenetic and synmetamorphic fluid circulation lead to mobilization and selective concentration of several trace elements in a great variety of uncommon minerals, including many new species, in vein-filling assemblages (Cabella et al., 1998, and references therein).

2. GAMBATESA MINE: BRIEF HISTORY AND REDEVELOPMENT PROJECT

In the Upper Graveglia valley several mining sites are listed (Molinello, Bossea, Cassagna, Statale and Mt Porcile) even if Gambatesa mine is the biggest one (Figs. 3-4-5): it included dozens of mine tunnels arranged on seven levels, linked by main shafts, ramps and ore passes, with an overall length of several kilometres, for a total extension is around 25 km (Fig. 6).

Figure 5: Historic photo of Gambatesa mine complex: air-operated shovel and dust gauge (archive SILMA, D. Vercellotti)

The history of Gambatesa mine started in 1876, when the french mine engineer Augusto Fages received the prospecting and research licence of manganese mineral called "Gambatesa" and "Zerli" (Cabella & Stuppini, 2006).

Due to the good results of the research, in 1879 a mining concession was obtained and since 1880 the Gambatesa mine has featured as a productive and in regular working for manganese. The greatest quantity of mineral was extracted during the two world war periods, until reaching the maximum production in 1966 (54,000 tons/year).

In 1974 Italsider company tried to close the mine declaring it exhausted. At the time the mine director was Giuseppe Vercellotti and he was contrary to the mine closure. So, together with former miners, he established the Silma company and got the mine concession: the mine resumed to work maintaining a production of 12,000 tons/year until 2012.

Figure 6: Map of mine levels of Gambatesa complex. Legend: 1) elevation 550; 2) elevation 555; 3) elevation 570; 4) elevation 595M. (Stuppini - SILMA)

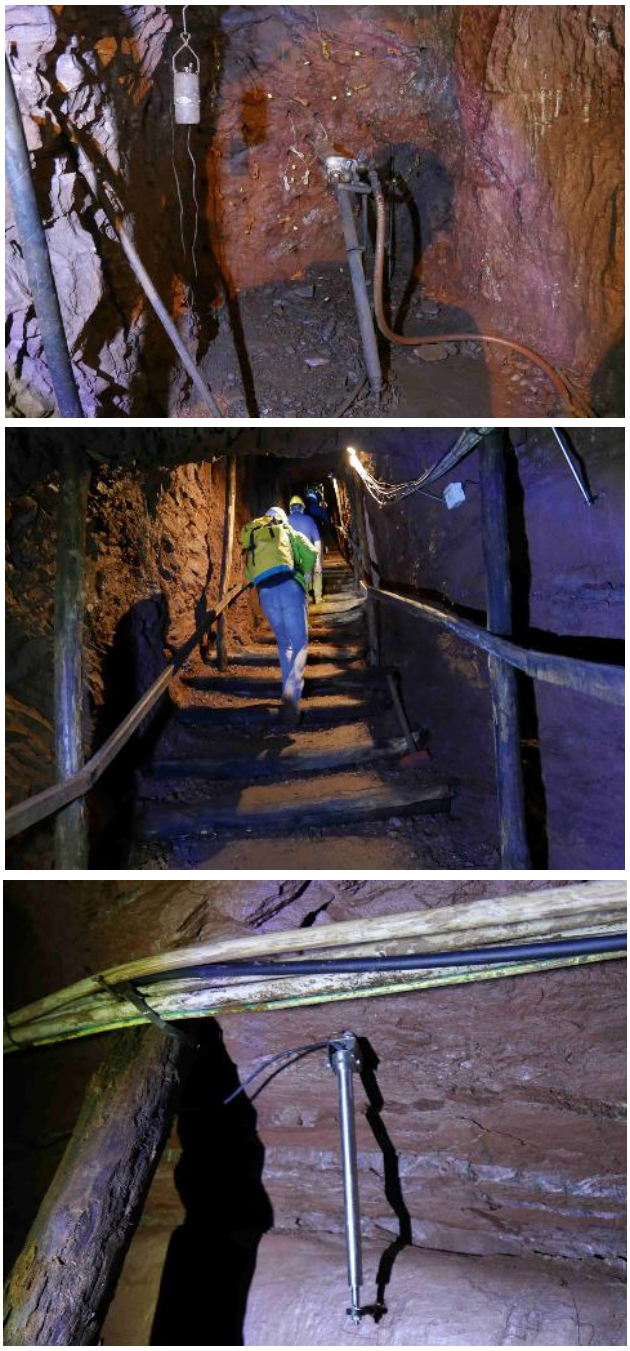

Figure 7: Gambatesa mine complex: controlled blast front, steps between levels, jointmeter

The state of activity of the mine and the competence of the last director engineer Domenico Vercellotti helped the conversion into a museum and the preservation of the industrial and cultural heritage of the mine complex; in fact on-site equipment and machinery, tools (Fig. 7), completed by material provided by individuals and scholars (publications, mineral samples, etc.) was maintained and exhibited.

The planning of touristic and educational center of Gambatesa mine began in 1996: the works continued until the underground path was opened, in 2000.

A visitor center near the tunnel entrance and the departure station was realized; the railway was modified and trains adapted to carry tourists. Some buildings for services and educational purpose have been planned and realized in the surrounding area: they completed the mine complex and related infrastructures.

At the Gambatesa mine the tunnels are in part covered by small trains along the traditional *decauville* railway and in part by walking paths. In the original extraction cavities, adapted with lights, there is a reintroduction about authentic machinery, tools, mining equipment and other educational facilities.

Visitors can look on site at the main phases of mining activity and recognize a huge stope (more than 250,000 m^3) which testify the largest manganese lens exploited underground until now.

During the opening to the public, which lasted until April 2012, a number of visitors ranging from 11,000 to 17,000 visitors/year were registered, mainly concentrated in spring (April-May due to school visits) and in August (Fig. 8). Therefore the Gambatesa mining museum has been visited by over 150,000 people.

Due to the expiry of mining concession, the museum was closed to the public. Only in 2015, thanks to regional funds, the basic project and planning activities required to restore the minimum security conditions to allow the mine re-opening for tourism, and educational purpose have started.

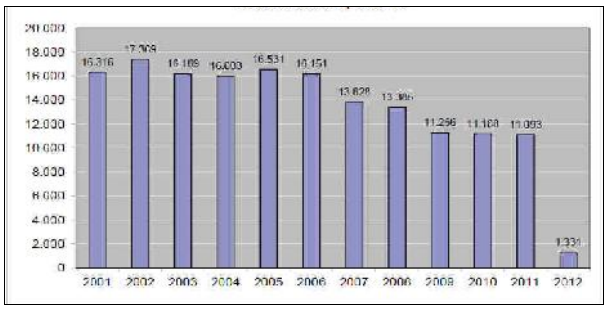

Figure 8: tourist flux from 2000 to 2012 (tourists /year). (Source: Cooperativa PANGEA 2012)

3. PLANNED ACTIVITIES DUE TO GAMBATESA MINE RE-OPENING

The issues addressed during the planning for the mine redevelopment project are of particular interest in mining engineering and underground works.

Among available several underground paths at this step it was decided to focus the activities for safe conditions restoring only the tunnel 550 elevation (Cadorin) and the tunnel 570 elevation ("barrel room").

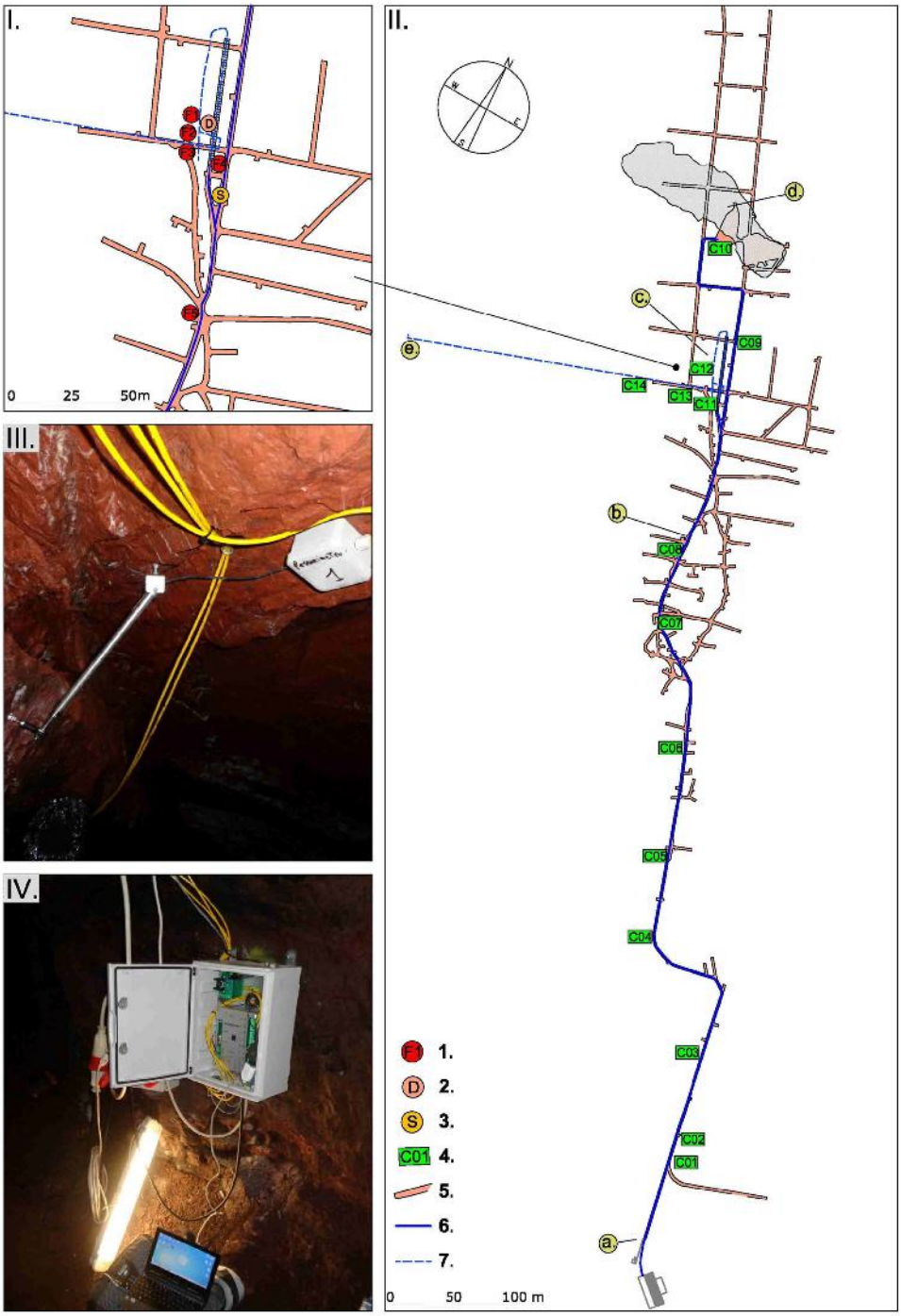

Figure 9: Map of tourist path with location of monitoring station. Legend: I) Continuous instruments placed; II) Fixed landmark, a) Cadorin tunnel entry; b) Intermediate post; c) Barrels room; d) North lens; e) Pontori emergency exit, Follador tunnel; 1) Continuous jointmeters (F1-2-3 in barrels room 570 elevation; F4 connection staircase at 550-570 elevation; F5 tunnel shaft at 550 elevation); 2) Continuous datalogger; 3) Traffic lght and sonorous warning devices; 4) Fixed landmark to crackmeter monitoring; 5) Tunnels and mine voids at 550 elevation; 6) Tourist path tunnel at 550 elevation, 7) Map projection of tourist path tunnel at 570 elevation and emergency exit tunnel at 595 elevation (Pontori Follador); III) Detail of jointmeter; IV) Detail of continuous datalogger

Works will also include the emergency exit at the above layer of 595 elevation (Pontori – Follador).

Moreover, in the redevelopment project the restart of the water pumping system, the restoration of electricity and phone lines, the closure of shafts and wells along the touristic trail, the installation of geotechnical monitoring instrumentation are planned.

The tunnels size are in fact always restrained and the excavation techniques adopted in the past for their realization, with limited use of explosives, are favorable in terms of stability: disturbance situations compared to the tunnel void were not identified.

Some troublesome situations in correspondence of huge underground voids have been, on the other hand, observed: the lack of support pillars linked to the voids size determined instability conditions at the top, with significant rock detachments and potentially large unstable rock masses.

In the preparatory work phase finalized to re-opening the mine for tourism purpose a monitoring system has been planned and placed: the goal is to check the most critical situations (Fig. 9).

A monitoring station made by 5 rock jointmeters with bar extension and direct potentiometric output, in correspondence of a “stop-up closed” shaft along the tunnel 550 elevation and in large empty room named “barrel room” at 570 elevation was installed. The system is connected either to a datalogger able to record continuous data and time planned (currently every 12 hours), either to a light and sound device which activates at the excess of precondition threshold value of the placed monitoring instruments (the current warning threshold is set to 1 cm); the recorded data are manually downloaded by PC in order to permit elaboration and analysis processing in specific illustrative graphics.

Moreover, in correspondence of a dozen cracks of minor importance, couples of aluminum landmark have been fixed: a detailed measurements via analogic crackmeters to check their potential opening and expansion are periodically conducted.

A detailed monitoring reports, inclusive of all the data both continuously and manually collected are drawn up with biannual frequency in order to obtain a knowledge framework of the voids stability in the part of touristic converted mine. This method allows the proper planning of any stabilization measures and/or safety works.

4. CONCLUSIONS AND RESEARCH PERSPECTIVE

The design and resulting realization of the preliminary work due to provide safety conditions of the tourist path allows a partial re-opening to the visitors of the Gambatesa mining site, the largest manganese mine in Europe, whose cultural and historic value and science is unique.
The hope is that, after this first operational step, additional funds to complete the recovery interventions in other sectors of the mine can be obtained, in order to provide a wide tourist offer able to fully exploit this great mining heritage.

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Holodna Balka Quarry Research (Ukraine)

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Abstract

Holodnaya Balka village is located 25 km north-west of Odessa in Ukraine. It is known that for more than 150 years the limestone was quarried here and used for construction. In that area a stone layer lies at the depth of 6 to 15 meters, that's why the stone was quarried by underground mining. The start of work is dated to the second half of the 19th century. Quarries made in different time periods were connected into a single underground labyrinth with a total length of over 120 km. For several years we have conducted researches of Holodnaya Balka quarries and made a complete plan of underground workings. Interesting historical and geological information was mapped, as well as information about the old mines condition.

Keywords

Holodnaya Balka, limestone, quarries, underground labyrinth, partisan's bases, speleo club "Poisk", miners drawing.

Holodna Balka village is located 20 km north-west of Odessa in Ukraine. It is well known that the limestone which was used for building and construction has been quarried here for over 150 years. In that area a stone layer lies at the depth of 6 to 15 meters, that's why the stone was quarried by underground mining.

Quarries were developed at different times. The beginning of work dates back to the second half of the 19th century. Interesting evidences of that period, the stonemasons' inscriptions and drawings, remained on the old mines walls. The stone was quarried by the sawing method. Stone quarries of the 19th and the early 20th centuries were cut by hand. The process of development itself can be divided into several steps. Separation of stone blocks from the roof was carried by a large crowbar. Then a small piece of stone was separated with the help of two saw cuts, usually in the middle of the bottom hole. After that the block of stone was separated with a glad picker. A worker had a possibility to penetrate into appearing saw cut and work with a special saw to separate the adjacent blocks of stone from the wall. Once a block of stone was tipped over, it was cut to a particular size of stone blocks, which was used in construction. Sometimes, mining tools still could be found in quarries. Stone was exported to the surface with the help of horse harnessed to a cart. Waste products were kept alongside underground tunnels, helping to improve the stability of the roof at the same time. But in some cases, waste products were processed (heated and turned into lime) and that is why there were no rubble walls in the mine. In the 1930s stone-cutting machines started to appear in the quarries of Holodna Balka. Therefore, various sections of the quarry look different.

Areas of the southern slope of the gulch separating present village into two parts were developed primarily. The slopes of the gulch, where the stone comes to the surface, partially processed with surface mining. Perhaps, long haul length was not cost-efficient. For this reason the quarries located at a long distance from the entrance had vertical shafts. Later on, some shafts were upgraded and some separate mines and quarries of different times were connected in a single underground maze with a total length of over 120 km. In the course of time configuration of the underground labyrinth has changed. Some parts of the quarries are destroyed, but some of them are in a good condition. Due to changes in groundwater levels, part of the quarry was flooded.

During the II World War catacombs were a shelter for all the citizens of Holodna Balka. When the army front came to the village all the citizens together with their pets went underground. Stone structures of that time (the barricades, protective walls, stone bunk, pens for livestock and poultry) remained intact in quarries. Different findings related to wartime were made in such places. In 1944 a small partisan detachment was formed in the quarries of Holodna Balka. The camp of the guerrilla unit in the catacombs withstands the ravages of time. Despite the fact that the guerrillas were not very much active, more than 250 residents of the village were shot as hostages during the retreat of the Germans in 1944 [Prjebeletsky S.S. 2006]. At the present time mine galleries facing the picturesque view of Hadzhibeevskiy firth are opened and catacombs are popular for visiting. Rescue operations for finding lost people in the quarries (a situation which usually happen every 2 years) can last for a few days sometimes. Besides that, some visitors leave on the quarries walls lots of graffiti and signs, destroying the inscriptions and pictures related to earlier periods.

Due to the fact that the village is located above part of the quarry, there is also a problem connected with down warping and the possible collapse of constructions located on the ground.

Figure 1: Holodnaya Balka. Fragment of the quarry plan (mapped by I. Grek, N. Podrutskaya, E. Romanenko)

Figure 2. Holodnaya Balka. Complete set of tools used for stone extraction. Miner's drawing on the wall (photo A. Samorukov)

Figure 3: Holodnaya Balka. Stone Removal. Miner's drawing on the wall (photo A. Romanov)

Further, some village citizens pour sewage into the old mine, which cause sevre pollution problem in the area.

In 2008 the team "POISK" began a comprehensive study of the Holodna Balka old mine.

The work was carried out in the period from 2008 to 2012. Topographical survey was taken with the help of liquid compass. We also used well-preserved miner maps for two areas that were completed in 1950s. These maps were corrected by us on the basis of the current quarries condition.

As a result, we succeeded in drawing up a complete quarries map. Some new plots of old quarries previously unknown were discovered during the work.
Information about condition status of the old mine workings, interesting historical objects, dates, miner's pictures and geological phenomena were marked on the map.
Map tile of the quarries is shown in Fig. 1. Diving suits were used for investigating watered ground areas of the quarries and for some areas diving equipment was used.
In our opinion the quarry in Holodna Balka provides an interesting monument of culture, nature and history of mining. Due to the fact that they are covering a huge area it is almost impossible to take the whole area under protection.

Therefore, we have selected quarry fragment with total length of 7,000 meters, outside of the settlement, including guerrilla party camp, miner pictures (fig2 and fig3) and also various mines with different mining technology dated late 19^{th} - middle 20^{th} centuries. We would like this quarry part to be preserved area. Currently this question is being discussed [Bobronsky T., Grek I., 2015].

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The Latomie of Ragusa (Sicily southern Italy): a case study of artificial cavities in the underground of the city

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Summary
The earthquake of 11 January 1693, with intensity at or above the XI degrees of Mercalli scale, was one of the most catastrophic to hit Sicily (southern Italy), crashing down so highly destructive in the eastern island, razing 45 cities and causing around 60,000 fatalities. Ragusa, one of the most affected cities, in the south-eastern Hyblean plateau limestone, alone counted for some 5,000 victims out of a population of 9,950. In the aftermath of the severe earthquake, the almost total destruction of the city forced the survivors to rebuild the same with material readily available on site consisting of the Miocene limestone cropping out in the surrounding valleys.

Today the testimony of the mining activity, which without interruptions until the middle of the last century gave form and life to the higher-new part of the city, is visible mainly along two valleys, the Santa Domenica and the Gonfalone, the former cutting and the latter surrounding to the south the city, respectively. On their slopes large entrances giving access to extensive and impressive underground caverns called *latomie*, from Greek language *laas temnein*, cut stone, the latter used in the form of blocks for the construction of houses or when finely crafted by expert stonemasons, as decorative facades of palaces and churches.

In the 1950s and 1960s the "wild" urban expansion determines the partial filling of these valleys, considered an obstacle to the buildings, causing the permanent abandonment and degradation of the same, many of which until a few years before, after the abandoned mining activity, were used as tanneries, as stables or as furnaces for the production of lime. If the beginning of the mining and limestone exploitation in Ragusa can be linked to the above earthquake, after an oblivion of nearly half a century in which these mines were left to sink, to another more recent earthquake, on 13 December 1990, we can attributable the renewed interest of the city towards the above *latomie*.

This interest, beyond the historical and cultural aspects, was linked to the real risks of collapses which could occur in these cavities, either for geostatic reasons or for the occurrence of earthquakes, given the high degree of seismic activity that characterizes the south-eastern sector of Sicily. Risks which could involve several sectors of the city and urban infrastructure, with danger for the life of the population, given that some sectors of the city are located occurred just over these large and extended underground voids.

From this situation of potential and real risk arose the proposal by CIRS, welcomed by the municipality government, of an investigation concerning the physical status of the quarries present in the underground of the city, in order to carry out monitoring on the conditions of stability and the state of deterioration of the ceilings and pillars, as an activity to mandatory to periodic checks on the evolution of the state of degradation, in particular in the presence of karst phenomena, linked to the infiltration of water from leakage of urban water network. In April 1992 this study started with a program of surveys covering 22 *latomie* in each of which both topographic and mapping surveys and geostructural surveys were carried out, these former on the fracture systems present in the bedrock also interested, in certain sections of the caves, by underground water seepage and karst corrosion.

The results of the study, which lasted a year and a half, pointed out the existence of situations of particular structural deterioration in some areas of the city, for which priority interventions of consolidation were recommended. In the cases of less structural degradation periodic monitoring were recommended in order to check the evolution of the stress state along the fracture systems, both in relation to the geostatic loads and to the loss of cohesion due to the corrosion karst phenomena. After about twenty years from these surveys, no real intervention o was carried out by the municipality administrations that have ruled the city in the years, not so interested to, that carry out measures to prevent and / or minimize the disasters and dangers to public safety arising from the occurrence of the described geological risk.

Keywords
Latomie, Sicily, Ragusa, 1693 earthquake, underground quarry, mining activity.

1. INTRODUCTION

Ragusa, one of the chief towns of Sicily (southern Italy), is located in the southeastern part of the island, in an area of 1,614 square kilometers in which about 350,000 inhabitants live. The natural environment surrounding the town is made up of a limestone plateau, at an altitude of around 600 m a.s.l. deeply affected by fluviokarst valleys, locally known as "*caves*", such as the *Cava San Leonardo*, the *Cava Santa Domenica* and the *Cava Gonfalone*, delimiting the city respectively to the north, in the middle part and south. The city is characterized by the presence of two towns, the upper modern city and the old town *Ragusa Ibla;* the new town was built after the earthquake of 11 January 1693 that almost completely destroyed several other cities of south-eastern Sicily. In the aftermath of this disaster, the problem of where to rebuild the destroyed city was solved by placing it, in part, on the original location and partly on the *Patro* hill, the current *San Giovanni* neighbourhood, by excavating the stones from the slopes of the valleys close to the old town. Today the testimony of the mining activity is still visible through a number of large entrances. The quarrying was uninterrupted until the middle of the last century, giving form and life to the higher-new part of the city. The huge openings of the quarries are located along two valleys, the *Santa Domenica* and the *Gonfalone* (Figs. 1-2), which respectively cuts and surrounds the southern part of the city.

2. HISTORY OF *LATOMIE*

In the underground of Ragusa, and in the surrounding valleys, 22 subterranean quarries were surveyed within a Speleological Survey Project described below. The term "*latomia*" comes from Greek and means "cut rock" (*laas* = stone, *temnein* = cut). *Latomie* are the stone quarries carved in the underground of the city, not as open quarries. Therefore, these are the underground sites where once limestone was quarried, worked especially after the earthquake of 1693 that destroyed almost all the city, forcing

Figure 1: Huge entrances of *Latomie* of Cava Gonfalone (photo R. Ruggieri)

Figure 2: *Latomia* of Cava Santa Domenica (photo R. Ruggieri)

the survivors to reconstruct with the readily available material in the vicinity of the city, just like the limestone of the neighbouring valleys.

Their origin, which seems to have a recent history, is tied to the extraction of limestone that had a considerable role in the economy of the Modica County territory, where Ragusa was located. However, in favour of the thesis of a more ancient origin, at least for some of the above mentioned quarries, there is some indirect evidence relating to discoveries of graves at *arcosolium*, dating from the 4th century AD, carved in stone quarries located in the *Balatella* area, near the city; and still more, by the covers of the tombs of the Greek necropolis of *Rito* area, made up of limestone slabs carved in the quarries of the *Petrulli-Pendente* hill, located south of the old town.

Father Zacharia in his "History of Ragusa before and after the earthquake," says that ten tall statues of white stone of "The Most Holy Martyrs", which had a marble appearance, were in the church of *St. George* (destroyed by the earthquake), while another surviving monument, where the white limestone holds a marble dignity, is the church of *Santa Maria delle Scale*, where a beautiful 14th century limestone pulpit is located in the ancient church entrance. The quarries excavated before the 1693 earthquake are most likely those carved in the *Pirrera* area, west of the old town, and those below the *Church of Carmine*, in the final part of *Cava Santa Domenica*. The latter, also, was used as home by the earthquake survivors.

Even before the earthquake the above valley, thanks to the presence of water, had to be inhabited. The medieval cave dwellings of Jewish ghetto neighbourhoods opened onto its slopes, while the presence of several necropolis (that of *Cava Mezzasalma*), along the slopes of *Mount Carmel,* and that of *Santa Maria delle Scale* hill, show that the valley was settled and had to have some access roads. In fact, mills, washhouses, lime furnaces, stables, troughs, reliefs with religious subject dating back to various periods have been found (AA.VV., 1994).

Figure 3: Collapse from the ceiling in a *Latomia* of Cava Santa Domenica (photo R. Ruggieri)

The destruction of the city due to the earthquake of 1693, led to its reconstruction in the style prevailing at that time, the *Baroque,* which in the white stone of the underground quarries found its material of election.

3. RECENT HISTORY

Through the examination of official documents, between the years 1800 and 1900, it is possible to deduce the importance that the extractive mining activity had in the economy of the city. In the 1920s a company managed 18 quarries with a daily output of 100 tons, 60 tons of which were exported. However, already in the 1930s the mining activity was beginning to show some concern, while its decline began with the advent of mechanization which replaced the hard work with a pick, and with the transition from the underground exploitation to that in open quarries. In the 1950s and 1960s the advent of reinforced concrete and bricks began to supplant the use of white limestone in the building which was accompanied by a sort of "hatred" for the quarry, manifested by filling up parts of the valleys as they were considered a serious obstacle to the unregulated expansion of the city.

The place of hard work and sweat of thousands of workers of Ragusa was erased with cold cynicism: the topography of the city was totally changed. The valleys became plains, where today supermarkets and buildings are present. Today, in some areas of the city, only some hatches, some embedded inside anonymous buildings, lead inside the *latomie*, the large underground spaces that could be used in a thousand different ways.

4. SPELEOLOGICAL SURVEY OF THE QUARRIES

If the beginning of mining at Ragusa can be linked to the above mentioned seismic event, to another more recent earthquake, the one called “Saint Lucia” of 13 December 1990, a renewed interest can be ascribed to the quarries, manifested by some cultural environments of the city, after the oblivion and the consequent degradation in which the same were "sunk".

The aforementioned interest even arose from the growing concern about the risks of collapse, of which some cases had already occurred (Fig. 3), in these cavities, both for geostatic causes and for seismic events, which could affect the overlying urban structures such as hospitals, roads and public and private buildings. It must be stressed in this respect that CIRS Ragusa had repeatedly and on various occasions highlighted such potential risks for the city, arousing almost always great attention by the interlocutors but unfortunately without any real effect from the public authorities to put in place concrete actions to safeguard these potential precarious underground structures.

Driven by these demands, finally, in May 1991 the municipal administration of Ragusa in order to verify the static conditions of some underground quarries and the effects that the earthquake of *Saint Lucia* had had on them, entrusted CIRS Ragusa with a speleological investigation and survey on the physical status of the quarries present in the underground of the city.

This research was also considered essential in order to plan and carry out continuous monitoring on the geo-mechanical features of the fracture systems present both in the ceilings and in the walls of the quarries, as these features could be affected from the occurrence of future earthquakes (taking into account the high seismicity of the Hyblean area) and from geostatic degradation due to karst phenomena (Fig. 4).

In April 1992, the investigation started and was carried out according to a program of work divided into the following phases:

historical research on the origin, development and subsequent decline of the *latomie* of Ragusa; topographic survey of the underground structures; geo-morphostructural survey to detect (1) the karst features in the different fracture systems (Fig. 5), quantified as "karstification Degree" and (2) the evolutionary trend of karst processes by determining the parameter “karstogenetic dynamic energy " whose methodology was developed in Cucchi & Forti (1982).

Figure 4: Karst features in the wall of *Latomia* of Cava Gonfalone (photo R. Ruggieri)

Figure 5: Discontinuity affecting the ceiling of a quarry in the Cava Santa Domenica (photo R. Ruggieri)

The investigation lasted one year, involving 22 quarries of which: 15 in the *Cava Santa Domenica*; 4 in the underground of *Viale Sicilia street*; 2 in the *Cava Gonfalone*; 1 in the underground of *Archimede - Carducci* streets.

5. RESULTS OF THE INVESTIGATION

The study results pointed out to the existence of a particular situation of degradation in some sectors below the city for which urgent consolidation works were prescribed. For the cases of less accentuated geostatic degradation a monitoring system was advised in order to follow the occurrence of movements and / or openings in the fractures of walls and ceilings caused by the karst corrosion of water seeping from the surface or from the leakage of the municipal water supply network (AA.VV., 1994).

In the following years, despite these recommendations, no consolidation work has been undertaken to prevent the occurrence of collapse or to minimize the occurrence of settlements that would almost certainly have an impact on the overlying urban structures, causing serious danger to the public safety. At this regard, it is stressed that some of the documented underground voids are below strategically important facilities such as two hospitals, a police station, some government offices, as well as some streets and numerous private dwelling buildings. On the issues of underground quarries, and the related instability problems, a wide literature is available (Parise, 2010, 2012; Parise & Lollino, 2011), also regarding the *latomie* of Ragusa (Cannata et al., 1995; Ruggieri, 2008; Schilirò, 2009).

6. PROJECTS OF FRUITION OF THE VALLEYS AND *LATOMIE*

Pending the interventions of consolidation and securing of the sites, in the last two decades some redevelopment projects of the valleys and quarries (*Santa Domenica* and *Gonfalone*) have been put in place with the purpose of the recovery and enhancement of the historical and natural beauty present, for the public and tourism fruition in general (AA.VV., 1996; Lembo & Gurrieri, 2009). In this regard, several projects have been carried out both in the *Santa Domenica* and in the *Gonfalone* valleys and quarries.

In the former the realization of a path along the valley, the construction of wooden bridges for the crossing of the stream, the recovery of old stairs, of a mill, of a water stone channel and of a pitch floor, were not sufficient to make the valley usable due to the presence of waste water flowing in the stream which caused unsafe health conditions along the whole valley (Fig. 6). The interventions made by the Superintendency for Cultural Heritage of Ragusa regarding the large *Latomia* of *Gonfalone valley,* extending about 1.5 hectares have been of a very different kind. This space has been conceived as a great "covered square" with a road to walk, cafes, shops and services; a gathering space with 4 small theatres, a movie theatre with about 200 seats, a theatre with 400 seats, two exhibition rooms, an artificial pond and a geological and karst museum of the Hyblean area (Scuto, 2009). The CIRS was also involved in this project for the planned realization of the aforementioned museum of geology and karst of the Hyblean area, thanks to the knowledge acquired with the investigation described above.

Figure 6: Stream polluted by waste water flowing inside the *Latomia* of Cava Mezzasalma, terminal part of Cava Santa Domenica (photo R. Ruggieri)

Figure 7: Flowstones in the Gonfalone karst cave (photo R. Ruggieri)

The idea put in place by the CIRS for the construction of the museum was done with the realization both of a geological guide booklet (Grasso et al., 2006) and with the preparation of thematic panels to be placed in an area of the *latomia* characterized by some karst features, such as two caves and different speleothems (Figs. 5- 7), discovered at the time of the limestone exploitation.

The setting for this geological exhibition was a rock amphitheatre facing the interior of the show space and the karst morphologies present on the walls The eleven panels have as themes the geology of the Hyblean area, the geomorphological and hydrogeological aspects, the surface and underground karst morphologies, the mines and mineralogical aspects, the fauna of the rivers and of the underground karst water.

A DVD was also prepared about these geological and naturalistic themes (AA.VV., 2006). The interventions mentioned in the project were almost all carried out, but the lack of funding for some structures, among which a lift connecting the valley and the surface, did not allow for the completion of the work as a whole and the eventual fruition.

7. CONCLUSIONS

The historic underground and the industrial archeology heritage, two decades after the speleological investigation and the early recovery efforts, is at present in a new phase of deterioration, this time affecting also the restoration works.

The works carried out in the *Latomie* of *Cava Gonfalone* have been vandalized, due to the lack of surveillance of the area which is easily accessible. The same applies to the *Cava Santa Domenica,* where despite repeated complaints for the elimination of the causes of deterioration of the stream, polluted by sewage, nothing has been done by the local authorities which in these last years have governed the city.

At the present time there is work in progress of a further project for the fruition of *Cava Santa Domenica* and *latomie* (Fig. 8), preceded by a radical cleaning of the thick weeds present along the whole valley.
An intervention which if done in isolation, will not resolve the problems of pollution in the valley, while for the *Latomie of Cava Gonfalone* nothing is happening.

Figure 8: Path of fruition in the *Latomia* of Cava Santa Domenica (photo R. Ruggieri)

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Underground Quarries of Gaziantep (Southeast Turkey)

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Abstract
The city of Gaziantep, located in southwestern Turkey, is built entirely on a soft Upper - Middle Eocene aged limestone. This argillaceous and chalky limestone formation, which is fairly easy to carve into, has determined the city's development and character in many aspects. This stone has also affected local architecture as it was used as main building element by cutting. When a building was to be built, the soft rock area where the building was to be placed upon was cut out as blocks in depth, and the rock blocks obtained were used directly for the construction. The emptied area served as the basement of the building built on top. While initially fairly soft, this rock would soften and change color as it came in contact with air. On the other hand, in addition to the underground dwellings carved to provide stone for the buildings, Gaziantep hosts gigantic underground quarries caused by great amounts of rock being removed. These were used later on for a variety of purposes such as factory or hovels. Three of these underground quarries in Gaziantep have been explored and surveyed and their later uses are explained in detail in this article.

Keywords: Gaziantep, underground quarry.

1. INTRODUCTION

The Upper - Middle Eocene age [MTA, 1997] soft clay and chalk limestone formation on which the city of Gaziantep is located (Fig. 1) upon has determined the development and character of the city in many aspects. This stone was cut and used as the main building material to affect the local architecture, texture of neighborhood and the general ambiance. The soft rock area on which a building was to be constructed could be cut in blocks, and emptied to the sub-basement level; and the quarried rock blocks were directly used in the construction. As the emptied space would be used as the sub-basement floor (or cave) of the building, this was a two-birds-with-one-stone situation. The spaces that remained within the main rock formation under the building could also act as cold storage rooms for the buildings. In many cases, the wells dug to reach the deeper water channels that ensured water distribution were dug in these cavities [Bircan, 2007; Çanakçı, 2007].

Figure 1: Location map

Apart from these cavities dug for the individual use of houses and mansions, another type of cavity, unique to Gaziantep, should also be mentioned. These are gigantic underground structures, such as the structure below the City Cemetery. Some of these are thought to have emerged as large amounts of stone were quarried for the construction of the city buildings. However, once they emerged, they undertook many different roles. In many cases, these underground quarries were used as workshops, and even factories. Even today, some places serve this purpose. For example, the ability to obtain very high levels of humidity has provided these areas with an advantage that cannot be found elsewhere for special fields such as yarn manufacture. These majestic spaces are still partially used. While there are some serving the tourism industry as cafés, there are also some that are still used as yarn workshops. All of these underground structures have the potential to be used in a manner that will contribute much more to the current culture of Gaziantep: for instance, they could be used as concert halls, museums, galleries, exhibition areas, restaurants and touristic facilities. The three largest underground quarries of Gaziantep that are neither yet protected or used are described below.

2. UNDERGROUND QUARRIES OF GAZIANTEP

2.1 Cemetery Caves

The Gaziantep Cemetery was built upon the largest underground quarry of the region, or maybe even of Turkey, as a result of a terrible planning error. Although the entries to these caves were blocked during the leveling and landscaping works many years ago, the eight ventilation

Figure 2: Cemetery Caves, collapsed part, roughly 35 meters in diameter (photo A. Yamaç)

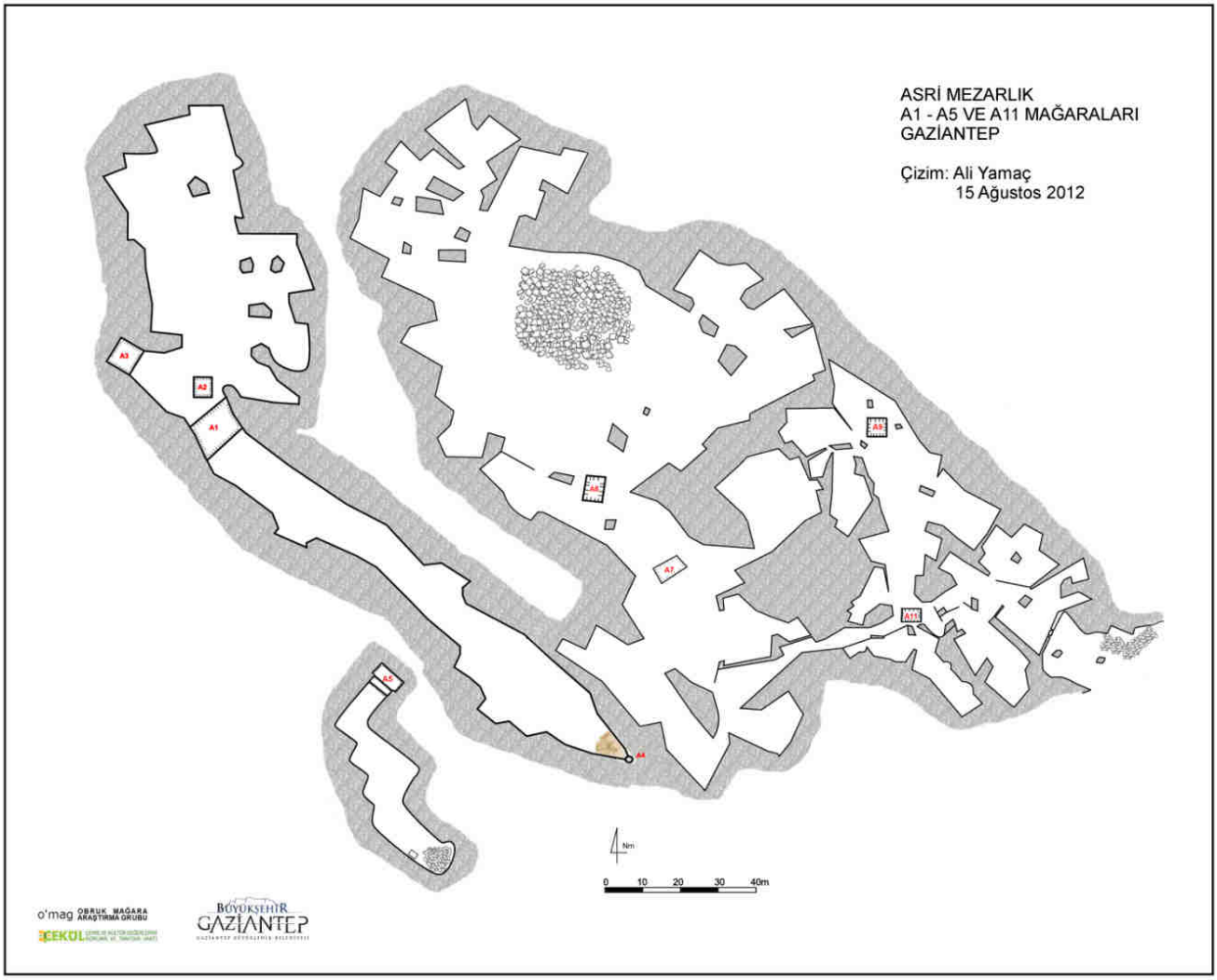

Figure 3: Plan of three separate caves under Gaziantep Cemetery. Collapsed part shown in the centre of the map with rubble (drawing A. Yamaç)

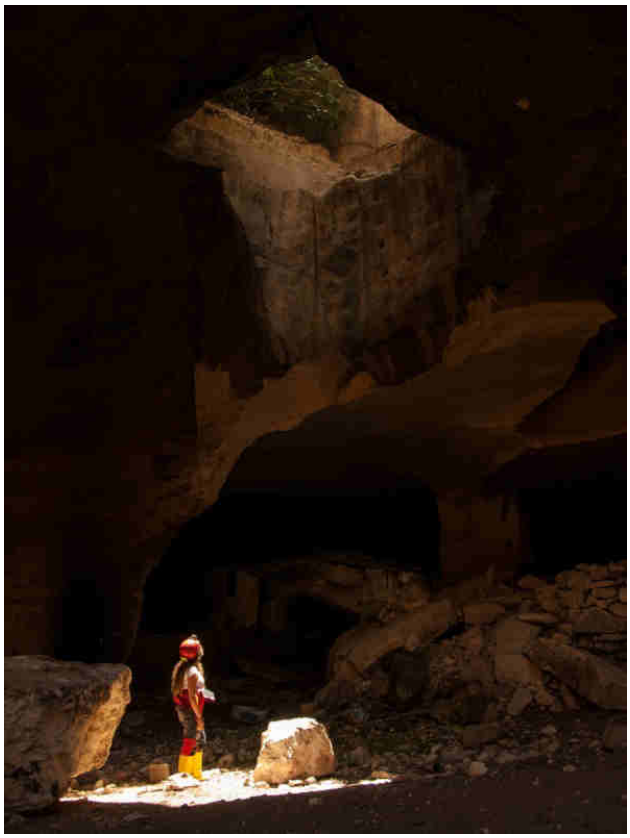

Figure 4: Cemetery Caves, below A8 ventilation shaft (photo C. Cankirili)

shafts that still exist should have given an idea about the cavities below. The consequences of this planning error became obvious, when a part of the cemetery collapsed on February 4, 2012 (Fig. 2). The investigation and survey that we conducted after the collapse has determined that an area below about 90.000 m^2 of the cemetery was riddled with cavities (Fig. 3). This system that basically consists of two large and one small cavities that are interconnected is the largest known ancient human-made underground structure in Turkey.

The average height of all these cavities is around 6-9 meters (Fig. 4). The ceiling thickness varies between 4-7 meters, as much as it could be observed from the ventilation shafts used for the descent and from the collapsed area. It is thought that the cave entrances near the main road were filled with earth during the leveling of the cemetery. Only a single connection exists from a small cavity near the main road. Apart from this, there are 8 ventilation shafts inside the cemetery. We think that at least a part of the cave system was used as a barn or cowshed after being created as a quarry.

2.2 Akbulut Cave

Akbulut Cave is located 7 km to the south of Gaziantep, on a rocky cliff, adjacent to the quarries near Akbulut (Fig. 5). This cavity consists of 4 interconnected sections, and it is

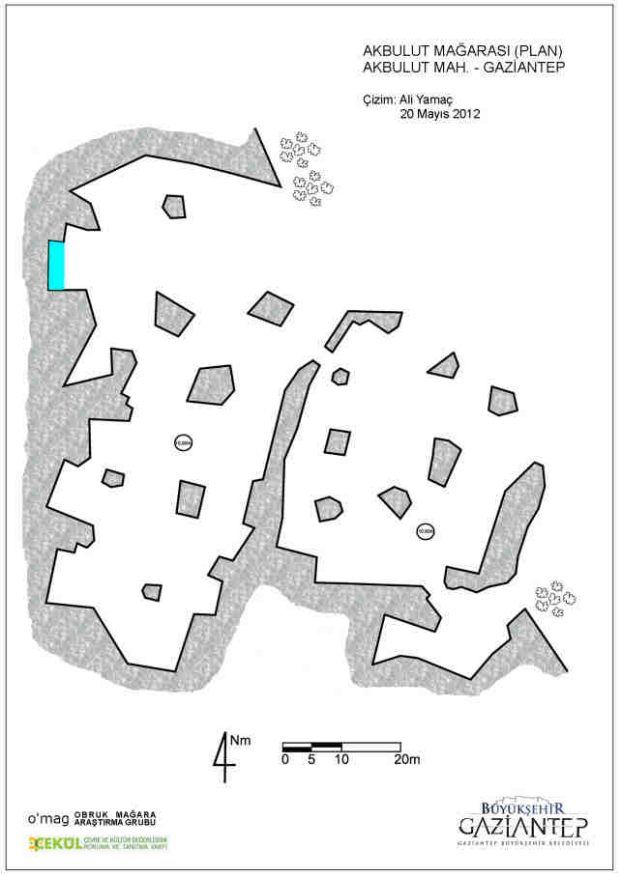

Figure 5: Plan of Akbulut Cave (drawing A. Yamaç)

Figure 6: Akbulut Cave, on the right of the photo middle wall separating two rooms (photo A. E. Keskin)

obvious that they were opened as quarries, just like the quarries nearby. It was later used as a pottery factory for some time. The interior of the cavity is quite clean and the limestone within which it is carved is hard and is different from the geological formation inside Gaziantep. The ceiling height is on average 6-8 m, but exceeds 10 m at some points (Fig. 6).

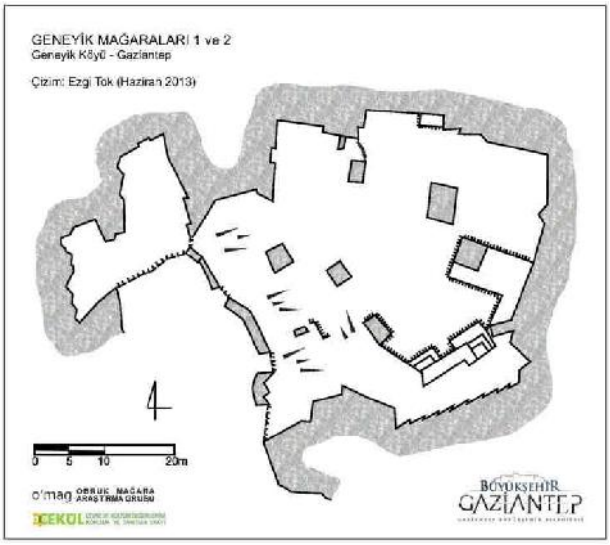

Figure 7: Plan of Geneyik Caves no. 1 and 2 (drawing E. Tok)

Figure 8: Geneyik Cave no. 1 (Photo A. Yamaç)

The measurements showed that the cavity is spread over an area of 8.500 square meters.
This makes Akbulut Cave the second largest artificial cavity in Gaziantep after Cemetery Caves. Terracotta remains on the floor of a small part of the cavity suggests that it was used, at least for some time, as a ceramic atelier or a storage area after its use as a quarry.

2.3 Geneyik Village Caves

This quarry, located 500 m from the Geneyik Village, to the south of Gaziantep, may be considered the third largest cavity in the area, after the Cemetery and Akbulut caves. There are two smaller underground quarries near the large cavity that has three different entrances. These artificial caves that spread over an area of 3.000 square meters and with ceiling heights that sometimes reach 6 m, are currently abandoned (Fig's. 7 and 8).

3. CONCLUSION

As we mentioned above, some of these majestic underground spaces of Gaziantep are still being used today. While there are some serving the tourism industry as cafés, there are also some that are still used as yarn workshops. However, all of these spaces have the potential to be used in a manner that will contribute much more to the current culture of Gaziantep.
It is not difficult to imagine some of them as concert halls, museums, galleries, exhibition areas, restaurants and touristic facilities. Unfortunately, these spaces are also under the risk of destruction under the pressure of urban development. The Cemetery Caves which were filled with earth, after a collapse that happened during our study, is a current example of this phenomenon.

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4. ACKNOWLEDGEMENTS

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SESSION 7

RELIGIOUS AND CULT STRUCTURES

The use of natural caves in the Christian religious practice in the Karoulia (Mount Athos, Greece)

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Abstract

St. Mount Athos it is a part of Halkidiki peninsula located in the Northern Greece. Speleological expeditions to this area have been organized during several years (2011-2014) under the long term project "Exporation of the caves of Mount Athos - Greece" of the European Speleological Federation. 155 cavities were researched for this years with attended by researchers from different countries - Bulgaria, Greece, Russia, Romania, Serbia and Turkey.

In this article we consider using of natural caves by monks to ascetic practice in the most interesting region of peninsula called Karoulia. Using the caves, monks increased it, made the cisterns (for collecting water), build monastic cells, chapels, shelters, graves and underground churches.

Keywords

Mount Athos, Greece, natural cave, artificial caves, orthodoxy, sacred cave, marble.

1. INTRODUCTION

There wasn't systematic researches of Athos's caves until the 2011. We have some information only from pilgrims tales and hagiographical texts. In 2011 by A. Zalov (Bulgaria) and L. Makrostergios (Greece) was launched a long term project "Exploration of the caves of Mount Athos, as integral part of the world natural, cultural and historical heritage" by patronage of Euro Speleo Projects – European Federation of Speleology.

Under the project were organized 4 expedition – in 2011, 2012, 2013 and in 2014. In October 2016 we plan to make one more expedition that wouldn't be the last one. Speleologists from 6 countries took part in the four expeditions: Bulgaria, Greece, Russia, Romania, Serbia, Turkey. 155 cavities of different origin and purpose were surveyed. The total length of surveyed cavesis about 1,500 m.

Main results of 4 expedition were published in several articles [Agapov 2011, 2012, 2014; Dolotov & Agapov, 2014; Lazaridis, 2014; Zhalov 2011, 2014, 2015; Zhalov, 2015]. In 2011 were published the book about cavites on the Mount Athos in Greek language [Βλάσιος., 2011]. There no discerptions of caves in this book but the information about it usage as religious objects.

Mount Athos (Fig. 1) is located in the north-east part of Greece and it is the one of extremity (Cassandra, Sithonia and Agion Oros (Athos)) of Halkidiki peninsula. It is a narrow and mountainous. Total length is 56 km, width from 7 to 12 km (narrowest part is only 2 km wight). Square is 335.6 sq km, maximum altitude 2033 m (Mount Athos).

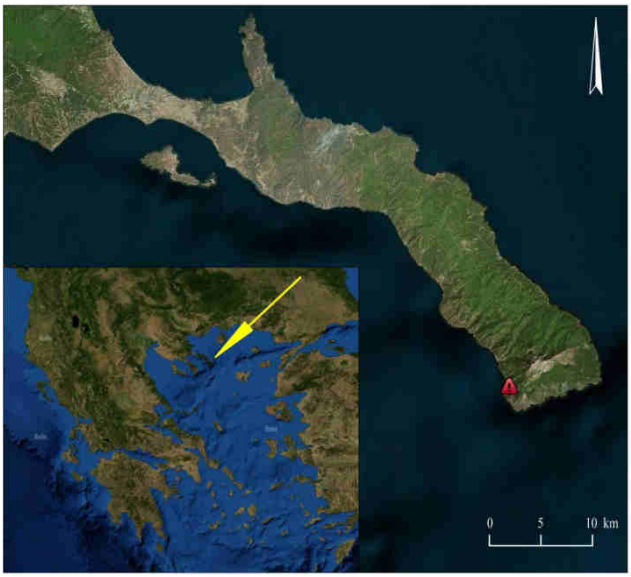

Figure 1: General map of the location of Mount Athos (source: Bing maps)

Geological structure of Athos is quite different. It involves massifs of Cenozoic granite, Mesozoic gneisses and migmatites (with areas of tectonic melange of metasedimentary rocks, marbles, gneisses, amphibolites, eclogites and peridotites) and Triassic marble and marbled limestone [Georgiadis et al, 2007; Himmerkus et al,. 2012].

The name Athos (toponym most probablypre-Greec etymology) associated with the name of mythical giant. The ancient history of Mount Athos is almost unknown. We can fined the information about some Greek city-States here - Sana, Fiss, Cleon, Dion, Olofiks, Akrofoi, Apollonia – their location is still unknown.

We still do not know when the first monks came to Athos. And also we have no intelligence about expansion and evolution of monks life here. The information that we have now (especially about situation until 9th century) scarce and divided and mostly based on tales and legends.

Some monks believed that establishment of some monasteries were made by patronage of Constantine the Great (1st part of 4th cent.) and that this monasteries were destroyed by Julian the Apostate. We can almost exactly be sure that monks appeared on Athos in the 7th century. To this time we can ascribe being here St. Peter of the Holy Mountain, who lived in a cave 53 years long.

In the 2nd part of 10th century peninsula get the public name – The Holy Mountain. Later in the middle of 11th century it was officially approved by diploma of Emperor Constantine Monomakh. The first monastery (Great Lavra) was founded in 963 by St. Athanasius of Athos.

The traditions of Holy Mount Athos made a great influence to the development of monastic practice in Orthodoxy. In the 10-11 centuries here were founded about 180 monasteries.

In the late 13 – begin of 14 centuries in the Athos spread the practice of Hesychasm [Zhalov, 2014] closely associated with living of monks in the caves.

Now Athos it is autonomic state as a part of Greece. It is a Federation of 20 monasteries (with 12 subordinate hermitages) witch can choose the delegates to the public administration that situated in the capital city Karyes. Monasteries do not obey to any church organizations except Ecumenical Patriarchate but only spiritual.You need special visa to visit Athos. Entrance to women is forbidden.

There are karst process on the territoty of Athos. We found natural caves of different genesis - karst, pseudokarst, erosion, hydrothermal. Also was found artificial cavites used for housekeeping purpose.

As a result of our research we identified this methods of using natural and artificial caves for religious and housekeeping purpose [Agapov, 2011]:

- Water galleries (for collecting water) and underground culvert aqueducts, mined in the rock massif (sometimes in the cracks or in the natural cavities). It used for collecting and transporting water to the monastery or hermitage. Length of that galleries from some meters to some score of meters.
- Cisterns for collecting water mined in the rock massif, length of some meters.
- Small natural cavities, grots or niches, using for ascetic practice (individual most of all). They usually have some markings of humans elaboration or backfill. Length about some meters.
- Ascetic cells in large natural caves, grots or niches. Some cave area near to the entrance stacked out of stone or wooden wall. Wall have windows and door. Length from 5-10 meters to 100 meters or more.
- Caves chapels dedicated to ascetic have been living here. As usually it is a natural cavities used in ascetic practice stacked out of stone wall with door. Length about 3-20 meters.
- Chapels or churches found in the natural caves. Length about some dozen meters.

Consequently artificial cavities of Athos is mostly natural caves (modified of humans elaboration) used for sacred purpose or some hidro-technical underground construction

In this article we represent caves in region Karoulia that were surveyed in 2013-2014 years. In 2013 with contributions of I. Agapov and S. Kaminsky and in 2014 with I. Agapov, Yu. Dolotov, G. Kolev. Main part of material published firstly.

Figure 2: Map of the explored caves on Karoulia.
Legend:
External Karoulia: 1. Cave at Karoulia.
Internal Karoulia: 2. Cave of Dormition of Most Holy Mother of God, 3. Father Tikhon's Cave. 4. Secret Passage Cave (Tayny Hod). 5. Ear Cave (arch). 6. Middle Ear Cave. 7. Lower Ear Cave
(drawing Agapov I. - source Google maps)

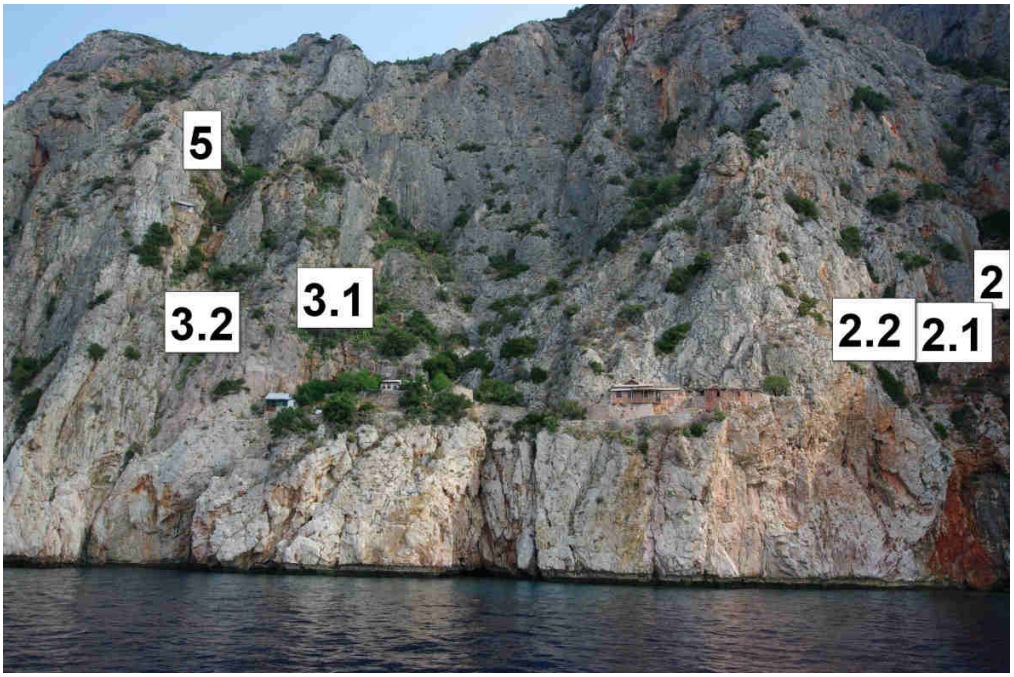

Fig. 3 - General view Internal Karoulia. (photo Agapov I.)

Legend:

2. Cave of Dormition of Most Holy Mother of God.

2.1 Cave with cisterns.

2.2 Cave Niche with vault.

3.1 Father Tikhon's Cave (top entrance).

3.2 Father Tikhon's Cave (lower entrance),

Father Athanasius's Cave.

5. Ear Cave (arch)

We surveyed the cavities that we could have only temporary access and the cavities didn't used for inhabitancy by monks. In the article present cavities that have topo survey or rough plan.

By spelestology classification [Dolotov and Agapov, 2014] Karoulia is the area of South Athos. This aria spans slopes of Mount Athos. The boundary passes on the ground from monastery of St. Paul thought the northern slope of Mount Athos to the Great Lavra. In administrative division it is the territory of Great Lavra. There is also tree hermitages - Agh. Annas, Kafrsokalivion and Timiou Prodromou and the monastic settlements of Agh. Vasiliou, Mikri Agh. Anna, Katounakia and Karoulia.

Massive material of the region is marbleized triassic limestones and marbles which contains karst cavities and caves.

Karoulia is a monastic settlement, located on the south-western slopye of penincula. Territiry Karoulia in general divided on Internal and External. Exteral Karoulia (Fig. 3) located on the south from Katounakia, Internal (Terrible Karoulia) on the brae to the west from External and have only one way thought the steep mountainous slopes equipped be metal chains and wooden stairs.

Since the old time on the territory of Karoulia have been striving most strong and disciplined monks. First of themsettled here in the natural caves probably in 17th centuries [Kadas, 2011] or in 18th centuries. In 19th centuries were build kalivas – small houses (καλύβα – greek, capanna - italian) and cells inside and around caves.

Anachorites [Βλάσιος., 2011] in general were Slavs – Serbian, Russians ect. Caves on Karoulia now use for prayer practice, like an ossuary and in housekeeping purpose. Almost in all caliva or cell there is a cave.

It is possible to identify Karoulia like a discrete karst area. There a lot of unexplorated natural caves that you can see from the board of ferry. Asses to that caves is very difficult and needs to use special equipment. We surveyed 13 caves that do not need any equipment – one cave in External Karoulia and other in Internsl.

You can see surveyed caves on the general map (Fig. 2)

2. STUDY RESULTS

EXTERNAL KAROULIA

2.1 Cave at Karoulia

This cave located about 120 meters to the north-west from pier Katounakia on the 90 meters high under the sea. Length is 10 meters (Fig. 4), the difference in elevation 4.7 (+1.5, -3.2) meters, high about 1.8 – 3.7 meters, width about 1 – 2.5 meters. Host rock is marble. Genesis – natural karst cave.

On the entrance to the cave was build kaliva (small house) (Fig. 4: № 2; Fig. 5) and the shelter above it (Fig. 4: № 4). Under the shelter there is an entrance to the balcony (Fig. 4: № 3) on the shelf with sea view.

Cave in general is a rambling corridor with a shelter in the deep part. High of the shelter is about 1.5 meters. Under it there is a cistern 3 meters deep (fig. 4: № 5). Cistern covered by wooden larry.

You can raise on the shelter by the wooden stairs (Fig. 4: № 6; Fig. 6) in the deepest part of the cave and find there a chapel in the east side (Fig. 4: № 8; Fig. 7)

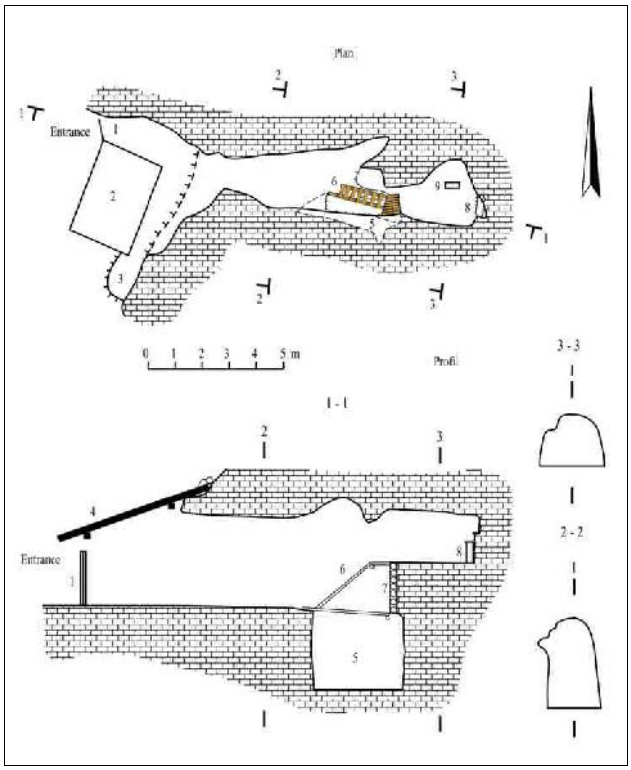

Figure 4: Cave at Karoulia. Survey: Agapov I., Kaminski S. Russian Geographical Society. Kolev G. , "Helictite", Sofia (Bulgaria). Drawing: Agapov I. 07.10.14)

Legend: 1. The metal gate (entrance). 2. Residential house (hut) 3. Balcony (on a rocky ledge) 4. The roof of the hut 5. Tank 6. wooden staircase 7. Retaining wall of stones, cement masonry 8. Chapel. 9. Bench.

Figure 5: Cave at Karoulia. Kaliva (small house) (photo Agapov I.)

On the wooden table you can finer a candlesticks, icons and other stuff. Under the table on the eastern side made the ledge for the icon. Foundation of the ledge fixed by planch of dark slate became the base for the icon. On the north side there is the niche with skull, cross and icon with foundation from dark slate.

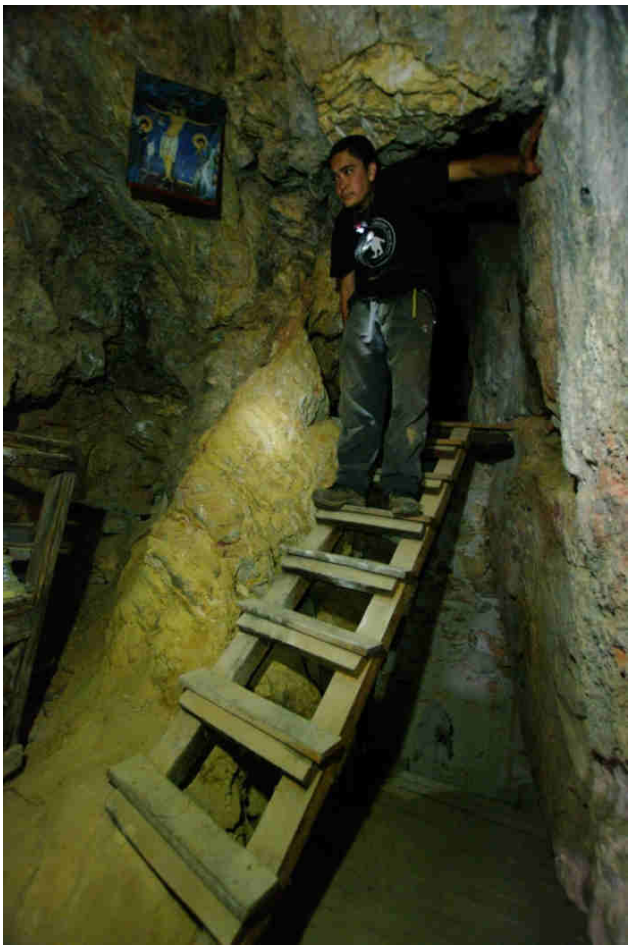

Fig. 6 –Cave at Karoulia. Inside the cave. A wooden stairs (photo Agapov I.)

Figure 7: Cave at Karoulia. Chapel (photo Agapov I.)

In the middle of the cavities there is a little banch for the monk (fig. 4: № 9)

This cave have the markings of humans elaboration and now is used for housekeeping purpose and prayer practice.

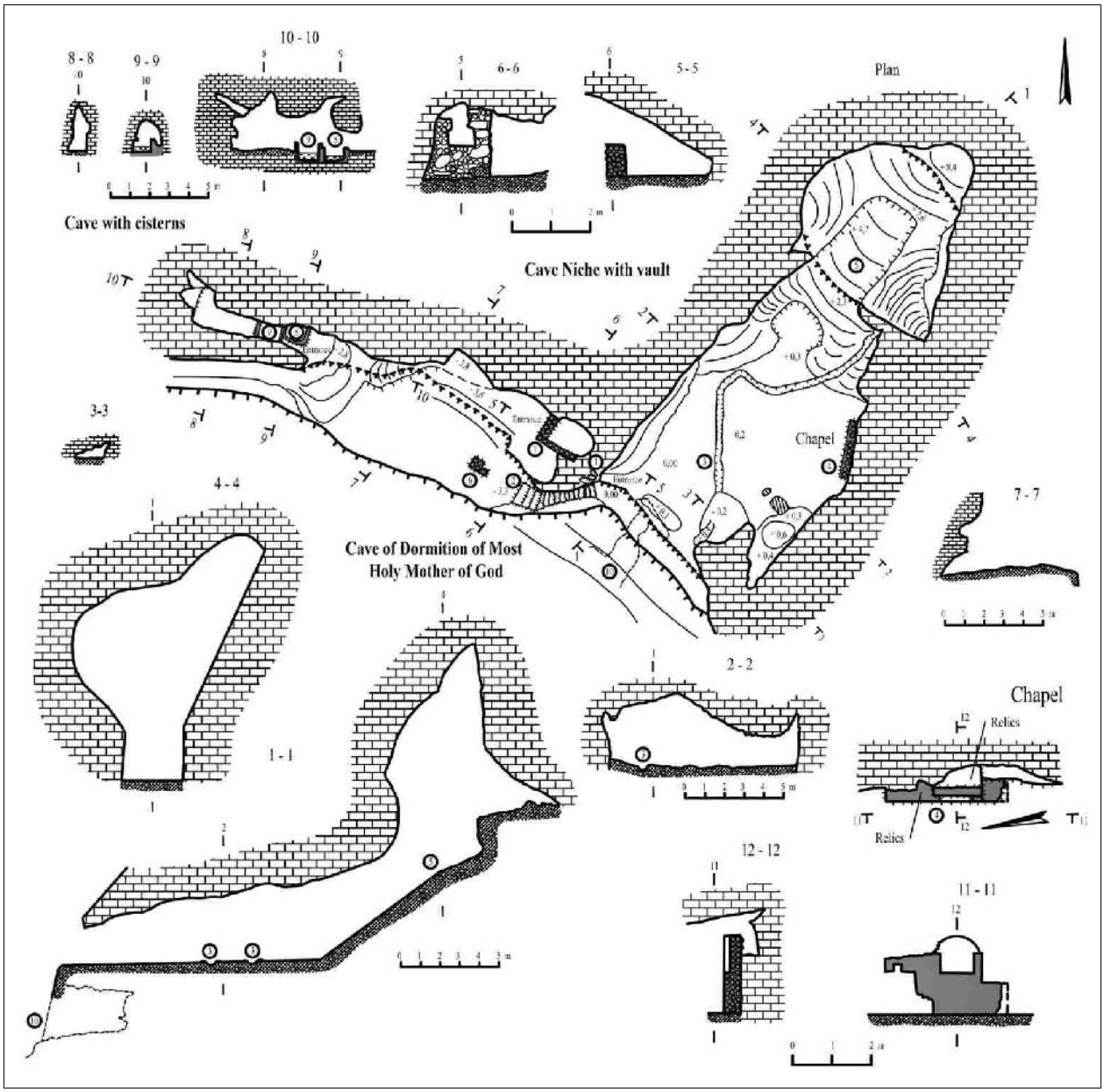

Figure 8: Cave of Dormition of Most Holy Mother of God. Cave Niche with vault. Cave with cisterns. (survey: Agapov I., Kaminski S. - drawing: Agapov I. Russian Geographical Society. 12-13.10.13)
Legend: 1. Steps (end of the first section of the trail from the External to the Internal Karulia); 2. Steps (continued trails) from the top to the lower terrace; 3. The groove for water drainage in flood; 4. Chapel; 5. Pit were extracted bright red clay for icon painting; 6. Stone base, cement masonry in the form of a cube; 7. Stone wall; 8-9. The water cistern; 10. Entrance in the Under Dormition Cave

INTERNAL KAROULIA

2.2 The cave complex of Dormition of Most Holy Mother of God.

This cave complex located about 200 meters to the north-east from Katounakia on the high about 76 meters above sea level and also on the road from External Karoulia to Internal (Fig. 8: №1). Every one who go down to the Internal Karoulia (from Katounakia) always passed by it.

Complex consist of 4 caves (Fig. 8), located above the sea inside two no large rocky terraces (complex outline of two terraces about 30x5 meters).

The name of the caves are Cave of Dormition of Most Holy Mother of God, Cave Under Dormition, Cave Niche with vault and Cave with cisterns. Host rock is marble. Genesis – natural karst caves.

Lets consider the caves on the top terrace.

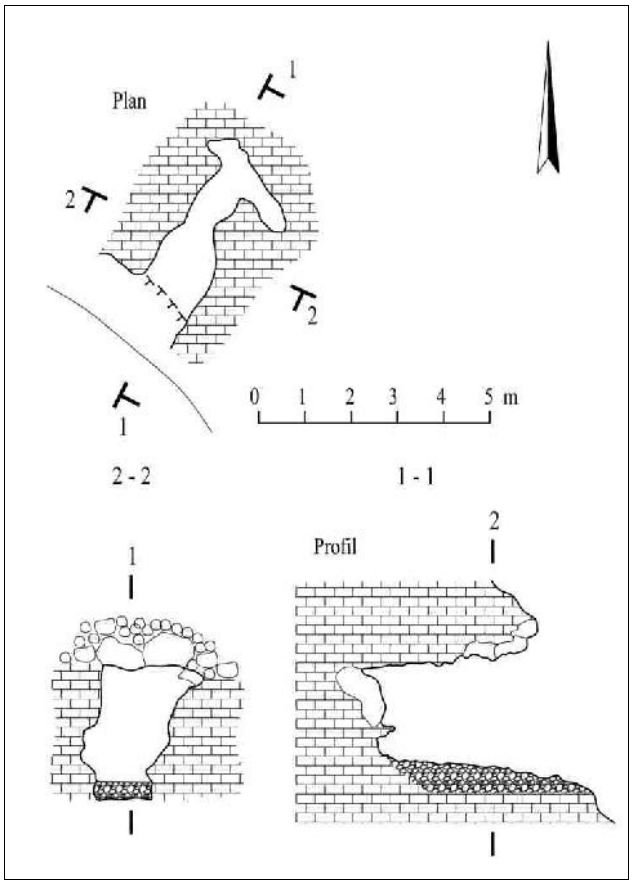

Figure 9: The Cave Under Dormition. Survey: Agapov I., Kaminski S. Russian Geographical Society. Kolev G. , "Helictite", Sofia (Bulgaria) (drawing Agapov I. 07.10.14)

Figure 10: Cave of Dormition of Most Holy Mother of God (photo Agapov I)

2.2. 1 Cave of Dormition of Most Holy Mother of God
Cave's length 31.5 meters, the difference in elevation +8.5 meters, width about3.5-10 and high 0.5 – 11 meters.

This cave has two more names.

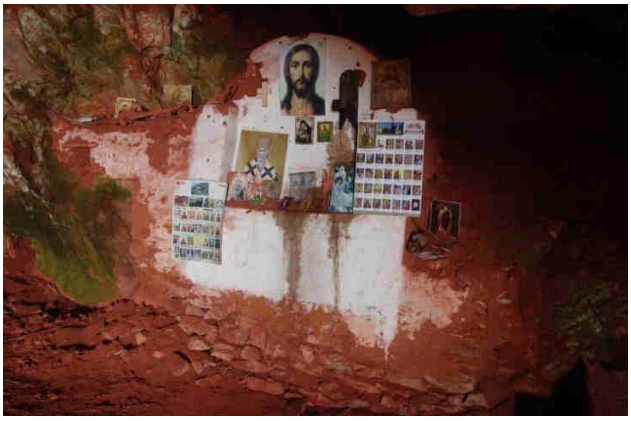

Figure 11: Cave of Dormition of Most Holy Mother of God. Chapel (photo Agapov I.)

Second name – The Robber's Cave. Believe the monks legends, one robber has been striving here and repent. And the third name – The Red Cave – because of host rocks color.

Cave consist of two grottos – nearest and distant one. In the near grotto organized drainage way for rain water (Fig. 8: № 3). It begins from natural crack and ends in the not big hole. In the eastern part (Fig. 8: № 4) have made stone chapel (παρεκκλήσι – in Greece, cappella di pietra – in italian) with remains of whitewash on the wall (Fig. 11).

Chapel it is the stone wall attached to the grotto wall. In the central niche and on shelves placed the icons. On the top and behind the central niche (the area between niche and caves wall) were placed bone remains of monks (mostly tibia, femur and spondyle) without skulls.

Height of the chapel – 2 meters, width 2.15 meters, thickness of the wall about 0.6 meters. Dimensions of the central niche HxWxD (0,95x0,85x0,150 m).Low shelf of the niche placed on the 1.05 meters height. Along the edges in some places chapel is destroyed.

In 2012 near the chapel was the bed with bed linen and blanket. In 2013 bed disappeared. The last who lived in this cave in the 21st century was Serbian man Father Daniil. He had been living here for 5 years.

According to the monks there were burials in the cave that were mixed with ground. If that is true, we think that it situated to the south-west from chapel in the blind pass. We think so because of smooth back filling in this part of the cave's area. Lower part of distant grotto covered by rockslide with dig-outing pit (Fig. 8: №5). In this pit is extracted bright red clay for icon painting.

Height of the grotto from the bottom of the hole about 11 meters and there on the top live bats. Also there are dripstone formations.

2.2.2 The cave Under Dormition.
This cave situated under the entrance in the Cave of Dormition of Most Holy Mother of God (Fig. 8: № 10).

Figure 12: Cave Niche with vault (photo Kaminski S.)

Figure 13: Cave with cisterns (photo Kaminski S.)

You can get there only with rope. Length of the cave 4 meters, high – about 2 meters, width – about 1 meter. It is only one gallery (Fig. 9). Presumably this cave was used for monastic practice from time to time. According to the Holy Father Aphanasius he went down to this cave using the rope in 2000 year (it was written in 2013 and the Father Aphanasius lives in cell on External Karoulia).

Lets consider the caves on the lower terrace.

From the top terrace to the lower one made stone stairs (Fig. 8: №2). Along them in the rocky wall punch in the iron chains. Near to the steps there is not large stone foundation cube form. Dimensions of this foundation 1x0.6 m. Height 0.6 m (Fig. 8: № 6). It could be the base for small house (kaliva). We supposed that there was a time when kaliva was here.

Under the northern part there is a small rock shelter.

This complex consist of two caves - Cave Niche with vault and Cave with cisterns.

2.2.3 Cave Niche with vault

Cave's length– 3.5m., width 1.6m., height 0.5-1.7m. This cave it is a part of natural niche that was insulate by stone wall (made of stones) (Fig. 8: № 7; Fig. 12). In the north-west side of the wall there is a breach (or window). Internal walls of the niche were covered by special plaster, which used usually for walls of cisterns. Function of this niche is not clear yet. It is possible it was used for storage water or food.

2.2.4 Cave with cisterns.

The length of the cave - 6.5 m., average width - 1.0 m., the height 1.0-2.9 m.

Cave with cisterns located in the western part of terrace. Genesis – natural carst cave with dripstone formations.

Near the entrance placed two cisterns with walls (Fig. 13). There is water in the cisterns and it is drinkable. Possibly this water condensed there. Both cisterns full for 30%.

The first cistern (Fig. 8: № 8) has dimensions 1.3x1,0 m (by outline of walls), depth (from the top to the bottom of the wall) about 0.7 m. The second cistern (Figs. 8: №9) has more high walls . Dimensions 1.4x0.8 m, depth - 0.85 m.

Thickness of the walls about 10-20 cm. The walls are made of stone with plaster.

Terrace ends near the entrance to the Cave with cisterns. The road continued from here to the Internal Karoulia.

2. 3 Father Tikhon's Cave.

It is located at 120 m to the west of the **Dormition of the Most Holy Mother of God Cave** at 100 m above sea level. The length of the cave is 130.0 m (Fig. 14).Ceiling height in the cave ranges between 0.5 and 10 m, gallery width ranges between 0.5 and 3.0 m.Height difference is 17 m, forming 4 levels. Host rock is marble. At present time it is the largest natural cave in the Mount Athos (considering the total length of all galleries).

The cave was used for the practice of prayer and for living of hermits. Father Tikhon of Mount Athos was the most famous hermit who lived in a cave.

Father Tikhon (Timofey Pavlovich Golenkov) was born in 1884 in the Russian village of Novaya Mikhaylovka, moved to the Mount Athos in 1908 and died in the Holy Cross cell nearthe Stavronikita Monastery September 10, 1968. Inthecavehelived 15 years. "His feat was harsh and

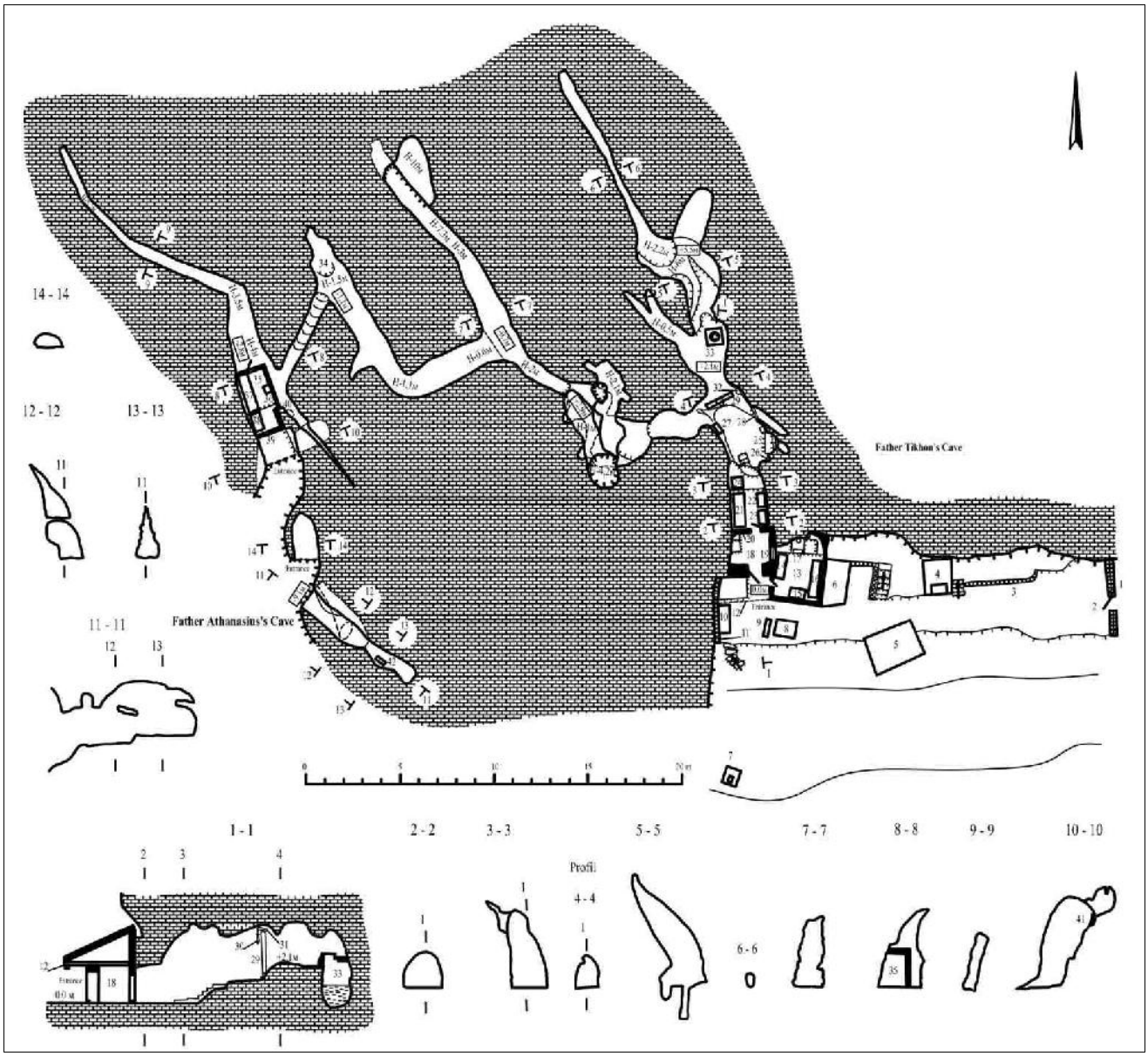

Figure 14: Father Tikhon's Cave. Father Athanasius's Cave. Survey: Agapov I., Kaminski S. Drawing: Agapov I. Russian Geographical Society 11.10.13.

Legend: 1. Fence; 2. The entrance gate; 3. Terrace Wall; 4. Stove; 5. Shed; 6. Shed; 7. Toilet; 8. Table (on the surface); 9. Bench (at the table); 10. Box hardware; 11. Retaining Wall; 12. Roof; 13. Kitchen; 14. Table; 15. Table; 16. Bed; 17. Oven; 18. Hallway; 19. Window; 20. Niche with the icon; 21. Bed; 22. Table; 23. Chest; 24. The Chair of prayer (stasidiya - Greek); 25. Chapel (Paraklisis - in Greek) - a table with a lectern; 26. Niche - 2 pcs. One under another; 27. Seat; 28. Ossuary; 29. Wooden cross; 30. Icon lamp; 31. The metal trough; 32. Shelf; 33. Tank; 34. Small dams to regulate the water flow (at the time of the surveying without water); 35. The cell (construction of the 19 century.); 36. Oven; 37. Bed; 38. Table; 39. Window; 40. The opening of the crack above;41. Masonry; 42. Bench

unrelenting. He did more than six hundred bows per night. He ate once in three days, and often once a week. Every Saturday he went to receive communion in the monastery of St. George, and then immediately returned to his cave" [Russian Athos..., 2012].

The last hermit, Father Andrey from Russia, lived in this cave until 2012 andleft the cave, because life there was quite heavy. The cave is sultry and humid, water from the tank contains a lot of calcite, causing health problems.
At the time of 2013-2014 the cave was uninhabited.

Figure 15: Father Tikhon's Cave. The small house (kaliva) at the entrance to the cave (photo Agapov I.)

Figure 16: Father Tikhon's Cave. Inside the cave. View of the chapel and the entrance to the cave (photo Agapov I.)

Ground part of the complex.
A gate in the stone wall leads from the main trail to the surface part of the living complex (Fig. 14: № 2). Behind the wall the main household constructions are located on the natural rock terrace (about 20x5 m2), namely sheds, a toilet, a table, a bench, a box for household inventory, a kitchen with awning, an outdoor oven (Fig. 14: №№ 3-13). The terrace is reinforced with the stone wall. Stone stairs are made to ascend or to descend to different levels of the terrace.

The basic building of the complex (Fig. 15) is attached to the rock, and consists of two rooms: a kitchen (Fig. 14: № 13) and ananteroom (Fig. 14: № 18). An awning is made in front of the anteroom (Fig. 14: № 12). Inside the kitchen there are a stove, a bed and a table (Fig. 14: №№ 13-17). The kitchen is connected to the anteroomwith a window. The kitchen has wooden walls, the anteroom has stone walls. A chimney goes to the karst cavities located above the hut roof.

The entrance hall (anteroom) is used for storing household inventory. Also in the anteroom there is a small table and a

Figure 17: Father Tikhon's Cave. Wooden cross (photo Agapov I.)

niche for an icon (Fig. 14: № 20). Apparently, most buildings belong to the period of 20-21st centuries.

Another door leads from the ante room to the Father Tikhon's cave. Because of the two constantly closed doors the cave is not ventilated. Therefore, the microclimate in the cave is not suitable for a long-term stay.

Description of the underground part:

Basic level.
From the entrance hall we enter to the cave. The cave is of karst genesis and shows a labyrinth type with narrow branching galleries. The proximal part of the cave (Fig. 16) is highly modified by human activity. Along the gallery we can see a bed, a desk and a chest (Fig. 14: № 21, 22, 23). Above them there are wooden beams for hanging of some massive object.

A wooden chair (stasidiya - in Greek) stays on the next ledge. It is used on Mount Athos for the practice of prayer (Fig. 14: № 24). These chairs are installed in the temples of Mount Athos and Greece. From the chair, you can ascendto the next platform following several steps. Around it there are concentrated the main elements having sacred significance, namely a wooden cross (Fig. 17) with Golgotha(Fig. 14: № 29) and an icon lamp (Fig. 14: № 30).

A metal gutter is above the cross (Fig. 14, 31), it protects the cross during flood. A wooden spear, a sponge, the crown of thorns of the Christ and the prayer beads are nailed to the cross.

In the east wall inside the natural niche there is a chapel (paraklesis - in Greek, Fig. 14: № 25.). It consists of a wooden table (lectern), which is attached to the natural wall, and two stone shelves with icons that are located above the lectern. On the walls fixed of different nails.

On the lectern there are few candles in sconces and without them. To the left of the lectern there is a shelf with hymnals. To the right there are two niches in the rock, one above the other (Fig. 14: № 26.). In the upper niche there is a cross, in the lower niche there are household accessories.

Figure 18: Father Tikhon's Cave. Ossuary (photo Agapov I.)

An icon lamp hangs at the top of the niche, an icon is on the left of the niche. Under the lectern there is a small low bench. To the southwest from the cross there is a small wooden seat (Fig. 14: № 27). To the east from the cross there is a shelf with a bottle of oil.

To the southeast from the cross there is a small karst cavity extending along the natural crack. Inside the cavity there is an ossuary (Fig. 18; Fig 14: № 28.). The base of the cavity is reinforced with stone masonry.

Behind the cross there is a tank with hatch (Fig. 14: № 33). The tank is half filled with water, and there is a bucket with chain to take water. The depth of the tank is about 2.5 m. The tank is located at the crossing of passages. The passage going to the left quickly tapers into impassable cracks. The passage going forward gets into a small hall of 6 m high. This is a top level.

The upper level.
There are debris on the bottom of the hall, produced by the rocks falling down. It seems that it was caused by gravity processes. The hall lower part is the highest point of the cave system. (+5.5 meters) Two dead-end galleries run out from the hall. The first of them is short and another one, developing along a tectoic crack, is much longer.

The main cave part develops to the west from the wooden cross. In six meters we can reach a small cavity. There is a passage to the middle level in the upper part of this cavity.

Middle level.
The middle level consists of two cavities connected with a well with its depth of 4,2 meters. The floor of the upper cavity is at the height of +2.9 meters. There are speleothems on the walls. The highest temperature and humidity values were measured in this cavity. The main reason is absence of ventilation in this part of the cave system.

The main level.
The main level goes lower. The mark of the next crossing is -0,7 meters. The north-western gallery leads to a dead-end with a ten meters high chimney with speleothems. The upper part of the chimney was not surveyed.

The south-western gallery isinclined down. A small dam (Fig. 14: № 34) used for flood waters control is organized in a dead-end before the passage to the lover level.

The lower level:
It is situated at the -2,8 meters mark. The lower level features a gallery running to the north-west and eventually turning into a narrow crack. There are a lot of speleothems here. The south-western part of the gallery leads to the lower exit.

It seems that a small stone cell was built near the entrance in the 20th century (Fig. 14: № 35). Its dimensions: about 1.8x3.6 meters, not more than 2 meters high. there is a stove inside the cell. Its chimney leads to carst cavities in the upper part of the gallery. A table, a bed and a window leading to the exit can be also found in the cell. There is a crack to the east from the cell. Very soon it becomes impassible. There is a small passage to the upper cavities in the top of the crack (Fig. 14: № 40). If you climb to the cell roof (Fig. 19) you can carefully descend to the lower exit and reach the Father Athanasius's cave.

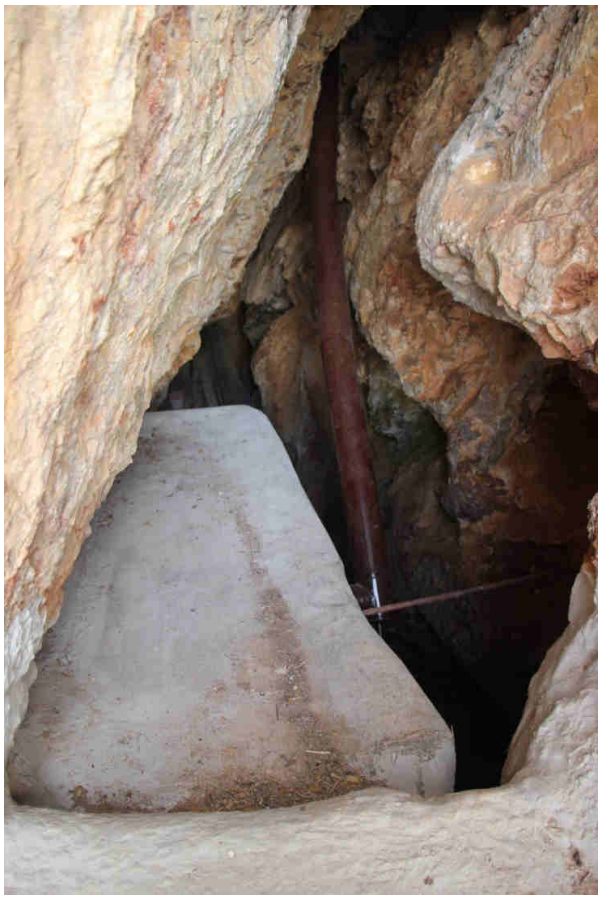

Figure 19: Father Tikhon's Cave. The roof of the cell in the lower exit of the cave (photo Agapov I.)

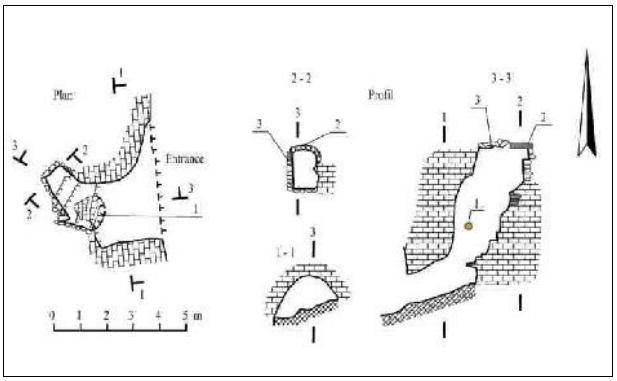

Figure 20: The Tainy Khod (Secret passage) Cave Survey: Agapov I., Kaminski S. Drawing: Agapov I. Russian Geographical Society. 12.10.13 Legend: 1. Baulk; 2. Masonry, made on cement; 3. Masonry, made without cement

There is a natural cavity in the upper part of the gallery roofing to the east from the entrance. It is reinforced with stone backfilling (Fig. 14: № 41).

2.4 Father Athanasius's Cave

The cave entrance is in 7 meters to the south from the lower exit of Father Tikhon's cave (Fig. 14).

Its length is 9.5 meters. Its height is about 2.0-2.9 meters; width is 0.6-1.9 meters, the altitude difference is +1.5 meters. It is a carst cave with speleothems. The cave consists ot two lower cavities. There is a small bench in the big cave (Fig. 14: № 42). It was used for praying.

It seems that the cave was connected with Father Tikhon's cave in the past. Later a collapse took place between the Father Tikhon's cave lower exit and the entrance of Father Athanasius cave. Only the walls of the rift where the cavity was situated have remained. The garbage thrown away from the huts built above.

The cave was used by hermits at least from the late 20th century - early 21st century. We know the name of the last monk who lived here. It is Father Athanasius (Russian). The information is a record of his statement in 2013.

It is known that Father Athanasius stealthily lived in this cave for 5 months (the exact date is unknown, but it seems to happen in the 2000s). He had no official permission to live long in Athos. He was found by the Athos police in 5 months.

To get the official status for permanent stay in Athos he joined the Great Lavra brotherhood. The Athos police gave him one month for it. Now Athanasius lives in a cell in Outer Karulia. Some of his private things are still left in the cave [Electronic..., 2013].

This story is not rare for Athos. Some of the hermits illegally live in Athos. They get to the Holy Mount using a short-term pilgrim visa.

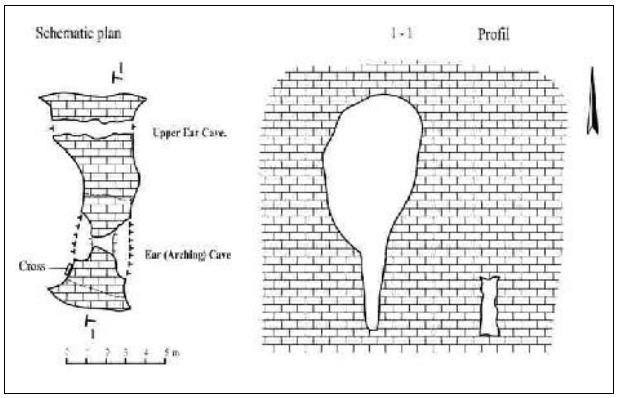

Figure 21: The Ear (Arching) Cave and the Upper Ear Cave. (survey Agapov I., Kaminski S. - drawing Agapov I., Russian Geographical Society 12.10.13)

2.5 The Tainy Khod (Secret passage) Cave.

It is situated in a cliff under Father Varnava's cell (Fig. 20) in 75 meters to the north of Father Tikhon's cave on the altitude of 120 meters A.S.L.

The cave total length is 4.5 meters. The altitude difference is +4,6 meters. The width is about 1-3 meters. The height is 1.5 meters (except the well). The cave lays in marbles.

It is a natural cave partially enlarged by people. The cave entrance is natural, it's inclined. A nearly vertical stairway leading upwards is in two meters from the entrance. There is a wooden balk laying horizontally next to the stairway. It may be a part of timber or a ladder. The walls and roofing of the cavity are partially reinforced with backfilling. The cave finishes in a dead-end with backfilling. The roofing of the dead-end is partially made of rocks reinforced with concrete.

The cave was named "The secret passage" due to a supposition that the there was an exit from the cave was organized in one of the halls of Father Varnava's Cell. Probably the cave could be used to escape in the case of danger. Later the passage from the cave was closed. Due to the presence of stairs the underground passage was surely used by people. Unfortunately its purpose is still unknown.

2.6 The Ear (Arching) Cave and the Upper Ear Cave.

The caves are situated in 65 meters to the south-west from Father Tikhon's cave (Fig. 21) on the altitude of 140 meters A.S.L. They are one of the Inner Karulia centerpieces. The "Ear" carst arcing (another name is the Karulian Ear) can bee seen from different views.

Various monk and pilgrim legends mention the arching of the Ear cave. For example pilgrims said "the words said here are heard by the god".

The ear cave (Fig. 22) is an arching (a carst bridge) remained after a former cave system had collapsed. The arching plan is about 3 meters long. The width of the lower part is about 4-5 meters. The arching height is 12 meters. A metal four-pointed cross welded of metal reinforcing is

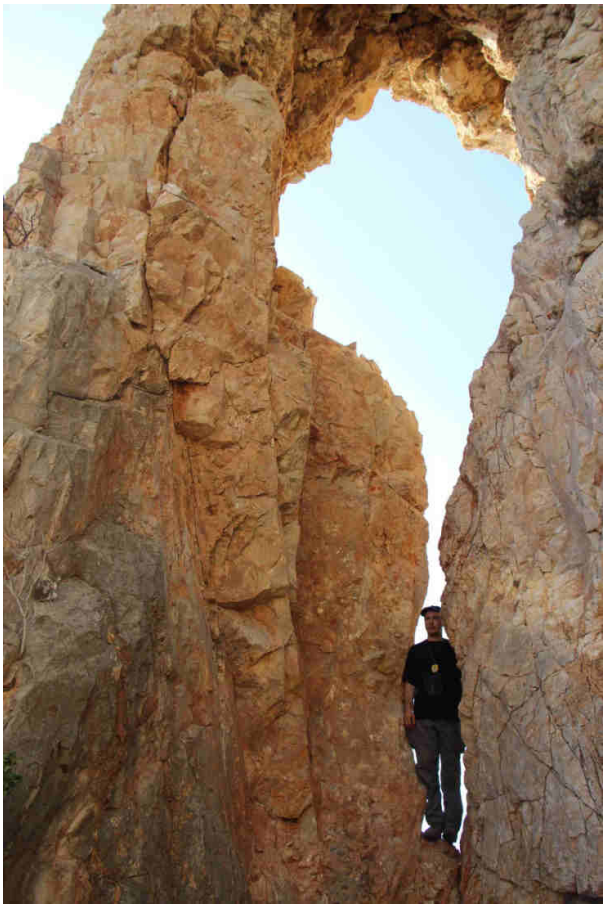

Figure 22: The Ear (Arching) Cave (photo Kaminsky S.)

installed under the wall on the western side of the arching. One can pass through the arching. Than the road is lost.

Another cave called the Upper ear is situated in 6 meters to the north of the Ear. It features a crack type cave fragment 4 meters long and 3 meters high. Its width is not more than 1 meter.

2. 7 The Middle Ear Cave

It is situated in 35 meters to the North-West and down from the Upper Ear cave on the altitude of 121 meters A.S.L. The length of the cave is 73 meters, its altitude difference is 21 meter (from the entrance to the bottom of the cave). Its height is from 0. to 10 meters, its width is from 0.5 to 2.5 meters. The cave lays in marbles. There are a lot of speleothems, stalactites and stalagmites inside.

The cave was discovered during the expedition in 2013 by Kaminsky and Agapov. That time a schematic plan was created and the main cave part was examined (except its part with rock backfilling). The detailed survey was conducted in the october, 2014 (Fig.23).

The entrance to the cave is situated in a well. An inclined gallery about 5 meters long remained near the entrance.

The cave can be divided into several sections: A-B-C-D-F.

Section A-B.

It consists of several small inclined wells. Their total depth is about 10 meters. It begins from the entrance well (A). It finishes in a small hall (B). There is a small pit partially covered with debris in the Southern part of the hall. The signs of excavations remained on its bottom (there is a bucket and clothes remains). The cave does not spread to the area of the excavation site.

Slavonic graffiti (for example the name of Gena) and several cross pictures were found on the cave walls here (Fig.23: № 1). It seems they were drawn in the 20th century. Perhaps the graffiti were created by the same people who conducted the excavations.

Section B-C

An inclined passage leads down from the hall (B) and reaches the gallery (C) ceilings. The altitude difference is about 5 meters.

Section C-F.

The gallery (C) continues to the North-West. After 5.5 meters it divides into the upper gallery and the lower one. The lower one soon turns into impassible cracks but the upper gallery continues. At first it goes up for 3 meters, than it leads down for 4.7 meters. After that it raises for 3.8 meters and finishes in a chimney about 10 meters high. In the highest part one can find the continuation of the cave but the speleothems must be destroyed to pass there.

Section C-D.

It is the most interesting section. The inclined gallery (C) continues upwards and finishes in a dead-end. There is a vertical well about 4 meters high in the roofing before the dead-end. The well leads to a small inclined hall. The hall dimensions are about 6x3.5 meters. Its height is about 2 meters.

There are two areas with rock backfilling (without concrete) in the Eastern part of the hall (Fig. 23: № 2). The height of the Northern wall is about 0.8 meters (Fig. 24). The wall is L-shaped. There is a small collapse in the center of the wall (Fig. 23: № 3). The wall dimensions are 1.6x1.8 meters. The Southern wall is constructed in the end of the narrow gallery. The height of this wall is about 0.5 meters. Its width is about 0.5 meters.

An inclined rockslide brought to the hall from the collapsed exit develops from stone walls to the well.

According to the surface conditions there is a hermit hut, which was not surveyed, behind the stone backfilling near the cave exit. Perhaps the nearest part of the cave spreaded into the volumes of the hut after stone walls reconstruction.

We had also a conclusion that the cave entrance could be backfilled intentionally to preserve a secret shelter which could be opened in the case of danger. There is another opinion that the cave was backfilled due to the collapse in its entrance.

Hermits and monks believe in secret caves where one can hide to flee. Perhaps we discovered such cave.

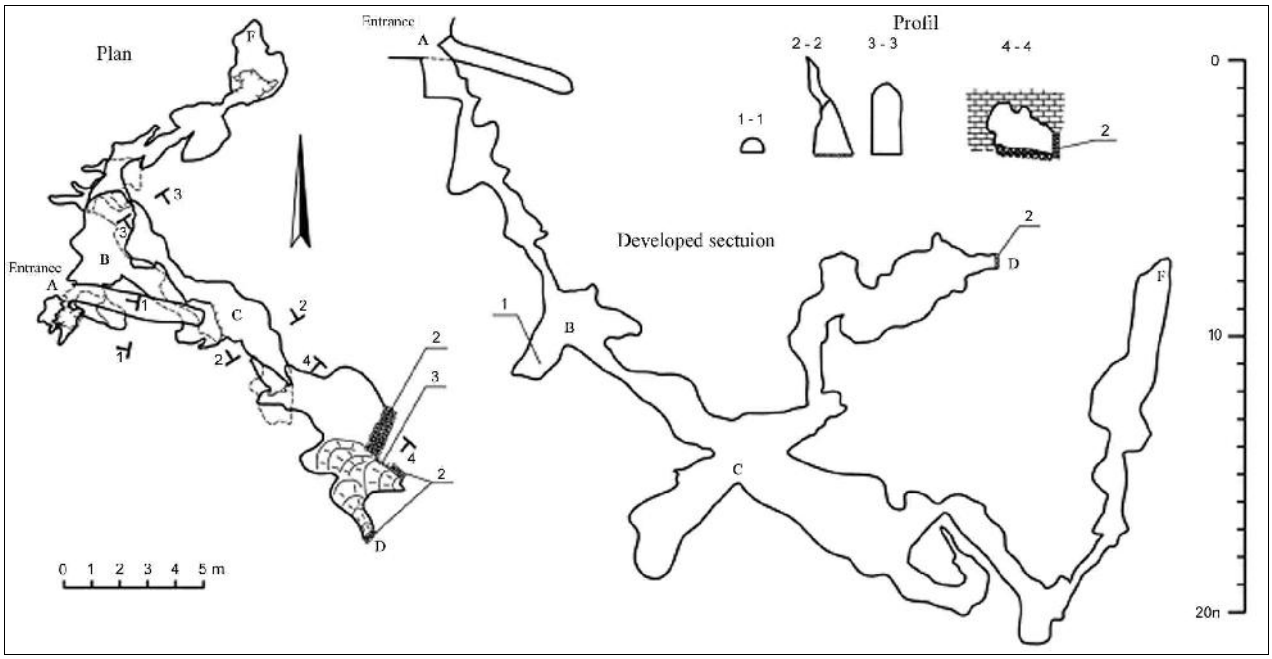

Figure 23: The Middle Ear Cave. Survey: Agapov I., Kaminski S. Russian Geographical Society. Kolev G., "Helictite", Sofia (Bulgaria) Drawing: Agapov I. 06.10.14
Legend: 1.Graffiti, traces of excavation; 2. Masonry; 3. Boulder choke

Figure 24: The Middle Ear Cave. Masonry (photo Agapov I.)

The Lower Ear and Cell Caves are situated in one big carst depression. They could be parts of one entire cave system in the past. The carst depression is situated in about 10 meters to the North-East of the Middle Ear Cave on the altitude of 110 meters A.S.L.

2.8 The Lower Ear Cave

The cave is situated in 10-15 meters to the East and down from the Cell Cave. This cave is 5 meters long (Fig.25). Its height is about 2 meters, the width is also about 2 meters. The altitude difference is +4 meters. The cave lays in marbles. The entrance of the cave is situated in the wall of a former inclined carst cavity with the collapsed roofing. One can reach the cave passing by a narrow inclined cliff shelf from the Cell Cave. The Lower Ear is of the carst origin. It is a fragment of that carst cavity. The bottom of the cave is covered with debris. There is a carst bridge lower. It remained after the main cavity collapsed. There is still no plan of the cave. According to monks inquiry there was a passage to a lower natural terrace in the depression area. There was a hermit hut on that terrace. They said thad ladder rounds and ropes remain on the cliff but we couldn't find any during our survey.

2.9 The Cell Cave.

The cave is situated at the edge of a big carst depression. Its length is 2.0 meters. Its height is about 0.8 meters; width is 1.2-1.6 meters, the altitude difference is -0.5 meters. The entrance of the cave is situated in the wall of a former carst cavity with the collapsed roofing. The cave is of the carst origin. The cell cave features a small chamber with its dimensions of 1.8x1.5 meters (Fig. 26). The bottom of the cave is covered with leaves mixed with ground. There is a small rock blocks structure on the slope af the carst depression opposite to the entrance. It is about 0.7 meters high and about 1.1 meters long. The structure is typical for Athos terraces. Probably the cave could be used by a hermit for praying.

3. CONCLUSION

Eventually we have made an overview of the usage of natural caves by Christian hermits using the example of one region of South-Western Athos. Modern caves arrangement is fixed in this paper. We also tried to describe the surface residence and household complex built next to the cave. It is important to understand the usage of the underground space in Athos. The research will be continued.

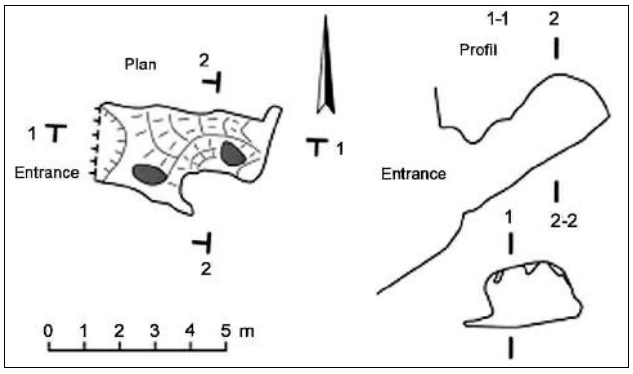

Figure 25: The Lower Ear Cave. (survey Agapov I., Kaminski S. - drawing Agapov I. Russian Geographical Society. 12.10.13)

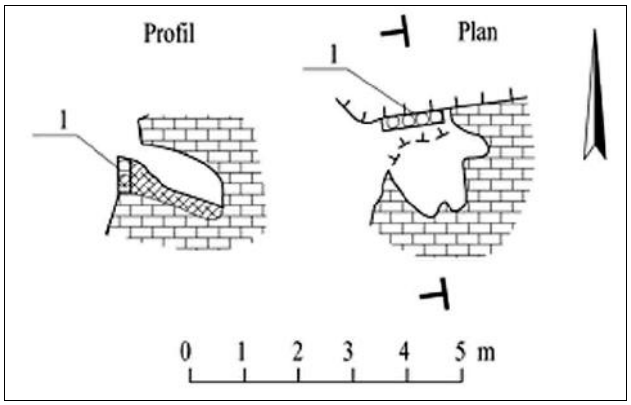

Figure 26: The Cell Cave (survey: Agapov I., Kaminski S. - drawing: Agapov I. Russian Geographical Society. 12.10.13) Legend: 1. Masonry

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Typological and Chronological Problems of David-Gareji (Georgia) Cave Churches Against the Background of Cappadocian Rock-cut Monuments

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Abstract

More than two dozens of Christian cave monasteries created at the different stages of the Middle Ages have been found in South-east Georgia, in the province of *David-Gareji*. According to the historic sources, the earliest of these monasteries were founded in the 6th century [Чубинашвили, 1948; Абуладзе, 1955]. The mentioned above monasteries consist of numerous caves having different size and design. As wall painting and inscriptions characterizing Christian iconography have been attested only in some parts of the churches' interiors, and besides wall paintings do not always coincide with the construction time, church dating is mainly provided on the basis of architectural analysis of their shapes.

The research outcomes conducted in the given direction enable us to presume that the cave churches of David-Gareji were constructed during the period starting from the 6th-7th and throughout the 13th-14th centuries. Among them, together with rather small in size, simple cave chapels with one nave, the free cruciform churches are also considered by us as the earliest rock-cut structures, which have flat, arched or dome-imitate ceilings. This conclusion is based on the following arguments: shapes of rock-cut churches constructed in different architectural style could have represented more or less precise imitations of the stone church structure interiors widespread in mainly the same periods and within the same regions. Stone churches planned as of free cruciform in plan were being built in Georgia only in the 6th-8th centuries, while example of neckless stone dome churches in Georgia emerge only in the 7th-9th centuries. As a result, creation of rock-cut church imitations with the given elements in David-Gareji monasteries should be supposedly dated back to the 6th-9th centuries.

It should be noted that rather close analogues of the David-Gareja-style cave churches can be traced in Cappadocia cave complexes. Substantial part of scientists dates the rather small-size, one-nave type and free cruciform in plan cave chapels of Cappadocia (including adorned with neckless dome imitations), from the same period - the 8th-10th centuries.

Certainly, it cannot be excluded theoretically that the given type of cave churches in these two regions (Cappadocia and David-Gareja) could have been developed independently from each other as a result of the mentioned above process of copying from their stone-cut prototypes. However, the version that the monk groups living in these two adjacent regions of the early Byzantine-culture prevalence, could have borrowed planning of one or another architectural-style facilities and especially church constructions from each other, is considered to be much more acceptable. Moreover, it is well-known from the historic sources that Georgian organizations, particularly, David-Gareji monastery, had rather close relations with the monumental monastery centres of Cappadocia.

Keywords

Georgia, David-Gareji, cave churches, monastery, architecture, Cappadocia.

1. INTRODUCTION

More than two dozens of Christian cave monasteries created at the different stages of the Middle Ages, have been found in south-east Georgia, in the province of *David-Gareji*, in the area located approximately 70-80 kilometres away from Tbilisi in the basin of the *Mtkvari* and the *Iori* Rivers (Fig. 1). According to the historic sources, the earliest of these monasteries were founded in the 6th century by St. David, one of the so-called "Thirteen Syrian Fathers" who developed a network of monastic centres throughout eastern Georgia [Чубинашвили, 1948; Mroveli Leonti,1955; Абуладзе, 1955; Bagrationi, 1959]. Zenith of foundation and active functioning of the rest cave of the monasteries by St. David's disciples and followers of his ascetic ideology within the area, is associated to different periods of early and late Middle Ages. For this reason these monasteries consist of numerous caves having different size and design.

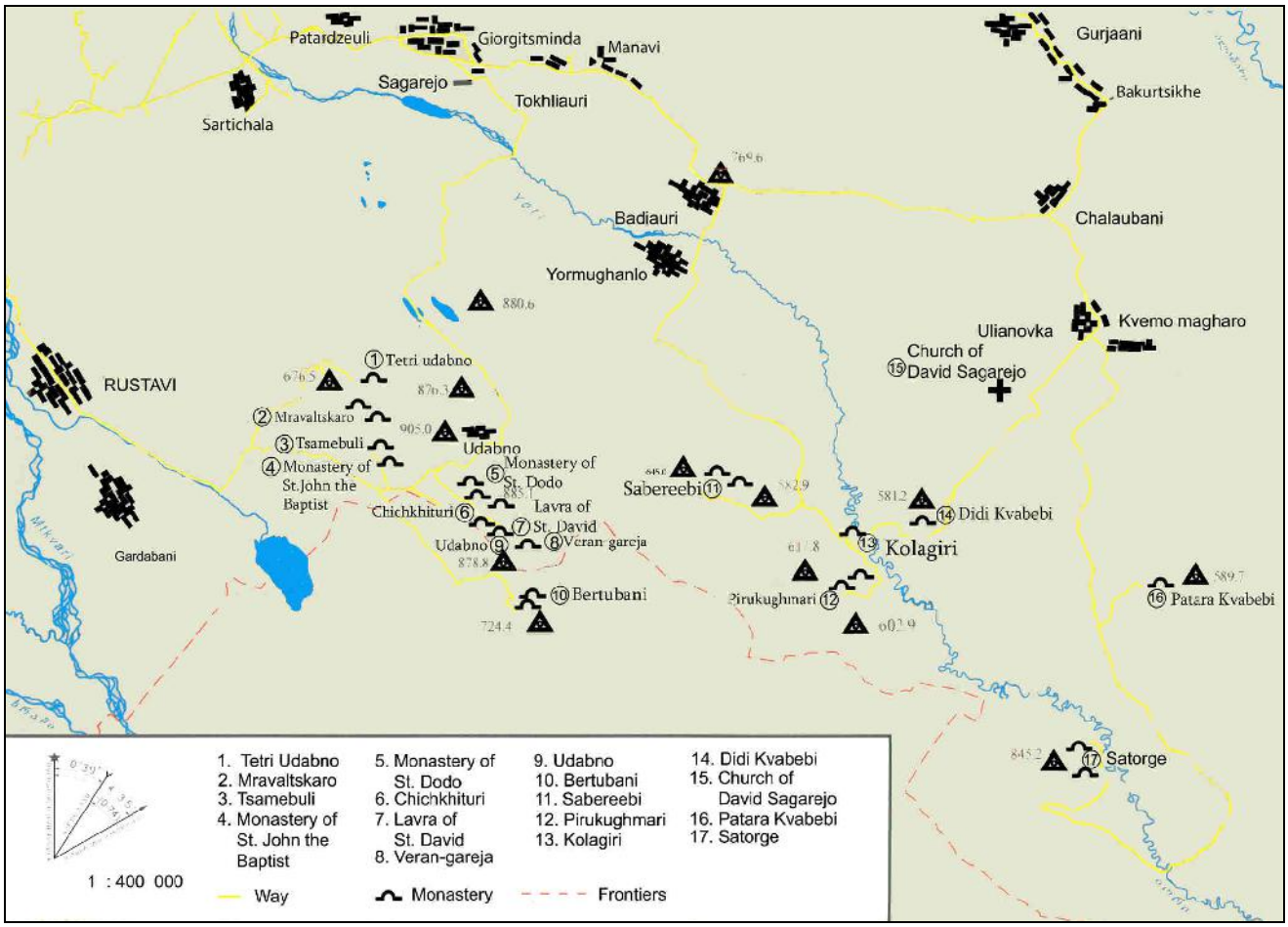

Figure 1: Map of the David Gareji Cave monasteries (drawing B. Gabekhadze)

It is also natural that a large number of cave churches revealed within David-Gareji monastery complexes, on the assumption of their carving period and specific functions considerably differ in architectural structure. As wall painting and inscriptions characterizing Christian iconography have been attested only in some parts of the churches' interiors, and besides wall paintings do not always coincide with the construction time, church dating is mainly provided on the basis of architectural analysis of their shapes.

In this article we would like to draw attention to dating problems of rather interesting and relatively rare type of cross-domed structured cave churches of David Gareji monastery complexes.

2. CROSS-DOMED CAVE CHURCHES OF DAVID-GAREJI MONASTERIES

In order to imagine their general architectural and stylistic features and diversity, we will characterise several cross-domed churches of David-Gareji Monasteries ranging from the small, simplest chapels to the rather well-formed monumentally built temples.

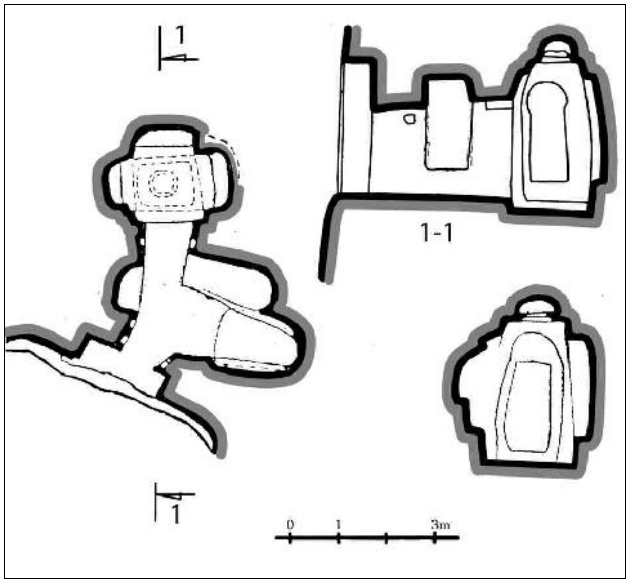

Figure 2: Plan and sections of the Cave Church from Monastery "Qvabebi" (drawing N. Bakhtadze)

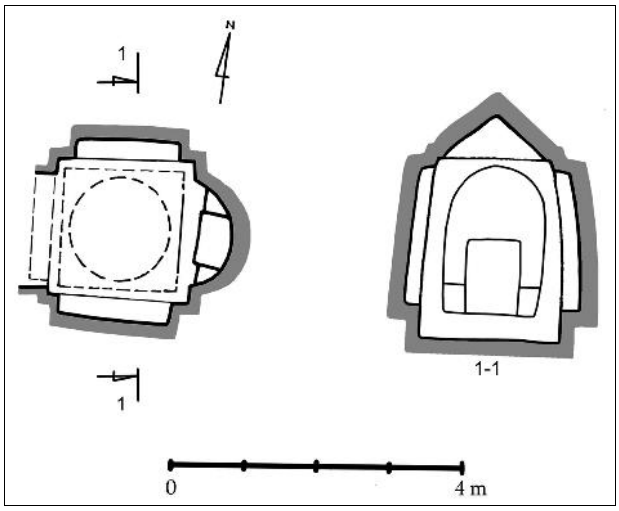

Figure 3: Plan and section of the Cave Church from Monastery "Kotsakhura" (drawing N. Bakhtadze)

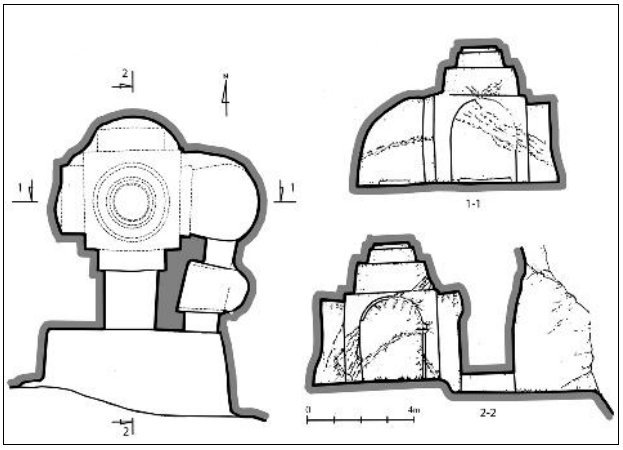

Figure 4: Plan and sections of the Cave Church from Monastery "Mravaltskaro" (drawing N. Bakhtadze)

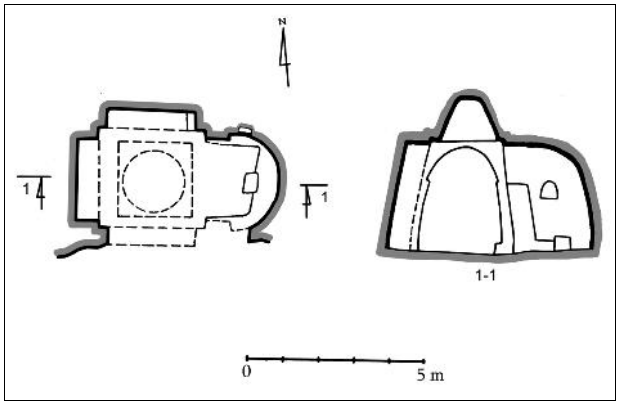

Figure 5: Plan and sections of the Cave Church from Monastery "Mravaltskaro" (drawing N. Bakhtadze)

A rather small-size (2.50 m long, 2 m wide) chapel roughly carved in rocks, found among David Gareji monastery "Qvabebi" has the form of a freely-planned cross, while at the eastern wall, a niche-shaped shrine altar, representing a round-cornered rectangular structure, has been carved, the triumphal arch of which has a precise horseshoe shape (Fig. 2). Above the central square, in a flat ceiling, a small, slightly approximated to hemisphere-shaped space has been cut, which is separated from the main space with two-stage shelf. This artificial cavity undoubtedly represents primitive imitation of the cupola-type roofed stone churches.

The rock-cut chapel of "Kotsakhura" Monastery is slightly larger than the mentioned above shrine (2.80 m in length and 2.65 m in width). It has short-arm simple cruciform structure (Fig. 3). The altar of the chapel also creates an impression of slightly enlarged shrine niche, the area of which is almost entirely occupied by a refectory stone, carved in rock. The cone-shaped space is cut in the ceiling of the chapel.

A cave church 7.2 meters long and 5.15 meters wide is located in the western part of the Monastery "Mravaltskaro"; its planning represents a stone-built imitation of free-cruciform temple (Fig. 4). In the east, horseshoe-shaped apse is carved. In the flat ceiling, a geometrical space has cut having the shape of three cylinders or truncated cones of different diameters placed one on top of the other.

In a small cave monastery "Verangareja", we found a rock-cut short-arm cruciform church. It is 5.7 m long and 3.9 m wide (Fig. 5). At the eastern extension of the arm, an altar in the shape of a slightly wider-based segment is cut. A truncated cone-shape cavity (hollowness) is carved in the flat ceiling of the *naos*.

In the monastery "Sabereebi", along the same tier, 4 cave churches are located (Fig. 6), the planning of which also represents different variations of a freely-planned cross, while the ceilings are formed with concavities in the shape of truncated cone or round-cornered truncated pyramid.

Each of them has horseshoe-shaped carved altars at the eastern side of the central square.

Two of them are relatively small-sized (the length of N1 is 4.25 m and it is 3.15 m wide; N2 is 4.9 m long and 3.65 m wide) (Figs. 7, 8). One of them has a cone-shape space, "placed" on it, cut directly from the ceiling plane, while another is crowned with an imitation of a semi-egg-shaped dome (Fig. 9).

Two more cruciform-dome cave-churches of Sabereebi are relatively large (the length of N3 is 6.1 m and the width equals to 4.6 m; N4 is 6.3 m long and 5.8 m wide) (Figs. 10, 11). They only differ from the first two churches of the same complex because their ceilings, apart from the dome- shape spaces, with the imitation of under-dome structures, are decorated with rather close imitations of trumpet arch system, characteristic, in particular, for Georgian dome churches of the early Middle Ages (Figs. 12, 13).

Figure 6: Cave Monastery "Sabereebi" (photo N. Bakhtadze).

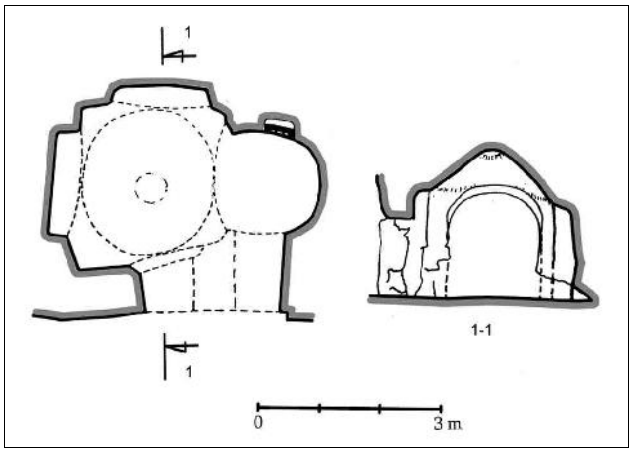

Figure 7: Plan and sections of the Cave Church no. 1 from Monastery "Sabereebi" (drawing N. Bakhtadze)

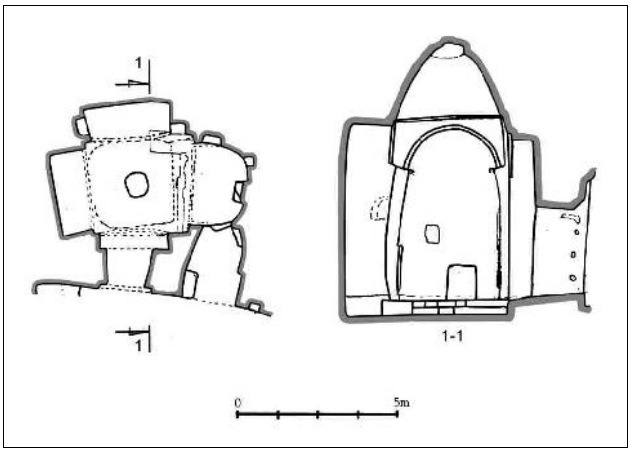

Figure 8: Plan and sections of the Cave Church no. 2 from Monastery "Sabereebi" (drawing N. Bakhtadze)

3. DISCUSSION ON DATING OF CROSS-DOMED CAVE CHURCHES WITHIN DAVID-GAREJI MONASTERIES

In our opinion, rock-cut churches of a freely-planned cross, having imitations of domes in the ceilings, together with small-sized, simple, single-nave cave churches, should represent one of the earliest canonical-style churches of David-Gareji monasteries.

This conclusion is based on the following arguments: shapes of rock-cut churches constructed in different architectural style could have represented more or less close imitations of the stone church structure interiors prevalent in mainly the same periods and within the same regions. Stone churches planned as of free cruciform in plan, were being built in Georgia only in the 6^{th}-8^{th} centuries, while example of neckless stone dome churches in Georgia emerge only in the 7^{th}-10^{th} centuries [Chubinashvili, 1948].

As a result, creation of rock-cut church imitations with the given elements in David Gareji monasteries should be supposedly dated back to the 7^{th}-10^{th} centuries [Bakhtadze, 2007].

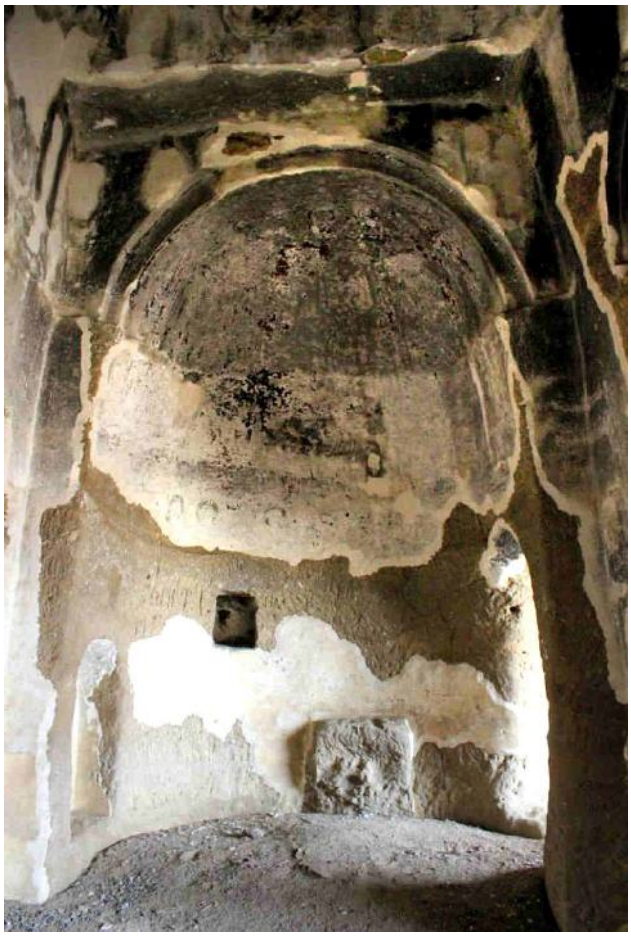

Figure 9: Interior of the Cave Church no. 2 from Monastery "Sabereebi". The View to the East (photo N. Bakhtadze)

Now we try to specify even more concretely the chronological frames of foundation of some of the cave churches, based on additional comparative analysis of the analogically planned monuments, found in stone or cave monastic architecture of Georgia, also taking into consideration the most reliable dating of the wall paintings remnants in the given churches available nowadays.

In the two cruciform, cupola-type cave churches of "Sabereebi" - one of the David Gareji cave monasteries, stone prototype architectural elements are imitated almost in details; therefore, based on comprehensive analysis of their planning and artistic and stylistic peculiarities, they can be considered as monuments created between the mid-9th century and the second part of the 10th century.

Our argumentation relies on the following circumstances:

1. One of the features typical for the mentioned above "cross-domed" churches is a horseshoe-like shape of apse plans and arches; similar forms cannot be found in Georgian stone church architecture after the mid-10th centuries [Beridse, 1980];

2. Under-dome trumpet arch constructions, characteristic for Georgian stone church architecture, are precisely imitated in the three dome-like temples of Sabereebi (Figs. 8-13); this fact makes us believe that churches were cut more or less synchronously with their stone prototypes. The upper chronological framework for application of under-dome trumpet arch constructions in Georgian architecture coincides with the mid-10th centuries [Chubinashvili, 1936, 1959] and therefore, cutting of the mentioned above rock churches cannot exceed this period of time;

3. Among the described temples with dome imitations, two of them have surrounding relief friezes between trumpet arc and dome imitations. Combination of these details was not peculiar to Georgian stone architecture earlier than the 9th century [Beridze, 1974].

4. Spaces left in the under-dome square corners of the aforementioned churches representing imitations of the bearing structure rested on arches and passing above cross-arm spaces, point out to the analogical chronological framework. Such structures were not typical for Georgian dome churches until 9th-10thcenturies [Beridse, 1980];

5. The imitations of the carved under-dome constructions are exactly repeated in Georgia, namely in Samsari rock-cut domed church located in Javakheti that is clearly dated back to 920-930-s by its construction inscription [Gaprindashvili, 1977];

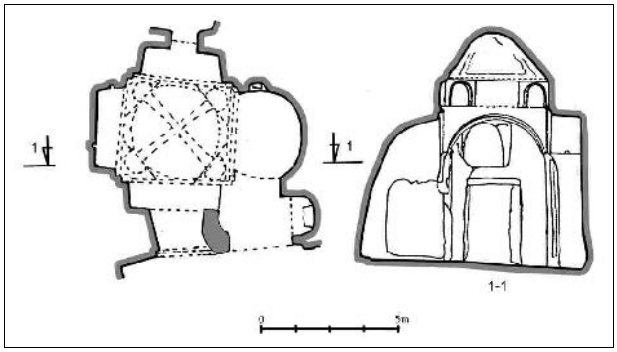

Figure 10: Plan and sections of the Cave Church no. 3 from Monastery "Sabereebi" (drawing N. Bakhtadze)

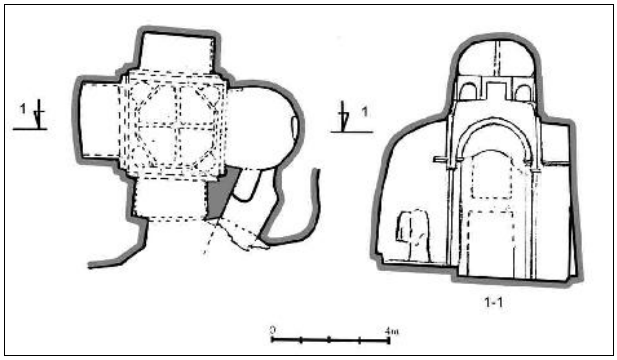

Figure 11: Plan and sections of the Cave Church no. 4 from Monastery "Sabereebi" (drawing: N. Bakhtadze)

6. The wall paintings preserved in the churches are considered by the majority of Georgian art historians as the frescos of the 9th-10th centuries [Bulia et al., 2008].

How logical will it be if, from the list of the described above David Gareji cross-domed rock churches we, influenced by the presented evidences, consider the samples decorated with only under-dome structure imitations, as monuments of the 9th-10th centuries, while the rest (for example, churches with a pyramid cut in the flat ceiling; or decorated with truncated cone, Sabereebi temples equipped with less detailed dome imitations) will be dated as before on the grounds that their close analogies have not been found in stone architecture?

Georgian and a number of foreign scientific circles have been recently considering these cave chapels as not only the oldest canonical-structure churches of this monastic area, but also the monuments of the 6th-7th centuries, contemporary to the foundation of the first Gareji monasteries [Gaprindashvili, 1987].

Figure 12: Interior of the Cave Church no. 4 from Monastery "Sabereebi". The View to the East (photo: N. Bakhtadze)

Figure 13: Interior of the Cave Church no. 4 from Monastery "Sabereebi". The View to the Dome (photo: N. Bakhtadze)

In our opinion, such reasoning would be inconsistent. The very fact that stone dome- churches do not exist in principle without carrying structure from flat ceilings, points out that we face simplified dome-roof constructions representing provisional reflection of the cave churches decorated in the presented style.

The same principle is applied to the space-planning of all the five cross-dome churches of the Sabereebi monastery complex: in each ceiling of their cross-plan central square, dome-like spaces are carved with under-dome structure imitations, or without them; from the southern elongated gate we can enter the church through the wide doors cut in the southern arm of the cross; instead of eastern arm, a horseshoe-like deep altar is cut with the additional exit in the gates from its southern part; the two-stage arches rested on simple imposts go around the cross arms and etc. These churches mainly differ in accomplishment of the details; as for copying or „leaving out" under-dome structures, this is the result of architects' subjective approach [Bakhtadze, 2007].

The cave churches of Gareji Mravalmta, presented by us in Dodos Rqa, VeranGareja, Didi Qvabebi, Kotsakhura and others, are based on approximately analogous compositional scheme. The general planning principles in them as well as Sabereebi churches clearly prevail over their individual signs which make us assume that prevalence and popularity of this church-architectural motif in Gareji desert represent the consequence of the influence provoked by the same cultural and ideological wave.

Obviously, relying only on resemblance of the general planning schemes, we cannot link construction of all listed above churches in the Gareji desert to the final stage of the mentioned above style, i.e., to 9th-10th centuries; however, the assumption that the 8th century can be considered as the lowest chronological limit for building the oldest samples of churches in Gareji Mravalmta with relatively primitive artistic techniques, must be close to reality.

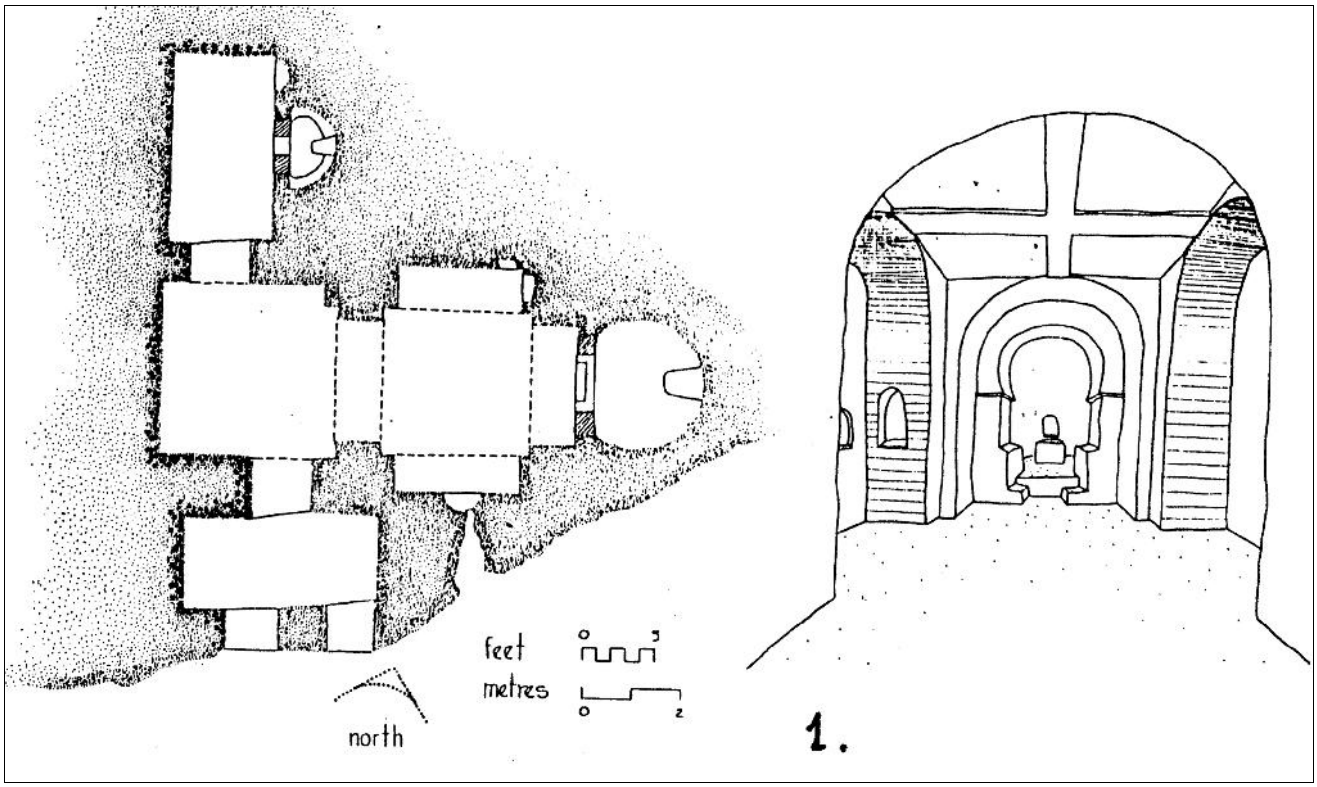

Figure 14.1: Cave Churches from Cappadocia. Yĭlanlĭ Kilise , valley of Peristrema: plan and interior perspective; (after Kostof, 1989)

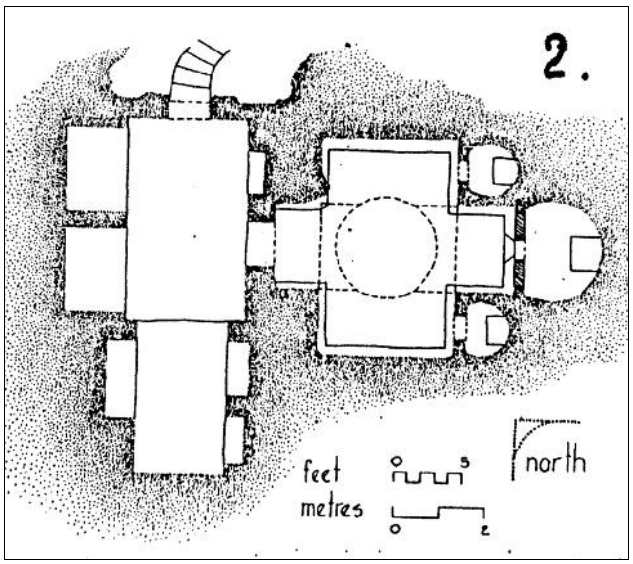

Figure 14.2: Chapel 27, Göreme, plan (after Kostof, 1989)

Since no other samples of rock-cut churches (apart from the mentioned earlier Samsara), created in accordance with the described above spatial planning principles, can be found in any other regions of Georgia, let us see, from the viewpoint of specifying chronology for David Gareji cross-domed cave churches, what outcomes can be expected as a result of their comparative analysis with the typologically similar cave monuments, attested in the countries of early Byzantine World.

4. COMPARATIVE ANALYSIS AND DATING OF DAVID-GAREJI AND CAPPADOCIA CROSS-DOME CAVE CHURCHES

Even at first glance, out of the Eastern-Christian rock-cut monastic complexes of this era, Cappadocia cave monasteries as by general structure as well as detailed specification stand closest to the Gareji Mravalmta deserts.

Such similarity is not surprising taking into consideration even the relative geographical proximity of the regions; moreover, close cultural and political relations of these two provinces, famous for their monastic activities, is well-proven in historical documents.

Our current object of discussion, freely-planned cross-shaped churches in Cappadocia cave monasteries, is presented in different variations. As well as in the Gareji deserts, there we can find simple cross-planned churches, the central ceiling-spaces of which represent cupola or dome imitations (Fig. 14) [Kostof, 1989]. In addition, cross-planned churches with completely flat roof imitations were rather common in the Cappadocia cave deserts what is unfamiliar to David-Gareji.

The churches of this type in each region are approximately the same size (sides of the central square are rather frequently 3-4 meters).

Arms of the mentioned above church types in both sites - Cappadocia and Gareji represent cupola-roofed, rectangular-structure niches cut from central space in three directions, and the eastern arms end in semicircular or horseshoe-like shape apses.

In the deserts of both regions, in parallel with flat roofing of central squares in cross-planned churches, the several main forms of dome-like space, cut in ceilings can be found: variations of semi-cupolas, truncated cones, cones, truncated pyramid or pyramids, proportionally. Imitations of carrying structures from under-dome square to dome, peculiar to stone architecture are not so uncommon in Gareji as well as in Cappadocia [Meltaem, 2004].

Rock churches of this type from Cappadocia and Gareji, still differ from each other by stylistic features. For example, arms of Cappadocian cross-domed churches are almost always much more oblong than in the similar-type churches in Gareji where the cross arms frequently have the form of slightly concaved niches. Here eastern arms are usually especially "atrophied“ and central squares infrequently join directly the altar apses, whereas in Cappadocia churches, even the eastern arms are equally the same length as the rest of them [Epstein, 1975].

Cross-dome Cappadocian churches are characterized with rather sharply outlined horseshoe-like apse plans and cupola arches that are not typical for Gareji churches.

We could continue listing distinctive features of "cross-domed“ rock-cut churches from the region, but one thing is apparent: common principles and related motifs in their planning and spatial structure considerably exceed the local peculiarities.

Thus, we should presume that typological resemblance of cruciform churches from David-Gareji and Cappadocia cave - monasteries is not caused by independent development of this motif, but represents the consequence of close cultural relations between these leading regions of Eastern Christian monasticism.

It is difficult even for foreign art historians and researchers of the Cappadocia cave monasteries to precisely date each cruciform cave church. Although the stone churches of this type existed in Cappadocia yet in early 5th century, however, according to St. Grigol Nizaneli, they, as well as throughout the early Christian World, were initially used only as martyriums.

Altars of the earliest analogical martiriums were built on the intersection of cross arms, and only in the 5th-6th centuries, when the similar form was used in ordinary churches, altar was moved to the end of the eastern arm. In the architecture of the Cappadocian cave monasteries the given motif is already represented in the form of churches targeted to regular religious ceremonies and, unlike their stone prototypes, is characterized with a number of typological peculiarities (reduced size of halls and arms, disproportionally increased altar space and etc.). Thus, this series of Cappadocian cave-churches (flat-roofed as well as decorated with dome imitations), represent rather transformed reflection of cruciform churches' motifs and, therefore, we should imply certain interval between the earliest samples of stone prototypes and the epochs of their creation.

It's hard to say, specifically what chronological interval separates each cruciform cave church from 5th century, and yet, based on a number of architectural details, it was possible to accurately date some of their earlier samples. For instance: Göreme chapel no. 27 represents a cruciform church with symbolically carved dome-imitation (without carrying structure) in the ceiling (Fig. 14). The church has a facade adorned with relief decor, the motifs of which are stylistically very close to the gateway facade of the rock-cut three-nave Basilica "Karanlık Kilise“ situated in the same region and dated from 7th century [Kostof, 1989].

Some scientists believe that other earliest samples of Cappadocian rock-cut churches adorned with dome-imitations, should have been carved approximately in the same era, however, many researchers assume large-scale construction and spread of cave-churches in the region more likely closer to the 8th-9th centuries [Rodley, 1985].

Cappadocian cross-domed rock-cut churches, the ceilings of which, apart from dome, are adorned with imitations of carrying structures from the central square to cupola, are dated back to even later period, namel the 9th-10th centuries, by the famous art historians [Giovannini, 1971].

Therefore, nowadays 8th-10th centuries are considered by foreign scientific circles as chronological diapason forcreation the monuments – Cappadocian cave churches, representing rather close typological and stylistic resemblance to the mentioned above David-Gareji free-shape cruciform rock churches.

If we take into account international character and geographical factor of Early Byzantine Christian culture (remoteness from recognized centres of Eastern Christian monasticism) [Hirschfeld, 1992], it will be hard to consider the period before 8th century as the date for construction of the earliest series of Gareji churches.

Otherwise, we should assume the following development of the events: the genesis of the given types of churches began namely from the Gareji deserts and in subsequent centuries it was spread throughout one of the leading region of the West Asian monasticism, Cappadocia; there the mentioned above style achieved utmost perfection (remember rock-cut triconch, cruciform cupola temples), while architects of these rock monuments in the David Gareji for some reason were contented with building single, relatively simplistic samples and refused the further development of the motifs

of cave domed churches (and namely, at the time when the domed church motif in stone architecture throughout the entire Georgia, from the described period of time to the developed Middle Ages inclusive, was becoming more and more prioritized).

Obviously opposite version is much more acceptable: The motif of rock churches typical in David-Gareji must be the repercussion of the style, widely prevalent in Cappadocian rock monasteries and, in Georgia, the tradition of their intersection was initially introduced by the Georgian monks as well as clergymen of other ethnic groups displaced from the described above leading monastic centres.

It is significant that based on the analysis of wall painting and mural inscriptions from Sabereebi, one of the richest complex, famous for its original churches among Gareji Mravalmta, some Georgian researchers have come to the conclusion that a cultural wave, coming from monastic centres in Asia Minor during 9-10 centuries, can be felt in creation and painting of these churches, representing constituent part of the complex [Thierry, 1963].

It should be apparent that we do not imply at all mechanical copying of these churches from West-Asian Christian centres to Georgian reality and complete replication of foreign models. In stone church architecture as well as in Georgian rock architecture, adoption of general planning schemes for cave-temple construction, elaborated in the depth of the earliest leading countries of Christian tradition, should have represented an usual experience; however, these standards, influenced by local traditions, historic circumstances and national aesthetic principles, possibly have undergone certain transformation and acquired definite distinctive form.

David-Gareji cross-domed rock churches more or less or appreciably differ from Cappadocian analogies; what is more, the more distinctly-formed, original, artistic and stylistic features the monument layers have, the longer chronological interval should be supposed between them and their Cappadocian prototypes.

On the other hand, due to regular cultural relations between Georgia and Asia Minor, we cannot rule out categorically the opposite impact of some rock-church diversities elaborated on Georgian grounds on Cappadocian cave church architecture.

Resulting from such comprehension of the issue, it is very doubtful even from theoretical viewpoint to consider the period earlier than 8th century as carving date of the first freely-shaped cruciform-plan churches adorned with dome imitations in David-Gareji. Moreover, the part of churches, in the planning of which local stylistic peculiarities are dominant and obvious (for example, Sabereebi cross-domed churches), cannot be dated from such an earlier period.

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Survey on a monastic complex in the area of Göreme (Nevşehir, Turkey)

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Abstract
Since 2006 the Department of Conservation of Cultural Heritage at the University of Tuscia (Viterbo, Italy) has been working in the territory of Nevşehir (Cappadocia, Turkey) in the mission "Rock painting in Cappadocia. For a project of knowledge, conservation and enhancement", supported by the General Direction of Monuments and Museums of the Turkish Republic and the Archaeological Museum of Nevşehir.

Focus of the project is the development of landscape and settlement in Byzantine period, through an approach that integrates archaeological, historical and artistic surveys in the region. The investigations in the areas of Şahinefendi (2006-2013) and of Göreme (since 2012, with the Department of Architecture of University of Florence) offer an opportunity to explore the interrelation between sacred and secular spaces in the Byzantine Cappadocia.

The contribution presents a preliminary report of the research conducted at one of the rock-cut monasteries located around the Open Air Museum in Göreme and the Tokalı kilise. The survey has been conducted through the stratigraphic analysis of the excavation traces and the typological study of furnishings and decorative elements.

The site documentation has been produced with digital techniques; in detail, the architectural survey was carried out using 3D laser scanner, photogrammetry and virtual tour panoramic 360.

Keywords
Rupestrian monastery, Cappadocia, Göreme, digital survey, 3D scanner, photogrammetry, virtual tour panorama.

Figure 1: The Göreme Valley (photo M. Viscontini)

1. THE 2014-2015 SURVEY AT GÖREME

1.1 The settlement

The Byzantine settlement of Göreme (mentioned in ancient documents with the names *Matiane* and *Korama*, and with the place-names Maçan and Avcılar during the Turkish period) [Hild & Restle 1981] is articulated in two main nuclei: the so called "Circus of Göreme", that is a natural exedra corresponding to the present Open Air Museum, including a dozen churches with refectory, and dated approximately to the 11th century; and the adjacent Göreme Valley (Göreme Vadısı), which develops through several rock pinnacles towards the present settlement and around the Tokalı kilise, including several churches and cave chapels [Jolivet-Lévy 2015] (Fig. 1).

The extraordinary concentration of churches and monasteries in the area of Göreme, surprising also for a region rich of material evidence from the Byzantine period such as Cappadocia, constitutes a unique case. The fact that the monasteries in the "circus" were founded by unrelated different individuals or groups in a short range of time suggests that the site was connected to a sanctuary or a place of worship, most likely to be identified with the Çarıklı kilise created during the 11th century [Rodley 1985; Jolivet-Lévy 1998; Cooper & Decker 2012]. In addition, the area of Göreme was an important center for pilgrimage already in the early Byzantine period, hosting the relics of Baptist (in the close church of S. John in Çavuşin) and the relics of a local martyr, St. Ieron, whose body was buried in a tomb in the late Roman necropolis of *Matiana* [Thierry 1987].

Its importance increased rapidly during the 11th century, but the pilgrimage to this site continued also during the Seljuk period, as witnessed by several graffiti left by pilgrims up to the second half of the 12th century (and probably also after this period) in different churches of the "circus".

The rural transformation of the valley, followed by the final abandonment of churches and cave monasteries, was completed by the end of the 19th century, as evident from the photographs taken by J.H. Haynes [Ousterhout 2011]. The reuse in the Ottoman and Turkish period slowly transformed the landscape with the gradual demolition of the excavated spaces and their conversion into dovecotes, stables and animal shelters. Only from the mid-1980s, with the constitution of the Open Air Museum and the inclusion of the Tokalı kilise and of other churches in the exedra of Göreme in the UNESCO heritage [http://whc.unesco.org/en/list/357], part of this territory was saved from agricultural use and protected by conservative restrictions.

1.2 The 2014-2015 surveys

From the year 2011 the site was object of a research project conducted by the University of Tuscia, which focused on the study, conservation and restoration of the main monument, Tokalı kilise One of the aims of this project was the mapping of the area surrounding the church for a better understanding of the functional distribution of the settlement and, inside the different nuclei, of the distribution of the religious, residential and farming areas. During the 2014-2015 surveys the investigations focused on the area between the Open Air Museum and the Kılıclar Valley, where, since the investigations of Jerphanion, the presence of several churches and chapels was identified [Jolivet-Lévy 2015 and previous bibliography]. No study, however, considered so far the exact relationship between the places of cult and the monastic settlements in the area. In the contributions by P. Lucas [2003] and R. Ousterhout [2010] the presence of a certain number of large rectangular chambers, characterized by the presence of a rock-cut table, was noticed.

According to the monastic rules (*typika*) identified in other regions of the empire (but, unfortunately, not in Cappadocia) [Cooper & Decker 2012], the *trapeza* was an essential part of the monastery. Its presence, as a consequence, could be a sufficiently valid indicator for the presence of a monastic site [Rodley 1985].

Figure 2: Kılıçlar Valley, the monastery front (photo D. Ventura)

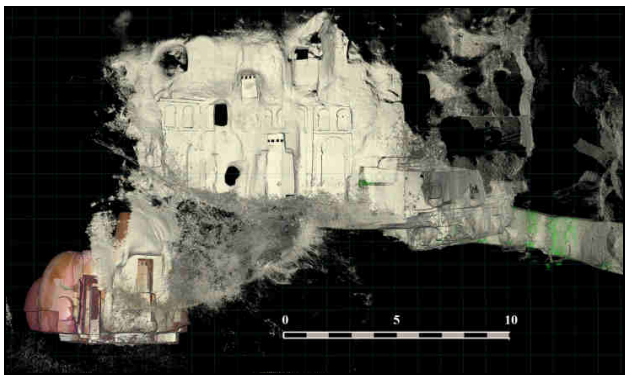

Figure 3: Front of the complex surveyed (elaboration C. Crescenzi)

Despite the fact that one must not exclude that some of the many halls in the settlement area of Göreme (35-40 in total) - particularly those not appearing as clearly connected to churches or chapels - might have been used for liturgic functions for the commemoration of the dead [Ousterhout 2010], in most of the rupestrian sites of the area the presence of characteristic elements of monastic settlements can be found: a covered rectangular vestibule, with the main façade sculpted and painted; a main chamber, more or less extended, with a common refectory; some residential and service rooms, including a kitchen; a church (or chapel) varying in dimensions and plan, depending on the volume of stone available.

2. THE MONASTIC COMPLEX

2.1 The Monastery

Among the settlements examined during our study in this region, the present paper considers a complex located about 350 m NNW of the Tokalı kilise and about 500 m from the Open Air Museum of Göreme, on the edge of the Kılıçlar Valley, almost exactly in front of the so called Kılıçlar kilise (about 100 m of distance as the crow flies).

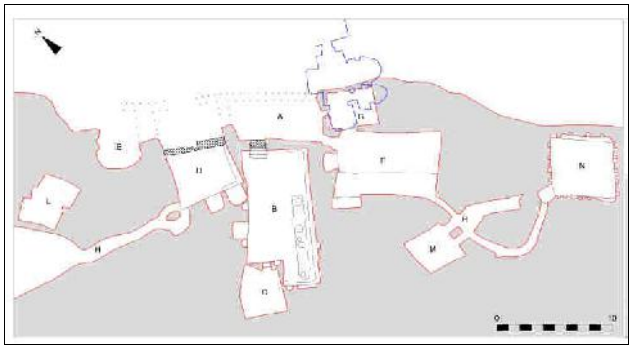

Figure 4: General plan of the complex, in blue the lower level (drawing G. Romagnoli)

(38°38'39.13"N, 34°50'37.06"E).

The different spaces of the monastic complex appear excavated on different levels along the stone walls: the main nucleus (vestibule, refectory, kitchens, private and service rooms) is located on a level which is approximately corresponding to the top of the plateau (about m 1130 a.s.l.); the church is located at a lower level.

Further rooms were excavated on different levels between the plateau platform and the bottom of the valley (Figs. 2-3).

The geological setting of the area is characterized by a sequence of Upper Miocene to Holocene ignimbrites, interlayered with terrigenous and lacustrine sediments.

The pyroclastic deposits were deeply incised and eroded, creating complex morpho-structures that can be admired in some of its most spectacular examples in the earth pyramids (the so called "fairy chimneys") where the caves of Göreme were excavated.

Figure 5: Painted decorations in the S corner of the vestibule

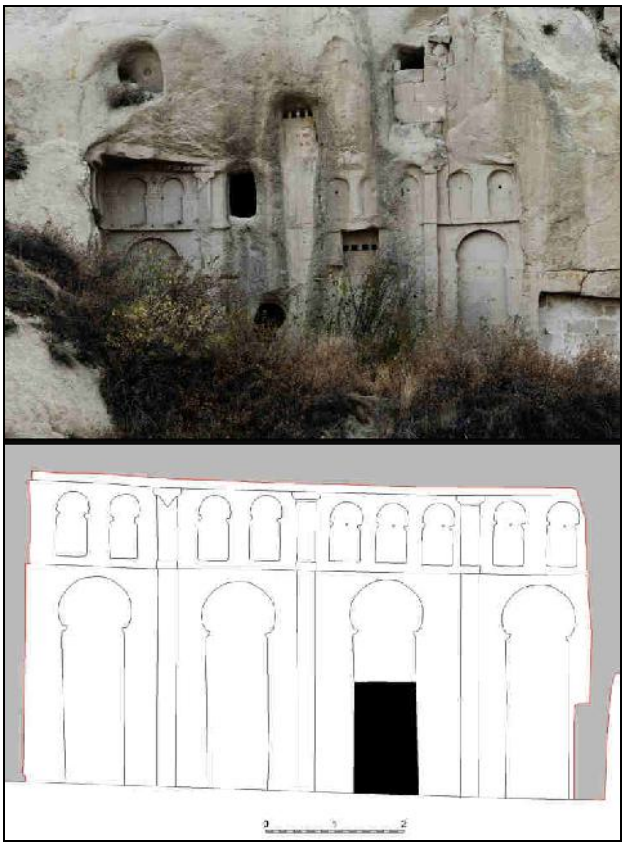

Figure 6: The monastery front, reconstruction (drawing G. Romagnoli)

The complex was first pointed out by Lyn Rodley as a "Complex opposite of Kılıçlar kilise" [Rodley 1985]. From the photographic documentation in Rodley's publication it is possible to understand that when his survey was conducted (around 1980) the complex could be examined only from the outside, because its entrances were completely obliterated by a recent dovecote. Only the following demolition of the pigeon house allowed the investigation of the rooms of the church, renamed by Pierre

Lucas "Église de la Colombe", after the bird paintings on its walls [Lucas 2003]. The monastery was then mentioned in the studies by Robert Ousterhout [2010] and Fatma Öztürk [2012], while the church is mentioned as "Göreme 33A" in the repertoire by C. Jolivet-Lévy [2015] and as "Göreme XXIX" in the database "*Cappadocia. Arte e habitat rupestre*" [Andaloro et al., this volume].

The stratigraphic analysis of the excavation marks allow a basic reconstruction of the original conformation of the complex, which was, however, strongly damaged by the collapse of a wall and erosion; it is possible to estimate that the stone back moved back no less than 5 m (Figs. 2-4).

For this reason it is not possible to identify the main access, which was most likely a steep passage cut into the rock of the Kılıçlar Valley. The remains of a closed rectangular vestibule were found along the northern side (8.20 x 3.80, height 4.70 m approximately), covered by a flat ceiling (Fig. 4, room A).

The main internal façade, heavily damaged by erosion and altered in modern times, was decorated with sculpted pilasters, which divided it into four sections. A belt course also divides the façade into two levels: in the lower one (height 3.30 m) four blind horse-shoe arches are present, whilst in the upper one (height 1.10 m) couples of blind horse-shoe arches can be seen.

A painted decoration was added directly on the rock in red and pink, with geometric, zoomorphic and phytomorphic motives. One of these deserves attention: a bird (probably an eagle), particularly close in style and execution technique to those in the decorations of the Aynalı kilise in Göreme [Rodley 1985; Andaloro et al., this volume] (Figs. 5-6).

2.2 The Refectory

The refectory (12 x 5.80 m), accessible from the vestibule through three steps, presents some peculiar elements: a 10 m long rock-cut table (width 0.95 m, height 0.60 m) located next to a bench 0.45 m wide, cut along the northern wall; a deep square and arched niche (1.70 m) at the eastern end of the *trapeza*; a small closet room (4 x 3.70 approx.) excavated in the SW corner of the area, presenting a lunette with an inscribed cross incision over its entrance (Fig. 4, room B; Figs. 7-8).

The spaces between rooms and the flat ceiling of this space were decorated by a simple frame with a geometric pattern painted in red. Among the furnishings of the refectory that can be dated to the primary phase of existence of the complex is a tank for water on the SE side.

A room connected to the refectory (today 5.50 x 6.50, but probably originally at least 7.50 m long), partially collapsed and filled in along the wall facing the valley (to create an additional dovecote), is characterized by the presence of two large tanks excavated into the stone bank, decorated on the outside by red geometric patterns (Figs. 4 and 8, room D).

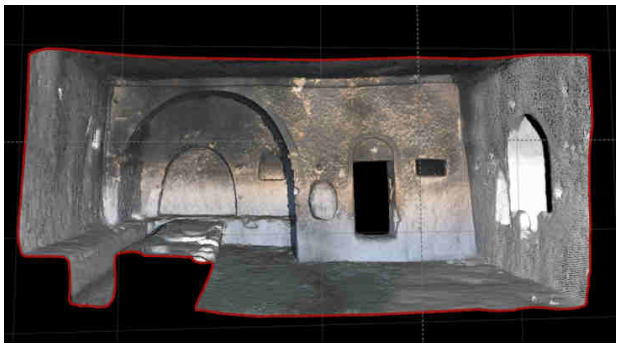

Figure 7: Plan of refectory and near room, by a point cloud (University of Florence - DIDA)

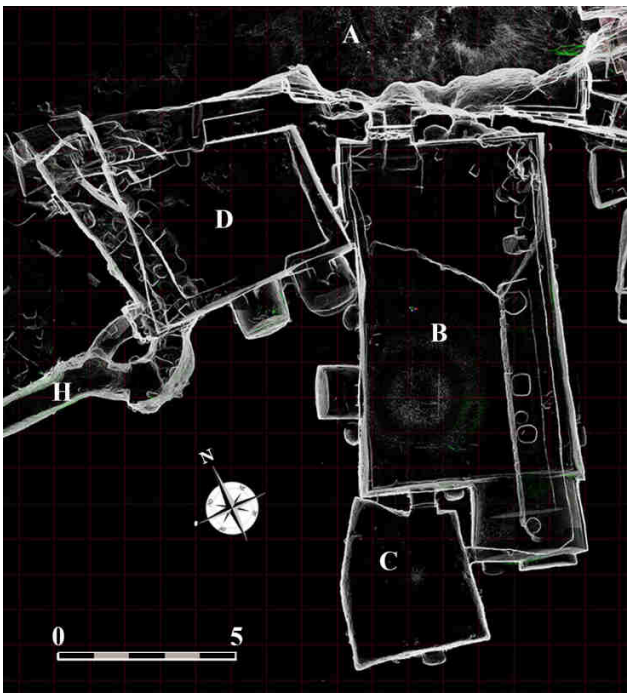

Figure 8: Perspective section of the refectory (University of Florence -DIDA)

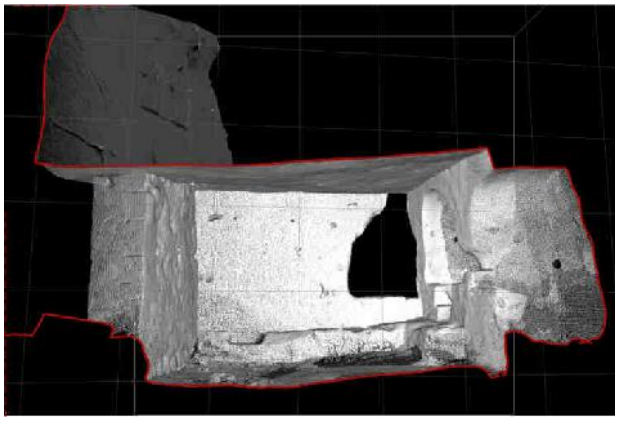

Figure 9: Perspective section of the room D (University of Florence - DIDA)

This space, covered by a flat ceiling, includes a seat cut into the rock on the SW wall and evident later excavation marks on the opposite wall.

The kitchen, easily identifiable from the cone chimney, was in the northwestern area (Fig. 3, room E). This area, strongly damaged and partially buried by debris, could not be investigated, as the room above it. The peripheral position and its separation from the *trapeza*, recorded in several other rupestrian complexes of Byzantine Cappadocia [Öztürk 2012], can be probably explained by the need to allow the exit of smoke from the room.

2.3 The chapel

The chapel next to the monastery (Fig. 10) is located on a lower level of the private rooms and faces directly the Kılıçlar Valley. The vestibule (about 4 m wide) has mostly collapsed and is filled with debris; the entrance was filled in and reshaped to become a dovecote. The chapel presents a central plan with a truncated cone dome and two apses (the western one of larger dimensions) with altars and iconostasis.

The altar in the main apse is significantly out of axis, perhaps to obtain a precise E orientation (Fig. 11). The minor (south) apse might have been excavated in a second phase, maybe by changing the original project: the anomalous presence of an isolated column to support the dome would not otherwise find an appropriate explanation. Also the sepulchral chamber, covered by a sphere dome could be part of a second phase. The two burial pits excavated in this space still present exceptionally a part of the stone covering plates.

The internal walls of the chapel are accurately chiseled and decorated in red (and sometimes also pink) applied directly on the rock. Among the decorations, besides the geometric divisions and the fake curtain walls, are several types of crosses (pate, Latin, teutonic, inscribed in a circle) and zoomorphic elements with bovine heads in the four sides of the truncated cone dome, probably a dog and perhaps a stylized dove on the sides of a cross in the funerary chamber.

These decorations can be associate respectively with the bovine protomes (heads) sculpted and painted in red on the capitals of the church of the so called Hallaç Monastir [Rodley 1985], the second decoration of the so called "Chapel of St. Daniel" in the same area of Göreme [Jolivet-Lévy 2015]. In the walls opposite of the apse are some painted crosses, accompanied by the typical apotropaic invocations to Christ ("Iesoùs Christòs nikà") and the Virgin ("Marìa Gennésasa Basiléa Christòn") [Walter, 1997; Jolivet-Lévy2015]. It is necessary to underline that these walls, already photographed in 2012, were damaged by vandals in 2014.

The presence of a truncated cone dome in association with a decoration of red crosses and zoomorphic elements suggests a dating to the 11th century, fully represented in the group of chapels that constitute the exedra of Göreme [Jolivet-Lévy 2014].

Figure 10: Plan of the chapel by a point cloud (University of Florence - DIDA)

The use of red together with pink in the chapel decorations, which can also be found in the vestibule of the monastery above, supports the idea of a contemporary origin of the two spaces.

3. THE REUSE AND TRANSFORMATION OF THE COMPLEX IN THE POST-BYZANTINE PERIOD

The rupestrian complex examined in this paper was object, just as the majority of the caves at Göreme, of heavy alterations and change of function in the post-Byzantine period.

The marks left on the stone walls by different actions (demolition of diaphragms between the different spaces, excavations to enlarge rooms or to create new spaces on different levels; opening of tunnels to connect different levels (Fig. 3 H, L); opening of doors and windows; creation of fences, partition walls and wooden attics; fill-ins and building new walls) witness an intense and long history of reuse of the spaces as stables, shelters, storage rooms, dovecotes, quarry for building material.

The exact chronological sequence of these interventions can be hardly reconstructed. The excavation of the two connected spaces along the southern side of the vestibule

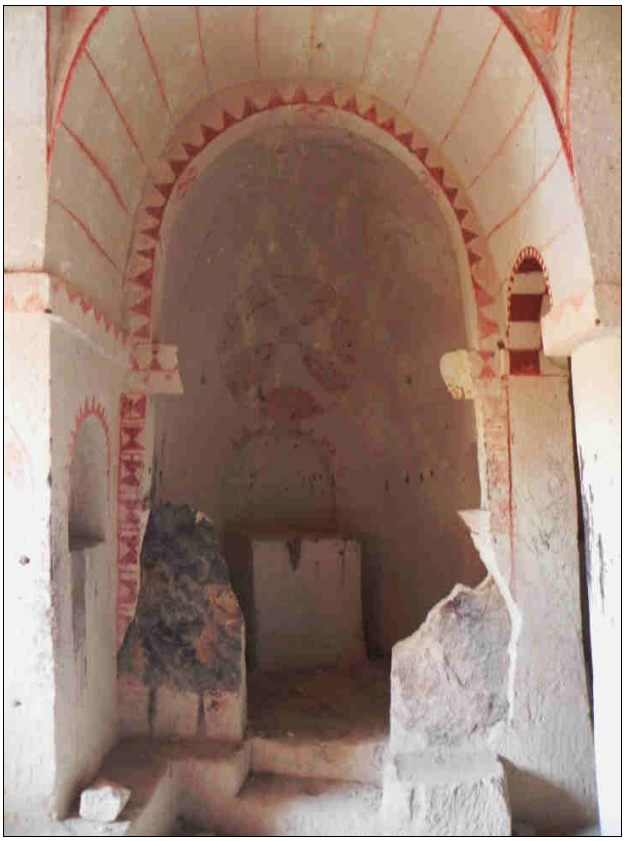

Figure 11: The apse of chapel

could belong to a phase following the use of the Byzantine monastery, as shown by the damage on the sculpted and painted decorations (Fig. 3 rooms F, G).

A long tunnel closed by two millstone doors (see Bixio et al. 2002 for details on this peculiar closing system) was excavated in the largest of the two rooms, enlarged by two later interventions and used most recently as a stable for cows.

This tunnel leads to three rooms distributed on different levels, used as storage units and dovecotes. The exavation of tunnels closed by these millstone doors, both in Göreme and other sites, appears to be fairly recent (Fig. 3, rooms F, H, M, N).

The transformation into a dovecote of several rooms facing the Kılıçlar Valley can be dated to the Ottoman period. Here, preexisting windows and doors were closed with tuff walls; the entrance to the church was closed by a wall structure and also the rooms along the northern side of the vestibule were closed and converted into dovecotes.

Some of these dovecotes are dated thanks to the presence of Arabic inscriptions between the second half of the 19th and the beginning of the 20th century. Probably to the same period belongs the systematic demolition of walls, division walls and jutting elements to exploit stone blocks for several structures in the valley (terraces, fences, etc.) in a context by now completely ruralized [Andaloro et al. 2015].

3. THE DIGITAL SURVEY

The environmental, orographic and architectural survey conducted on the monastic complex is the first complete and detailed collection of documents made using advanced technologies like L.S. that, integrated with previous knowledge, will allow deeper and more extensive studies on the settlement.

Currently the complex is accessible only passing through a hole in a N-NW pinnacle of a rocky spur overlooking the Kılıçlar Valley. The 10 rooms remained of the entire complex look different for dimensions and use and they can be hardly entered through narrow tunnels. Many entrances are blocked and some rooms are accessible only by using the appropriate caving equipment.

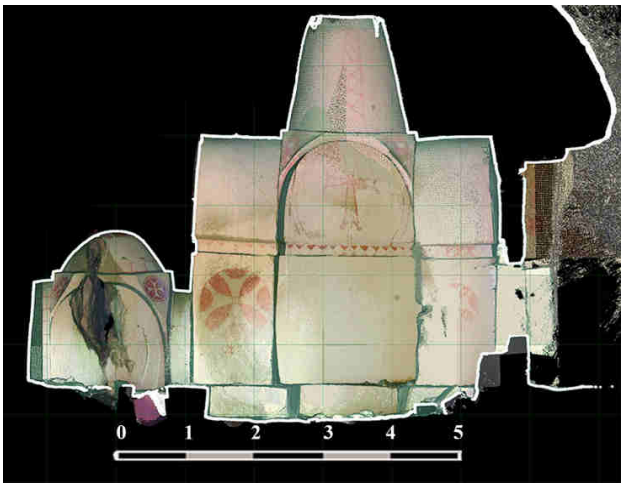

Figure 12: Sections NNE-SSO of Chapel by a point cloud (University of Florence - DIDA)

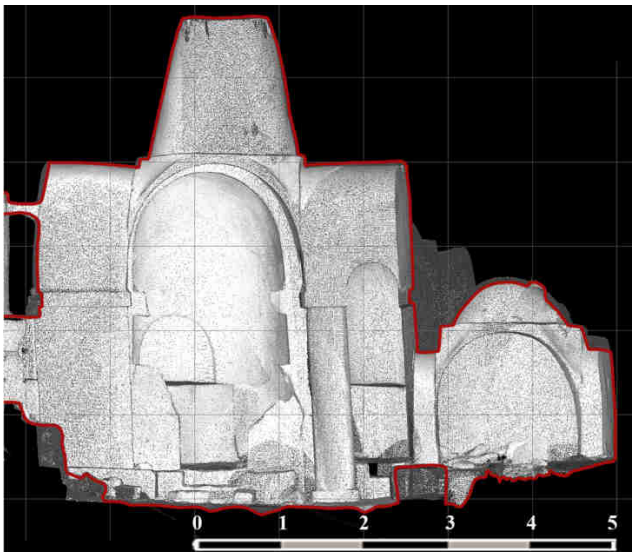

Figure 13: Sections NNE-SSO of Chapel by a point cloud (University of Florence- DIDA)

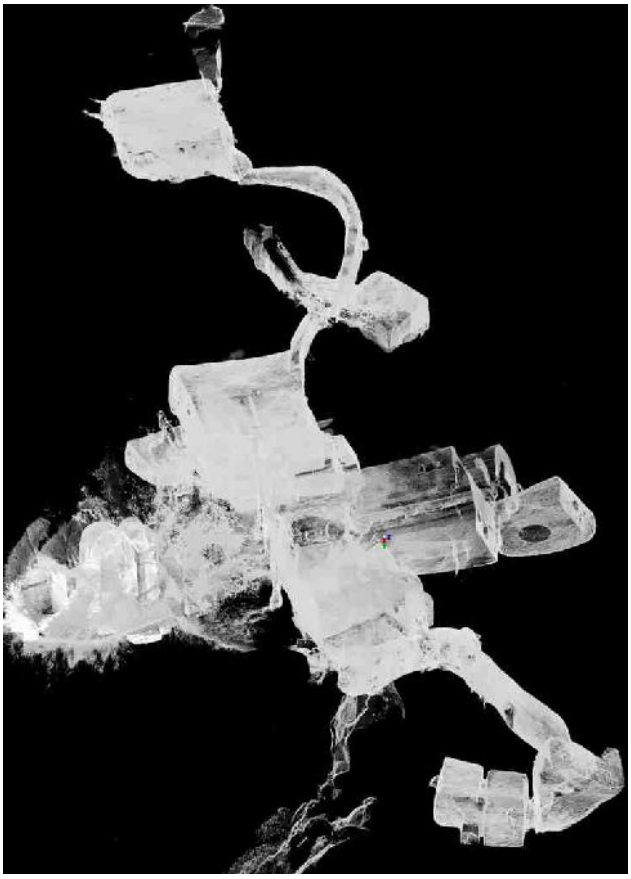

Figure 14: Axonometric view
(University of Florence - DIDA)

The complex survey of the settlements has required a large number of scans because of the narrow passages and the low level of the ceilings.

This detailed kind of relief will be integrated with the survey conducted using the S.L. Riegel on the whole research area, approximate 2 km wide and 600 m deep. Eightynine scans have been produced with a density of resolution of 1/8, (quality 4x, 3 mm point density at 5 m) for both outdoor and indoor environments.

Because of the carved facade many station points have been required, in order to cover its complex morphology and have enough natural target for the files' registration.

The same definition has been used for interior spaces whose length did not exceed 9 m.

A resolution of 1/8 , (quality 4x, 6 mm point density at 5 m), has been used only for small rooms, fettered galleries and narrow passages.

Every scan had an overlap of approximately 50%.
At least 5 natural points (reference points on the structure that being surveying) have been used for each individual registration, and all the registrations are linked together, aligned into a single coordinate system.

The overall dataset scans were organized in thematic sets:

1) the existing tunnel entrance, room with water and refectory;
2) the front of the complex and the chapel;
3) the second series of rooms and galleries;
4) the interior of chapel

3. DATA PROCESSING

The first data processing was performed with Faro Scene: scan files (*. FLS) were collimated with images taken by the same instrument, and then exported in PTX. The register setting file PTX was performed with Cyclone.

At least 5 natural points, belonging to the files to align, were selected; these points, with different heights and distances, were chosen manually and conveniently distributed in the scanned area. The maximum accepted error was 0.009 m; next the cloud-constraints for the error distribution and the realization of an optimal cloud-mesh were made.

Afterwards layers for each rocky building and parts of outdoor were created. This data management, the careful selection of the "reference plane" and "cut plane" and the correct view of the many screenshots have allowed to extract clear images.

Furthermore the image size has been defined (pixels/cm at 300 dpi) and the screenshots with 60/80 ml of points have been performed.

Then the established practice for the architectural and environmental data representation has followed. Therefore the use of laser scanner in this kind of survey has been invaluable for its precision in collecting data: the 3D models that have been being produced allow to measure and investigate the rupestrian urban system.

Snapshots have been created in orthogonal views for every room in order to recall the traditional graphics and to be useful in let the environments be readable even if not easily reachable.

In order to get a good quality performance for representative and monumental architectures, photo shoots for a three-dimensional photogrammetric restitution were made and more realistic models of the chapel and the refectory were created. At the moment it has been realized only the 3d restitution of the refectory; the chapel and the sinks' room will follow.

Furthermore, a thorough photographic survey describes the architectural element and its relationships with the landscape and the environment, contributing to create an interactive virtual tour that reveals the landscape and architecture.

The different photographic surveys (punctual, 2D and 360 panoramas) and 3D models will respond to the cultural needs of different users and requirements of knowledge, and of upgrade of the environment.

Figure 12: Perspective of Göreme Open Air Museum, points cloud (University of Floremce - DIDA)

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7. ACKNOWLEDGMENTS

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The results of the present research were obtained from the ten-year old Italian research group of the University of Tuscia in Cappadocia, directed by Maria Andaloro, with the title “Rock painting in Cappadocia. For a project of knowledge, conservation and enhancement”.

Between 2012 and 2015 this research develops within the research project PRIN “Arte e habitat rupestre in Cappadocia (Turchia) e nell’Italia centromeridionale. Roccia, architettura scavata, pittura: fra conoscenza, conservazione, valorizzazione” (Art and rupestrian habitats in Cappadocia (Turkey) and in south-central Italy. Rock, excavated architecture, painting: between knowledge, conservation, enhancement) conducted by the University of Tuscia (main role) and the other following universities: Sapienza of Rome Roma Tre, Firenze, Calabria-Cosenza, Modena- Reggio Emilia, Bari, Salento and the CNR. The Research Team in Cappadocia received the authorization from the following institutional authorities: General Direction for the Cultural Heritage, Museums of the Ministry of Culture and Tourism of the Republic of Turkey.

Survey in 2012-14. The metric survey of Urban and landscape area - it was made by U.R of the Department of Architecture, University of Florence. The acquisition of the metric data was performed with laser scanners of different types; in particular, in 2014, for the environmental survey it has been used a scanner Riegl VZ400 with T.O.F. technology, that is capable of reaching and measure objects at a distance of 600 m from the instrument. To survey all area were made about 270 scans with different acquisition density due to distance.

The architectural survey and the external of the individual complexes (2012-2014 campaigns) were used the Faro Focus 3D - 120 and Z + F

Survey 2014. Landscape survey: C. Crescenzi, F. Tioli, C. Giustiniani, G. Tarabella. Settlement Dove monastery survey: G. Verdiani, A. Pasquali, T. Pignatale, A. Leonardi; settlement survey photogrammetric: C. Crescenzi. The data treatment and the post processing: landscape F. Tioli, monastery C. Crescenzi, C. Giustiniani, A. Manghi, L. Meini. Drawings and stratigraphic analysis: M. Benucci, G. Romagnoli. Photo by Gaetano Alfano, Domenico Ventura.Translation by A. Serino (sections 1-3) and E. Vannacci (sections 4-5).

Catacombs of Kerch (Ukraine)

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Abstract
Speleologists from Odessa Club Poisk in cooperation with archaeologists, conducted research on the northern slope of Mount Mitridat in Kerch (Crimea). The underground cavities - catacombs were discovered and mapped during their work. Necropolis uniqueness is connected with the fact that a compact limestone layer covers a soft marl layer in which the tombs were arranged thus forming a rigid roof top. Examined tombs are dated back to AD 4-5. Later, the burial structures were connected by holes constructed by thieves into larger underground cavities of 350-450 meters length each. Monochrome and polychrome paintings were observed on tombs interior surface some representing Christian symbolism.
Superpositioning of a map on the underground cavity plan allowed researchers to perform the high complexity of work to clear the passages and to protect the most valuable objects. Many interesting findings were discovered during work process.

Keywords Mount Mitridat Kerch (Crimea) underground cavities - catacombs polychrome paintings Christian symbolism**.**

In the 5th century BC in the northern region of the Black Sea a big state arises - The Bosporan Kingdom, which existed in this area for more than a thousand years. Its capital Panticapaeum was founded by Greek settlers and was located on the territory of modern Kerch. Over the centuries this state evolved as a complex symbiosis of Greek cities, settlements and nomadic tribes which lived in the surrounding areas. As a part of the Byzantine Empire, Bosporus, the modern Kerch, exists as the city until the end of the 11th century.

In 1816 on the northern slope of the Mount Mithridate were excavations of the necropolis of the Panticapaeum started and continued during 19th and early 20th century. These excavations were finished in 1916 and were never resumed. This monument was considered thoroughly studied until the most recent time [Tsvetaeva G,A, 1951].

Among the many tombs of the necropolises of the Pantikapeum there are tombs which have monochrome and polychrome drawings on the walls. Modern researchers date these drawings to the 4th-5th centuries AD. A number of drawings with Christian symbols are also related to this time (see fig.1).

Structurally, each tomb consists of several parts. The descent to the underground chamber is carried through a narrow and long well of 4 to 8 meters depth. There are steps in the narrow opposite to the entrance wall of the well that have been used as technological platform. A small about 1.5 meters long vaulted corridor – dromos goes from the bottom of the well to the tomb chamber.

Figure 1: Kerch (Crimea). Drawings on the burial vault wall (photo I. Grek)

Tomb chamber has a square, rectangular or trapezoidal shape. There are niches – benches in the walls of the chamber. Their number varies in different crypts, from one to four. A niche for the lamp carved within the walls of the chamber (see Fig. 2).

After the burial the chamber entrance was closed with a stone slab stone plate and the well was covered with ground. Archaeologists suggest that such vault could belong to rich families only and used to re-burials for some time.

Figure 1: Kerch (Crimea). Burial vault (photo M. Nazarov)

Uniqueness the necropolis of the Pantikapeum connected with the dense limestone stratum that covers the layer of the soft marl, where the tomb has been arranged in. This limestone creates a stable roof. In addition, the vaults are very close to each other. Calculations show that about 30 percent of the underground area was excavated. Therefore, some tombs were interconnected on the stage of construction.

All this, apparently, was well known to robbers. They preferred to open the chamber neighboring crypts from underground, using short and narrow tunnels. This was not only easier, but also less visible.

Before making that tunnel they searched for the voids. Nowadays traces of such investigations in the form of small carved holes can be seen in the walls of the underground tombs. This way the catacomb system was created consisting of joint tombs.

Due to the fact that excavations were unsystematic in 19th century, now no one can tell if there are still undiscovered tombs there. Maps of the underground systems were not superimposed over surface maps that's why some interesting tombs with drawings in it discovered in the 19th century have been lost.

Later residential buildings were constructed on the northern slope of the Mount Mithridate. Due to that fact the traditional archaeologist method of working from the surface has become almost impossible. At the same time, many underground cavities were completely or partially filled with soil from the surface.

In 1993, when our Speleological Group together with the archaeologists of Kerch start catacombs exploring on the northern slope of the Mount Mithridate, there was only one accessible underground system known. Topographic plan we made provided an opportunity to fixate the location of the 5 painted tombs in the underground cavity consisting of 55 vaults and a total length of 306 meters [Grek I, Zinko E, 1997]. In this underground cavity, we have seen the signs of the other catacombs nearby, hence eight more tombs were discovered by us in the next few years.

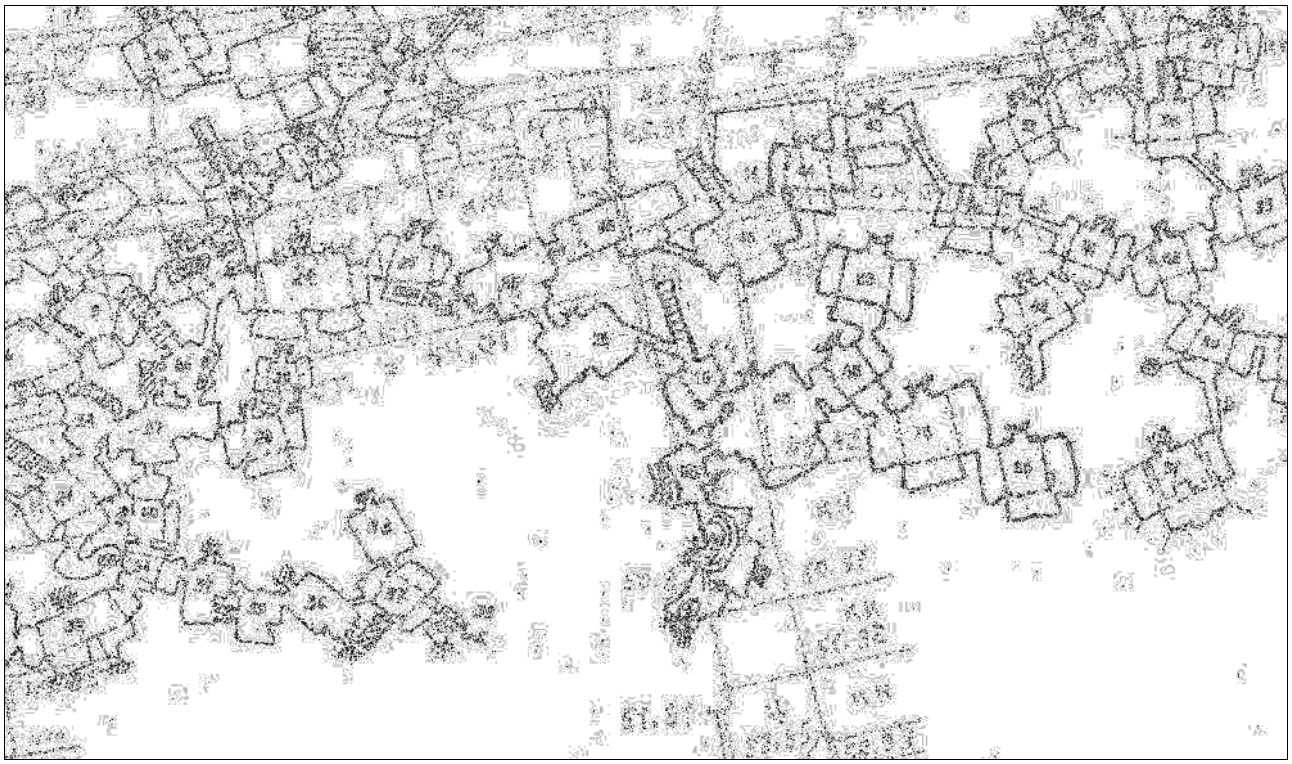

Figure 3: Kerch (Crimea). Fragment of catacomb plan superimposed on the surface (mapped I. Grek)

In this underground cavity, we have seen the signs of the other catacombs nearby, hence eight more tombs were discovered by us in the next few years. In 2000 the washout opened another underground system consisting of 47 vaults interconnected, three of them with paintings. It was examined by the Moscow speleologists. In 2002, our group has opened another catacomb and made a map of the underground system, there are 45 tombs in it. And in 2004, another large underground cavity, which consists of 50 crypts, was discovered and mapped.

During the topographic works in the crypt which was highly filled with soil from the surface the fragment of drawing was found. When we tried to open the crypt from the surface another previously unknown underground system consisting of 10 interconnected crypts was discovered.

This tomb complex was examined by robbers rather sloppy. Unnoticed fragments of gold women's jewelry were found on the bench, and unspoiled burial of the Bosporus soldier was found on the floor in the one of the vaults of the new system. The deceased was buried with his sword and shield. His left hand was adorned with two silver rings. The robbers did not notice it because it was filled with soil from the neighboring tomb in ancient times [Grek I, 2005].

After some time, a crypt with frescoes was opened to the surface, cleared and taken under protection. Clearing those filled with soil areas allowed to connect these two close to each other underground systems into one cavity (See fig,3).

At the present time four large catacomb systems are known on the northern slope of the Mount Mithridate.

Their length is from 350 to 400 meters and there are many small systems. At the same time, considering the size of the necropolis it may be assumed that the total number of vaults on the north slope of the Mount Mithridate is more than three thousand.

Our work showed that the study of the burial cave complexes is effective to conduct by combining archaeological and speleological methods, adding excavations from the surface where it is possible.

There is no doubt our understanding of the Pantikapeum necropolis topography will be expanded as a result of further research. There are all reasons to believe that not only archaeological artifacts, but also interesting early Christian and Late Antiquity paintings will be found.

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Exploration and researches in the Holy Cave of Altura (Castellón, Spain)

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Abstract

The Holy Cave of Altura is a Catholic Sanctuary dedicated to the Virgin Maria, which since the beginning of the 16th century has been a relevant religious center in the East of Spain, receiving regularly peregrinations from eighteen villages and cities up to 50 km from the Holy Cave.

Today the Sanctuary consists in a baroque chapel erected inside a great cave. This structure is the result of a deep reform of the cave and sanctuary performed around 1640.

Linked with the celebration of the 500 anniversary of the Sanctuary, we were authorized to explore parts of the cave closed to the public access. In this exploration part of the original Sanctuary of the 16th century was rediscovered, including an area named as "Vicars' Room", where graffiti dated from 1516 to 1634 are the testimony of the habit of the new Vicars of the Sanctuary of signing in this room's walls. Some of the signatures have been identified and its contents and typology studied.

Keywords

Holy Cave; Sanctuary; graffiti, Altura, Spain.

1. INTRODUCTION

The history of the Sanctuary of the Holy Cave (*la Cueva Santa*) is quite different to that of other Sanctuaries dedicated to the Virgin Maria, frequent in Spain and in other Catholic countries.

The origin of the Sanctuary is linked with the Monastery of de Valldecrist. In the beginning of the 15th century priests from this monastery had the habit of manufacturing very simple plaster images of the Holy Virgin, and distributing them among shepherds and farmers of the area to reinforce the Catholic faith in a population that, at that time, included a relevant proportion of Muslims.

One of these priests was Frater Bonifacio Ferrer, brother of Saint Vincent Ferrer, who worked in the manufacture of these plaster images, using wooden molds, and according to the tradition, he was who crafted the image of this sanctuary.

One century later, one of these images was discovered in the cave, and according with the tradition, all the attempts to move it away from the cave ended with the image re-appearing in the cave. Finally, it was interpreted as a message to establish a Sanctuary dedicated to the Virgin Maria in this cave.

In 1640, the Sanctuary was re-organized and the present chapel was built in the center of the main cave. In these works, part of the original cave was closed by the construction of the stairs and accessory rooms, and it remained closed to access until today.

We were asked to explore and study these parts of the cave. The surprise was the finding of an area that was certainly part of the original Sanctuary, with a relevant number of graffiti dated since 1516 to 1634, that is of the first century of the Sanctuary's history starting only few years after the discovery of the image of the Virgin, and ending in the time of the construction of the new Sanctuary.

2. THE HOLY CAVE OF ALTURA

Originally the cave was named *Cueva del Latonero* (Hackberry Cave) and was used by local shepherds to protect their livestock. Today the cave accessible to the public is a great room, approximately 30 m long, 25 m wide and up to 15 m high, almost rectangular (Figs. 1, 2, 3).

The access is descending 18 m using the stairs constructed in the 17th century. In the center of this room the chapel is placed. In the NW corner of the room, a modern gallery exits to the surface (this gallery was constructed during the Spanish Civil War, when the cave was used for different purposes).

Before arriving into the main room, as we are descending the first steps of the stairs, we find on the left the Chapel of the Communion, where the supposed author of the image of

Figure 1: Plan of the public area of the Holy Cave (graphic G. E. la Senyera)

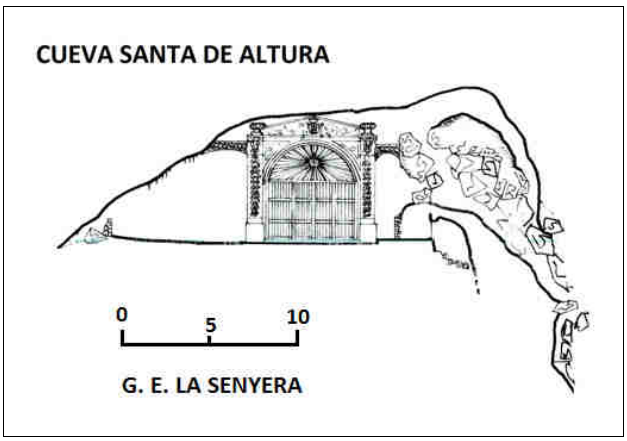

Figure 2: Section of the Holy Cave with the Chapel (graphic G. E. la Senyera)

the Virgin (Frater Bonifacio Ferrer) was buried and another room that during long time was used as hall of the votive offerings. This room, not used today, is important for our study because by a hole in the south wall of this room we access, going behind the mother rock and the Chapel of the Communion's walls, the main area of exploration.

3. EXPLORATIONS

Except for a series of explorations in 1954-55, no remarkable speleological research have been made in this cave before the start of our researches. The complete exploration, study, topography and analysis took about four years. As result of these explorations, two unexplored parts of the cave were located and surveyed. In the North of the main room and accessing directly from this, a series of rooms and wells reach depth greater than 100 m. A complex area was located in the SE sector, accessing from the hall of the offerings, including a well, 80 m-deep.

Figure 3: Developed projection of the public area of the Holy Cave (graphic G. E. la Senyera)

In a chaotic sector, massive rock blocks have formed a room that seems to have been accessible before the works of 1640. In any case the access probably was not easy, as we found rope remains (Fig. 4) and one of the graffiti includes the date 1600, the name Jaime Cabas and after the name, the adjective *'valiente'* (brave). This room has been named as Vicars' Room and is the main result of this research, together with an adjacent well named Well of the Engravings.

4. THE VICARS' ROOM AND THE WELL OF THE ENGRAVINGS.

The Vicars' Room is 6 m long and 2,5 m wide, defining a space of 15 m^2 between the mother rock (north side of the room) and the massive blocks, result of clastic processes.

The Vicars' Room allows access, through a narrow passage, to the bottom to the Well of the Engravings. This well is formed by two staggered wells followed by a large gallery, main fracture of the underground complex in this part of the cavity.

Graffiti and engravings in the Holy Cave have been made with techniques of painting and engraving, the latter being the majority. As for the painted elements, they have been made with pigments of red and black color. The first, prepared with ocher, have been applied with a brush and represent exclusively crosses. The second, of black color, are crosses and epigraphic motifs made directly with charcoal.

Figure 4: Rope remains in the Vicars' Room (author A. Fornes)

Figure 5: Calvary with three crosses (author J. Fernández)

More frequent are the engravings. Among them we have documented different techniques such as thin incisions, scraping and chipping. The technique more used is the metal engraving, drawn by a knife, razor or punch that generates thin lines with sections in "V" of less than 2 mm wide.

This same technique has also been applied by using an improvised lytic instrument, consisting of a small slab or angled stone, that produces more than an incision, a scraping thicker and, in most cases, stroke "intermittent". Finally, we have documented the pricking with a lytic element, which generates slightly rough bas-relief motifs.

The graffiti of the Holy Cave can be classified in two different typological groups, depending on their character: symbolic or epigraphic.

4.1 Symbolic Graffiti

Table 1 summarizes the religious symbolic graffiti. It has to be highlighted the important number of this type of graffiti: more than five hundred.

We found graffiti of different types of crosses (see Table 1), stars of five, six or eight points, two *icthus* (fishes) and one ladder.

Of special interest is the number of crosses of different type present in the cave. During the time lapse covered by the graffiti, religion was a question of conflict, with a Muslim population compelled under pressure to adopt the Christian religion. Figure 6 shows examples of graded crosses and crosses with *imago mundi*.

There are also non-religious symbolic graffiti, including flags and geometric forms. Only 29 of this type of graffiti are present, according to the religious character of this sanctuary-cave.

4.2 Epigraphic Graffiti

In the Holy Cave we have documented an interesting set of epigraphic motifs grouped into 72 units of analysis. Epigraphic signs have been studied as compositions and not as isolated elements.

Similarly, the chronological and *auctoritas* elements accompanying anthroponyms have been analyzed together with the names, but have been recorded in each of the groups to which they belong. The largest number of elements of this type is documented in the Vicars' Room.

There are six types of epigraphic graffiti: Christological epigraphy; Mariological epigraphy; Anthroponim epigraphy, *Auctoritas* epigraphy, Votiv epigraphy and Chronologic epigraphy. Sometimes two or more of these types of graffiti are combined in one epigraphic element, as in the form name+date+prayer, as in *Santo Deus miserere nobis 1516 Mon Bautis Helimeni*.

Obviously the detailed analysis of these epigraphical elements exceeds the possibilities of this paper. Only some items of special interest will be commented.

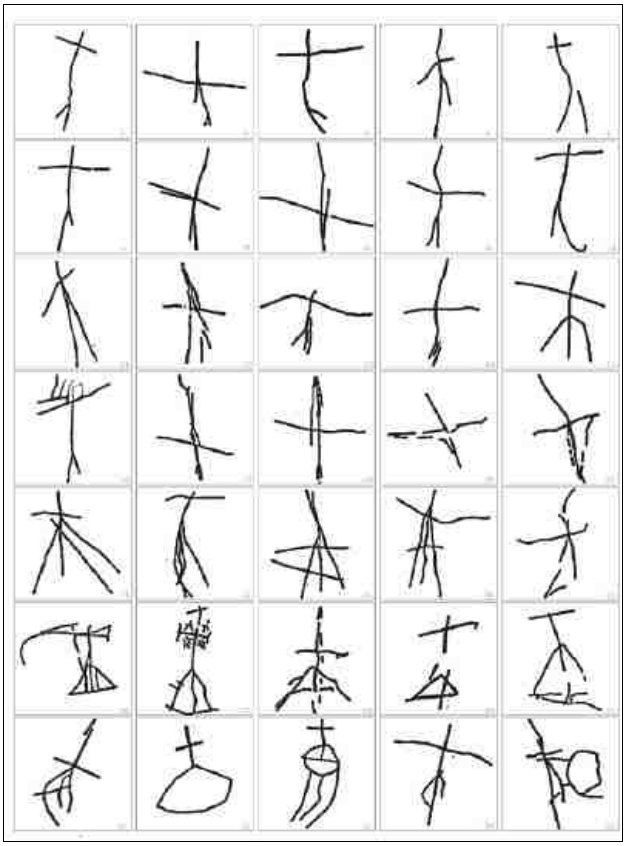

Figure 6: Graded and *Imago Mundi* Crosses (graphic J. Fernández)

Table 1. Religious Symbolic Graffiti

TYPE			TECHNIQUE	NUMBER
Crosses	Simple Crosses	Latin	Incision, chipping, scraping and painting	269
		Greek	Incision, chipping, scraping and painting	24
		St Andrews	Incision	6
	Compound Crosses	Potent	Incision, chipping	6
		Latin framed	Incision	5
		Latin Graded (open)	Incision and painting	21
		Latin Graded (closed)	Incision	5
		Latin with imago mundi	Incision	4
	Multiple Crosses	Over imposed	Incision	130
		Calvary with three crosses	Incision and painting	30
Stars	Pentalfa	Pentalfa	Incision	3
	Six-pointed star	Six-pointed star	Incision	4
	Eight-pointed star	Eight-pointed star	Incision	13
Zoomorphic	Ichthus or fish	Ichthus or fish	Incision and painting	2
Ladder	Ladder	Ladder	Incision	1
Total				523

"*Santo Deus miserere nobis 1516 Mon Bautis Helimeni*". (Fig. 7) Epigraphic assembly located in the Vicars' Room. This text is distributed in multiple lines. In the first place a litany in two rows in the first written "Santo Deus" (Holy God), with the first letters in uppercase, and in the second *"miserere nobis"* in lowercase. Below the litany appears the date "1516" - the oldest documented the sanctuary - and under it a name that, with some reservations, has been interpreted as "Mon Bautis Helimeni". Thus, this epigraphic narration could be translated as "Holy God, have mercy on us, 1516, Mon (Bishop) Bautis (Bautista) Helimeni". It is made with fine incision technique.

Figure 7: Santo Deus miserere nobis 1516 Mon Bautis Helimeni (author V. Benedito)

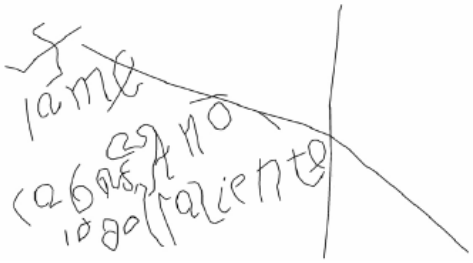

Figure 8: Jaime Cabas Año 1600 valiente (graphic J. Fernández)

"*Jaime Cabas Año 1600 valiente*" (Fig. 8) Epigraphic text of the panel placed in the end of the Well of Engravings. It is structured in three lines and adorned with a potent cross in its upper part. The top line says "jaime" (James), in lowercase, below "cabas", also in lowercase, followed by "Year" with the first letter in uppercase and adorned. In the third line is documented a date "1600" followed by "brave" with the first letter in uppercase and the remaining characters to lowercase. The final text says, therefore, "Jaime Cabas Year 1600 courageous". It probably reflects the pride of the author as a sign of courage to have reached this deep area of the pit.

"*Geronimo Decho mosen*" (Fig. 9). Epigraphy located on the Vicars' Room that presents a text recorded on four lines. In the first two lines it has the writings "geroni" and "mo", respectively, both in lowercase. In the third line, and with

Figure 9: Geronimo Decho mosen (graphic J. Fernández)

the first letter in uppercase reads "DCHO" and in the fourth, lowercase letters, "ms", an abbreviation of priest. The final text can be interpreted as "Gerónimo Decho priest". The text is done using the fine incision technique.

Dr. Gerónimo Decho is well documented in the historical sources of last third s. XVI. It was a famous canon, Capitular Vicar before bishops Francisco Soto (1571) and Martin de Salvatierra (1591) (also identified in another graffiti).

Figure 10 presents some examples of this type of graffiti. Among them we can find anthroponims, and *auctoritas*, etc.

We include finally an *Auctoritas* epigraph, as example of this type of elements.

The *auctoritas* items majority are those who make reference to the figure of the Perpetual Vicar (reason for the designation of Vicars' Room), and are represented by the abbreviations "V", "VP" and "VPo", all made with cobble and larger than 10 cm. The example presented in Fig. 11 includes the year 1626.

The dates recorded in the Cueva Santa in chronological order are: 1516,1600 (2), 1601, 1606 (2), 1609, 1610 (3 and a dubious) 1611, 1612, 1626 (2), 16-6-1626, 1627 and 1634.

5. CONCLUSIONS.

Holy caves of medieval and modern times are underground areas, located in different territories of the Iberian Peninsula, considered sacred spaces linked to the divinity. This consideration goes back, generically, to prehistory, although in each geographical and chronological context have a different origin and development.

In the specific case of Cueva Santa, a prior pre-christian cult does not exist. As noted by the father Iosef Iusticia "The popularity of the cave as Holy is from 1515 by the miracles occurred, but until 1574 was abandoned and use of the shepherds" (Iusticia 1664:15). With the discovery of the image of the Virgin, the Latonero cave would become known as Cueva Santa, "*fundamenta eius in montibus Sanctis*", being consecrated in 1581 with the first official cult.

Figure 10: Examples of epigraphic elements (graphic J. Fernández**)**

Figure 11: *Auctoritas* epigraph (author V. Benedito)

The conclusions that can be obtained in a first study of these spaces covers several aspects such as the authorship of the graffiti, its chronology and, finally, the functionality of the Vicars' Room and the Well of the Engravings in the context of this Holy Cave.

With regard to the authorship of the graffiti data are quite explicit and allow us to establish the firm hypothesis that they are not merely pilgrims or travelers, but members of the regular and secular clergy - monks, friars, priests, vicars

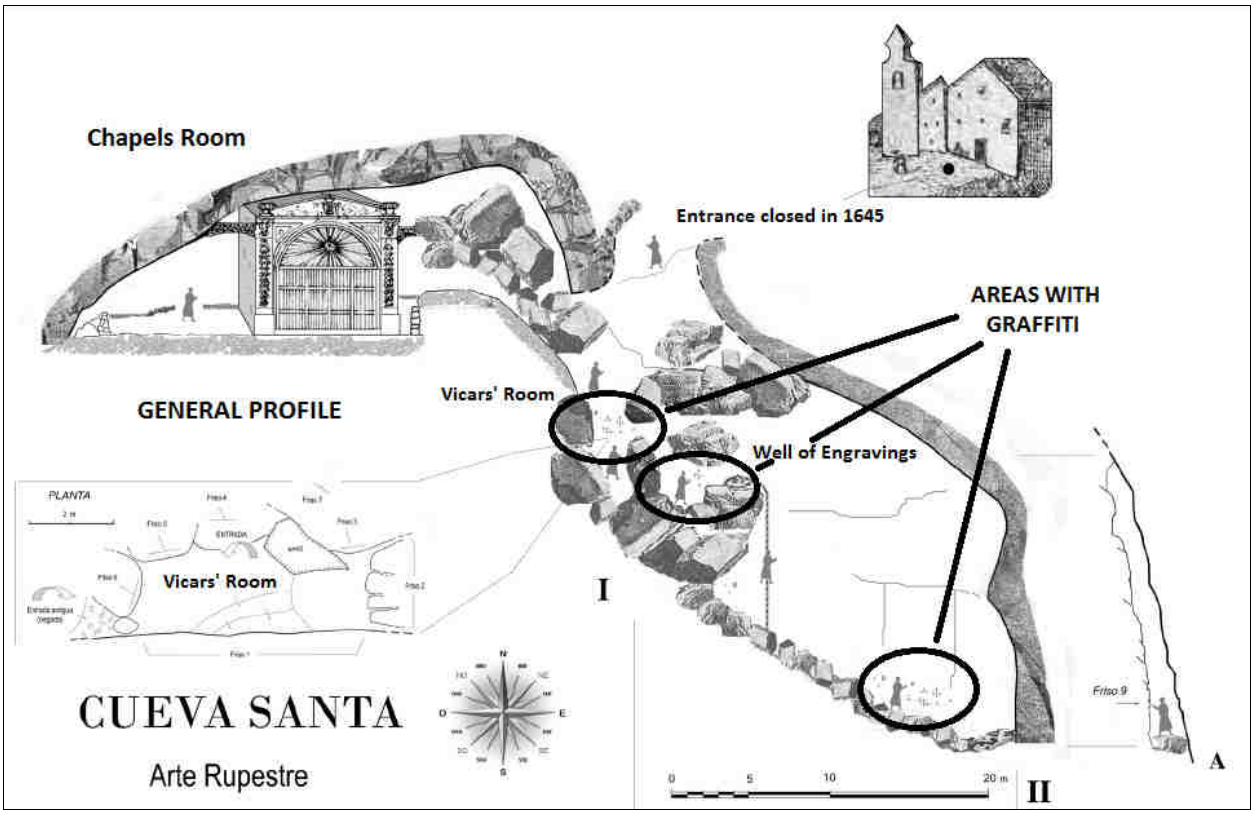

Figure 12: Hypothetic reconstruction of the Cave, with the entrance closed in the 17th century and the location of graffiti areas (drawing G. E. la Senyera)

and bishops - responsible and carers of the Sanctuary Cave, people with certain social recognition - teachers - and, exceptionally, intrepid characters that explored the place, as may be the case of Jaime Cabas in the year 1600. Symbolic representations are mostly of a religious nature (99%of the total graffiti), with a clear predominance of crosses.

Another important fact is the relative abundance of epigraphic graffiti and the existence of writings concerning ecclesiastical offices, religious ceremonial aspects and specific dates that could commemorate certain events.

From the graffiti identified and as result of the research in local ecclesiastical files, we know that Dr. Gerónimo Decho was already Vicar General in 1581 and Vicar to capitulate in 1571, so his signature under the title Mosen must be prior to this date and after his appointment as priest, late 60. Similarly happens with the signing of Gusep Martí, below that of Decho.

Dr. Juan Valero had to leave inscribed his name when he was vicar of the sanctuary, between 1579 and 1589, and already in the 80s, particularly between 1584 and 1589 was due to run the probable signing of Bishop Martín de Salvatierra, since it was at that period when, being Bishop of Segorbe, became interested in the Sanctuary, visiting it and making constructive and cult management reforms. The remaining dates are late and come from the three names that underlie a graffiti dated 1626. This is also the case of the signature that can be read as Aras, whose authorship is likely that of Diego de Aras, notary from Altura who visited the cave in 1629 [Iustitia, 1664: 34].

This research, initially oriented to a mere speleological exploration, was re-addressed to a multi-disciplinary study to allow understanding the cave as a physical space and the history of the Sanctuary, to better interpret the findings of the Vicars' Room.

Finally, and to try to recreate the cave in the time the Vicars' Room was accessible, Fig. 12 shows the hypothetic reconstruction of the cave, prior to the reform works of 1645, also indicating the areas where the graffiti are located.

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ACKNOWLEDGMENTS

We have to thank the Patronate of the Holy Cave of Altura and especially Pater Juan M. Gallent, present Vicar of the Santuary.

The expeditious survey of Tokalı kilise in Soğanlı valley.

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Abstract
The ancient village of Soğanlı is located in the historical region of Cappadocia, in the province of Kayseri. It is dug in the rocky ramparts of the valley from which it takes its name. The presence of water makes the lush valley rich in orchards and vineyards.

Along the ridges of the valley there is the abandoned rock village whose dimensions lets imagine a very populated valley. Along the valley there are several churches, many of them with frescoes. The artistic heritage and the particular architecture of some of them make the settlement an Open-air Museum in the countryside. Among its architectural interests there are Tokalı Kilise, Geyikli and Kubbeli Kilise.

In September 2015, during a cognitive excursion a photographic survey aimed at photogrammetry of Tokalı Kilise was realized. Photogrammetry returns the architecture in its three-dimensionality and makes accessible its metric data.

Keywords
Rupestrian architecture, digital survey, 3D modelling, photogrammetry, rupestrian church, kilise, Cappadocia, Soğanlı, Kayseri.

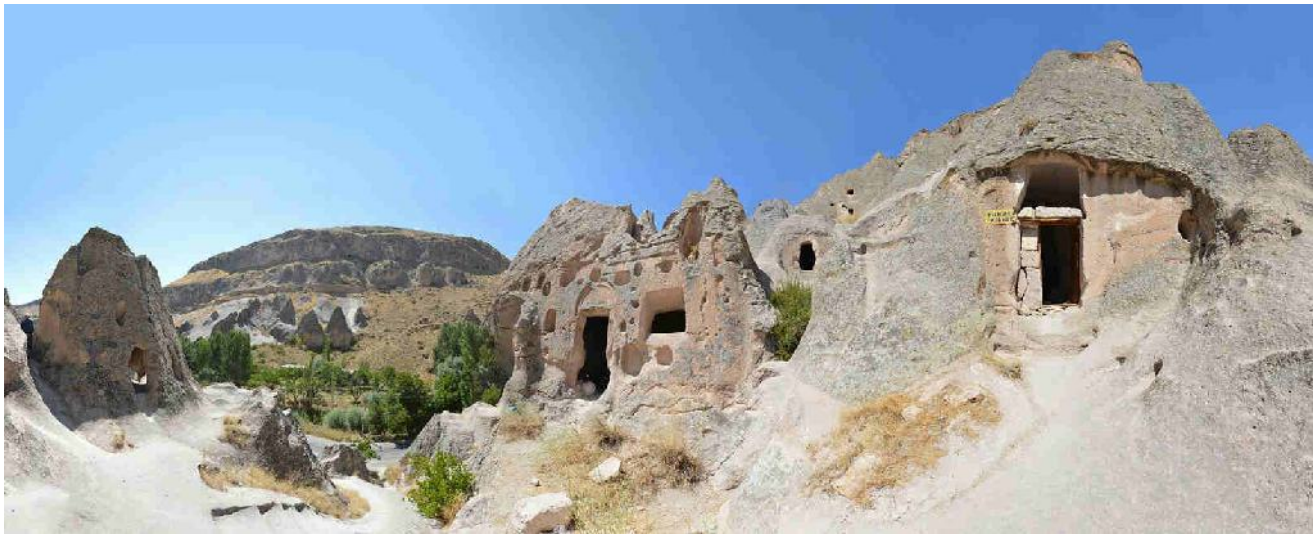

Figure 1: Panoramic view of Tokalı complex (photo C. Crescenzi)

1. INTRODUCTION

The Soğanlı valley is one of the most important centers of monastic life in Cappadocia; however it is not very popular. Located about 50 km south of Ürgüp, the green and lush valley welcomes visitors with its natural beauty and its special architectural features. A one day visit allowed a photographic survey, during which it was possible to realize some architectural models as in the case of the rooms of Tokalı.

The survey enriches the studies carried out under the European research projects CRHIMA-cinp and of national interest 2010/2013.

2. THE SETTLEMENT OF SOĞANLI

Along the valley of Soğanlı, on its SE side there are many rock buildings, in the map shows the sites visited (Fig. 2): on the side of the canyon, just before arriving at Soğanlı Open Air Museum are located, on the left of valley, the churches of Münchil, and at right the Tokalı complex. Immediately after the entrance, the valley divides into two branches: in the right route, on the SW side, is located the complex of Kubbeli, while on the NE side there are settlements of Karabaş and Yilanli. In the left branch of the valley there are the complex of Geyikli and Santa Barbara church.

Figure 2: Soğanlı valley Plan: locations of visited site (white) and photographed (yellow) (photo C. Crescenzi)

The Geyikli site has a the best "*trapeza*", it is a unique feature: the walls are characterized by sculptural elements that adorn the architecture.

The NE wall differs from all the refectories, it is divided into two sections: at the bottom one they were carved niches eighteen, they could simulate the refectories or council halls the backs of wooden seating; at the top, three deep and wide niches in addition to two pairs of blind false mullioned windows have been carved.

Figure 3: Building opposite the Geyikli church (photo C. Crescenzi)

Figure 4: Refectory of Geyikli (photo C. Crescenzi)

The complex of Kubbeli consists of three rocky pinnacles. Its special feature is the tip, modeled to mimic the drum and the typical conical roof of the domed churches. In the drum, there were windows, and it is divided with ring nut and boxes. Some parts are decorated with simple or toothed ring nuts. There are many frescoes, the oldest ones in the "*petit cône*" [De Jerphanion, 1936, p. 25]. Another peculiarity is the plan of the lower funerary chapel, located in the "*grand cône*" of Kubbeli complex.

Santa Barbara's chapel, frescoed, is one of the most studied and visited. A unique nave covered with a barrel vault is divided into two parts by an arch; on both walls there are two niches. Through the first recess, currently situated on the northern wall, you have access to the funeral chapel, while in the second there is a baptismal font.

The apse, with iconostasis, is gutted and faces a second narthex funeral. There are also two niches, *prosthesis, diaconicon*, and a seats.

All the sacred buildings of Soğanlı valley are described in some publications by De Jerphanion [1936] and Jolivet-Lévy [2015], which should be referred for detailed bibliography of individual buildings.

3. THE TOKALI COMPLEX

About 700 m before arriving to the Open Air-Museum entrance, on the right bastion, a steep staircase leads to a court-space overlooked by many pinnacles; it is the complex of *Tokalı Kilise*, which it was previously called by

Figure 5: Kubbeli: the "*grand cône*" (photo C. Crescenzi)

De Jerphanion [1936] with the name "*Église en face de Munchil Kilissé*".

Westward of court, there is a rupestrian two-room connecting space, while northward there is the *Tokalı Kilise* with two pinnacles and beside the church, there is a space probably used as a kitchen [Jolivet-Levy 2015].

3.1 The west rooms

Since the data processing is still in progress, the images of this building are without scale and orientation.

3.1.2 The Façade

The current façade is, as often , a possible sketch of a front regularization or an interior room that become visible from the outside by a cave-in. A small portico brings into the space at the south of the front; it has a barrel cover, which is set on a frame rectangular section. The entrance wall has a decorated frame with triangles surrounded by striped and is characterized by red and black colors. The frame closes a lunette overcoming the rectangular entrance; there are residual traces of decoration on the lunette. The second entrance is rectangular and above it, there is a lunette with ring nut, with two windows on both sides. The left window is the most ancient, while the one on the right was obtained

Figure 6: The church of Santa Barbara, internal entrance wall (photo C. Crescenzi)

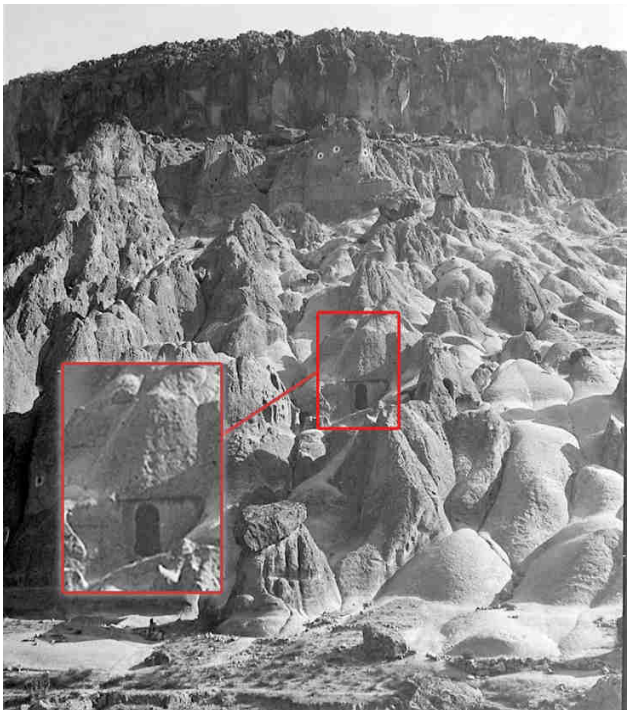

Figure 7: Soğanlı -Tokalı (elaboration by C. Crescenzi, after De Jerphanion illustration, 1936)

by destroying part of an internal closet. Holes placed over the openings could be the space for a cantilevered roof of the rooms; and the top opening on right is a fireplace made in the re-use process.

3.1.2 The first hall

The small room have two niches, probability cabinet, decorated with red picture frames. One is located on the eastern wall to the entrance side, the other on the south wall. On the west wall there is a deep niche, whose arch it is positioned on a frame with a rectangular section; under this, it is supposed that due to the reuse of the space there was a shelf. The flat bottom is characterized by a frame and a lunette of which remain traces of decoration of white mortar.

Figure 8: Tokalı complex – the west rooms (photo C. Crescenzi)

Figure 9: Tokalı complex, west room, decorative elements (C. Crescenzi)

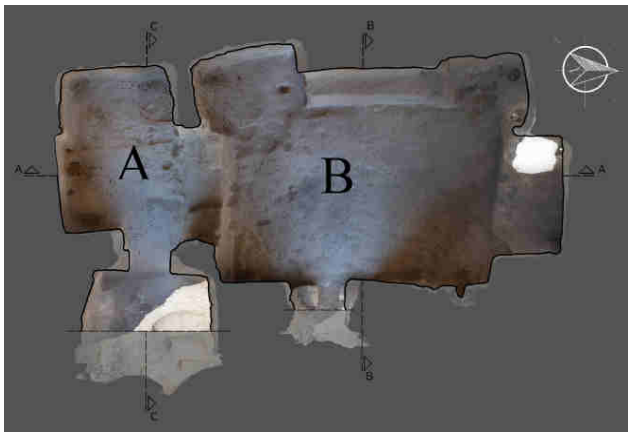

Figure 10:Tokalı complex – plan of west rooms drawing without scale (authors: C. Crescenzi, V. Firenzuoli, E. Vannacci)

The central figures are fragments of two circumferences deteriorated that probably inscribe a cross potent, similar at another that was painted in a niche in the northern wall, which is red and realized directly on the rock.

The northern wall divided the space in two rooms, but it was demolished; however his tracks can be recognized: it possible to identify the old door using the step; the latter may still be a further reshuffle of probably *subsellium* on the western wall of the northern hall. The ceiling is flat and with decorated frame.

3.1.3 The Second room

The second room, located at a different level, could be a refectory [Jolivet-Levy, 2015]; on the western and northern walls several niches were made, destroying a bench that ran along the western wall and probably on the southern wall.

On the longitudinal wall we can see there were two cabinets, in the eastern one was opened a window. On the northern wall there is a deep niche with a barrel vault, the arch is decorated with a double ring nut, and on the bottom plate there is a niche made as that of the first room.

The ceiling is flat with frame and in the NE corner there are two frames.

3.2 The Tokalı kilise

The Church, with a system that aim to *quincunx*, is constituted by the naos, an entrance narthex and a second narthex funerary.

3.2.1 The Façade

The front of the cone has partially collapsed, there was a funeral narthex as large as the actual one.

Before the entry entrance there are 3 graves, two of them only traces. The wall is smoothed and shows (Fig.7) the arched opening that stood by architectural elements.

3.2.2 The Narthex

The current entrance brings into a barrel-vault narthex with N-S axis. The vault is decorated with red lines to simulate a vault with ashlar; the line of the keystone is highlighted by green lozenges and triangles surrounded by red lines.

A decorated frame with other green triangles emphasizes the springer.

Figure 11: Tokalı complex, west room, section A-A, drawing without scale (authors: C. Crescenzi, V. Firenzuoli, E. Vannacci)

All the walls were decorated with paintings on white mortar at a later stage of red and green aniconic drawings. On the eastern wall there is a door with raised arch set on architectural elements, decorated with a green and red ring nut, shaped wave elements colored in white and ocher. All the walls were decorated with paintings on white mortar at a later stage of red and green aniconic drawings. On the left of the opening there are the holy martyrs o "αγηος" [Jolivet-Lévy 2015]; "K /// ΉΔΙΟC (Kattidios - Candide) and ΚΑΕΤΚΗΔΗΑΝΟC (Kattidionis - Candidianus)" [De Jerphanion], a tree divides them; Cantidius, Cantidianus and Sobel are Egyptian Martyrs of uncertain date. Cantedius and Cantidianus (whose names are variously spelled) are believed to have been stoned to death. But nothing is really known concerning them or Saint Sobel [Book of Saints, 2016].

Figure 12: Tokalı complex, west room, B-B and C-C sections drawing without scale (authors: C. Crescenzi, V. Firenzuoli, E. Vannacci)

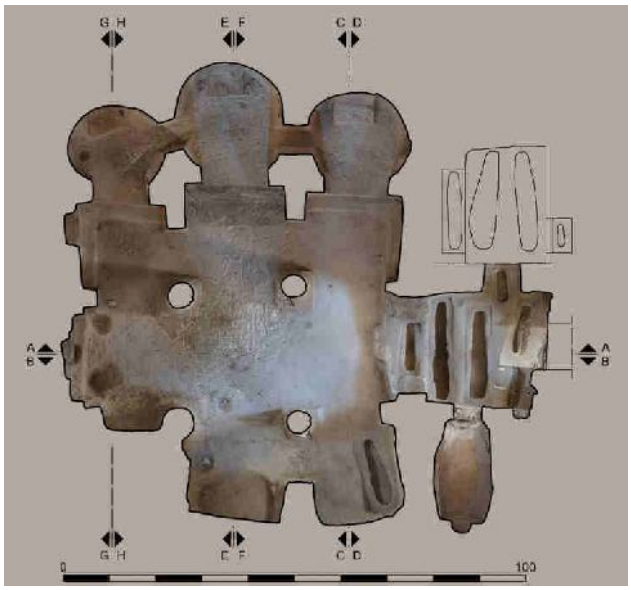

Figure 13: Tokalı complex, kilise – plan (authors: C. Crescenzi, V. Firenzuoli, E. Vannacci)

On the right is KYRHKOC (Ciriaco) [De Jerphanion 1925]. The inscriptions are white on a black background; the panels are closed by a red frame with a blank line; all painting is characterized with ocher, green, red and black color.
Below the saints two figures on horseback can be seen, the right is smaller and both have their heads turned towards the access wall, probably looking at the bust of Christ (IC XC) reported by G. De Jerphanion and now no longer visible.

De Jerphanion, in *tome* II.1 p.380, declares that M. Rott reports the two knights Saints George and Demetrius, and mistakenly puts them on the left wall of the narthex; Jolivet - Levy argues that to San Giorgio is positioned at the right because there's written ὁ ἁγιοςά; Also indicates the two figures who look at the entrance to the funerary chamber.

On the entrance wall, mostly destroyed, some traces remain of white plaster and some red and green geometric patterns that decorated the entrance arch resting on a cantilever spring line; the lunette hung over the entrance was torn.

The wall bringing into the church was destroyed, and the narthex looks directly into the Naos; instead the wall thickness can be read on the wall itself and the entrance extent in the plan.

Figure 14: Tokalı complex, kilise, tomb in the West all and vault of narthex (photo C. Crescenzi)

Figure 15: Tokalı complex, kilise - St. Cantidius and St. Cantidianus (photo C. Crescenzi)

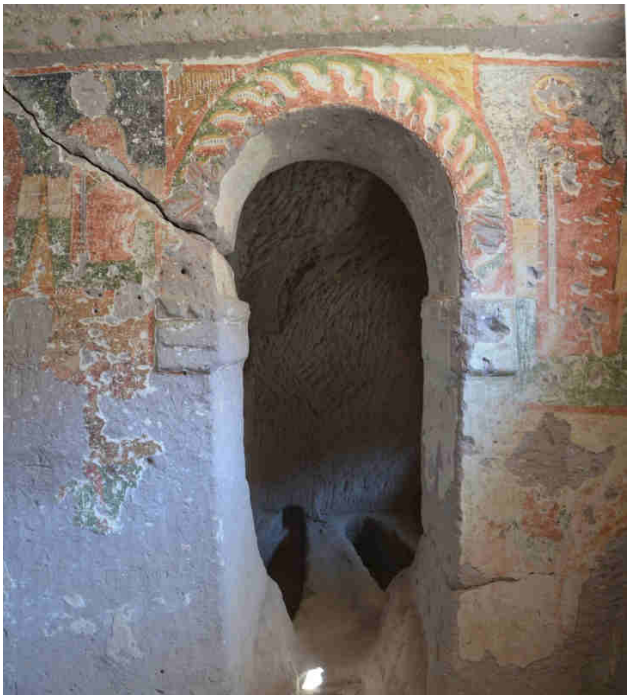

Figure 16: Tokalı Kilise, east wall of the narthex; St. Cantidius and St. Cantidianus (left); St. Cyriacus (right). Traces of St. George and Demetrius (photo C. Crescenzi)

In the entrance of narthex floor there are five tombs, two large and three smaller. The east narthex has two tombs on the ground, one in a *arcosolium* and another in a small niche in wall. On the western wall a square opening leads into a tomb, "*un petit reduit*" [De Jerphanion, 2015], the head includes a small niche. A second box suggests a second slot only brought to fulfillment.

3.2.3 The Naos

From narthex, looking to the upper part of the Church, you have the perception that originally it had a transverse axis system , similar to Tokalı and Meryem Ana in Göreme or St. John in Çavuşin [Crescenzi, 2012].
Originally it was a cross-in-square plan, without NE bay, and probably lacked of bay 10 and 11.

Figure 17: Tokalı complex, kilise – the front door (photo C. Crescenzi)

Figure 18: Tokalı kilise, the evolution of plan and the numbering of the spans (photo C. Crescenzi)

Bay 10, in front of central apse, could have been realized first, constituting the booms of the cross, then extended towards SW with bay 11.

Certainly the spans 10 and 11 are at an higher level than the floor of the church.

The bay 11 has the most defined walls in the upper part of the frame at the time; but later reworking do not allow a clear reading.

Into the lunette of vault, just above the frame, there is a small window with a ring nut; in the SW edge there is an crack that compromises the structure and in the ground, with WE orientation, there is a tomb. This span is connected to N with the 10 span, but the passage with an arch is not well defined. The bay 11 has the less damaged walls, but its base is too compromised to get a clear reading; there are also some holes in the ground, they could be traces of tombs. At the top of the western wall there is a small double window.

The bay number 3 is equipped with two niches, the first into the northern wall is small and blind, the second in the western wall could be, for shape and size, an attempt to complete cross-in-square plan and cave the last bay of the church. Finally, it should be emphasized that the ring nut on the arch is well defined and decorated.

On the western wall there is a rectangular niche decorated with green and red designs; at the beginning its shape

Figure 19: Tokalı kilise – F-F and E-E sections (authors: C. Crescenzi, C. Salvadori, E. Vannacci)

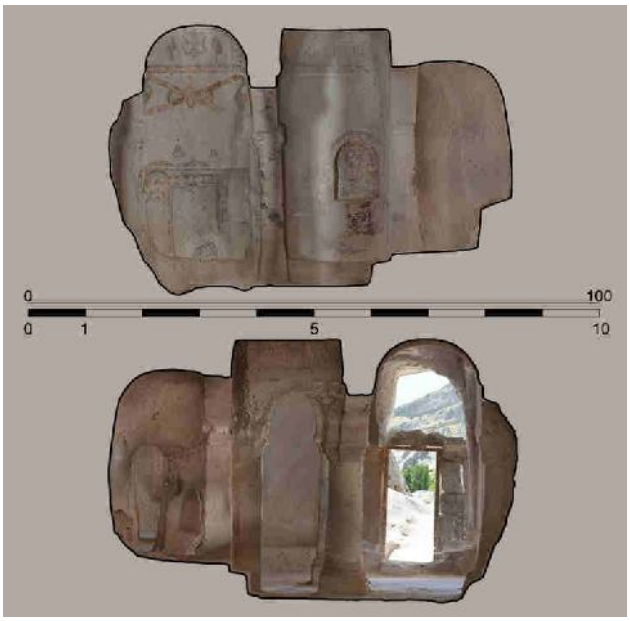

Figure 20: Tokalı complex, kilise – sections G-G, H-H authors: C. Crescenzi, C. Salvadori, E. Vannacci)

Figure 21: Saint Eustache Complex, Göreme – Niches (photo C. Crescenzi)

Figure 22: Tokalı kilise, niche in bay 3 and 4 (photo C. Crescenzi)

probably was three-lobed like the niches in St. Eustache complex in Göreme.

On the left wall is still visible the original cut, made with a bow-saw while it is disappeared on the right side; some traces of arched decorations are still observable.

These were interspersed with stylized trees also present on the sides of the cross potent into the upper lunette. Into the niche there is a second box, on its base it was carved a little sump, which could be a baptismal font. The upper lunette, closing the barrel vault, overlooks a St. Andrew cross, also visible on the southern wall of bay 6.

3.2.4 The Apses

The three apses point to the main room, they do not show traces of iconostasis in the rock, however it could be made of wood: traces are found for the joint of wooden elements on the walls in front of the apses and on the stairs. The three overstepped arched apses are furnished with altars against the wall and with a seat, they are linked each other

"*comme on le voit souvent à Constantinople: le fait est assez rare en Cappadoce*" [De Jerphanion 1936].

The space between the wooden iconostasis and the apse passages constitutes the area (zone) corresponding to a *bema* of reduced dimensions.

3.2.5 Decorations and Paintings

Bases and capitals of the columns are well preserved., they do not show traces of iconostasis in the rock, they are still

Figure 23: Tokalı complex, kilise – vd. note 10 (photo C. Crescenzi)

Figure 24: Tokalı complex, kilise – particulars of the column (photo C. Crescenzi)

covered with the white mortar base of the frescos that entirely covered them.

Observing the shape of the capitals it can be deduced that in a first phase of the church the columns were cross pillars. The first decoration of the church was constituted from linear red and green motives directly applied on the rock, and from subscribed crosses in *clipei* put in the barrel's lunettes or to halves the columns and of the pillars.

Those higher columns are also retained in the subsequent decoration as you can see on the front of the pillars that surround the central apse and the right column. Certainly, the frescoes decorating the whole septa and the central apse; on the left front of the pillar there is still the clothing of the Saint.

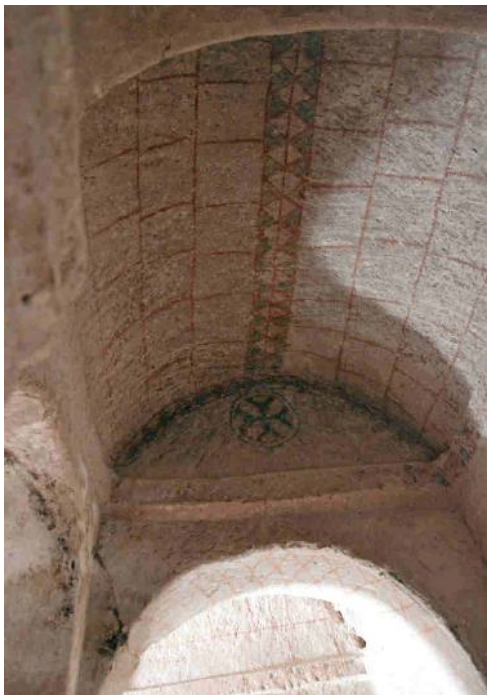

Figure 25: Tokalı kilise, span 4 ceiling (photo C. Crescenzi)

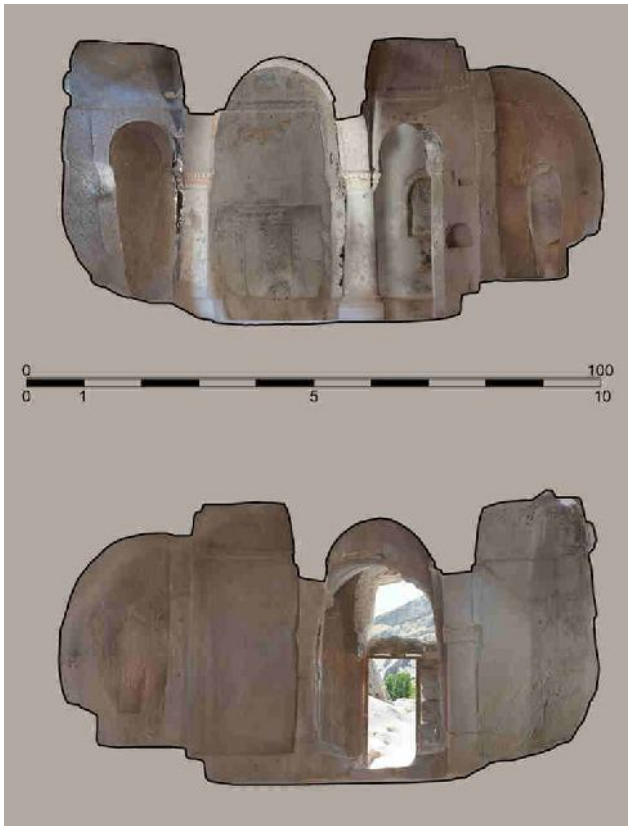

Figure 26: Tokalı kilise, sections C-C, D-D (authors: C. Crescenzi, C. Salvadori, E. Vannacci)

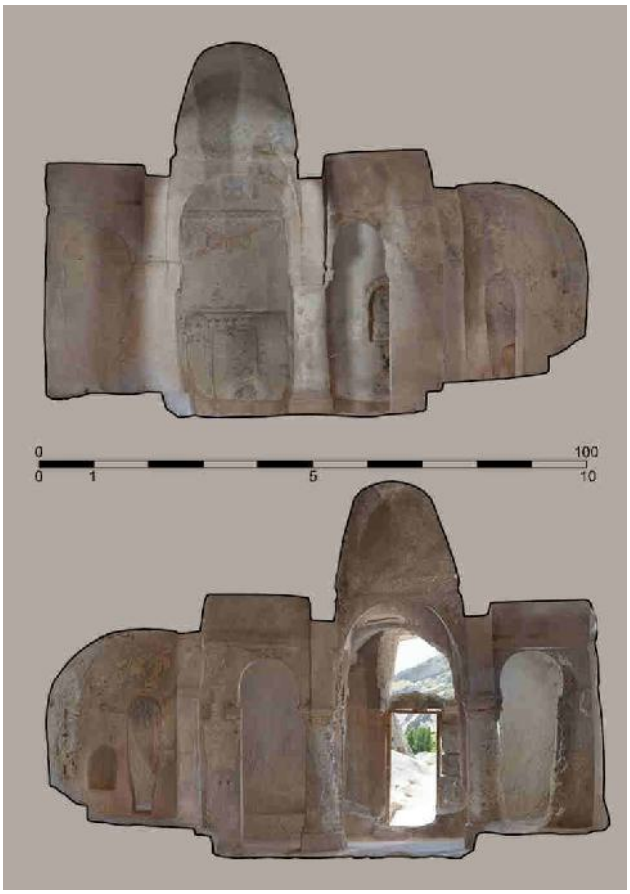

Figure 27: Tokalı kilise, sections E-E, F-F (authors: C. Crescenzi, C. Salvadori, E. Vannacci)

"*Dans l'église…*: Ο ΑΓΗΟC ΒΗ [χτωρ?] *en clamyde… A gouche… image de l'Annociation…Les deux personnages debout, l'un en face de l'autre : l'ange* [Γαβ] ΡΗΗ,… et la Vierge [ΜΡ] ΘΥ. [De Jerphanion, 1936, p. 80].

3.2.6 The Ceiling

The 9 vault bay is a truncated cone; from the square frame, a relief decoration starts with overlapping circles like a double ring; on this support, triangles are located to create an octagonal base, on which rests the dome. It has an internal surface decorated with red lines (*assise)* of ashlars, these converge in the upper giving the perception of a hemispherical vault. It is interesting to note that the first line is decorated with diagonal crosses.

Finally in the dome there is an opening with a compartment not inspected. On NE direction from the bay 9, branch off the longitudinal and transverse barrel vaulted axes to create a cross on the main axes. The other bays are also vaulted barrel with the direction of E-O. The vaults begin by a string course frame, and their surfaces are all designed to spin the blocks. The line of keystone is decorated with elements in green and red lozenges.

4. NOTE ON THE SURVEY AND DATA PROCESSING

The measurement was exclusively photographic and therefore to consider as preliminary; only for the church we had some measures to scaling. Therefore the representations, while getting a good interpretation of the architecture may not be dimensionally correct. The photos were processed with photogrammetric programs.

5. CONCLUSIONS

The survey contributes to the knowledge of Soğanlı valley and of the artistic and architectural heritage dug in the rock, allowing considerations about the state of the places and integrating the historical record on the landscape and monuments. Surveying and documentation is integrated in the modern conception of data knowledge and disclosure, as required in the notices of the European Community, which promote the repository for a database that preserves and shares the entire cultural heritage, raw data or processed, or processed. They are even more precious for the rock heritage, much of which is destined to disappear.

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The activity carried out in the Kayseri's province is part of the studies initiated in 2007 and treated in the European Project CRHIMA-cinp (2010-12), coordinated by UniFI – DIDA, chef C. Crescenzi, participants countries: Italy, -France, Greece, Spain and Turkey. 2010- 2012. The same studies were treated also in PRIN 2010-11 (2013-2015), coordinated by UniTUS, of which UniFI-DIDA is UR (Unit research).

Mission of University of Tuscia in Cappadocia, directed by Maria Andaloro, with the title "Rock painting in Cappadocia. For a project of knowledge, conservation and enhancement". Between 2012 and 2015 this research develops within the research project PRIN "Art and rupestrian habitats in Cappadocia (Turkey) and in south-central Italy. Rock, excavated architecture, painting: between knowledge, conservation, enhancement" conducted by the University of Tuscia (main role) and the other following universities: Sapienza of Rome, Roma Tre, Firenze, Calabria-Cosenza, Modena-Reggio Emilia, Bari, Salento and the CNR. The Research Team in Cappadocia received the authorization from the following institutional authorities: General Direction for the Cultural Heritage, Museums of the Ministry of Culture and Tourism of the Republic of Turkey.

Survey 2015. Photogrammetric's survey and test conducted by: C. Crescenzi.
The data treatment by E. Vannacci.
Post processing rooms A and B of V. Firenzuoli.
Post processing Tokalı church by C. Salvadori.
Translation par 1-2 by E. Vannacci, par. 3 by S. Nardoni.

Negotiating Above and Underground Sacredness in Nineteenth-century Cappadocia: The Use of Underground settlements

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Abstract
Today, the underground settlements of Cappadocia are regarded as places of mystery and therefore attract tourists in search of unusual experiences. Most of these places are closed these days, with only a few open to visitors who have become the main actors in these ancient places. However, although the underground settlements of Derinkuyu and Kaymaklı are said to have been discovered in the 1960s, these and many others had been known to and were used by local villagers at least since the 19th century. This presentation aims to elucidate the ways in which these villagers, mostly Orthodox Christians but also Muslims, made use of the underground settlements for profane purposes, for example as storage space for agricultural products, as permanent living spaces, or for refuge in times of war, but also as sacred places.
Comparing the communal use of the underground settlements, we arrive at contradictory views of sacredness. In most cases, the underground settlements were not considered as "places of everyday sacrality," since the modern church (or mosque) was usually not included in the underground space, but rather built above ground. Notwithstanding, old underground churches did exist and were sometimes used as "places of occasional sacrality," namely as thaumaturgic places, often shared between Christians and Muslims. Only the villagers of Misti (today's Konaklı) used their underground settlement as a permanent living space. But, paradoxically, their underground settlement was not a sacred space since the only building in Misti built above ground was the main church and, therefore, the main sacred place of the village. The villagers of Misti were known to inhabitants of the neighboring areas as particularly savage and backwards. Contrary to other Orthodox Christians of Cappadocia, they derived their livelihood from livestock farming and the preparation of *keçe* fabric, while other *Rum* communities had largely given up on agriculture and lived from trade.
Through examples of several communities of Cappadocia, I will attempt to understand how different ways of life influenced the way underground settlements were used and especially the diverse ways in which local communities negotiated sacrality between the above and underground realms.

Keywords
Cappadocia, Underground settlements, Ottoman period, Nineteenth century

1. INTRODUCTION

Today, the underground settlements of Cappadocia are regarded as places of mystery and therefore attract tourists in search of unusual experiences. We know today around 150 underground or smaller undergrounds composed of a few rooms, generally on one or two stories.

Most of these places are closed these days, only a few are opened to visitors who have become the main actors in these ancient places. Although the underground settlements of Derinkuyu and Kaymaklı are said to have been discovered in the 1960s, these and many others were already known to and used by local villagers in the 19th century. My presentation will thus focus on these actors of the 19th century, on their use of undergrounds as profane or sacred place. By comparing several villages of Cappadocia where underground settlements were already known by locals in the nineteenth century I will try to show how villagers used to negotiate sacredness and spirituality between the above and the undergrounds.

For that purpose, I have based my analysis on descriptions available in publications of the nineteenth and early twentieth centuries, mainly travelogues and in Greek and Karamanli books and articles about Cappadocia. But our main sources are actually testimonies today available in the Center of Asia Minor Studies in Athens.

These testimonies have been collected from the late 1930s to the beginning of the 1960s by collaborators of this center founded by a woman, Melpo Merlier, who aimed, with

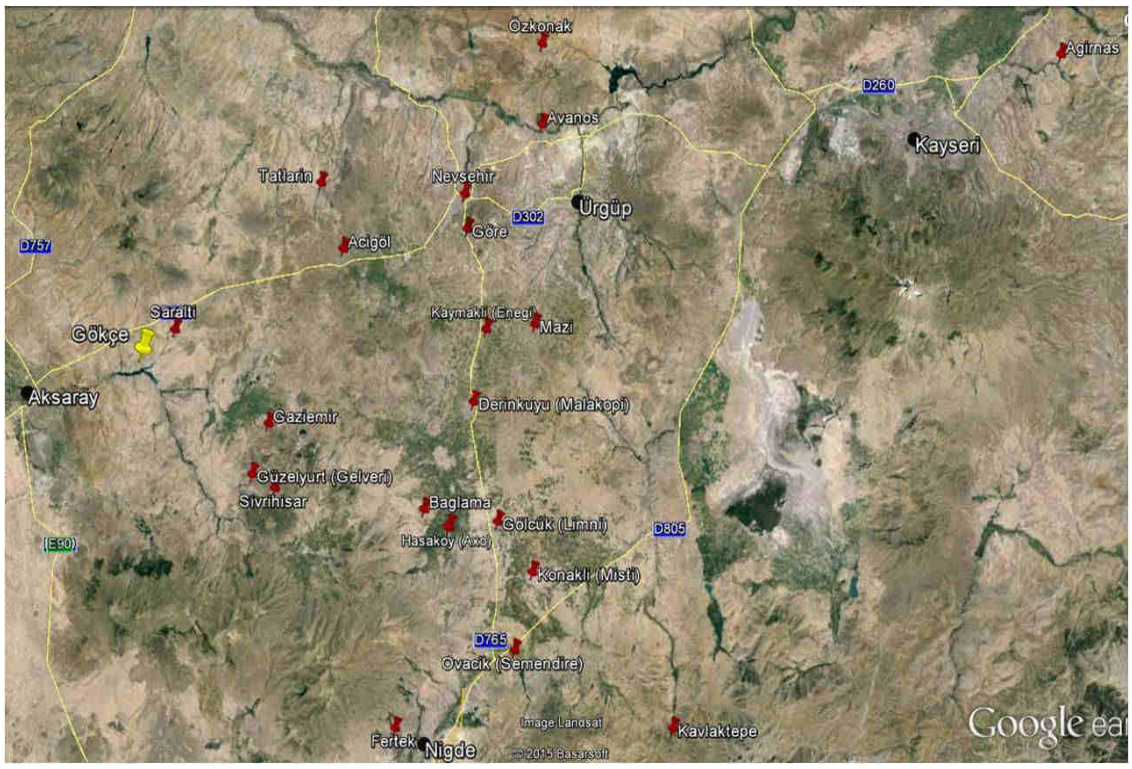

Figure 1: Main known underground settlements of Cappadocia (Source: Google Earth)

quite precursory methods of oral history, to collect information on the way of life of Greeks who lived in Anatolia in 1920s. These oral archives contain all kinds of information about villages and villagers, about geography, economy, cultural and religious aspects of everyday life. Particularly important for our purpose, descriptions of sacred places, celebrations and rituals bring very interesting details on local religiosity and interpretations of sacredness. Before getting in our specific issue of the use of undergrounds and especially on the sacredness issue, it is useful to have a general introduction on nineteenth-century Cappadocia and especially on the ethno-religious and linguistic sharing of local population.

Then, through examples of different village communities, I will focus on the communal and individual use of undergrounds, considered as profane or sacred places.

2. COMMUNITIES OF CAPPADOCIA

Until the 1923 exchange of population between Greece and Turkey that was decided during the conference of Lausanne, the region of Cappadocia was inhabited by a pluri-religious, ethnic and linguistic populations. In this presentation, I define Cappadocia as the region located approximately between the Kizilirmak in the north, the Taurus in the south and east and the Tuz gölü in the west, centralized on 4 main centers which are Nevşehir, Aksaray, Niğde and Kayseri. The underground settlements were more concentrated on the western part of Cappadocia, especially in the regions of Aksaray and Niğde but also in the large plain of Derinkuyu. We will thus focus on this western part more in details and let the region of Kayseri aside, except for the village of Ağırnas and its underground settlements about which we have interesting data concerning sacrality of undergrounds.

In the nineteenth-century, the population of Cappadocia was, for a large majority, Muslim but an important minority of Greek-Orthodox was also present in towns and in villages. Very small communities of Armenians were settled in the western part but, as we move toward the east, from the region of Kayseri and Develi, the number and size of Armenian communities tend to increase while that of Rums to decrease.

Many settlements of the region (Fig. 2) were actually mixed, inhabited by Orthodox Christians and Muslims. In a town like Nevşehir, the Rums were around 30% of the total population, and more than 20% in Niğde.

By the way, Niğde, in the early nineteenth century became the official seat of the metropolitan of Ikonium because most Orthodox of the diocese actually lived in the surroundings of Niğde.

Linguistically speaking, the majority of the Orthodox communities of the region spoke Turkish are called Karamanli and used to write Turkish in the Greek alphabet, but there were also several communities speaking different Greek dialects who, however, tended to be turkified in the course of the late nineteenth-century (Fig. 3).

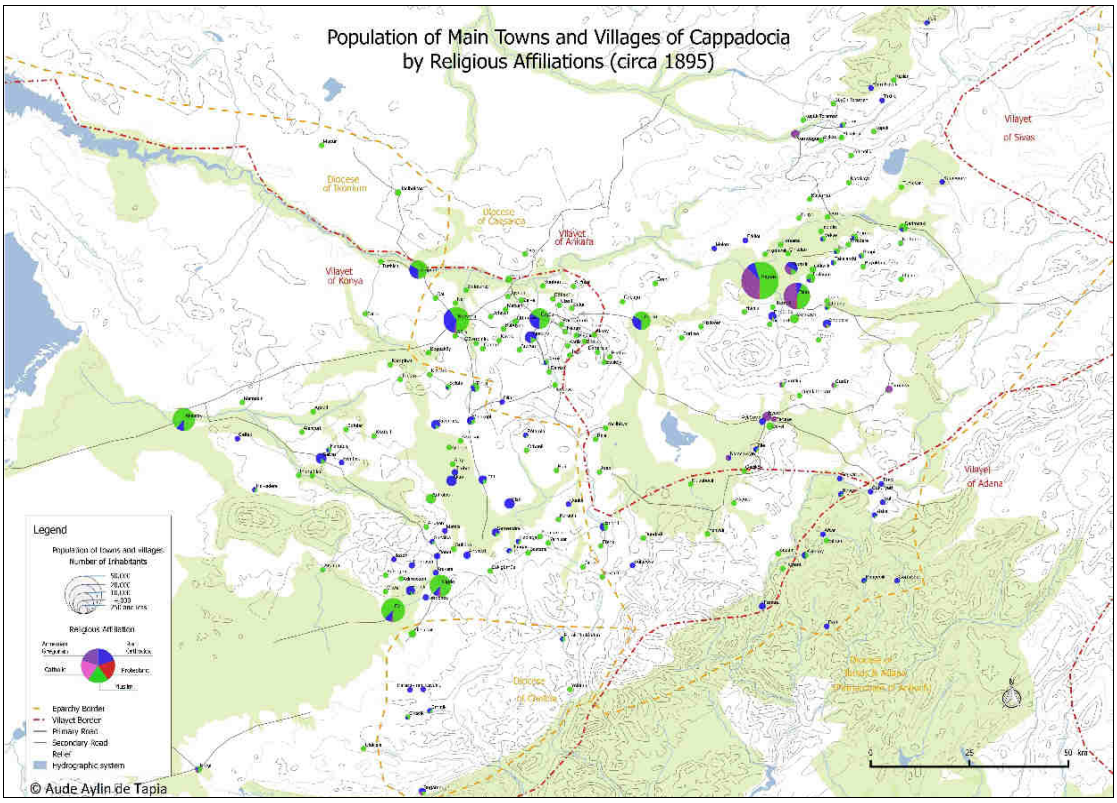

Figure 2: Population of main Towns and Villages of Cappadocia by Religious Affiliations (circa 1895) (A.A. de Tapia)

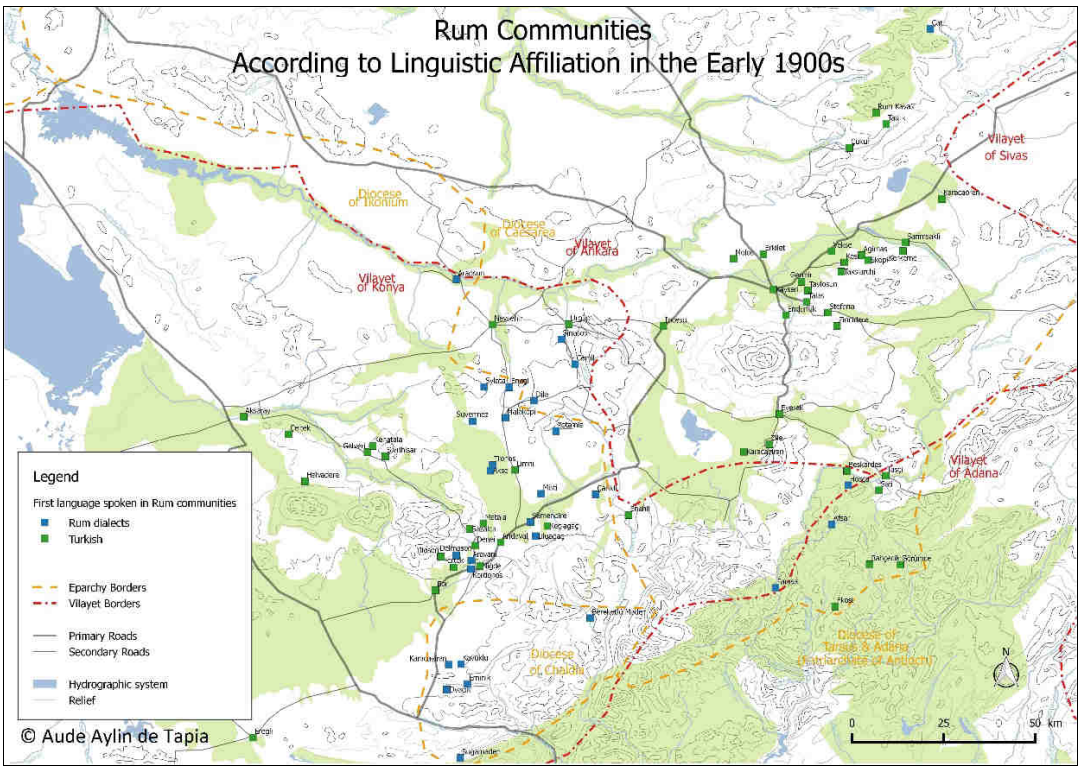

Figure 3: Orthodox Christian Communities by Linguistic Affiliations (circa 1900) (A.A. de Tapia)

For instance, in the region of Niğde, the villages of Fertek and of Andaval were about to totally abandon their Greek dialect in the early twentieth century. In fact most Turkish as well as Greek-speaking communities of Cappadocia had open a Greek school thanks to the revenues earned from immigration to large cities of the empire (especially Istanbul, Izmir) and taught Greek to their pupils.

However, in the large majority of communities, they were not particularly successful in terms of language education. Only in villages such as Sinasos and Cemil in the region of Ürgüp, from where many men immigrated to Istanbul, Greek language was strengthened in the course of the nineteenth-century and local dialects tended to be replaced by the Greek speaking in the Constantinople. An example of village which preserved its Greek dialect until 1923 was the village of Misti described further and which was a quite exceptional case among other communities of Cappadocia, for its way of life as much as for its particular use of its underground settlement.

3. UNDERGROUND AS PROFANE PLACES

These details can appear to be far away from our main issue but they are necessary to understand the complexity of local population. The movement of immigration to large cities in search of economic revival and the withdrawal from agricultural activities and development of trade but also the opening of schools in villages aiming to promote Hellenism and to develop, in communities which were quite isolated from the Greek-orthodox centers, a feeling of belonging to the Greek nation and the particular involvement of the Patriarchate of Constantinople in this issue are important keys that we need to keep in mind.

In everyday life, undergrounds were basically used as warehouse for agricultural production, and wine. In most Christian settlements, each house had its own “cave” with a direct access from the house but they were also often connected to each other. To such a way that, if necessary, inhabitants could flee their house through the undergrounds and go out through another house. These caves were called, by Greeks as well as by Turks, “in”.

However, according to many testimonies, only Christian houses had such a cave. Emmanouil Tsalikoglou, a researcher who worked for the CAMS and made a field research in the 1970s in Zincidere, the village of its parents wrote in his report:

> *I think that even in mixed villages, the Turks had no “in”, or at least not so large ones. And mostly, if the purely Turkish villages would have had “in”, it would have been difficult for Christians to know if, at the end of their underground escape, they would go out in the midst of a Christian or of a Turkish house. Consequently, I think that we can find only “in” in formerly Christian villages converted to Islam and that the Christians had invented the “in” long before the Turks conquered the region.*

Some Christian villagers indeed explained that they or their parents had used the undergrounds for escaping from the Turks at different period. In 1895-96 and in 1915-1916, during the massacres of Armenians, especially in the surrounding of Kayseri, as well as in the region of Niğde, many Greek and Armenian villagers found a refuge in these caves. In several legendary stories, Christians had even been able to escape their village by using these tunnels up to another settlement but according to narrative, it only occurred in very old times and nobody among the informants had never experienced or heard this kind of escape during their own time.

However, many testimonies show that undergrounds were still used as refuge in the nineteenth and twentieth centuries. An informant from Germir, a mixed village of the region of Kayseri, for instance explained that

> *In the past, all the houses of Germir had “in” which were dug in stone and served as place of refuge. It was in the basement of our houses and in time of tensions, we could live there during several days. Under our house, the in was formed of two floors: the first floor received daylight but the other was in the dark and we could close its access with a large round stone. For accessing to the first floor, we walked down 5-6 steps.*
>
> *The walls were all stone, and it looked like but was not a natural cave. When we were afraid by a situation outside, we went down to the second floor and we locked it. But it happened almost never. Most of the time, we only used them during summers to keep cool our cheese, wine and fruit. In 1915, however, during the persecutions against the Armenians, they served as refuge for them but also for us because we feared to have the same destiny.*

Another interesting narrative is given by an informant from Misti, a Greek-speaking Christian village known in the region for its savagery and especially feared by Turks because villagers did not hesitate to kill Turks who came too close. Mistiotes are actually the only community to have lived, up to 1920, in underground houses (Fig. 4 and Fig. 7).

Figure 4: House of Misti (Source: "Μικρασιατικόν Ημερολόγιον ο 'Αστήρ' – 1914)

Figure 5: Underground settlement of Kaymaklı/Eneği. Round stone used to close the access (A.A. de Tapia)

In times of dangers, the villagers used to go down on the lower levels and to close the access with round stones.

My father did not experience it but my grandmother did. When she was a child, a decree of the sultan obliged all Christians of the region to turkify or to be beaten.

[in fact; it seems that this even happened in 1770s when the vali of Nigde decided to torture the Christians who did not pay on time their tax. A sultanic firman of 1777 indeed orders the vali of Niğde to stop to persecute Christians of the region]

When the agents came to Misti, they found no one because the inhabitants had sneaked into the undergrounds. The agents consequently wait because they thought that there was no water and that Mistiotes would be obliged to go out. Actually there was a wells. When the Turks saw it, they tried to throw buckets of water to empty it but Mistiotes cut the strings down. So the agents tried to go down. There were first 5 or 6 rooms to go through then, a door and after it a long slope. In the middle of this slop, there was a wheel that protected the Mistiotes from outsiders (Fig. 5). *The Turks stood there for 1-2 days and then, unable to do anything else, broke camp and left.*

Gradually, the Mistiotes went out, looked down the street, recuperated animals and products and returned to hide in undergrounds. Then, when the Turks abandoned the application of the decree, they definitely went out and began to build houses but kept the caves as refuge in case of necessity in the future.

These first examples are representatives of the way the undergrounds were basically used. In general, there were simple warehouse for wine, cheese, *pekmez* (molasses) and other perishable goods which were easier to preserve in the coolness of the undergrounds. In that sense, it was not, contrary to the words of Tsalikoglou, exclusively used by Christians. Besides, undergrounds were not only old places. In Andaval, for instance, when a new house was built, new undergrounds were dug under it in order to have a warehouse connected to the house. An inhabitant of Andaval even dug a large warehouse for the *mufti* of Niğde right under his house. He worked three years and opened three rooms where the *mufti* was able to store 3 wagons of apples he then sent to Istanbul each year.

When the conditions required it, however, undergrounds, especially the older ones which were composed of several levels, had access to a wells and could be closed with a wheel stone, became place of refuge for Christian villagers, Rums as well as Armenians (Fig. 6).

4. UNDERGROUNDS AS PLACES OF SACREDNESS

In nineteenth century everyday life, undergrounds were not used as place of daily or even weekly worship. Sacredness and religiosity was rather connected to the above world. In the course of the nineteenth century and especially after the beginning of the Tanzimat, Christian communities of Cappadocia began to build large churches in dressed stone. They also continued to use troglodyte Byzantine churches but only a few days each year, generally for main celebrations such as Eastern, Theophany or saints' days.

It is worth noting that underground and troglodyte religious buildings are described as two different categories by villagers. If the latter continued to use more or less regularly troglodyte churches, most Christian communities had given up the underground chapels as communal worship places. Locals often knew where the entrance of these underground chapels were however, in many cases, they neither used them as worship places nor knew to what saint they were dedicated.

In the Muslim village of Eskigümüs with which the Christians of Andaval had many relations, an underground church was known but not used neither by Christians nor by Muslims. An informant of Andaval explained:

The Turks of Eskigümüş said that in the past their village was Greek but they did not know when they had been turkified. They had an underground church but we, Andavaliotes, we did not know it but one time,

I visited it. There were 2 rooms, in one of them, there were benches to sit carved in the rock. The church could welcome 25-30 people but there was nothing inside; neither painting nor anything else. We did not know to which saint this church was dedicated. We never prayed there. The turks of Eskigümüş actually used it to store apples.

In the midst of the fields of Kalleli (between Andaval and Eskigümüs), there was an underground site. When we entered, we came to a vaulted church where there were paintings on three sides. We did know to which saint it was dedicated. Actually we not give so much importance to the underground churches.

This disinterest for underground sacred places was actually linked to their localization. When the entrance of the,

Figure 6: Kaymaklı. Ruins of Ottoman houses built on the underground settlement (A.A. de Tapia, 2015)

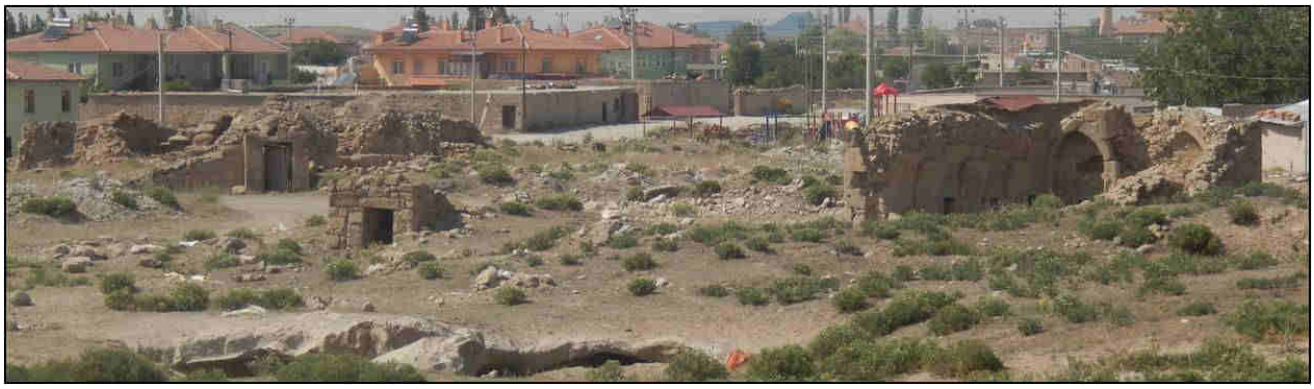

Figure 7: Misti: Former and current houses (A.A. de Tapia, 2014)

undergrounds was located outside Christian villages or in the middle of a Muslim village such as Eskigümüs Christians generally did not visit them, not necessarily because they feared the Turks but rather because there were so many churches in their close environment that they did not need to visit churches too far away. As for Muslims, when they visited churches, it was rather in places that Christians also visited since, in a way, the rituals performed by Christians attracted the Muslims who saw in it the confirmation of the spiritual power of the place.

The situation was quite different when the underground chapels were located in the midst of Christian villages. These chapels were still not used for regular messes or for celebrations but for thaumaturgic purposes. In that sense, villagers kept alive their sacredness but it remained exclusively connected to desperate situations which needed the intercessions of saints. Darkness of undergrounds, difficulty of access seemed to strengthen the sacrality of the place while it simultaneously bonded it to a kind of obscure sacrality, almost dangerous to frequent too regularly. The thaumaturgic power of these places made often them famous throughout the region, among the Christian but also among the Muslim communities. For Christians and mostly for Muslims, to visit an underground chapel had something of mysterious and mostly of frightening but people did overcome this fear when the issue was vital.

In the village of Germir, the church of St. John the Theologian was also underground:

> *There was no stairs but a long slope to get to the entrance of the carved room. There was no door or stone at the entrance. The interior was straight, 4-5 m wide. There was no icon or cross or any other object in the church. The priests did not come to celebrate Mass. It was mostly women who came alone or in group. And Turkish women came too.*
>
> *It was said that St John gave voice to the silent children. If a child was silent at an advanced age, but also, if he had difficulty for walking, we took him there. When we reached the entrance of the room, we left the children on the floor of the church and we left them inside for a while.*
>
> *Once in the room, we lighted up candles, burned incense and made prayers and we also put down small stones for the saint accepts our vows.*
>
> *The Turks also left pebbles. But they never came without oil lamp. They were very cautious and afraid when they came but their distress incited them to believe in our saints.*

In Malakopi too, one of the three underground churches located in the underground settlement was visited for therapeutic purpose by Christians and Muslims of the village. The church was known as the Sts. Anargyr church and was located on the second level of the underground settlement but in a part today closed to visitors. The place was believed to be thaumaturgic and especially to heal madness. An informant described the place and the worship as follow

> *The oldest church of Malakopi was underground. It was known by Greeks and Turks to be miracle worker. To reach the church, we had to go down on a fairly long distance tunnel. When they came, the Turks lighted candles to illuminate the road. Near the entrance arch was a little chapel. The Turks thought that the tunnel only led to this room but actually, we could go lower.*
> *In this church, sick people came and stood and going out being better. There were chains to attach them because when the priests were reading, sometimes they tried to escape, they shouted, and they cursed everybody. The Turks who were sick often slept in one night walked away the next day.*

Generally, only laymen and especially women came alone or in small groups, seeking for health recovery and no priest came to preach but in few cases, as that of Malakopi priests can participated in prayers. Actually priests generally participated in the prayers when the visitors asked for their presence, whilst rare are the cases of mess or celebrations organized by the clergy in an underground church.

In Ağırnas for instance,

> *St. Prokopios the Elder was an underground church located under the Turkish houses of the village. (...) Christian and Muslim women wanted to do their personal wishes, in the light of candles. They went there when they wanted to pray for the health of a family member. But sometimes priests came too and performed services*

In Zincidere too, the underground church of St. Panteleimon was visited for its healing power. According to several informants, it was particularly famous among Muslims. According to Heracleia Palazoglou, the Turks came more regularly than Christians and often asked the priest to come with them and to pray for their sick relatives. For therapeutic purpose, people had to sleep in the church during the night.

The Turks were fond of the church to such an extent that they bought dust from the church's soil and water from its wells. According to another informant, the Turks came all the Thursdays and paid one *kuruş* in order to stay in the church during the night when they were sick. Each Thursday, the Christian community thus collected money from around 70 Turks.

From these various examples, it is difficult to propose a generalization, specifically because there was not an only way to use and to negotiate the sacredness of undergrounds. In some settlements, villagers made use of the undergrounds only for profane purposes, especially as warehouse and, in period of conflict as refuges, even when they knew that a room was obviously an old church or chapel.

Only few communities used the undergrounds as sacred places and when it was the case, the sacrality of these places was experienced through specific ways. For "regular" or "institutional" sacredness, villagers rather used the churches that their community built in the course of the century or for important celebrations the troglodyte Byzantine churches located in or near to their settlement. On the contrary, underground sacred places were places of occasional sacrality, exclusively linked to thaumaturgical power. In that sense their sacrality included a part of mystery and of darkness both in the literal and figurative sense. It frightened but also attracted villagers who often found there a supernatural power impossible to find above ground.

5. CONCLUSION

Notwithstanding their supposed extraordinary power, undergrounds were generally considered as representatives of the primitive way of life of former communities of Cappadocia. This vision came from the West. European travelers but also Greek elites of Istanbul considered that Cappadocians who lived in undergrounds were primitive people who had not succeeded in developing a real architecture because of their remoteness but also because they were surrounded by Turks.

To confirm this idea, the Greek community of Misti, the last one where people continued to live undergrounds in the late nineteenth century, was described as the prime example of this primitive community, incapable of founding a real school and of educating its children. In 1916, Dawkins noted indeed:

> *It appears to be only at Misti that until recently the people lived entirely in these subterranean dwellings without any houses above ground (...) This undergro-und village consisting of 4 hundred houses, apparently lay round about the present big church: the crowns of the vaults of some of the houses may still be seen rising just with the surface".* [Dawkins, 1916]

Population of Misti, up to 1923, was composed only of Greek-speaking Christians and was a particularly closed community feared by other Christians as well as by Muslims of the region because of their savagery and hostility towards outsiders. Greek writers of the nineteenth century described them as totally uneducated and ignorant people. Mistiotes were also the last Greeks of Cappadocia to live from animal husbandry and from the preparation and itinerant selling of *keçe* fabric**.**

Figure 8: St. Basil church of Misti (in restoration), next to the underground houses (A.A. de Tapia, 2014)

This activity explains, I think why they had an image of backward people among other Greeks. The traditional preparation of keçe fabric required indeed a very strong physical condition which made that Mistiote men appeared to villagers of other communities as quite uncouth people. By the way, no one in the region wanted to marry their daughter to a Mistiote as well as no Mistiote men married outside the community because they considered that women of other communities were too frail and lazy

Mistiotes were also very religious people. As a result, in the mid-nineteenth century, the only building they decided to finance and to build above the ground was the impressive church of St. Basil (Fig. 8) with its ten domes while the villagers continued to live undergrounds. Through this way, they extracted sacredness from undergrounds and settle it above ground, the undergrounds becoming exclusively a profane place while the church, exposed to bright daylight became the symbol, above the ground, of communal devotion to sacredness. In the village, the St. Basil church became the only place of worship, undergrounds being totally excluded from the local understanding of sacredness.

The case of Misti, next to the other examples I exposed earlier show that sacrality and with it spirituality and worship were locally negotiated by communities which produced their own understandings of the relation between individuals, beliefs, above and under-ground worlds d and sacrality.

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People behind Places.
The Role and value of the hermitages of San Michele in the settlement of Colli Albani (*Latium,Italy*) during the Middle Ages

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Abstract
Aim of this paper is to highlight the role of two important places in settlement evolution during the Middle Ages around the lake of Albano and Nemi (Latium, central Italy): the hermitage of S. Michele on the lake of Nemi and the hermitage of S. Angelo *in lacu* on the lake of Albano. Both of them are in connection with the cult of the Angel, and both of them are on lakes, but despite these and other similarities, these sites presented during the entire medieval period a different role and value in the evolution of the historical landscape. Moving from the statement that "Every social context is , first of all, space"(F. Braudel) and from the idea that historical landscape should be perceived as the space of a community and networks, this study suggests the possibility to move from artifacts to the community, understanding the double value of special sites, such as the two considered, as both a specific place and as part of an anthropological landscape: a landscape presenting complex relation and networks; a landscape that is place of complex relations and networks. With this premise the present article puts in evidence the origins, dating problems and the historical reconstruction of these sites, highlighting when and where they were dug and their relationship with the road network and other housing models. Looking at all these elements it will be possible to define their surrounding context and the topographic and functional connections helpful for defining chronology and cultural role. Thus from two places that appear similar, it could be possible to shift into two completely different historical landscapes, in which the cult of S. Michele developed in different natural, social and architectural contexts, taking on a different value in the ancient communities, and becoming part of the complex cultural process that is behind the constitution of medieval settlements.

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Keywords
Hermitages, Middle Ages, Landscape archaeology, Colli Albani.

1. INTRODUCTION

The present paper offers some reflections on the two hermitages of S. Michele, located on the lake of Albano and Nemi, both sharing several features but also representing a completely different role in the transformation of their surrounding landscape. This topic appears extremely interesting, given the proximity of these two sites, and highlights as well the complexity of the history of this territory in the diachronic and also synchronic dimensions. Moving from the statement that "Every social context is, first of all, space" [BRAUDEL 1978] and from the idea that the historical landscape should be perceived as the space of a community and of networks, the present contribution aims at underlining how the study of these two sites should be examined in close connection to the communities settled in the same area, reading in this way the landscape and the artifacts determining its identity as part of the cultural process.

Reflecting on the concept of landscape under an anthropological point of view means thinking of the landscape as the territory of a community, a lived space, a moment of interactions. This consequently implies looking at communities as open entities, dynamic, continuously interacting with each other, prepared for exchanges, interactions and innovations, considering therefore the humanized landscape not as a physical place and mere container, but rather as a space in constant development and as the location of complex internal and exterior interactions.

2. THE COLLI ALBANI IN THE MIDDLE AGES: AN EXAMPLE OF COMPLEX LANDSCAPE

The Colli Albani(Fig. 1), in particular that portion between the *via Latina* and *via Appia*, presents historically a complex articulation, subject in medieval times to interesting settlement patterns that are still mostly unstudied. Rather than examining this topic exhaustively, I

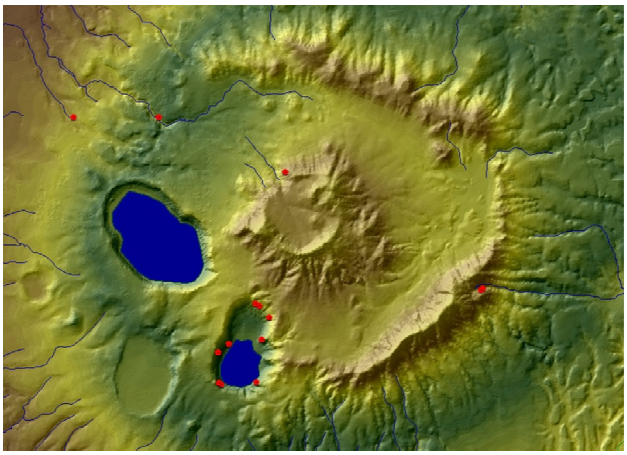

Figure: 1 An overview of the area with the main important rock cave settlements. (map processing N. Giannini, P. Dalmiglio)

will consider a certain set of problems of the medieval period, analyzing specific case studies, in order to identify the context of the two sites studied in the present paper. Despite the small number of studies on the understanding of settlement patterns in the Middle Ages, a combination of information collected from the consistent documentary and archaeological records appears symptomatic. The paper will reference only a selection of publications useful for the reconstruction proposed. For an updated and annotated bibliography see Giannini 2015 and Giannini in *c.p.* It is however important, given the location of this conference, to recall the significant recording work conducted by the research center Egeria on cave structures in this territory. The center's publications constitute a relevant starting point for whoever approaches the study of a territory by integrating cave structures to the study of settlement patterns.

The lack of data in documentary sources on the medieval inhabitation of the area has been long interpreted as the symptom of a total abandonment; recent surveys allow however the identification of historical nodes of an articulated and diverse pattern.

A careful reinterpretation of archaeological data coming from the large housing sections of the *Nemus* questions for example the role of villas in the inhabitation pattern of the very first centuries of the medieval period, an area that, as well known since ancient times, is famous for its residential function. An interesting case study, for the topics examined in this context, is certainly that of the villa in the area of S. Maria along the shores of the Nemi Lake, where archaeological investigations conducted by the Northern Institutes between 1998 and 2002 have for instance proposed the use of the site as a necropolis.[Moltesen & Poulsen 2010; Braconi et al . 2014]

After all, another quite extensive burial area was found towards the end of the nineteenth century on the shore in front of the lake, in the area of Orti S. Nicola, in connection to the reoccupation of other thermal structures. Despite the presence of bodies is a clear sign of the presence of live people living there, the latter was scarcely studied and examined in depth up to no more than ten years ago [Leander Touati & Zahle 2000]. After the investigations conducted in recent years, it assumed a completely different meaning in relation to the discovery of a significant presence of cave settlements- which can be dated across a wide chronological range between the 6th and 10th century, distributed in several spots along the lake bed and along a secondary road network which was however fundamental for the life around the lake, certainly in connection with the first inhabitation phase of the hermitage on this site [Giannini 2008, Giannini 2008c, Giannini 2010, Giannini 2011, Giannini 2015].

These investigations allowed the proposal of new hypotheses on the internal layout of the *Massa Nemus*, known in documentary sources since the 4th century and whose preponderant features are surely the lake and sacred forest. In this setting an important role is certainly assumed by the preexisting structures and road and water network. The area of Colli Albani is a territory characterized by the presence of impressive hydraulic structures with the function of guaranteeing the use of soil, so much to represent almost a *unicum* for richness, reuse and network arrangement of these artifacts. [Giannini 2006, Giannini 2008a, Giannini 2012b,Giannini 2014]

A further extremely interesting phenomenon is the encastellation, which involved in different ways all the settlements tied to the Appian Way. Interesting aspects emerge for example from the reinterpretation of the *castra* of Nemi and Genzano, while the preexisting elements of the *castellum albanense* are still to be analyzed and clarified, especially in relation to the inhabitation of the villa of Domiziano, of the *castra albana* controlling the territory and of the farming activities involving water, one of the elements besides the fertility of the land which resulted appealing to the powers for the economic control of the territory. [Giannini 2012a, Giannini in c.s.b, Cardulli 2014]

These dynamics, that obviously fully involve also the Albano Lake, a significant element of the hydraulic exploit system and suggest the dating of the territory to the full medieval period, allow the insertion in this already complex frame of the role played by monasteries and abbeys- for instance, the Cistercian monks of S. Anastasio ad Aquas Salvias from the first half of the 12th century or Grottaferrata Abbey- and the cave connected to the cult of S. Angelo, with a hermitic destination confirmed by the Bull of Gregory IX in 1237, assuming as well a significant role in relation to the road network and the settlement patterns connected beyond all to the present of other inhabited sites identified in the same area [Lefevre 1987; Giannini 2008a, Giannini in c.s.a].

Figure 2: The entrance of the Hermitage of S. Michele (Nemi) (photo by N. Giannini)

It should not underestimated the role covered by this area in the mountain paths of the Appian Way, a feature bringing us to not disregard their value within pilgrimage routes, such as the so called "Via Francigena of the south". On this note the data emerged from the reinterpretation of roads and votive sites dedicated to the *Angelo* is also important. These were reconstructed in the area also in relation to the presence of burials of pilgrims, such as the one of the 10-11th century found near "S. Angelo in monte Crescentuli" and attributed to a pilgrim coming from France. [www.academia.edu/1484397/Un_gruzzolo_di_monete_medievali_da_un_contesto_funerario_in_località_Montecrescenzio_Marino_RM_.]

3. THE HERMITAGES OF NEMI AND ALBANO

From the brief introduction, it is evident how hermitages are included in an anthropic landscape in continuous evolution, characterized by settlement models which develop and grow in close connection to the local environment and the two lakes. The analysis will start from the hermitage of S. Michele Arcangelo located below Nemi along a quite steep path spread around the lake bed and connected to the town. The complex is located about 480 meters a.s.l., along the southern side of the stone bank on top of which stands the town of Nemi. (Fig. 2) The access to the site is obtained from the inside of a wall structure, which has gradually obliterated the stone bank, probably hiding what must have been the original entrance.

Despite the bad state of conservation, this complex presents certain characteristics that should be considered. Even if it was analyzed by several authors, the description by Galieti [1948] is still today a point of reference, and no one ever considered its features and components in terms of comparison with other similar contexts and limited himself by repeating the words of the notorious scholar. In addition, the studies of recent years examining cave places of cult never considered this site. In this occasion I will therefore present some starting points, on which it will be necessary to come back, concerning two aspects in particular: the cave layout and the wall decoration.

The layout. Inside the artifact is characterized by a quite simple plan divided in two parts with one used by the priest and the other for praying: a stone built railing divides the area in two separate spaces.(Fig.3) The largest one is characterized by the presence of a cut away section, carved on all sides and probably having the function of a seat. An opening currently obliterated can also be noticed here, probably leading to other rooms, carved and added to the complex. The second part of the complex, the actual presbytery, appears slightly out of axis from the entrance; it is characterized by a reduced height and a three apse plan, also presenting a cut away section along the walls.(Fig.4) The presence of a presbytery inside a hermitage separated from the so called *templon* is not largely spread across Latium region and can be found mostly in southern Italy in contexts connected to the Greek-Byzantine dimension [Raspi Serra 1976; Caprara 2000; De Minicis 2008].

This is definitely a research topic to be further studied, however it appears quite relevant to find a *templum* in a cave church because it recalls a specific kind of liturgy. It recalls in addition a close connection between liturgy and architectural experimenting which, in a cave context at least in southern Italy- for istance Apulia [Prandi 1962; Rupestrian settlements 2010 and 2011]- sees the spread of churches between the 10th and 11th centuries in relation to actual specific needs: liturgical changes bringing to architectural adaptation. In the 12th and 13th centuries the predominance of the Latin ritual on the Greek one brought to the destruction of the *templum*, often replaced by plain small walls.

On behalf of this, it is evocative that this area belongs to the monastery of S. *Anastasio ad acquas Salvias*, a monastery of Greek ritual, at least until the 10th century, as witnessed by the life of saint Nilo the Young written after 1032 and only afterwards passed to the Cistercians.

The wall decoration. Proceeding with the analysis of the decorative attire, many are the appealing elements.

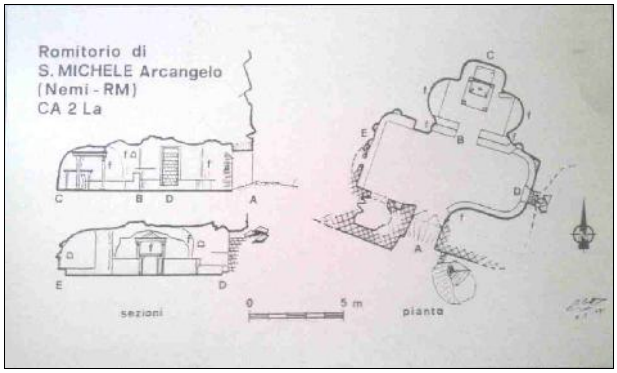

Figure 3: Layout and section of the Romitorio di S. Michele Arcangelo (relief by G. Cappa in Felici A. Cappa G. 1991, source Dobosz et al. 2003, fig 2.17 p. 113)

Figure 4: A view of the inside (photo N. Giannini)

The side apses and the right wall present in particular a painted decoration which can be associated to a single decorative program dating to the end of the 15th century.
Despite the fact that this dating is already known in studies[Galieti 1948; Felici Cappa 1991; Leander Touati & Zahle 2000; Dobosz et al. 2003;], the aim here is to underline the importance of looking at these decorations by giving attention to the program as a whole and as a consequence to the role of the hermitage receiving this *restyling* had for the settlement of the area. We find ourselves in front of a re-decoration of the complex of not so beautiful manufacture, but extremely interesting.
On the right wall are represented the saints Peter, Bernardin from Siena, Sebastian and probably the Archangel gone lost. In the lower part of the fresco is an inscription in Gothic characters with the name of the author, part of the group of Antoniozzo Romano.

Extremely interesting is in the presbytery the decoration of one of the side apses representing Christ on the cross between the virgin and S. John the Evangelist. Noteworthy are the inscription in both Greek and Latin and the landscape surrounding the scene which does not follow the normal iconography, but represents the castle of Nemi in its 15th century phase (datable to the year 1471), seen from the lake.

Further elements which were started to be considered are the representation of the virgin with child, accompanied by Saint Sebastian and two archangels Michael (with the sword of fire) and perhaps Gabriel. These features should be analyzed not for their stylistic elements, but rather for the value assumed by the painting in a medieval cave; this is always of religious property and tends to represent the sacred inside the place of cult in close connection with the community interacting with the artifact and as a consequence with its settlement.
For this reason the value of the scene of Nemi seems particularly interesting, as well as the fact that the painting appears to have several points in common with others of

Figure 5: Particular of the landscape in the decoration (photo N. Giannini)

the same period, mostly in connection with cave churches dedicated to the cult of the virgin *Teotokhos*[1]. (Fig. 5)
The Byzantine world is recalled not only by the virgin in red robes holding the child, but also by the presence of saint Bernardino. In regards to the virgin in iconography, one should not forget of *Our Lady of Snow* where Mary is worshipped according to the cult of Iperdulia (*Theotokos*), although the painting also recalls the famous icon of Grottaferrata, surely earlier but clearly of Greek-Byzantine manufacture. So it appears evident that the complex received a significant *restyling* during the 15th century, probably due to the value that the site had for the community. If the frescoes date back to the late fifteenth century, and the regalia included in the complex to the 12-13th century (the pyx) and 9-10th century (the altar), it appears possible to locate the hermitage within the early medieval inhabitation of the area characterized by the

[1] Remember for example the series dedicated to *Madre di Dio Tutta Santa*, in Ostuni inside the *chiesa della Madonna nuova* dating to the period of the second Byzantine colonization. The research in this sense needs further study, however this example was chosen, despite its distance from the territory here studied, to the give also the unexperienced reader a certain idea of the paintings that ours seems recalling also for its layout.[Greco, Le Grottaglie 2004]

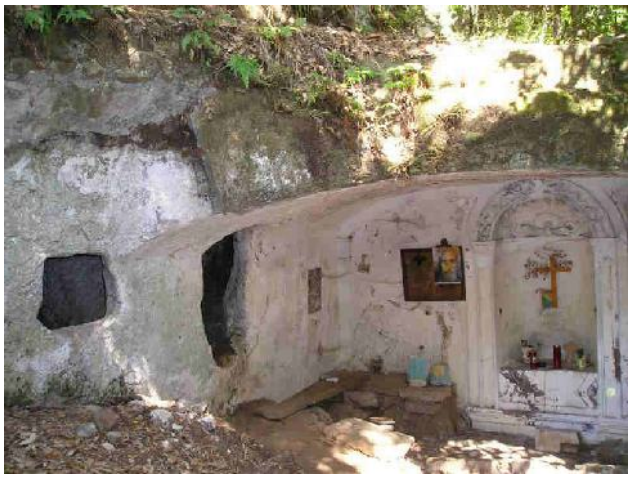

Figure 6: The Hermitage of S. Angelo in lacu (photo N. Giannini)

presence of several cave settlements with a residential function distributed on the shore along the lake bed. The cult of Saint Michael to which the hermitage is dedicated seems to be originally in connection with the presence of the cult of the Egeria spring and probably to the goddess Diana; in addition, given its encastled position, the irregular surfaces, the presence of spring water, it presents typical features of these artifacts. I believe it is possible to suggest that at first the complex was a simple cave shelter, then closed by a wall structure at the entrance, which could be dated to the late 15th century according to the building technique. Finally its topographic position appears extremely interesting, being the hermitage reachable from a path bringing from the lake and the area of the early medieval settlement to the encastled site . Given the artifacts there distributed, it was part of the ancient road network especially during the medieval period.

Examining now the hermitage of Sant' Angelo *in Lacu*, we see a completely different context. The complex was first mentioned in 1116 and it is located along a path going from S. Maria *ad Nives* (Palazzolo) towards the lake. In relation to that of Nemi, this complex appears today quite articulated.(Fig. 6)

It is in fact restored at first by the noble family Savelli [Lefevre 1987] and then by the monks, it is in connection with other rock-cut spaces which can be hardly interpreted for the presence of collapses and fillings. In order to understand the complex, a set of natural caves should be added to these rooms, furtherly cut and adapted into small housing recalling a first monastic settlement. In particular the small cave SE of the hermitage appears extremely interesting and in connection with this same monastic settlement. (Fig. 7)It is a partially collapsed settlement, also rock-hewn and characterized by the presence of several niches in the walls. The pavement presents a draining canal ending in a small tub, cut in the roc as well and in axis with an exit hole. (Fig. 8) All these features suggests the use as a dovecote that could be put in confront with other similar farming structures. [Desiderio 2008]

The settlement, also organized in its first layout on two levels, presents a significantly articulated canal system, which could be connected to a water draining system for its manufacture, organization and topographic position. Always of monastic and/or hermitic nature are the other cave settlements found along the lake bank. I will not examine their features in this context, for which the reader is kindly invited to refer to Giannini [2008] however it is better to recall certain aspects. The caves of Albano Lake are of difficult interpretation also because of the terrible state of conservation and for the impossibility to analyze them in detail, most of them being occupied for a long time by homeless people. Tomassetti [1975] interprets these caves as ancient quarries, in contrast Devoti [1987] dates them to the medieval period, at least the isolated ones along the path next to the convent of Palazzolo, also highlighting how one of these cuts across a hydraulic canal, in line with Lugli [1969], who assigns them the same function given by Tomassetti, but dating them to the medieval period and identifying them as quarries for the construction of the convent of Palazzolo and of Malaffitto castle.

Figure 7: the access of the dovecote (photo N. Giannini)

Figure 8: The dovecote inside (photo N. Giannini)

4. CONCLUSION

From the investigation conducted, it seems possible to suggest a medieval inhabitation connected to a monastic settlement, rather than a kind of spread settlement like that at the Nemi Lake.

The results presented have yet to be developed thoroughly, but they definitely underline how the two cave sites of cult dedicated to S. Michele Arcangelo are artifacts referring to spaces and to completely different social contexts. They represent spaces of actions for a community for the use of artifacts and the landscape, as the location of complex interactions, entirely dissimilar, an element not to be ignore when analyzing artifacts in relation to the territory. If the case of Nemi is included within context of continuous inhabitation, given the anthropic dynamics of the lake from the abandonment of the sanctuary of Diana up to the present, the complex on the Albano lake, although inhabited until the 18th century, remains an isolated area and almost outside the settlement dynamics of the lake. Both certainly appear in close connection with some typical features of the cult of Michael- such as the mountain, the border, the waters, however they present important differences. The first one, on Lake Nemi, seems in close connection to a re-dedication probably already in its first layout, given the strong presence of pagan cults along the lake.

This appears as a place of cult closely related to the community and the settlement, at first spread and then centered characterizing the lake area. So not an actual isolated hermitage, but a cave church with peculiar features. This seems possible also by looking at its topographic position, certainly decentered, but located however along one of the main road axis of the medieval period. It is with this perspective that the layout characteristics of the first settlement (tri-chorus cell) assume a relevant meaning recalling a specific context, and the re-decoration of the complex connected to the virgin and in close connection with another place of cult, this time built, always located along the lake and related to the cult of the Madonna of Versacarro. This is more precisely the church of S. Maria mentioned in the Bull of Lucius III in 1183 located on the opposite shore of the lake, where the structures of the complex of the so called villa of Caligola and the emissary of the lake are located. This building, according to this interpretation, appears of extreme interest because it remains connected across time to the devotional system characterizing the cult of the Madonna of Versacarro in Nemi. The first mention of the icon of Madonna da Versacarro seems to be in the letter of 1593 when the church of the Madonna di Versacarro was remembered together with the hermitage as a property of the Cappucine friars here settled. [Galieti 1948]

In the local tradition there is a "*Chiamata di Maria*" which recalls the crossing of the icon over the lake from the church towards the town during the night. This appeared strongly interesting because, given the settlement patterns of the area and the topographic distribution of the mentioned places, several elements can be found suggesting the presence of a processional route involving the entire lake area and justifying in this way also the involvement of the cave complex. The involvement in this important community process (the procession) would explain in a certain way this important 15th century restoration. Also the relationship between the *templon* layout of the hermitage and the presence of a mobile icon (which could play in such a place of cult the function of *Dèisis* typical of the Christian east) would assume a different value.

Regarding the hermitage of Albano, everything brings to a hermit kind of settlement, being therefore an isolated place in the development of settlement patterns in the area. If some of the built structures of the complex can be dated to the 17th century, when eremitism appeared to receive a new impulse after the Council of Trento, the rock cut structures, according to documentary sources, stratigraphic analysis and topographic-functional analysis, should be put in relation to the monastic-hermit complex also for the first forms of settlement. The monastic presence and the study of material structures in this sense is still a topic to be examined in depth for this territory, aimed at reflecting in the future also on the actual presence here of the Greek-Italic community. After all, one of the historical phenomena particularly relevant for the definition of a settlement pattern on the Colli Albani during the medieval period is constituted by the presence of monastic settlements, especially in relation to the layout assumed by the territory with the rise of powers and the foundation of Grottaferrata Abbey, and to previous monastic experiences of eastern perspective, already active in this area, such as the monastery of S. Anastasio ad aquas Salvias.

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From columbaria to dovecotes: two thousand years of use of cave dwellings in Ağırnas (Kayseri, Turkey)

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Abstract
In Ağırnas (Cappadocia, Central Turkey), the tradition of underground settlement lasts since more than two thousand years. People used to excavate underground structures in ignimbrites for different purposes. Even if one cannot exclude prehistoric rock-cut dwellings, the first structures are Roman graves. They were transformed in churches and graves during Byzantine period, then in normal houses, dovecotes or storage place in Ottoman and modern periods. Some old cave dwellings are still in use, and new ones are now dug to make fruit and vegetable storage places, cattle sheds or even underground museums.

Keywords
Cave dwellings, columbarium, dovecote, Roman graves, necropolis.

1. AĞIRNAS VILLAGE

Ağırnas is a Turkish village located in Cappadocia, east of Kayseri. It is a famous place for being the birth village of the famous architect Sinan (Fig. 1), who built several mosques in Istanbul and other places in Turkey, during the 16th century [Necipoglu, 2005].

The old part of Ağırnaş Village contains several underground rooms and passageways below the present houses, including that of Sinan. They are very frequent in whole Cappadocia [Bixio et al., 2002].

Figure 1: The famous Ottoman architect Sinan

In Ağırnas they were used for storage and shelter and are, more or less, interconnected, which makes a network of tunnels and chambers that extends below the village [Yamaç & Tok, 2015].

Some parts are now used for touristic purpose but most of them are abandoned or used as cellars. Two of them were studied during a field trip with Obruk speleologist group: Sinan's house (Figs. 2, 3 and 4) and Mustafa's one (Fig. 5).

To the North of the village a small valley, Akbin valley (Fig. 6), also contains numerous cave dwellings that were used at different periods. They are excavated in the ignimbrites widely spread by the Ercyies volcanic system [Toprak et al., 1994].

Figure 2: One of the underground entrances of Sinan house

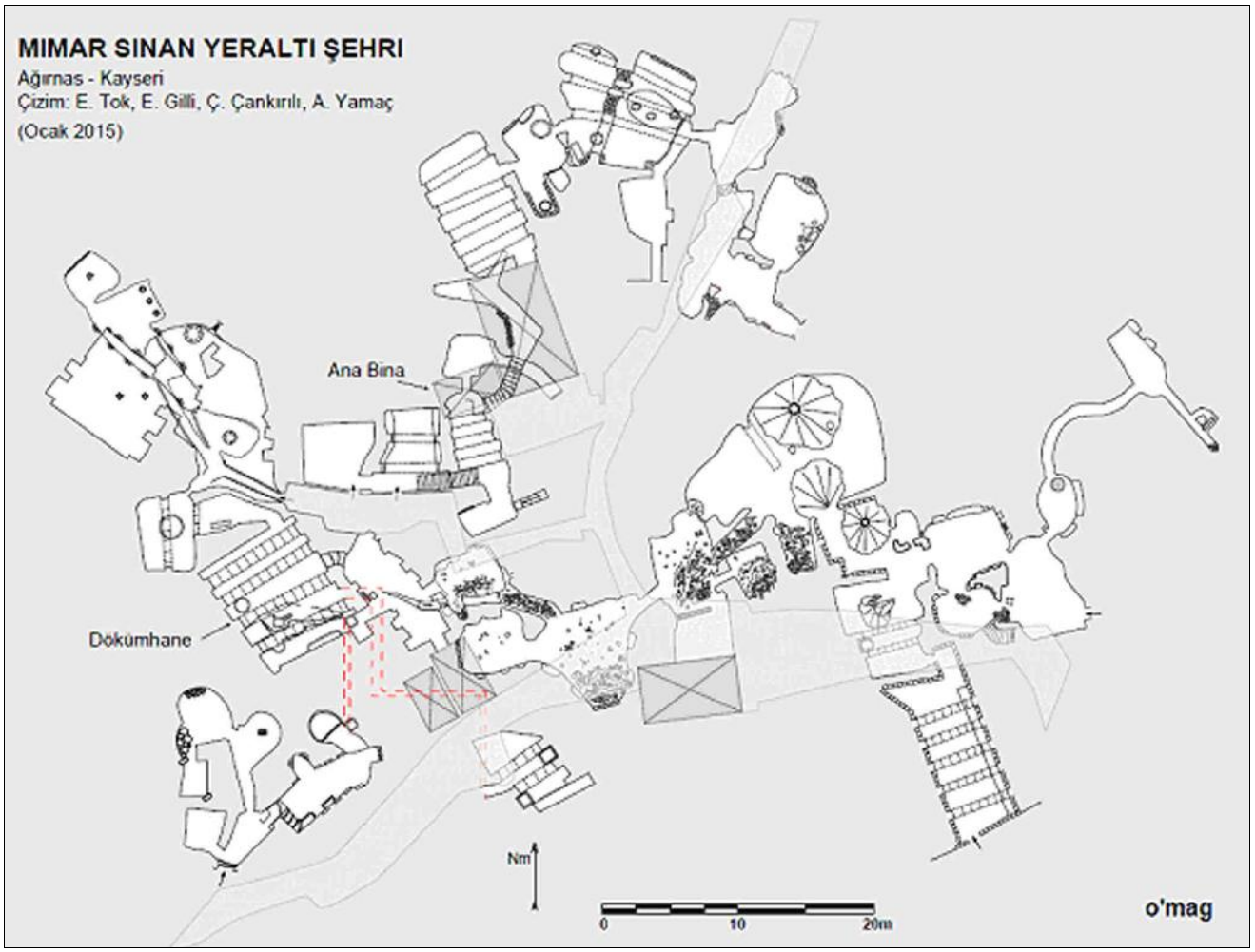

Figure 3: Map of the underground passages below the Sinan architect house [after Yamaç and Tok, 2015]

Figure 4: Underground chamber of Sinan house and entrances of neighboring rock cut dwellings

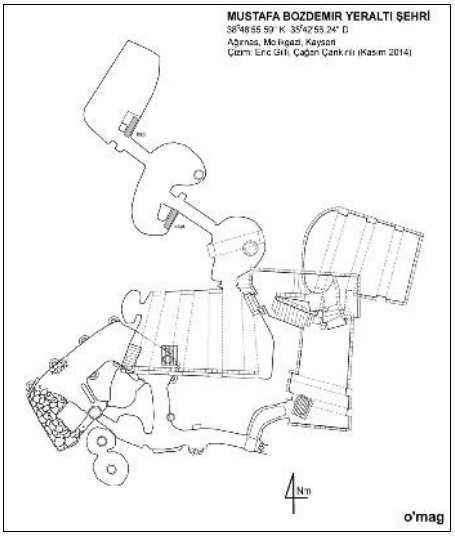

Figure 5: Map of the underground passages below Mustafa Bozdemir house [after Yamaç and Tok 2015]

Figure 6: Akbin valley north of Ağırnas Village

Figure 7: Roman graves. Note the presence of two Byzantine, or modern Greek crosses on the right (red circle)

Figure 8: Akbin antique road

Ignimbrites are very sensitive to erosion which makes it difficult to define the chronology but several examples show imbricate features; older structures are re-used and modified by modern people. The most recent ones are lemon storage places in rural areas, hotels or museums in touristic places. This constant use since unknown time makes it difficult to know when the tradition of digging underground settlements started.

2. GREEK AND ROMAN PERIODS

2.1 Graves

The oldest remains are graves. They could be from Greek period, but the architectural features are more consistent with the Roman period. Usually Roman graves had a front entrance with pillars and sculptures, but weathering is active on ignimbrite, causing slope retreats and revealing the inner rooms of the graves. Remnants of frontons and friezes are still visible (Fig. 7).

Roman people used to incinerate dead bodies, and then they placed the ashes in coffins or urns in niches carved in the graves walls. The smallest urns could be placed in small square or triangular featured holes that totally covered the wall in places called columbarium [Borbonus, 2014].
To prevent fires and epidemics, it was forbidden to burn the bodies and to bury them in the cities or the villages and funeral places were always outside the living places.

They were installed along a main road which gave to travelers an indication on the wealth of the place and of its inhabitants [Prieur, 1986].

The richest family had large places to bury their members. Some graves were similar to houses with several rooms. The graves were rent for several generations, if people were able to pay the rental fees. As necropolis contained hundreds graves, one can imagine that the incomes could be important for funeral specialists and for the local economy.

The presence of a road (Fig. 8) bordered by numerous entrances of rock-cut graves and the observation of structures like a circle that could be an agape table (Fig. 9) or feeding holes for the dead (Fig. 10), both used in Roman funeral rites, support the hypothesis of Akbin site beeing the necropolis of a Roman city that is now Ağırnas.

In Akbin some places contain pigeon houses (Fig. 11). They were widely bred in Antique times. Aristotle or Pliny the Elder wrote about pigeon farms, dovecote construction or military use of pigeons. It is difficult to know if the pigeons in Ağırnas were used for food, sacrifices or other purposes like manure or even aerial mail. It is also difficult to know if the present dovecotes are from Roman or younger period. They were still in use a few years ago to collect guano, but modern extensive agriculture that uses chemical products lead to disuse these places. We assume some of these dovecotes were first funeral columbaria whose niches were carved to receive cremation urns.

2.2 Colombaria

Columbarium tombs are typical forms of the Roman funeral architecture (Fig. 12). They were used as economic solutions or as a collective burial for a given community. Indeed, many of the tomb occupants were slaves and freed men, for whom collective burial was one strategy of community building that counterbalanced their exclusion in Roman society [Borbonus 2014].

Figure 9: Possible remains of an agape table

Figure 10: Probable feeding hole in the necropolis of Akbin valley

Later, the niches were used for pigeon's nests if an entrance could be dug on the ceiling (Fig. 13). It could be topped by a masonry chimney (Figs. 14).

Moreover the presence of silos in some places support this hypothesis (Fig. 15). When the places were full, old bones and ashes were deposited in silos in the floor and new coffins or urns could be installed in the grave.

3. BYZANTINE PERIOD

After the Roman period, Christians started using the same places but they did not burn the bodies and carved tombs either outside (Fig. 16) or inside the abandoned roman graves (Fig. 18). Roman rock-cut dwellings were transformed in churches with paintings and Christian crosses.

One can suppose that some places were also transformed in houses. In opposition to the roman culture, where burial zones had to be far from the city, Christian people could live close to their tombs. It is probably at the end of Byzantine period that people started to dig shelters and panic rooms protected by millstone doors [Bixio et al., 2002].

Figure 11: Columbarium in Akbin valley

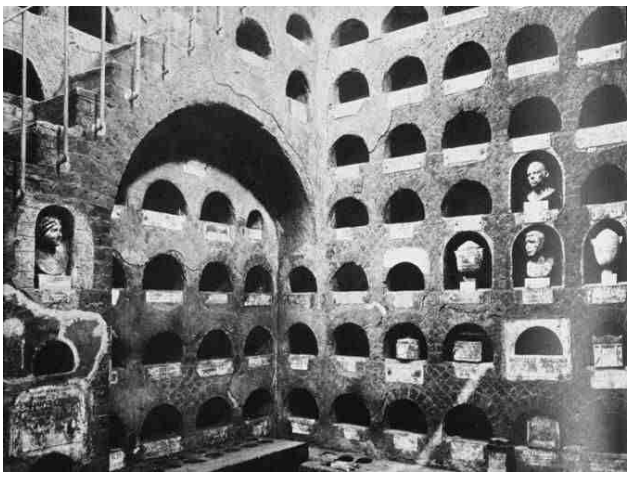

Figure 12: Columbarium of freedmen Vigni Codini in Rome 1st century BC (photo E. Inglis)

Figure 13: Opening in the ceiling of a funeral columbarium to transform it in a dovecote

3. OTTOMAN TIMES

Human representation being forbidden by Koran, most of the Byzantine religious paintings and engraved symbols were destroyed. The previous funeral and religious places were transformed in new places with respect to the Muslim rules.

Figure 14: Masonry chimney on top of a columbarium transformed in dovecote

Figure 15: Bones and ashes silo in the soil of a Roman grave

In addition to the transformation of columbaria in dovecotes (Fig. 18), underground graves and niches for sarcophagus or coffins could easily be transformed in feeders or storage places.

4. MODERN PERIOD

Cave dwellings are still in use in many places of the whole Cappadocia and new ones are developed. Due to tourism expansion many underground hotels or pension houses are commonly excavated in the touristic places, like at Göreme, Ürgüp or Uçhisar.

People are still using old ages techniques, with hammers and picks, and the inhabitants of Lavak village are famous

Figure 16: Outside tombs on the Akbin road

for their ability for digging the ignimbrite. In addition, modern digging equipments make it possible to excavate very quickly, large underground volumes like lemon storage places.

In Ağırnas Village, except for the numerous cellars, the underground places that are still in use, are the three museums of the village: Sinan house, Mustafa Bozdemir and the municipality museum.

In Akbin valley some places are still in use for domestic purpose (Fig. 19), for storage (Fig. 20) or even as cattle sheds (Fig. 21).

In Cappadocia, large lemon storage tunnels are excavated in the ignimbrites. This makes it possible the storage of fruits and vegetables in places where the temperature is low and constant.

The important economy in electricity expenses is an argument to develop these underground structures that are now numerous in Cappadocia.

The rock is soft enough to be dug by any kind of modern tool. Nowadays, electric or pneumatic hammers are used that allow fast working even for individuals. For larger works excavating vehicles with cutting wheels are used. Large size chambers up to 10 m in width are possible (Fig. 22).

Figure 17: Byzantine tomb dug in a Roman grave

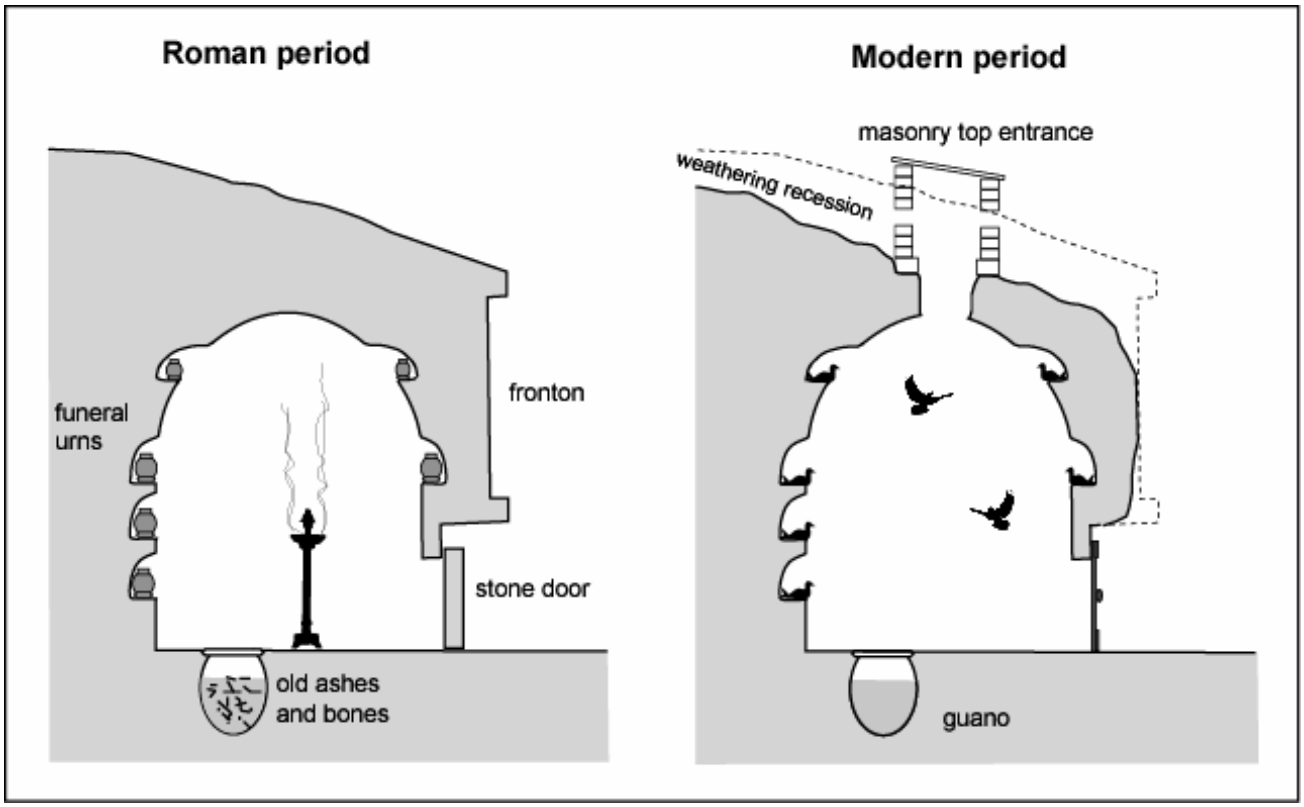

Figure 18: Transformation of a funeral room in a dovecote

Figure 19: House with electricity line in Akbin valley

Figure 20: Modern underground storage place for animal fodder (Note the presence of niches on the right side that are remnants of an antique tomb)

5. CONCLUSION

Successive civilizations in Agîrnas and Akbin have dug an important system of underground settlements. Each new civilization has more or less erased the architectural features of the previous one which makes it difficult to characterize them. It remains difficult to know when the tradition of excavating cave dwellings in Cappadocia is present but it lasts since at least 2000 years.

Due to the facility for the ignimbrites to be excavated, cave dwelling is probably as old as the first human settlements in Anatolia.

For instance houses in Aşıklı Höyük (11000 BP) were simple holes dug in the soil and covered with a wooden roof [Özbasaran & Duru, 2011].

In that case the settlement is not a cave dwelling but it proves the ability to excavate underground volumes.
Aşıklı Höyük is a flat area, and one can suppose that people living close to an ignimbrite cliff may have dug horizontal houses into the cliff. However there is no evidence of totally underground structure older than the Roman funeral places.

Figure 21: Cow shed at the entrance of Akbin valley

Normal houses were probably wood and clay ones but anthropogenic pressure could have driven to a timber scarcity. Agriculture, building, and funerals led to a high consumption of wood. Then, due to the lack of wood, people were obliged to use more mineral material. As building stones were not present in the ignimbrite area, their use was probably difficult or expensive. The previously religious settlements could, easily be transformed in normal houses. A hypothesis is that the underground necropolises that were closed by millstone doors, could be used as shelters or food storage if a new entrance was dug to allow a visit in the reverse direction. The millstone doors could then be used as internal door. The previous entrance must be closed with stones and clay. This theory could be supported by the research of older entrances blocked by earth and stones.

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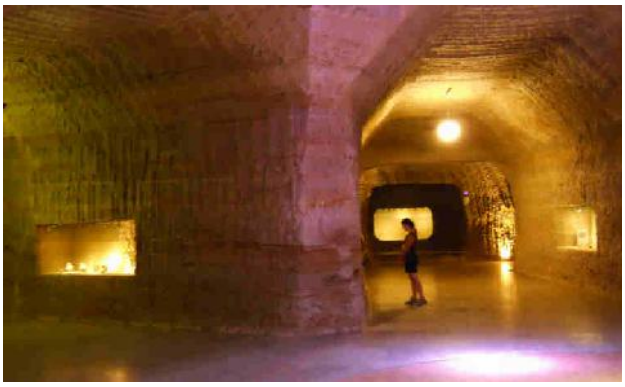

Figure 22: The Pottery Museum, in Avanos, excavated in ignimbrites like lemon storage tunnels

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Gülşehir- Karşı Kilise (a 13th century church in Cappadocia, Central Turkey)

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Abstract

Karşı Kilise is located in Gülşehir (Zoropassos in Byzantine era and Arapsun in a later period) a town in Cappadocia region in Turkey. The church, which is also known as St. Jean Church is built inside a rock mass as a two floor building. It seems to be a part of a monastery complex. As a rectangular and vault covered building, it has not a different architectural style compared to other buildings in Cappadocia region. Inscriptions, which has the date 25 April 1212 and figures of donors are exceptional in the regional art and architecture since there are a few monuments that have dated inscriptions and donor figures. The building has an intense iconography, despite it is a small church. There are many physicians (anargyroi) depicted in the entrance of the apse. Such a density of anargyroi is extraordinary for the region. The Last Judgement and Hell scenes are exceptional due to the composition of iconographic elements.

The paper aims at describing the religious events, sociological consequences and political conflicts between the Byzantines and Seljuks/Mongols leading to the iconography of the church.

Keywords

Cappadocia, Karşı Kilise, St. Jean Church, Gülşehir, iconography, 13th century, salvation, anargyroi.

1. INTRODUCTION

Karşı Kilise, which is also known as St. Jean Church [Restle,1969] is located in a town, Gülşehir (Zoropassos, later Arapsun) [Hild-Restle 1981] in Cappadocia region in Turkey. The church is located on right side of the road connecting Gülşehir to Nevşehir. Its coordinates are 38°44'26.52N and 34°38'5.03E. The church is about 1,5 km away from the city center. The church is accessible through a narrow road marked with a road sign. (Figure 1)

Karşı Kilise is a rock cut church with two floors. From the outside of the building, the features cannot be seen except a single window and blind niches. (Figure 2) When it is entered through a small door that is located on the West, the first floor can be accessed.

This floor has a cross plan with crosses covered with barrel vaults. It is a 9.7 m by 5.5 m area. The nave is surrounded by a bench (subselia). There are stylized animal figures and geometric figures between crosses. Paintings are made in red ochre on the walls. This paintings were dated to the 11th century by Jolivet-Levi [Jolivet-Levi 2001b].

Figure 1: Map of Gülşehir - Karşı Kilise (Google maps)

Figure 2: Exterior view of the church

The second floor can be accessed through iron stairway. This level is a separate church built after the first floor, which seems to be an older different religious building. Some modifications were made in the first floor on the southwestern part of the hall and a rock cut stair was constructed. It seems that the rock stair was destroyed and replaced by an iron stairway in a later date. It can be seen that the builders damaged the dome of the first church when building the second level. Two floors were not identically put on top of each other. The dome of the lower church is not coinciding with the center of the upper level but moved towards southeastern direction.

The second floor, named as Karşı Kilise (St. Jean Church) covered with a single barrel vault is elongated towards East to West direction. Its shape is a resctangular form. Its length is 6 meters. The width on the Eastern side is 5,20 meters and 4,45 meters on the Western part. The apse is on

the northeastern side and on a little height with respect to the other parts of the floor.

In this study, the second floor wall-paintings of the rock-cut church have been analysed. The church is not well-known, although it has a rich and an unusual iconography, probably because it is not situated in one of the most famous valleys of Cappadocia.

After the land survey that was carried out by archeologist R. İşler between 1995-1996, the church and its wall-paintings were restored to its original form [Peker, 1997].

2. THE WALL PAINTINGS

One of the thirteen scenes in the church is originated from Old Testament, all the others are from Bible. The scenes are generally about the "passion" period of the life of Jesus Christ. When the scenes have been analyzed according to the clockwise cycle program, it can be seen that the scenes are not in the traditional order.

There is a damaged Deisis scene on the apse [Rott 1908; Lafontaine-Dosogne 1963]. Only small part of the scene exists. The feet in sandals and two round shapes seen on the right part of the apse show that it is a Deisis. Under this scene, there is an inscription (induction done) on the molding that contains the name of Emperor Theodor Laskaris.

…ου..έπή..βασηλέοντος..Θεοδόρου..Λάσκαρη..ἔτους,ςΨκ΄. .κέ..ένδ(ικτιῶνος) ιε΄ μ(η)νή άπρηλύοής τ(άς) κέ

……u…….epi Basileontos Theodoru Laskarietus,…ke… endiktionosie mini abriliu is taske……. : ……..In the time of Emperor Theodoros Laskaris…..

‘’In 6720 (1212), in the reign of Theodor Laskaris, 15 (induction), the 25th of April [Rott 1908; de Jerphanion 1925; Restle 1969; Hild-Restle1981; Thierry 2002]. (Figure 3)

The date of 1212 as given in the inscription is very important for Byzantine Empire. According to Savvides, the eastern border of the Byzantine Empire could not be defined since there was a problem of sovereignty. Although it is not know who owns the region, there was no interruption in religious practices. [Savvides 1981]

The Annunciation - "O XEPETHCMOC" scene is located on the bema.

On the southern part of the vault, on the first band, The Last Supper- "(ΔΕ) I ΠΝΟC", The Betrayal of Judas- "H ΠΡΟΔΟCI", The Baptism-"H BAVTHCH" can be seen respectively.

Figure 3: Inscription on the apse

On the second band, Koimesis -"H KHMICH" and The Three Young Jews in the Furnace are located. (Figure 4)

Along the northern part of the vault, on the first band, there are The Descent from the Cross -"H ΑΠΟΚΑΘΗΛΟCI", The Holy Women at the Sepulcre-"H MPOΦOPE", The Anastasis-"H ANA..ACI" scenes from west to east. (Figure 5) On the second band: The Heaven-"O ΠΑΡΑΔΙCIC" scene is depicted.

The Hell, The Last Judgement-Psikostasi (The Weighing of Souls)-"O ΨΙΓVCTI O" are on the west wall. (Figure 6)

There is a number of Saint frescoes around apse and bema.

Nikolaus and Gregory of Nyssa can be seen in the apse on the lower band near St.Chrysostom, St.Etienne, St.Romain, St.Ephrem the Syrian, St.Arsenius, St.Sabas, physicians of the church (anargyroi), St. Johannes (ὁ ἅγιως Ήοάνης), St.Taleleus (ὁ ἁγιως Θαλελέος), St.Kosmas (damaged) and St.Damianus (ὁ ἁγιως Δαμηανός), St.Kirus (ὁ ἅγιως Κῆρος), St.Panteleimon (ὁ ἁγιως Παντλεύμον), and also St.Sergios (ὁ ἅγιος Σργιως), St.Bacchus were painted on the east part of the apse.

The depictions of two archangels are clearly seen on the vault of bema. Gabriel-"ὁ άρχ(άγγελος) Γαβρηή(λ)", and "άρχ(άγγελος) Μιχαήλ" Mikael hold globus and scepter in their hands.

Figure 4: Southern wall of the vault

Figure 5: Northern wall of the vault

Figure 6: Picture of the barrel vault from the Eastern part towards Western wall of the second floor.

On the south wall, frescoes of "ὁ ἅγιως Κοσταν(τῖ)νως" - Konstantinos and, "ἡ ἁγίά Έλένυ - Hagia Eleni are depicted.

Stilit Simon The Elder is placed to the opposite of Stilit Daniel. "ὁ ἅγιως Προκόπιως" - St.Prokopios, "ὁ ἅγιως Δημίτρηως"-St.Dimitrios, There are also two military saints: St.Theodor and St.Gregorius.

Donors of the church (females) (a woman and her two daughters) are depicted in a standing frontal position. Male donors of the church are depicted on the north wall, close to the apse. Although there is a controversy about these figures, Jolivet-Lévi [2001b] defines them as male donors of the church.

"ΗΑΓΙΑ ΘΕΟΔΟΤV" -Hagia Teodota, Paraskevi - "ΗΑΓΙΑ ΠΑΡΑCΚΕΒΙ", "ΗΑΓΙΑ ΚΙΡΗΑΚΗ"- Kiriaki, "Α ΑΡΤΕΜΙως"- St. Artemios, Α(γιως) ΤΡΗ(Φω)Ν"- St.Tryphon are shown on the niches.

The Old Testament prophets are placed on medallions that separates the vault in to two parts. The abbreviation " ΠΡΟΦ.(ήτης) - Prof.(itis)" appears near them. "ΠΡΟΦ.(ήτης) ΜΑΝΑCΗC" - Manas, "ΠΡΟΦ.(ήτης) ΗΕζΕΚΙΗΛ" - Ezekiel, "ΠΡΟΦ.(ήτης) ΗCΑΗΑς" - İsaias, "ΠΡΟΦ.(ήτης) ΕΝΟΧ" - Enok, "ΠΡΟΦ.(ήτης) ΗΛΗΑC"- Ilias, "ΠΡΟΦ.(ήτης) CΟΛΟΜΟΝ" - Solomon and "ΠΡΟΦ.(ήτης) ΔΑ(υί)Δ" - Prophet David exist inside medallions. (Figure 5)

3. ICONOGRAFIC EVALUATION

Although Karşı Kilise as a rectangular and vault covered building has a different architectural style compared to other contemporary buildings in Cappadocia, scenes are depicted in hierarchical order.

With these properties, Karşı Kilise is a rare example. A similar building, Yüksekli Kilise, dated 13th century has a single nave and barrel vault.[Uyar 2011]

Karşı Kilise has an intense iconography, despite its small size. This reminds us a Komnenos saying, "Large church, little God's grace; small church, more God's grace" [Angold 1995].

Besides twelve scenes, the thirteenth scene, which is accepted as the Deisis scene.

In most of the single nave churches in the region that date back before 13thcentury, 12 out of 19, Bible cycles can be seen. All scenes are painted on the vault of nave, as can be seen in Eski Tokalı Church (10th century) [Epstein 1986].

According to Jolivet-Lévi [2001a], donors had a role in the selection of scenes in order to be prayed upon them afterlife. Maguire says that the iconographic program must be considered together with the building and the selection of scenes and saints reflects the demands of the donors and their status in the society [Maguire 1992]. Therefore, the existence of Nycean patron Saint Tryphone, Nycean Martyr Teodata, Saint Kiriaki and Saint Paraskevi in the building can be considered in this respect [Kazdhan 1991].

Chronology of scenes are completely given up in Gülşehir-Karşı Kilise. In this church, Annunciation and Koimesis are about the life of Mary. Baptism is the end of childhood of Christ. Last Supper, Betrayal of Judas, Holy Women at the Sepulcre scenes are about the passion period of the life of Jesus Christ. Three Young Jews in the Furnace scene takes its subject from Old Testament and is about salvation of humankind. (Figure 4)

John Chrysostom accepts the Old Testament as the predecessor of the New Testament. Old Testament prophets are the messengers of the arrival of Jesus Christ. Mary connects the Old and New Testaments [Akyürek 1996].

Although chronological placement of scenes were given up, selection and placement of scenes must not be arbitrary. In my opinion, scenes are selected to form a special composition and also some scenes are placed due to their symbolic and liturgical properties.

There are two focal points in the Church. The first is the vertical hierarchy that starts from the nave wall with saints going up to the vault that contains scenes of Christ's life.

The horizontal hierarchy on the lower parts of the church ends with the Deisis scene on the apse and the Last Judgment on the west wall. Deisis and Last Judgment scenes are directly connected. On the lower parts of the western wall, there are female donors and saints. Male donors are placed on the eastern side of the southern wall under an arch close to the apse.

Some scenes are placed according to the traditions. Deisis and Church Fathers scenes are on the apse half dome, Last Judgment is located on the west wall in accordance with the Byzantine monumental art [Ötüken 1980].

Salvation of mankind starts with Incarnation of God (Christ) and Annunciation scenes, ends up with Second Coming (Parusia) of Christ and Last Judgment.

Figure 7: Anargyroi

Although it is not unusual to see physicians (anargyroi) in the entrance of the apse, such a density is extraordinary. Accumulation of many saints around the apse entrance shows the importance given to physicians (anargyroi) by donors. (Figure 7)

Angels, saints, prophets, martyrs, bishops are selected to be mediators for God's grace. In the iconographic composition, these figures are painted in almost full human height signifying the mediators between the God and humans.

Last Supper, Betrayal of Judas and Hell scenes are used to convey betrayal and punishment concepts. Incarnation is stressed with Baptism, Three Young Jews in the Furnace, Koimesis, Descent from the Cross, Holly Women at the Sepulcre (Myrofori) and Anastasis scenes. Annunciation, Deisis, Last Judgment and Heaven shows the redemption concept. In the iconographic composition, these scenes are selected to convey messages that donors want to express.

An Old Testament scene, Three Young Jews in the Furnace is located under Baptism. Special attention is given to this scene by separating it from others by a red line. This scene is connected to Baptism scene since the fire in the oven can be regarded as hell fire. Baptism with fire, eschatologically, means purification from sins. (Figure 8)

In the scene, Betrayal of Judas, two groups of Jews come with swords and sticks (Matt. 26:47; Mar. 14:43). Not only they are in military uniforms, but also they have armours and shields in order to emphasize their military status.

Figure 8: Baptism and Three Young Jews in the Furnace

Figure 9: Betrayal of Judas

After 1204, the soldiers are often depicted in Latin soldier uniforms [Jolivet-Lévi2001b]. All soldiers stand up like audience and they do not attempt to take Christ in custody. Crowd with arms are grouped on both sides of Judas and Christ and Judas standing on the left side of Christ are interesting and unique. (Figure 9)

Mary's grief in the Descent of Cross becomes important after 12th century within Passion cycle. Replacement of Crucifixion scene with Descent from the Cross is sometimes seen in the Western art [Jolivet-Lévi 2001b].

Salvation of humankind is the subject of Anastasis. Under the Anastasis scene, in another band, there are prophets,

Figure 10: Holly Women at the Sepulcre (Myrofori)

Isaac, Jacob and Abraham carrying the souls of the chosen people. Below them, on the northern wall niche, male donors are placed. If the scenes are analyzed vertically, it seems that donors hope to be among the chosen people in the Heaven.

Koimesis, Last Supper on the higher band and Betrayal of Judas have same widths. Good Thief (Dismas) in the Heaven on the north wall of the vault, Mary and Three Patriarchs are located face to face.

Koimesis scene, which must traditionally be located on the west wall, is placed on the southern wall. A large area is reserved for the scene in order to emphasize its importance. Death of Mary is an early reincarnation that is told to the righteous.

Two soldiers sleeping in front of the grave in the scene of Holly Women at the Sepulcre (Myrofori) have distinct small and round faces, with unusual hoods. The physical properties of these soldiers resembles the features of Seljuk or Mongol soldiers that started to penetrate into Anatolia around 13th century.

Seljuk or Mongol features are also seen in Belisırma-Kırkdamaltı and Ortaköy-St. George Churches. (Figure 10)

The western wall is dominated with conflict concept by soldiers fighting with a monstrous creature and Hell and The Weighing of Souls (Psikostasi) scenes. Three headed dragon like creature reminds us Middle Asia's monsters. Although subjects are not new, selection and placement of scenes within the church is intriguing.

The Weighing of Souls (Psicostasi) inside the Last Judgment scene on the west wall is oriented towards the audience. (Figure 11) Some parts of the scene is missing, for instance, Judge Christ, Mary, intercessors, John the Baptist, Hetoimasia (Throne), angle surrounding the sky and reincarnation of the death. Generally, left and right poles of Last Judgment determines the composition. Right of the Judge (Christ) is for elites and left is reserved for sinners. As described in Matt. 25:32,33, "...As a shepherd that separates goats from sheep, He separates humans. He takes sheep on the right, goat on the left."Since there is no Christ in the scene, the left is inferior according to the audience and the Hell is located on this side. The lack of Deisis on the west wall is tolerated by the now damaged Deisis scene. In other words, missing Judge Christ, Mary and John the Baptist force the existence of Deisis scene on the apse. Heaven, on the north wall, is placed on the right of Christ. Iconographic integrity can be seen throughout the Church. The cycle is completed with Deisis in the apse and Hell, Weighing of Souls (Psicostasi-Last Judgement) on the western wall.

Stairs connecting lower church to upper parts are corresponding to the Gates of Heaven. Stairs are in front of the Weighing of Souls (conflict between the bad and the good) that is located on the western wall. There is a metaphoric connection between the entrance of the church and the heaven. The faithful, when climbing the stairs walk in front of the scene and reach God's Kingdom. When leaving the church, they pass in front of this scene as well. Stairs describe the concept of salvation. The beginning of the salvation of humankind by the reincarnation Christ, will be ended by the Second Coming of Christ (Parusia) and the Last Judgment. [Akathist Hymn to the Blessed Virgin Mary].

The Hell is a small and dark colored scene located on the west wall is separated from Weighing of the Souls by a window. The negativity of the Hell is in accordance with the symbolic value of the west. East symbolizes Christ, light and eternal life, west means the Satan, sinners and darkness. (Figure 12)

Figure 11: The Weighing of Souls (Psicostasi)

Figure 12: Hell

The angel on the left side of the composition pushes the sinners to the Hell. Naked and winged Satan pulls the beard of two priest and Judas described as a big red figure is pulled by the master of the Hell. Prince of darkness is depicted as a Satan. He is white and naked, riding a strange creature. Monster from the depths look alike Turks' traditional dragon with a raised nose and a body covered with flakes. The monster is painted when swallowing a sinner. In front of it, a top sinner Judas is depicted as red naked figure. Four sinner groups, each of which is depicted with their heads, are punished with different penalties. On the top, never extinguishing fire, darkness of hell under the tail of the monster, under the monster, bitumen and eternal worm can be seen. The heads bitten by snakes symbolizes sinner that have sins related to mouth, eyes, ears and sensory organs. The main theme of the Hell scene is the role of Judas and the faith of cleric. The existence of cleric in the hell and Judas holding them are unique [Jolivet-Lévi2001a,b]. For instance, naked and tailed Satan figure cannot be seen in another church [Thierry 1988].

The description of Hell is used to convey messages related to the social and religious debates and political and ideological conflict the era. Judas, as an example sinner, is a perfect example of sinners, betrayal, greed and heresy. N.Thierry indicates the declaration of cleric as traitors as a sign of the position of Orthodox Church under Turkish rule [Thierry 1988]. Another reason for his depiction can be the situation of Constantinople under Latin rule. Another possibility can be heresy debates that occur in middle 12th century and the beginning of the 13thcentury.

Generally speaking, the Church shows a traditional style. Besides local and religious traditions that exist in this era, local artists contribute by their personal aptitudes. Soldiers with Seljuk-Mongol types, Hell monster, three headed dragon are among the regional effects.

In middle ages, salvation and need for divine help were important subjects among the religious and the cleric. Salvation concept is reflected by Three Young Jews in the Furnace scene. Cross and Mary figures are iterated for the same purpose. Cross as a perfect safeguard symbol cease to exist and symbolizes the victory of the passion over the death [Thierry 1971]. Many forms of crosses are removed from scenes and a single big cross evolves as a main symbol at the beginning of the 10th century.

Painted subjects emphasize the concepts of passion and reincarnation, the fate of the soul after death, salvation brought by Christ are supported by the scenes.

According to Byzantine iconographic traditions and regional political connections, there are frontally painted saints that represent a connection between the God and the faithful [Jolivet-Levi 2001b; Akyürek 1996].

4. RESULTS

In the church, in accordance with Demus, compositions are two dimensional and there is no depth.

Otto Demus describes the unreal features of the composition as a reality of icons and names the frontality of the figures as hieratic frontality. He gives the Dura Europos wall paintings that are affected by Iranian art as examples. He, moreover, adds that these influences comes from Syria to Anatolia. He asserts that such effects create some strange forms such as frontality of figures, handicapped gestures, and legs hanging in the air. Also he thinks that spatial image becomes frontal. When the depth of the image vanishes, main lines of the figure are simplified, linearity comes forward and figures start to interact with the background. Frontal figures surrounding a place dominate the scene. Demus explains this situation as the result of Partian influence [Demus 2008].

There is no obvious Constantinople influence in the church except the arrangement of saints. In compositions, artists copied old capital styles. However, frontality of figures can be the examples of 13th century archaic and local styles. The Syrian influence can be explicitly observed.

Karşı Kilise is an important example of the regional art and architecture with inscription dated April 25th 1212 and donor figures. Also, after the restoration works done between the years 1995-1996, most scenes becomes more observable. This church is an important resource for the 13thcentury Cappadocian art.

Figure 13: Three headed dragon

Two distinct people with different cultures and religions exist in the middle of Anatolia. It seems that both peoples start to create a common culture and language. Same images and objects are used. The Last Judgment monster that is killed by saints resembles the dragon figure brought from Asia by the Turks. (Figure 13)

Christians generally preferred to live around Gülşehir and Soğanlı after Seljuk Turks acquire Konya as their capital city. Although, both people have different backgrounds, Christians continue on their artistic activity. There are eight Churches built in the period: Gülşehir - Karşı Kilise (1212), Tatlarin II (1215), Şahinefendi - Forty Martyrs (1216-17) [Andoloro M., Benucci M., Bixio R., De Pascale A., Romagnoli G. 2015], Sivasa (1222-54), Mavrucan (1256-57), Belisırma-Kırkdamaltı (1283-95), Ortaköy - Aziz Georgios (1293), Yüksekli Kilise (middle of XIII. century). Christians in the area are connected to Byzantine Emperor Laskaris although they are under Turkish rule.

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Artificial caves in chalk outcrops in the Don basin

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Abstract
The article describes the use of chalk outliers of the Don region for religious and economic purposes.
There are 14 household rooms (including cells and refectories); 3 cave churches; 1 rocky bell tower; 1 tomb (in the galleries); a number of communication galleries.
Outliers-divy attracted people with a good overview of the terrain, provision a defensive function and with the ability to organize an acceptable security of interior space inside more dense rock.

Keywords
Outliers, architecture, artificial caves, Russia, Don.

1. INTRODUCTION

Cretaceous sediments, which cover a vast territory of the Russian Plain, are marine sediments of the Upper Cretaceous reservoir. They are widespread to the west, north and east of the Dnieper-Donetsk Depression. These Cretaceous sediments represented a reason for development of exogenous processes. One of the consequence of these processes is the formation of fancy chalk outcrops - the so-called "divy", which are situated in the valley of Don and the Seversky Donets.

Colossal chalk poles could not be ignored by human. Probably already in the ancient times they became the special objects of worship. With the spread of Christianity this special attitude was inherited by monks who came to the Don region. It is not an accident that the first more or less reliable mentions of the appearance of the monasteries here are connected with the territories, where the chalk outcrops were – Divnogorye and Svyatogorye (Fig. 1). In both cases, these outcrops have played a major role in the formation of the main part of the future monastery complexes. Chalk pinnacles were used as basis for creation of rooms inside rock.

Most of the well-known and preserved chalk outcrops show traces of human intervention. These transformations, depending on the purpose, can be divided into three types: mining, sacred and household. Household purpose consists in the use of the outcrops for cutting-out rock living and other rooms, which are not directly connected with a religious ceremony. Sacred and household types regard transformation of the natural landscape in various architectural forms by external works, thus obtaining usable space. The present article deals with these two types of transformations.

2. BOLSHIE (BIG) DIVY

Bolshie (Big) Divy – a group of large chalk outcrops at the northern outskirt of Divnogorye (Liski district of Voronezh region). The most famous among them is that at the base of which is the entrance to the two-level cave complex. This complex consists of a cave church, the procession gallery around it and a number of rooms at the second level (“refectory”, cell, “kitchen”). The largest part of underground complex in Bolshie Divy is dug in solid ground. Directly in the body of the outcrops with a common base are niche (kiot), two entrance (on two levels), window and chimney.

Entrance to the complex and part of the gallery near the entrance. During the creations of the complex cave workers leveled the base of the outcrop and part of the rock facing the river Tihaya Sosna (Quiet Pine). By this work they got relatively smooth surface, which became a kind of "facade", with a width exceeding 1.5 m and a height of over 5 m. The *diva* began therefore to look like a man-made construction (Fig. 2/1). Within a "facade" there was a window with three-centered arch and a niche (kiot). Later, the outcrop base was destroyed: extending base fragments had been removed, as well as part of the deeper rock. During the restoration work, this part of the diva was reconstructed by using chalk bricks.

Niche-kiot (icon case) – rectangular shaped recession which is situated above the main entrance to the complex (Fig. 2/1). This niche was made for over-the-gate icon and represented local legend about invention of Sicilian icon of Our Lady on the chalk pinnacle. The niche was decorated in baroque style by chalk carving (in the symbolic form of pilasters and zone).

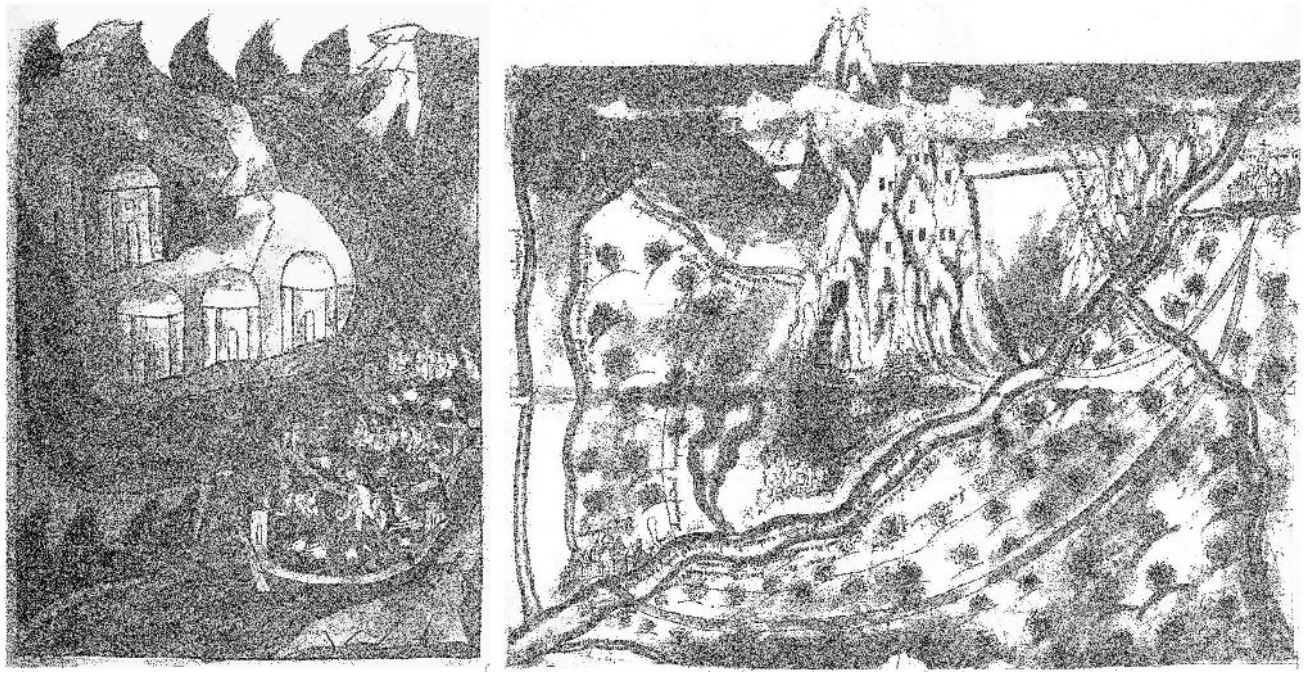

Figure 1: 1 left) Outcrops in Malie Divy. Miniature picture of 16th c. - 2 right) Picture of Svyatogorsk Lavra in 1679 [source:1. Illuminated Compiled Chronicle. Ostermanovsky second volume. National history 1378-1424. 887 p, 1581 miniature 2. Russian State Archive of Ancient Acts. Fond 210 - Belgorod desks, unit of storage 886. - L. 35.]

Entrance to the upper tier of the complex is a rectangular doorway 0.95 m wide with fragments of the recesses for the door-post. It was made by removing the chalk bricks between the fissures about perpendicular to the line of slope, and later slightly expanding it. At the present time it is closed with wooden door. Exactly behind the doorway is the room size 2,9 × 4,3 m, a part of which, near the entrance, is in the body of the chalk -outcrop.

«Window» to the cell. Slot is located 4 m to the right from the entrance to the upper level. It is 1.9 m in height and width of 1,1m. It was dug at height of 0.7 m from the bottom of the outcrop. Slot depth is 1.7 m (Fig. 2/1)[1] and leads to a cell-kitchen. After restoration, a window in wooden frame was installed. During the period of the functioning of the complex the mentioned slot also played the role of the window. On the other way we should pay attention to its unusual construction - wide part of it is outside.

«Chimney». It seems quite obvious that the cell with the window was used as a kitchen, because inside of it there was a furnace or even open fireplace [Makarenko, 1911]. So far as there was no opportunity to built a fire inside the room where there was no natural draft, cave diggers were forced to construct a chimney channel. For this purpose in the wall of the cell near the ceiling they cut out a deep channel. Builders of the cave complex found the original decision, and used one of the outcrops as a vertical funnel. Chimney channel was continued with the chute exactly on the surface of outcropping, using its natural shape. Thus the channel reached the bottom of the outcrop and passing on its sides goes on the back side, faced toward the solid rock. The average width of the channel is 20-25 cm, depth 15-20 cm, with total length of about 14 m. Unfortunately, there is no reliable information about closure of the open part of the chimney to provide its tightness.

3. MALIE (SMALL) DIVY

Malie (Small) Divy is a group of chalk outliers situated 2.1 km to the north-east of Divnogorye on the territory of functioning Holy Dormition Divnogorsk male Monastery. Is generally accepted that in Malie Divy there are three outcrops. **Northwest outlier** is the largest, with a width of about 30 m. Currently, it consists actually of two separate outcrops, due to degradation processes. At the bottom of the north outcrop are the entrance, windows to the household room and part of the procession gallery. At the bottom of the southern, are windows and entrance to the cave church of the Nativity of St. John the Baptist. It is important to mention that entrances and windows in both cases are in rock solid ground.

South part of this site earlier was much higher, but during the 1940s its top was ruined. On the photos of the beginning of the XX century this part was like the tall diva with the cross (Fig. 2/3). As a result of analysis of the photographic material of the first part of XX century and

[1] Depth is specified between the external surface of the outcrop and the wall of the cell.

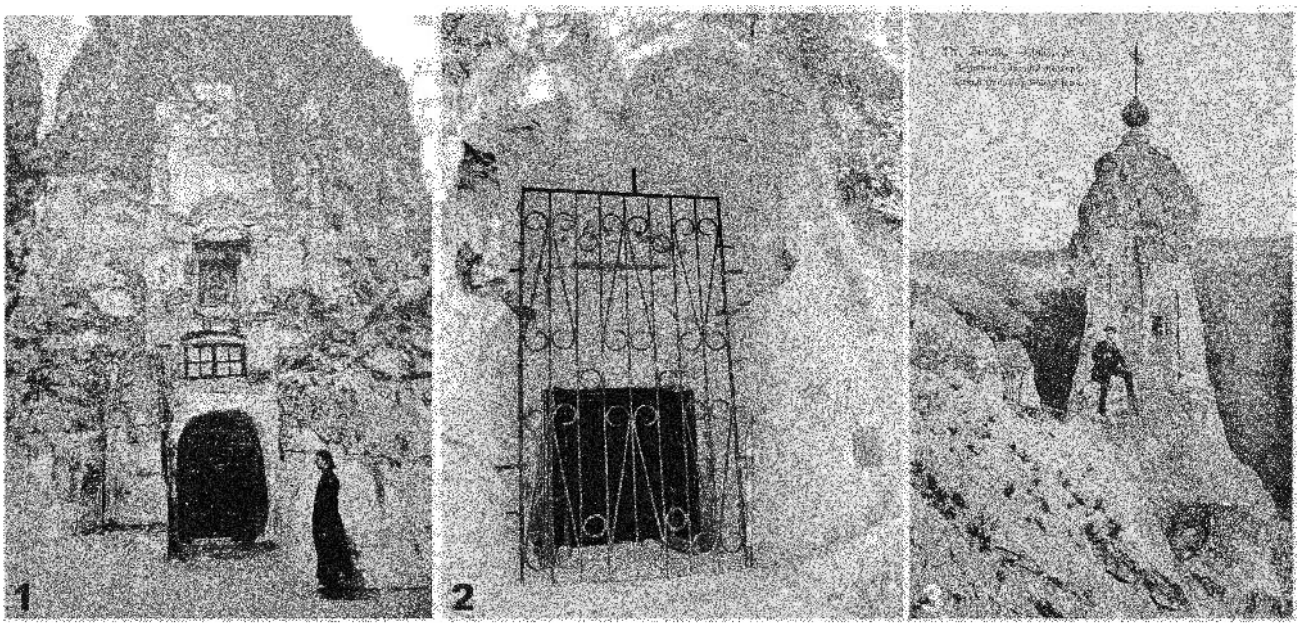

Figure 2: 1 left) The facade of the complex on the photo early XX century; 2 center) "Window" of the second level (photo Gunko A.A.); 3 right) Top of the outcrop in Malie Divy, now destroyed (1911 postcard).

field studies, we came to the conclusion that within this *diva* there was a carved room, which could be used as a bell tower [Gunko, Kondratyeva, 2014]. Its inner area does not exceed 1.5 m². There was a doorway leading inside it and high window faced to the front side facing the area in front of the church.

The **Southeast outlier** is located about 180 m south-east of the Divnogorsk monastery. It is one of the most interesting and suffered heavy destruction. Its lower part has wide base with stepped top. At the top, there is quite narrow high crest, 6 m-high, with through-holes. On the eastern side of the crest well distinguishable lineaments of rooms on two levels are visible (Fig. 3).

The lower room was cut out at height of 4 m from the lower base of the outcrop. Substantially the western wall is entirely preserved. Its length is 2.25 m, and height - 1.7 m in the upper point and 1.5 m in the right corner. Part of the northern wall is partly preserved. Traces of niches are clearly visible on the walls. The floor of the room is partly preserved in the area adjoining the western wall.

The upper room was cut out at height of 5.8 m as the second level. It is divided from the lower room with chalk 0.2 m-thick. Sections of walls and crown are preserved. The height of the room was 1.8 m. Few small niches and holes are visible in the walls. The three-centered arch of the room continues to the south. On the edge of this pillar is visible a slot of the door-post.

On the western side of the crest, horizontal, vertical and single rectangular cuttings are clearly visible. One of the horizontal cuttings cuts the part of the support pillar which from the west also shows clear traces of treatment.

In the voluminous south part of the outcrop on the level of lower and upper rooms there are spaces, which could be interpreted as fragments of pre-existing floor in rock rooms. Here, on a kind of headland is the fragment of the outcrop inside of which is through-wall arched slot. Its height is approx. 2.9 m. Height of the slot is 1.77 m, width is 0.82 m, depth is 0.94 m. Inside of slot is depression for door-post.

In the south-eastern part of the outcrop, at a height of 0.6 m from its base, a short rock room is preserved. Its height at the entrance is 1.9 m, the width is 0.9 m.

We suppose that the complex had a household function. One or two persons probably used this rock rooms for living. The entrance to the cave complex was in the upper level by use of access wooden ladder. There were two rooms both on the lower and the upper levels. During cutting these rooms the cave workers made several mistakes. As a result of these mistakes, a weakness of the outcrop in its south-eastern part had to be recorded. Attempts to extend the useful inside space resulted in wall thinning, which later on resulted in further destruction of the outcrop [Gunko, Kondratyeva, 2014].

4. SHATRISCHE

Shatrischegorsky cave complex. 8.8 km east of Divnogorye, on the right bank of the river Don, there is the hill Shatrische. It is a large cone-shaped chalk massif, more than 50 m high and over 160 m in width at the bottom. On the top of it there are entrances to Shatrischegorsky caves. Their main gallery spirally slopes down to the bottom of the massif. It was part of the monastery cave complex, which included cells and cave church.

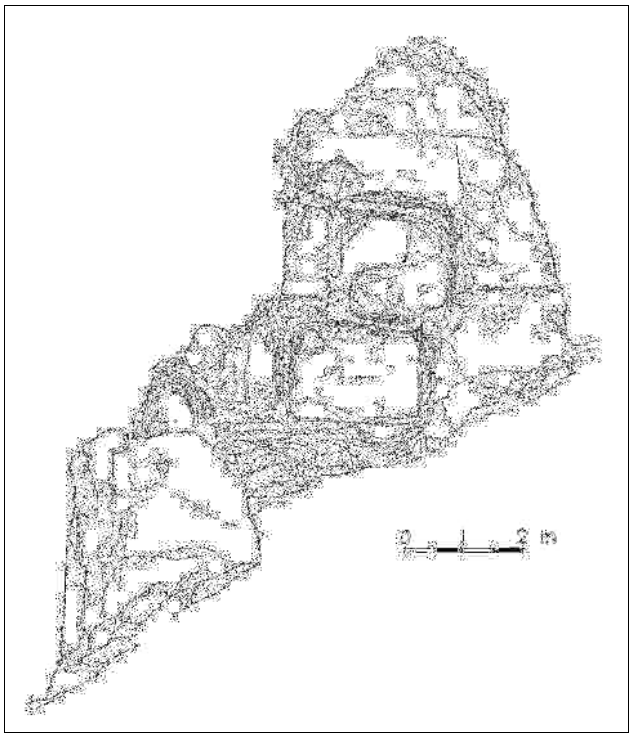

Figure 3: The ruins of the rock-cut complex (drawing A.A. Gunko).

The time of foundation of the monastery is unknown. It could have been realized simultaneously with the neighboring Divnogorsk in the XVII century. At the end of XVIII century the monastery was closed, and in 1854 its caves were under the jurisdiction of Divnogorsk male monastery.

At the end of the XIX century there was a large *diva* on the slope of Shatrische (Fig. 4.1, 4.2). It was destroyed in the middle of the XX century as a result of chalk mining [Gunko, 2012]. There is little information about the internal structure of the church. It is most likely that only a small part of the southern wall of the church with low partly backfilled pass has been preserved.

5. KOSTOMAROVO

A group of chalk outcrops is situated to the east of Kostomarovo village (Podgorensky district of the Voronezh region), 5 km from the river Don on the left slope, within the territory of the Spassky female monastery. This complex includes several caves, as well as caves in outliers.

«Cave no. 1» is the easternmost cave in the Kostomarovsky cave complex. Its entrance is at the bottom of the chalk outcrop (Fig. 4.3, 4.4). To the southeast the arch pass is 0.6 m-wide and 1.65 m-high. It leads to a small room (total length of about 3 m), which use is not clear. Speleologists from Voronezh researched it in the 1970s and suggested that the outcrop was the entrance to a small cave directed to the north. Beside there is a slot-like pass to a small chamber with traces of wall processing. They supposed that the pass collapsed and by the time of study it was no longer open.

«Cave no. 3» is the biggest cave of Kostomarovsky cave complex, and consists of two cave churches [Gunko, 2013]. There were three entrances to the cave, two of which were exactly inside the two-point (north-west and south-east) large outlier. The main entrance is at the bottom of the south-eastern. Entrance has a three-centered arch (width 1.7 m, height 1.95 m), closed with two doors. In the body of the outcrop a small part of the gallery leads to the Spassky church.

On the walls of the gallery, at a distance of 0.6 and 3.4 m from the entrance, some slots and depressions are preserved. They show the location of the door-post at different times of functioning. The second entrance to the cave now is closed with boards and chalk bricks. It is situated a little higher at the bottom of the northeastern outlier, with an irregular elongated shape. Over the entrance there was a wide room, irregular in shape, too, situated higher than the galleryslot.

At the surface of the outcrop there are a great amount of niches, and different hewn areas. Much part of it was made after the World War II. During the restoration of the monastery from the late 1990s between the pinnacles a beam for hanging bells was fixed (protected by pent roof). For this purpose in the walls of the outlcrop horizontal gutters and rectangular depressions were cut (Fig. 4.5).

«Cave no. 7» is the third cave church of Kostomarovsky complex, with entrance at the bottom of the *diva*. The church was consecrated in 1903. Unfortunately we do not know the size of the outcrop. By the end of the twentieth century it was heavily damaged, only its base being preserved. There, an artificial diva was constructed, showing at the top a cupola with crest.

6. SVYATOGORYE

One of the largest sacred cave complexes of Eastern Europe is situates on the right bank of Seversky Donets river to the south of Svyatogorsk city (Donetsk region., Ukraine) on the territory of the Holy Assumption Svytogorsk Lavra. The northern part of the complex is inside big chalk rock-outlier with a base width of 50 m and a modern height of 33 m (Fig. 4/6, 4/7) The base of the outlier lies at an altitude of 45 meters from the river on the abs. elev. 104 m [Dedov, 2012].

The Svytogorsky cave complex includes two cave churches, several rooms with different purpose and numerous galleries. In the past there was also another, upper level, in the complex. We can see it in schematic view in the figure of Archimandrite Iolia. In 1679 archimandrite mentioned the cave church of Assumption of the Blessed Our Lady, which was cut in 1630s. It was in one of the tops of outlier. Caves weakened the chalk *diva* and this inevitably led to their destruction.

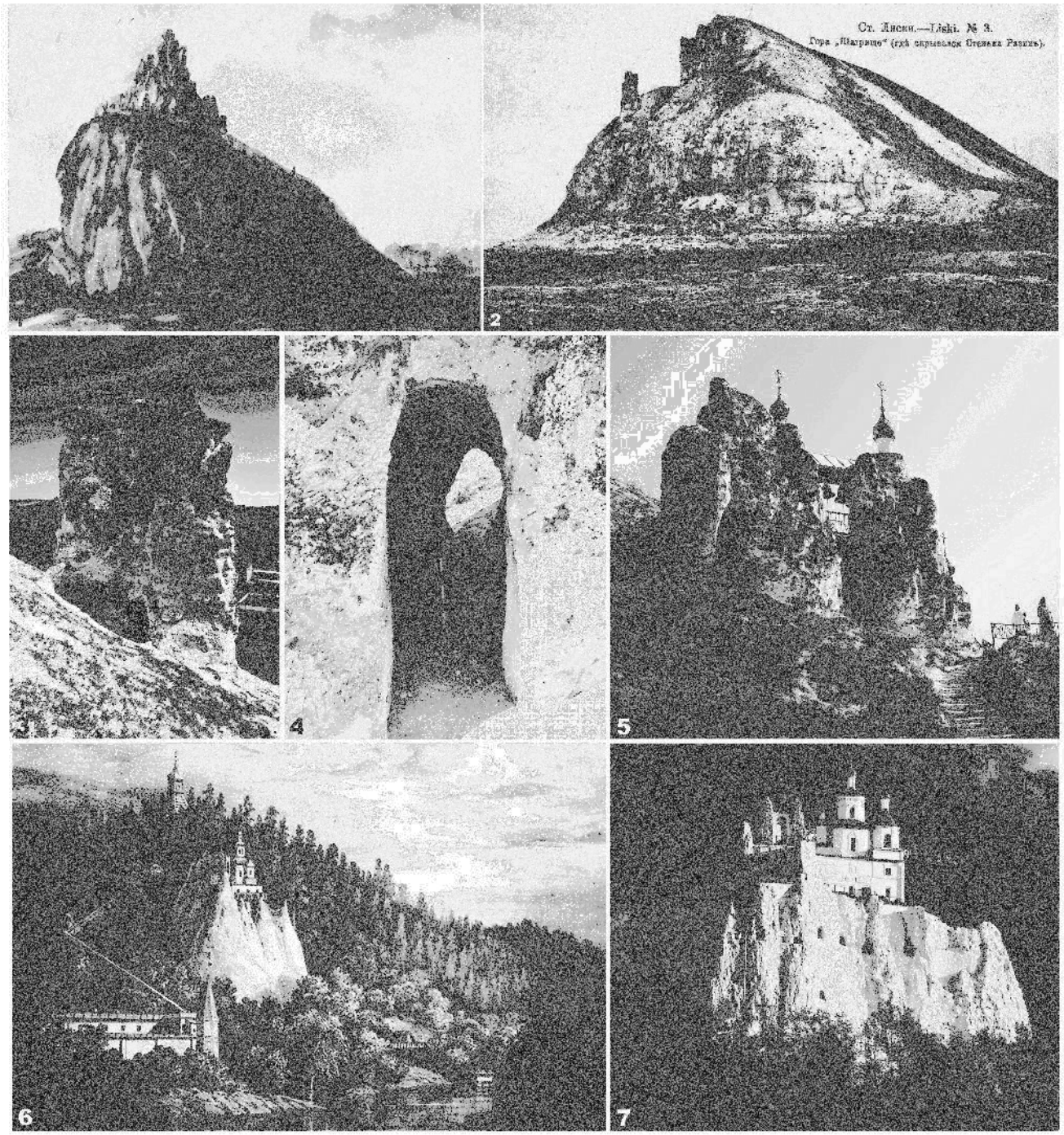

Figure 4:
1) Shatrische (Strukov's D.M. drawing fragment);
2) Hill Shatrische (postcard of early XX century);
3) Single outcrop of Kostomarovsky complex with the entrance to cave no. 1;
4) Cave no. 1;
5) view of a group of *divas* of Kostomarovsky complex from west;
6) View of the Svytogorsky Hermitage (engraving of the XIX century);
7) Present view of the Svytogorsky outcrop

After that, which occurred at the end of the XVII century, the church was partially ruined, and only parts of the eastern wall are preserved.

Church of the Nativity of St. John the Baptist. This church is one of the main caves of Svytogorye and the only one that is situated at the body of outlier. It is cut at a depth of - 9 meters from the present surface level of the outcrop. Currently, the temple area of 42 m² has a square shape in plan view. In the north-eastern part there is an altar, separated from the rest of the room by a stone wall. Two windows are located in the northern wall of the church (one is in the altar). There are three exits from this room. In addition, in the south-east corner, opposite the small "southern" altar gate, is a small circular passage.

Forechurch. The room is adjacent to the church from the west and connected with it by wide passage. Its area is 12 m² and there is a large window. From the room to the west is the passage, followed by a corridor with a window.

Refectory. In the western part of the «upper level» a refectory is preserved, with area of 25 m². In the XIX century the remains of the furnace were visible. Lighting of refectory was through two windows in the west wall. In addition there were two rooms nearby that were lost during the destruction.

Cells. During reconstruction of the XIX century the church was connected by the passage with the system of galleries. One of the galleries (from south to north) led to three cells, with were cut to the east of it. Cells are walk-through, connected by doorways. Their area is 4-9 m². Kiots (kiot is shelf for icons the synonym could be icon case) and chalk stove benches are preserved in the walls. Gallery from west to east leads to another small room with a window (the so-called cell of schemonk (in Russian orthodox church it is the most strict rank of monk) John Recluse, who lived in the cave for 17 years). However, historians suppose that in reality his cell has been destroyed during the destruction of that part of the cliff.

Table-tomb. A small system of galleries in the lower level of the cave complex with independent exit to surface on the eastern side of the rock, and one window to the north, are situated at the level -15 m from the top of the outcrop. In the wall of the passages, at height of about 1 m and higher, there are 12 burial chambers, 1 m-deep. The chambers were used for burial and realized with chalk bricks. On their edges hewn areas for filling remain.

7. BELOKUZMINOVSKIE ROCK

A large group of chalk outcrops, up to 25-m high, is located on the right bank of the Belen'ky river, 400 m to the north-east from Belokuzminovka village (Constantine district, Donetsk region, Ukraine).

Belokuzminovskie cave. In the southern part of the group at the bottom of one of the most large rock bodies is a small cave, with width and depth of about 3 m, and height of 1.9 m. According to local residents, in the cave lived the Orthodox hermit Stepan Bosoy. According to one of the legend he was shot by Germans in 1943. This cave is clearly visible on the photo of 1930s. It is artificial because on its walls there are traces of chopping tool. There are also fragments of cut rectangular niche which could be use as a kiot for icon. Unfortunately, the cave has been damaged by the tourists who visit it regularly.

8. KEY TAKEAWAYS

We analyzed part of the cave complexes which are in the body of the outcrops. There are 14 household rooms (including cells and refectories); 3 cave churches; 1 rocky bell tower; 1 tomb (in the galleries); a number of communication galleries. All known groups of chalk outcrops of the Don region were used by man. In most cases, except mining, their use is connected with the spread of Christian asceticism as a result of which was the foundation of monasteries and hermitages, including caves.
We suppose that monks who came to the new land had pragmatic reasons and took into account a set of favorable factors which prompted to use *divas* for settlements inside.
It is obvious that the first stage of the future settlement of the territory of monasteries was connected with the creation of rock household rooms (rock household complex in Malie Divy, upper levels of Svytogorye). On the second stage, when the number of cave inhabitant increased, cave churches began to appear (documented in the first half of the XVII century). On the third stage, when the borders of the state have expanded and monasteries have lost their function of «outposts of Orthodoxy», pragmatic ideas of «pioneers» also lost its importance. Religious ideas become the main and pilgrims go to sacred outliers. Active colonization stimulates these processes. Ordinary people gave to these bizarre outliers the energy of holiness and the presence of them helped monasteries to become large and important pilgrimage centers. As a result, there was the rapid development of their infrastructure, the core of which were still caves and divy.

9. CONCLUSIONS

The attractiveness of outliers foredooms the further tragic fate. Active construction in the internal space inevitably leads to their destruction. With the arrival of the Soviet regime, and the increase of anti-religious attitudes, the caves were desecrated and monasteries were closed. During the 1930-40-ies for the most part among young people divy did not have any special significance. During this period most of the sites in Divnogorye, an outcrop with the church in Shatristche, the bell-tower in Malie Divy, and some outcrops in Kostomarovo were completely ruined under the pretext of chalk stone production.

Only in the second part of the XX century the outcrops were taken under protection by the state and began to be perceived as unique natural monuments. Nowadays they regain their value not only as an attractive tourism objects, but also as sacred objects. As well as caves they are very popular among tourists and pilgrims.

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Cave temples in the Don region, Russia and Ukraine

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Abstract
The catchment of the Don River covers a large area of south-western Russia and eastern Ukraine. On this area there are more than 50 artificial caves connected with the traditions of digging caves by the Orthodox Christians. These caves were dug in the chalk rocks mainly from the 17th to the beginning of the 20th centuries. In some cave complexes cave churches were built. The article analyzes the special features of all known cave churches of the Don Region. We compare the common characteristics and individual architectural elements.

Keywords
Cave churches, temple, architecture, artificial caves, Don, Russia, Ukraine.

1. INTRODUCTION

Currently, in the catchment of the Don River there are more than 50 sacred artificial caves [Stepkin, 2008], most of them created in the period of 17th-19th centuries in official and popular Christian tradition. The length of caves vary from a few meters to 1 km, with temples in the biggest caves. At the present time there are 19 temples (Fig. 1). However, many of them are still scarcely explored.

An important task is to identify the characteristics of the architectural and liturgical structure of temples. This allows comparing the structure of Don temples with that of temples in other regions. It will also contribute to differentiate the typology of Russian cave temples, based on the territorial and chronological features.

Architectural appearance of the most famous caves complexes in Don region has been studied by Pluzhnikov [1985]. Researches of Gaidukov and Stepkin were dedicated to liturgical temples in forest-step Don region [Stepkin, Gaidukov, 2011; Gaidukov, Stepkin, 2013]. This article continues investigation of cave temples, presenting general information on their structure and size. The authors used information from field work during 2009-2015.

2. CAVE TEMPLES

2.1 Donetsk region, Ukraine

The **Temple St. Anthony and Theodosius** is situated on the right bank of Seversky Donets river on the territory of the Holy Assumption Svytogorsk Lavra (Donetsk region, Ukraine). It was dug presumably within the 18th century and later it was lost. In 1846 it was opened and renewed. It shows a system of rooms and galleries intercrossing at acute angles (Fig. 1.1). The altar (in Russia by the word alter we mean place behind the iconostasis. And we know that in the Catholic Church altar is open and often this word mean the Holy Throne, not a place. To avoid confusion, we use the word alter part for the room behind the iconostasis) is a rectangular room size of 4×3.5 m oriented to the east. In the northern wall there is a passage in a small L-shaped room.

Complicated asymmetric (and even somewhat chaotic) construction may indicate that the temple was dug on the basis of the underground complex for household purposes.

The **Temple of the Nativity of St. John the Baptist** is situated inside the main cave complex of Svytogorsk Lavra. It is one of the most ancient temples in Don Basin, dug presumably before the 16th century.

Currently it covers 42 m^2 (Fig. 1.2), with square ground plan. The north-eastern part is the altar which is separated from the rest of the room by a stone choir screen the angle of which is a column-pillar that supports the arch. In the choir screen which in the same time is stone iconostasis are three passes: to the west, small "northern" and Holy Gate; to the south, small "southern".

Two windows (one in the altar) are located in the northern wall of the church. There are three exits from the room. In addition, in the south-eastern corner, opposite the small "southern" gate of the altar part, there is a small circular passage. From the west, a wide passage connects the main room of the temple with a forechurch. This is a passing room 12 m^2 with its own window onto the surface.

The **Temple of St. Alexis, the Man of God** is situated inside the cave complex of Svytogorsk Lavra, south-east of the Temple of the Nativity of St. John the Baptist. It was dug in 1860-61. The area of the church is more than100 m².

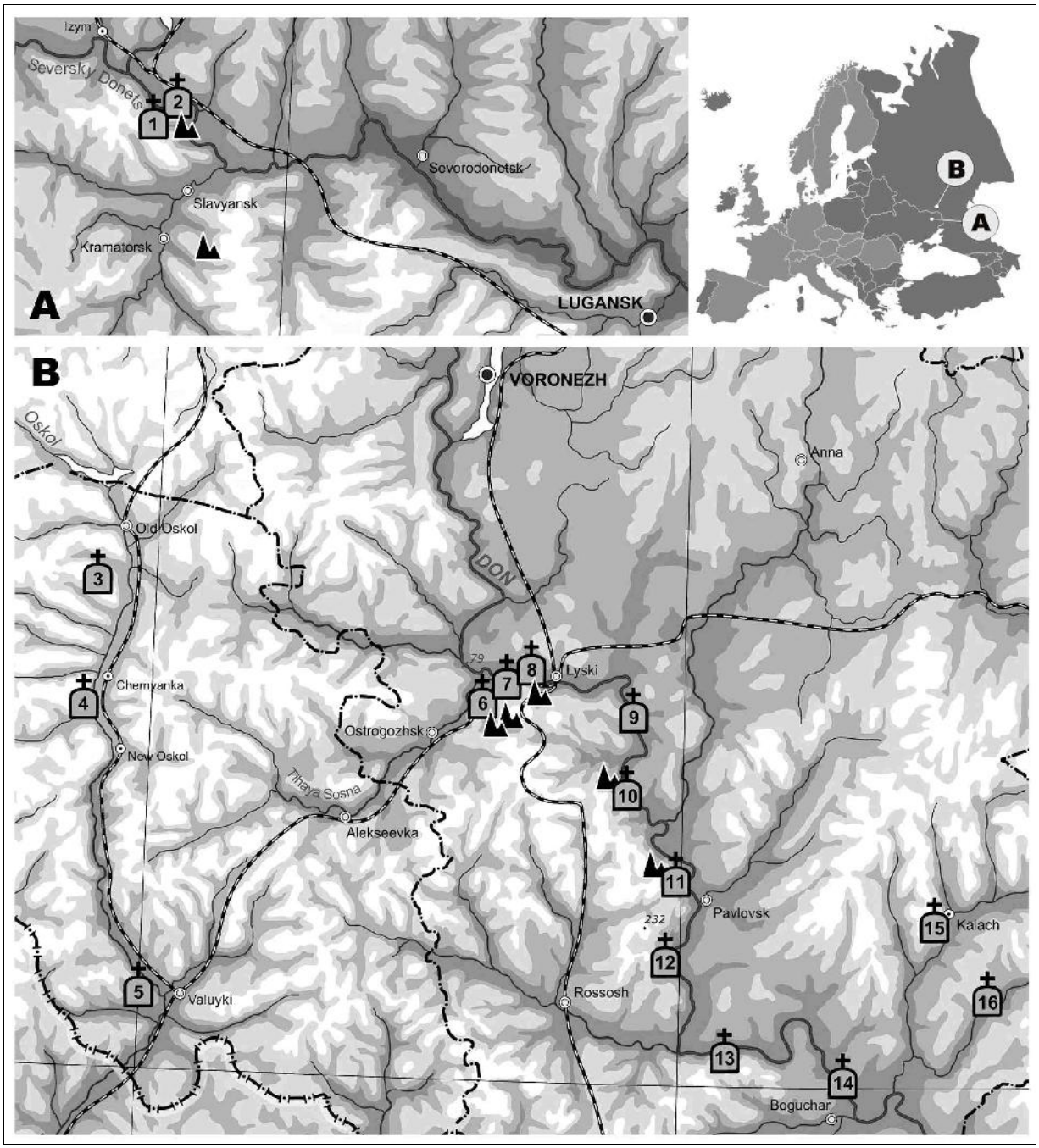

Figure 1: Cave temples of the Don region (graphics: Gunko A.A.)

A - In Ukraine = 1 - Temple St. Anthony and Theodosius ; 2 – Temples of Svytogorsk Lavra: Temple of the Nativity of St. John the Baptist, Temple of St. Alexis, the Man of Go;

B - In Russia = 3 - Temple of Shmarnensky complex; 4 - Temple of the Holy Trinity in Kholky; 5 - Temple of Ignatius of Antioch in Valuyki; 6 - Temple of Sicilian Icon of Our Lady; 7 - Temple of the Nativity of St. John the Baptist; 8 - Temple of Selyavninsky complex; 9 - Temple of Kolybelkensky complex; 10 – Temples of Kostomarovo: Temple of Vernicle, Temple of Faith, hope, charity and Sophia, the Wisdom of God, Temple of St. Seraphim of Sarov; 11 - Temple of Alexander Nevsky; 12 - Temple of Semeykinsky complex; 13 - Temple of Gorokhovsky cave complex; 14 – Temple of Galyevsky complex (partly ruined); 15 - Temples of Kalacheevsky complex; 16 - Temple of Starokriushensky complex.

It has a symmetrical structure and is divided into three parts: narthex, naos and altar. There are 4 entrances, two in the narthex area, and two in the area of naos (Fig. 1.3). The altar is a rectangular room, oriented to the northeast, connected with naos by a wide passage, and divided by iconostasis. There are two exits from the altar: from southeast to diaconicon, and from northwest to comparable in size passage room.

2.2 Belgorod region, Russia

The **Temple of the Holy Trinity** is situated inside Kholkovsky cave complex, in the Kholkovsky Holy Trinity Monastery, Chernyansky district, Belgorod region. The temple was dug presumably in the 17th century, with its western part dug in the 21st century. It is asymmetric and oriented to the southeast (Fig. 1.4). Its total area is 61 m². The main part of the temple is a trapezoidal room, 6.3 m-wide and 3.3 m-high.

The arches are supported by 4 support pillars, that divide the room into three naves. The central nave (naos) does not have traditional collocation with Holy gate. It is oriented onto the pillar before the altar and the northern gate. On the line of naos there is a column.

The column is based on the stepped rectangular base. It is slightly crooked. Probably there was a southern "couple" - similar column-pillar, which has been lost over time. The space between them was the naos of the ancient temple. The altar is separated by two column-pillars. A special feature is the location of the altar in the center of the two support pillars, between which there is a stone Holy Table. Six niches are present within the walls of the altar.

The **Temple of Ignatius of Antioch** is situated inside the cave complex, located southwest of the city Valuyki, Belgorod region. Opened in 1914, it is single-nave in plan, cruciform, asymmetrical, oriented to the southeast, with passages on all four sides (Fig. 1.5). The naos near the entrance is 2 m wide.

On the north-west it adjoins through step to a small room, the choir-place. To the southeast the naos narrows and intersects with the high transept. The central inner part of the church is a spherical dome. Height of the temple in this point is 4.7 m.

The altar part is south-east of the transept. In the past, an iconostasis has been installed there. Before reconstruction there was a small passage to the altar from the north-east wing of the transept. Obviously, that its entrance played the role of the Northern Gate and the small skirt pillar was as supporting column. The passage is currently closed by wall. The altar apse has an irregular "angulated form".

The **Temple of Shmarnensky complex**. The cave complex is situated in the Stary Oskol district of Belgorod region, west of the village Shmarnoe. Its age is not established, but it is mentioned since the 19th century in archival materials. There is one nave in the temple (size 9 × 5 m), oriented to the southwest (Fig. 1.6), with an area of 33 m². Part of narthex is supported by column-pillar. The altar is separated from the main part of the temple by two column-pillars, one of which is destroyed. Thus, the columns formed three passages. Before the Holy gate in the arch of the naos there is a truncated dome-shaped hole. The height of the temple in this place is 3 m. In the altar there are a number of niches and protrusions.

2.3 Voronezh region, Russia

The **Temples of Kalacheevsky complex** are situated inside the complex located in Kalach city, Voronezh region. Their exactly age is not known. The temples, each with one nave, are located on the same axis, with the altar parts oriented to the east. The western temple consists of two rooms, connected with a wide passage, which is a naos (Fig. 1.7). There are two passes to the narthex of the temple from the north and from the south.

The altar is of complex shape with broken-line trapezoidal apse. Beside the main pass from the naos there are two passes in the altar from the northern and southern sides. The eastern temple is asymmetrical (Fig. 1.8), with two passes to the naos from north and two passes from the south. The altar is slightly displaced to the north and is separated by the column-pillar. From the transept there are two gates into the altar part. A further pass is from the northern side. The altar is rectangular, with a large number of cut protrusions, niches and hewn areas.

Temple of Starokriushensky complex. Cave complex is situated on the outskirts of the village Staraya Kriusha Petropavlovsky district of Voronezh region. The date of appearance is unknown. There is one nave in this temple. It is strongly damaged by collapse. Altar part has preserved. It is oriented to the northeast (Fig. 1/9).

It is a rectangular room, which is connected with a naos by wide pass. Also there is an entrance from the northwest. Inside alter part there are a number of niches and prothesis, which combines cut protrusion with half-round front part and a deep niche. To the north-west of the altar part in the adjoining gallery is a small room that could be used as diaconicon.

The **Temple of Sicilian Icon of Our Lady** is situated inside the cave complex in Bolshie (Big) Divy, northwest of Divnogorye, in Liski district of the Voronezh region. It is known since the first part of the 19th century. The main entrance is in the base of a large chalk outcrop. It has a complicated structure and is oriented to the northeast (Fig. 1.10).

The main room is rectangular (size 15 × 14.5 m). The arches are supported by supporting column-pillars: 6 are large and located on the periphery, 4 are small and located in central part, and 2 are small and separate the altar from the temple. There are niches in column-pillars from transept side. Maximum arch height is 3.9 m. The altar is 3.6 m-wide and 3.7 m-high. There are 7 niches in the walls.

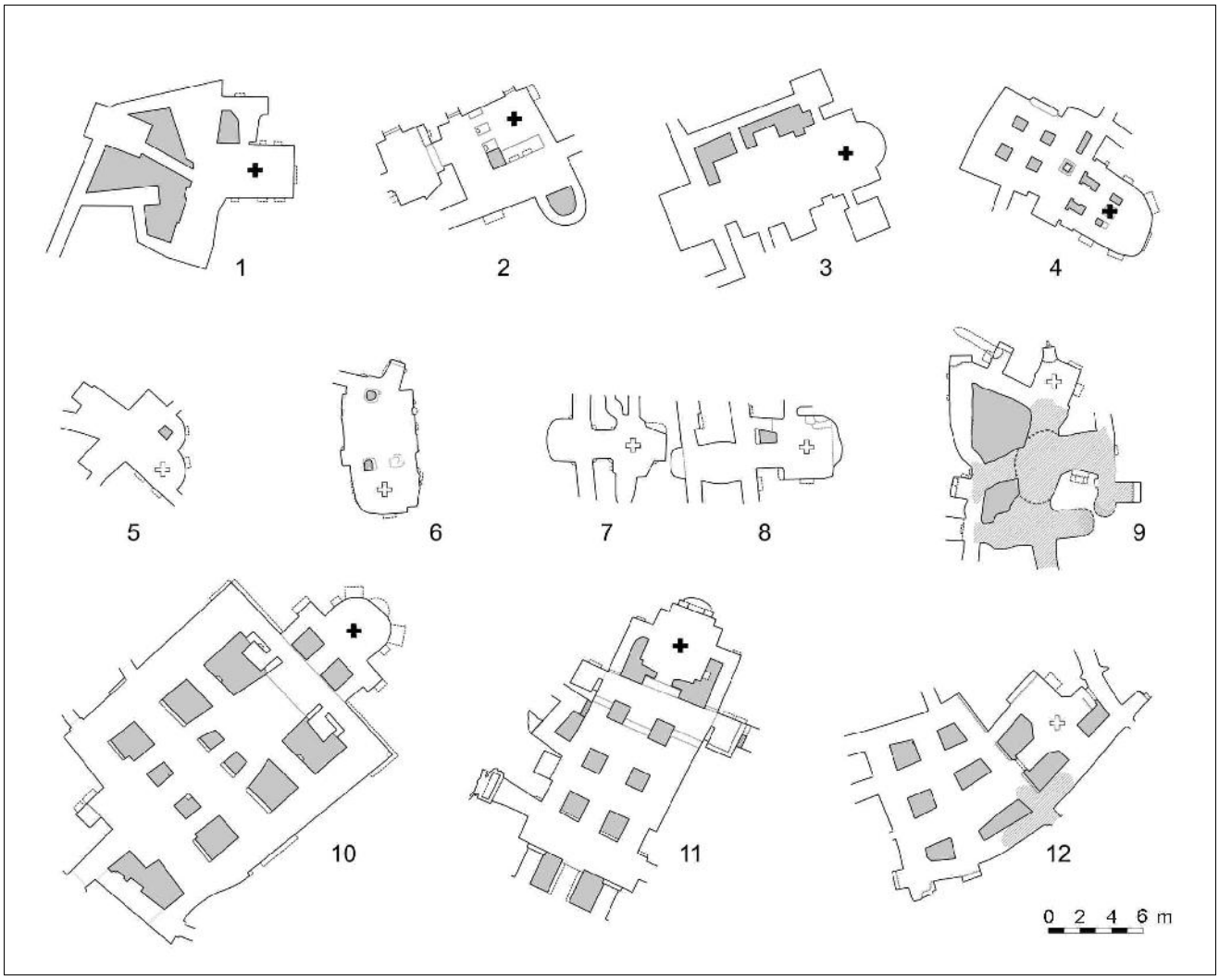

Figure 2: Plans of cave temples (see the description in the text - graphics: Gunko A.A.). Topographical survey: 1 - by A. Kovalev; 2-3 - by V.N. Dedov; 10 – by E. Kvashina; 4-9, 11-12 – A.A. Gunko, S.K. Kondreteva, V.V. Stepkin, A.P. Gunko.

The **Temple of the Nativity of St. John the Baptist** is situated inside the cave complex in Malie (Small) Divy, in the territory of Holy Dormition Divnogorsk male Monastery, Liski district of the Voronezh region. In written sources it is mentioned since the 17th century. Oriented to the northeast, it is rectangular in plan (Fig. 1.11), with area of 127 m² and maximum height 5.24 m. There is an entrance from the surface and three deep window slots. Two rows of three columns divide the space of the temple in three naves. The form of arches varies from semi-circular, to lance-shaped, and cross vaulting. Rectangular rooms-choirs are cut in the walls of aisles near the altar. There are three passes into the altar. This latter, square in plan, is 4 m-wide. Height of the arch is 4.93 m. The high place is marked as a wide apse-shaped niche with protrusions.

The **Temple of Selyavninsky complex** is situated 1.2 km north-east of the Divnogorsk Monastery. It was dug in the second half of the 19th century. Asymmetrical in plan, it is semi-circular, with the altar oriented to the northeast (Fig. 1.12). Its size is about 14 × 10 m.

The arch is supported by 6 main column-pillars and 2 pillars near the altar. The main columns divide the space of the temple in four naves: the central, northern and two southern. Apparently, wide tectonic crack prevented the creation of another southern nave.

There are three entrances into the altar. The South Gate in fact is a wide passage from the extension of the south nave. This nave passes into a gallery, which rounds the temple from the north-east. The altar has irregular cruciform shape with a domed vault.

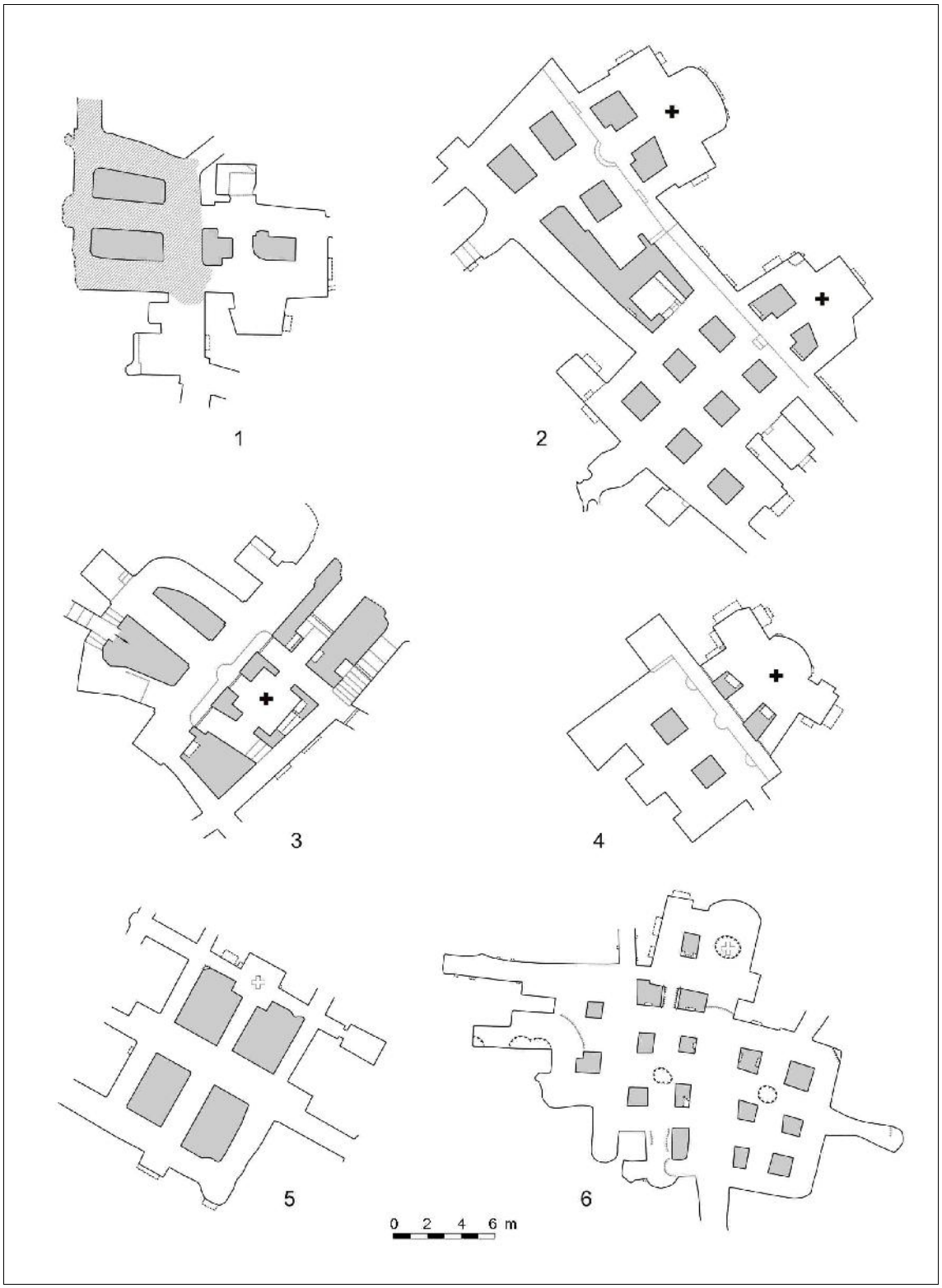

Figure 3: Plans of cave temples (see the description in the text - graphics: Gunko A.A.). Topographical survey 1 A.A. Gunko, S.K. Kondreteva, V.V. Stepkin, A.P. Gunko., M.V. Leontiev, A.V. Kirscha, O.G. Gunko, E.V. Yakovlev.

The **Temple of Kolybelkensky cave complex** is situated on the left bank of the river Don, 5 km north-east from the Kolybelka village, in Liski district. The date of appearance of the temple is unknown. Its western part is collapsed (Fig. 2.1), so that the available space is now 12 × 7 m. Height of the arch is up to 4.2 m. The arch is supported by 4 column-pillars. There are two main passes into the east-oriented altar part. The naos corresponds to the north entrance. Structure of the altar part is not clear. In the center of rectangular room is column-pillar. Two rooms are linked to it on the south and the north sides. The altar, as well as the main space of the church, was not completed.

Temples of Vernicle and temple of Faith, hope, charity and Sophia, the Wisdom of God. Both these temples are situated inside the cave complex in the territory of Kostomarovsky Spassky monastery, Podgorensky district of Voronezh region. Age of the complex is unknown. The size of the Temple of Vernicle is 17 × 8.5 m (Fig. 2.2). The arch is supported by 6 column-pillars which divide the space of the temple in three naves. Choir places are linked to the side naves choir passage an L-shaped gallery, formed by the seven column-pillars, is linked to the southern nave. The asymmetric altar part is oriented to the northeast, and is separated from the main space of the temple by two pillars. The rectangular apse is a section of the altar. The transept of the Temple of Vernicle passes to the northwest to that of the Temple of Faith, hope, charity and Sophia, the Wisdom of God. Gallery from the northern nave also leads in it. This temple is asymmetrical and clearly not completed, with size 15 × 12.3 m. The arch is supported by 3 large column-pillars which divide the space of the temple into two naves (central and northern), while the southern nave was not dug completely. It is connected with naos by narrow pass, and formed by a rectangular room used as a choir. There is a separate entrance to the surface from the narthex of the church. The altar is separated by two column-pillars, oriented to the northeast and with semi-circular apse.

The **Temple of St. Seraphim of Sarov** is situated west from the temple of Vernicle, in the Kostomarovsky female monastery. It was dug in the 20th century. The temple, clearly not completed, can be entered through the southern nave in the zone of intersection with the transept (Fig. 2.4). Two massive columns divide the main space in three naves, the northern being the longest. The height of the semi-circular arches is up to 5.2 m. Continuation of the transept to the north forms a rectangular room-choir. The altar is separated by two columns-pillars, oriented to the northeast and asymmetrical. The broad "pockets" with niches link to the room on the north and south sides. The altar ends with a semi-circular apse.

The **Temple of Alexander Nevsky** is situated inside the Belogorsky cave complex, in the Belogorsky male monastery, 3.3 km to the northwest from Pavlovsk city, in Voronezh region. The temple was dug in the first half of the 19th century with the participation of the architect from Voronezh. Entrance to the temple is from the northeast through transept (Fig. 2.3). The main space of the church is divided in three naves by two big pillars. In the northern part, the naos passes into a rectangular room-choir. In the central inner part of the church a truncated dome is carved. In this place the height of the arch is 5.1 m.

The altar is oriented to the southeast and is separated by two pillars. The north and south Gates lead to through galleries, from which there are entrances to the altar. The southern gallery is partly blocked with stone partition, and used as *diaconicon* (the diaconicon is, in Eastern Orthodox and Eastern Catholic churches, the name given to a chamber on the south side of the central apse of the church, where the vestments, books, etc., that are used in the Divine Services of the church are kept [1]. The sacred vessels are kept in the Prothesis, which is on the north side of the sanctuary).

The altar is square in plan, with a through hole in the area of high place, leading to the gallery encircling the temple from the southwest.

The **Temple of Semeykinsky cave complex** is situated inside the cave complex near Semeyky village, in Podgorensky district of Voronezh region. Date of appearance of the complex is unknown. The temple has a clear structure and relative symmetry, looking like a system of perpendicular and parallel galleries of limited development (Fig. 2.5). The main space (transept and naves) are divided by two large pillars. The central inner part is with a truncated dome. From this part there is a narrow gallery to the northeast-oriented altar part. Two galleries, parallel to the entrance to the altar, play the role of southern and northern gates. There are two more side exits from the galleries to the altar, parallel to the transept of the church. To the south-easte, this gallery leads in a rectangular room – the *diaconicon*.

The **Temple of Gorokhovsky cave complex** is situated inside the cave complex near Gorokhovka village, in the Verhnemamonsky district of Voronezh region. It has a complicated structure and is not completed (Fig. 2,6). There are 5 naves in the main part, formed by rows of column-pillars. There are 13 completed and one unfinished column. The altar is oriented to the northeast, separated by two supporting pillars. You can enter into the alter part through wide gate on the line of naos and through two side gates. The first two gates are cut down to the west of the transept axis, while the two others from the linking corridor. The altar has a complicated structure and could be divided into three zones: that near the entrance is a high arched room (height 5.25 m, width 2 m). Through two arched passes two other zones can be accessed, separated by column-pillar. In the main (east) zone there was the Holy Table. Height of the arch in this place is 4.7 m. In the northeast direction it ends with a semi-circular apse.

The accessory zone is situated to the west and leads out of the main one with a wide passage. There are several niches, one of which in the northeast part could be a prothesis

3. DISCUSSION AND CONCLUSIONS

Preliminary analysis of the cave temples in the Don region shows that they are considerably variable. In contrast to the regional architecture there are no identical forms of temples. This indicates the absence of standard designs for churches one-time construction. This is logical, because most of the cave complexes were created according to popular Orthodox tradition. In addition, the shape of the temples is greatly influenced by the geological features of the chalk massif – lithology, cleavage and opening of cracks.

Among the caves in the Don Region there are small one-nave temples, as well as the large ones, with three and five-nave temples. In most cases temples are asymmetrical. Also, the contours of the temples do not always could be clearly identified. The corridor, which is connected with naos, could be a communication passage or an additional nave of the church.

This situation is in the cave temple near Gorokhovka village. The temples are generally located deep in a complex, far from the surface. Only in three cases, they have a direct connection with it through windows (temples of the Nativity of St. John the Baptist in Svyatogorye and Divnogorie, and temple in the Belogorsky cave complex).

Most cave complexes (ten out of the nineteen) are oriented in northeast direction. Four temples are oriented to the east, three to the south-east, and one to the south. In ten cases the altar apse is semi-circular in plan, in three cases it is rectangular, and in six temples there is no apse. The form of the prothesis is also variable. In eleven temples it is in the form of niches, in six temples in the form of a rocky protrusion in one case (in Starokriushansky cave) there is a combination of these forms.

Such diversity in orientation, construction of the alter apse and form of prothesis is also typical for ordinary temples of the Don Region in the 17th-19th centuries. However, in contrast to the usual temples, those in caves in Don region do not have the same construction of choir screen. Only in five cave temples there is the classical construction with 3 gates.

These gates are formed by two column-pillars through which it is possible from the front side to enter the rock room. In most cave temples there is no *solea* (present only in cave churches near the villages of Kostomarovo and Belogorye, and Divnogorye). In this cave complexes there also space for choir place.

It is relevant to continue this work in other regions of the country to identify the specific typological features due to the territorial placement.

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Hypogean structures under the jurisdiction of the monastery of St. Silvestro in Capite between 10 and 13th centuries, in the Viterbo area, central Italy

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Abstract
The monastic community of St. Silvestro in Capite, composed of Basilian monks refugees from the Eastern Roman Empire because of the iconoclastic persecutions (726-767), had received, in 844-845 from Pope Sergio II, all rights on the St. Valentino Gate in Rome for the collection of tolls on people and goods in transit to and from the city.The substantial profits derived from the control of these kinds of key points of the Flaminia road encouraged the monks to try to obtain others and, thanks to the purchase of plots of land, to guarantee their increased presence on the banks of the main rivers of the countryside north of Rome. This continuous activity is well attested by the seal dated March 25th955, with which Pope Agapito II recognizes and confirms to the abbot Leone all the goods of the monastery of St. Silvestro. This activity lasts, at least, until 1285 when all the properties of the monastery are hand over to the order of the Poor Clares.
Examining the distribution of the properties, the widespread presence of the monastery in the Viterbo area, between the Cimini mountains and the Tiber river, is really evident and confirms a strong will to gain control of the territories gravitating towards the Amerina road and its secondary roads.In particular, the management of these territories seems to be in charge of two well-structured rocky settlements (Palazzolo and Aliano) and of some religious structures that seem to testify about the special bond between the morphology of the soil and the presence of the monastic possessions.
Therefore, starting from an analysis based on visual evidence of the hypogean structures, using a study that favors an extremely detailed observation of the cavities and their topographical context, the aim of this paper is to reconstruct the conditions that allowed the monastery to become an economic and social cohesion factor. This evolution took place thanks to the ability to organize and manage wide landed estates distinguished in vital areas near the main road, where there are more hypogean structures, and in remote areas, where there are more structures of hermitage style.

Keywords
Monastery, medieval, cavities, San Silvestro in Capite, Palazzolo, Aliano, San Salvatore

1. TERRITORIAL BACKGROUND

The territory under exam is included within the foothills of the Cimini Mountains and that part of the Tiber Valley that falls in the province of Viterbo; this is an area of 150 square kilometers including the Municipalities of Orte, Gallese, Soriano nel Cimino, Vallerano, Vignanello, Vasanello and Bassano in Teverina, in the Province of Viterbo, in central Italy.

The area is characterized by a wide plateau sloping from the Cimini Mountains to the Tiber Valley, with altitude varying from 500 ma.s.l. in the mountain sector and 67-70 ma.s.l. in the alluvial plain. The landscape is composed of tufaceous spurs of volcanic origin and shows rugged and irregular shapes, with the water stream carved into the incoherent tuff and determining the collapse of many rock spurs, which are often been regulated and excavated by the inhabitants. Often, along the ridge of the land between the valley and the mountains the erosion formed many natural flatlands and small plateaus, due to the different stiffness of the igneous rocks (tuff, ignimbrite, trachyte), shaped by human activity and excavated along the scarps with hypogeal spaces of different function, thanks to the presence of stiff tuff.

2. THE MONASTERY OF SAINT SILVESTRO IN CAPITE IN VITERBO AREA

As concerns the territory under exam the role carried out bythe monastery of Saint Silvestro in Capite shouldnot be neglected, even though its widespread presence in this sector of the Viterbo province between 9th and 13th centuries, testified by the rich archive, has never been subject to studies concerning the monastery's policies of land management. The expansion of the monastery seems to follow the Amerina road, all its properties are deployed along this route and its side trails; in addition to these waste properties included into the *massa Maiana* or *Ortana*, between the actual territories of Orte and Vasanello, other

properties were aquired by the monastery, thanks to an expansive policy made of purchases and donations, on the foothills of the Cimino Mountains, where a *fundus Corilianus* [Federici, 1899] is registered on an act of confirmation of properties by Pope Giovanni XII in 962, becoming the site one of the most famous hypogeal settlement in the Tuscia area, of which today remains only the Grotta del Salvatore, with the internal walls completely painted.

3. ANALYSIS OF THE ROCK STRUCTURES

The research carried out in the past years on the rock settlements in Latium region, and particularly in the roman countryside and Tuscia area, defined the methodology and the strategies for the study of this kind of structures and, at the same time, allowed to set up the main elements and features that characterize them. Today the state of studies, both on the gathering of data and their elaboration, offers a good starting point for deep analysis not only on the features recurring in rock settlements, but also on the diachronic evolution of each single cavity [Pastura, 2011 2013].

This last point is particularly important because, often, the research also analyses, together with rock settlement in good shape and with a complete documentation (like the settlement in Palazzolo and Aliano), groups of cavities that, even though they had a sure fundamental role in the dynamics of the land occupation, are "forgotten" by the historical and written sources. This is often the case forrock churches, surrounded by small clusters of cavities, like in San Valentino in Gallese, San Leonardo in the territory of Vallerano and San Silvestro and Santa Rosa in the territory of Vasanello, where the information could only be gathered through archaeological surveys. Leaving the discussion about the methodological aspects of the research to other works [De Minicis 2003; De Minicis & Pastura 2015], here it should be addressed that some "steps" in the approach to the knowledge of rock settlements are fundamental, because they offer important instruments of interpretation that, if correctly elaborated, could become a reference point for setting a chronology (even if relative).

During the first investigation, for example, it is the drafting of a precise metric survey and the recognition of the stratigraphy of the excavation marks, when readable, the fundamental instrument, together with the filling of a detailed data sheet for the database, that establishes any other following observation [Dalmiglio, 2008]. Only in this way the initial "planimetry shape", the shape before eventual enlargements and modifications, of a cavity can be identified and give information about its functional aspects. Thus, starting from a singular functional category and through a satisfying record of possibilities, deriving from the confrontation with the topographic context, it is possible to reach a good chronological proposal.

When studying a single unity, it is the reading of the exavation marks that represents the central part of the research, because the recognition of eventual different phases, in the making of the cavity and in its use, allows to define the moments of its enlargement or modification and to make hypothesis about its function in the different steps of its life cycle. In an homogeneous territory, as our case study, with a widespread diffusion during the centuries of inhabited tuff spurs, this methodology of analysis results particularly effective due to the characteristics of the rock (red tuff with black scoriae), that results easy to work and preserves perfectly the exavation marks.

This characteristic, with some exceptions, also allows to define the evolution of the instruments utilised in the differents phases of excavation. Althought this aspect is also kept a side, it is fundamental because, often, the use of defined instruments is connected directly with the functional role of the rock structures; for example the polished walls, made with axes or adzes, is rarely found in houses while itis typical of religious structures.

In this area the proposal of chronological sequences can take advantage from the relation between hypogeal structures and the architectural features at the same site, that can receive a sure date thanks to the copious bibliography on the subject. In many cases, when a modification takes place, a masonry work is used to stop or to stabilize the excavated structures, leaving a good sign of *ante* and *post quem* both for the masonry, that often comes with a well known chronology, than for the cavity, that often offers less information.

These considerations clearly come from the study of a wide territorial record, from the case of Palazzolo to Corviano, Aliano and Torricella where, for example, the fortifications of the *castra* obliterate a part of the rock settlement, in this way offering interesting elements for the relative chronology of the hypogeal structures at these sites. Further considerations can be made upon those structures that are partially excavated in the rock and completed with masonry, as in the case of the San Leonardo rock church in Vallerano. In thiese cases the chronological elements derive completely by the study of the building techniques.

To conclude, the processing of planimetric datas, together with other methodological considerations that have been shortly described above, allowed this area to get a typological classification and a relative chronology (Fig.1).

4. SAN SILVESTRO IN CAPITE'S PROPERTIES

4.1 Palazzolo

The settlement of Palazzolo[Pastura, 2011 2013] is situated in the territory of the Municipality of Vasanello and extends over an irregular plateau, with altitudes varying from 200 and 270 ma.s.l. The site was already occupied in the Roman period, probably in connection with kilns for the production of "*terra sigillata italica*" and relative structures, as testified by a tunnel dated to the 1st century B.C., used to deliver water to the pottery production activities and a sunken road, probably contemporary to the tunnel, that avoided to circumvent the plateau and created a direct way to cross it.

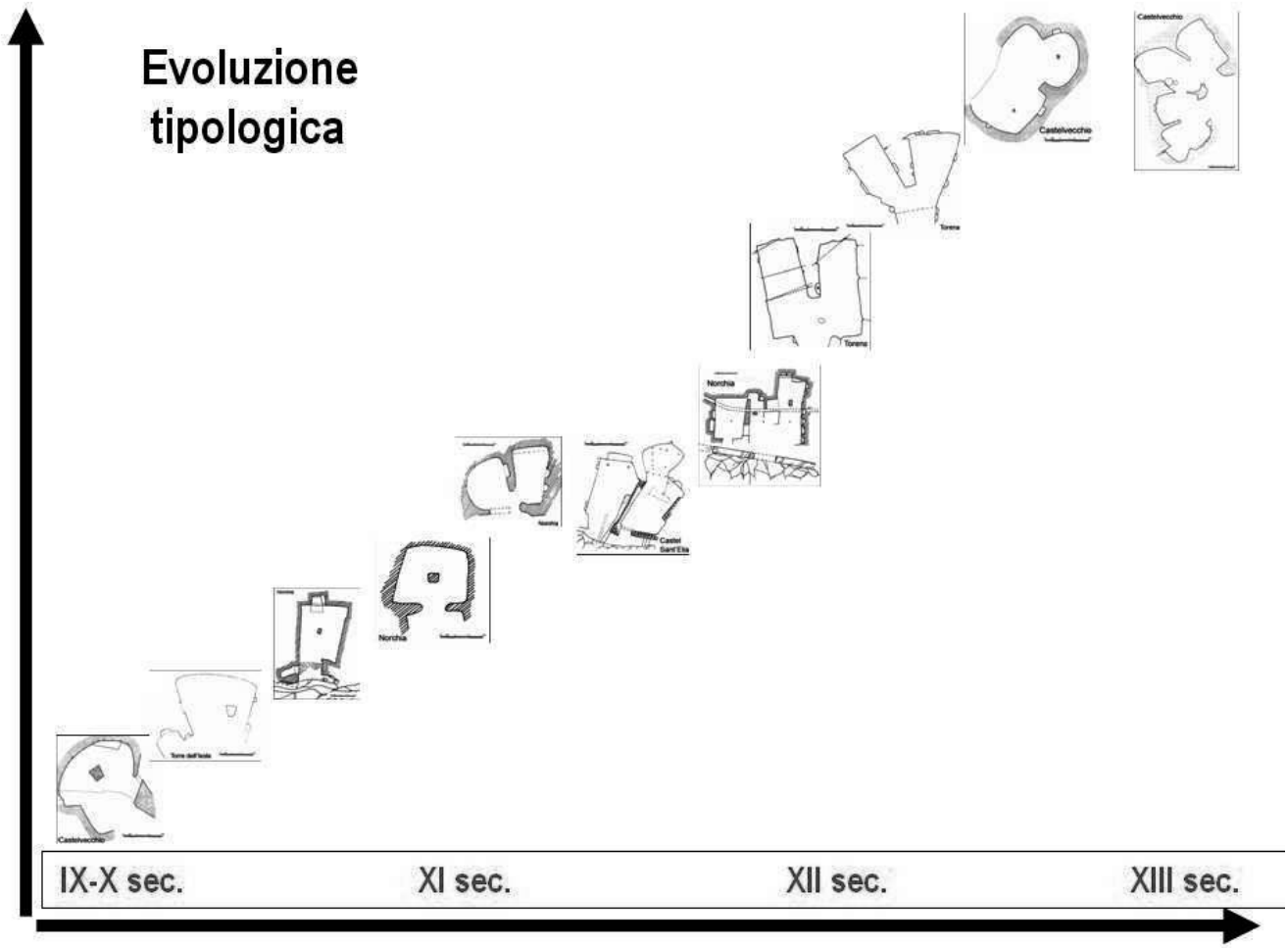

Figure 1: Typological evolution

Written sources are silent about the Early Middle Age, opposing to the archaeological findings over the plateau and the nearby area.

The presence of graves, hypogeal and build structures attributable, based on comparison, to the Early Middle Age testify that in this period the plateau was already occupied by a settlement. At a distance of 400 metres from the plateau there are series of graves excavated in the rock, organized on ledges at different levels, between the right side of the road and the Valle Canale moat. It is possible that this group of graves belonged to a wider cemetery, because similar graves are found to the north on the other side of the road and to the East (Fig.2).

The element that could link the cemetery with the first phase of the settlement is an enclosure wall made of big blocks, discovered during recent surveys, located just before the central sunken road in the plateau. Itis the only section of the enclosure wall thathas been left on the northern sector and it is important because is located in an area of the site that was believed to be not occupied by the settlement. The segments of this wall still in place lead to the hypothesis that the first Early Middle Age settlement in Palazzolo used the preexisting sunken road as a mean of defense other than of communication. So, in Early Middle Age the settlement is founded in the area of the plateau that was the easier to defend, because of the sunken road, once excavated to allow a better praticability of the paths towards the kilns, some hundreds of meters away.

The slopes of the plateau are occupied by 30 hypogeal structure, the majority of which is still accessible; to this number other structures should be added but their identification and accessibility still remain impossible because of their bad state of preservation. Other spaces have been cut by the excavation of the defensive sunken roads in the Late Middle Age settlement. The northern slope is the one with the most difficulties, because breaking of the tuff led to destruction of many structures. In the south-eastern slope there are five structures used in modern times as pens, that are difficult to read in their original function because of their long life and utilisation.

Eighteen out of the thirty cavities analysed are situated on the southern slope, whilst twelve are on the northern one,

often structured on more levels. Most part of the spaces are subdivided into rooms with openings on the walls that are often connected with a modification in the function of the cavities. Some structures to the South are really important and show masonry works to support the ceilings; these build up structures are dated to the 14th century and are sign of a modification and yet of a continuity in the use of these spaces. It is possible to say that the rock dwellings in the Early Middle Age rise on exposed rock ridges with a good water supply [Dalmiglio, 2008]. The diffusion of this kind of settlement seems to be connected with military and strategic needs, finding a good defense in the deceptive character of the places and defense equipment.
From the 11th century the history of the settlement is connected with the *castrum*, and the cavities seem to be located homogeneously along the ridge of the fortifications and are living together with them.
The cavities on the southern slopes are of particular importance because of their build up support walls that allows to set up a relative chronology of the modification in the function of the structures.

On a general assessment it could be said that the settlement was extended on 7500 square meters, unbelievable because the elements here represented didnot find comparison in the studies.
Palazzolo is shown on this map as a castle with round towers that donot have a comparison on the field.
The built-up settlement was established on the western part of the plateau, partially obliterating the hypogeums and giving *ante quem* and *post quem* terms for their life cycle.
The *castrum* was fortified by a strong enclosure wall that is still visible on the southern sector, while only few segments can be seen to the North, due to the erosion of this part of the plateau's ridges.

The settlement, as proved by many written sources, suffered many sieges and the life of its inhabitants was often disturbed by wars, fact that led to the decision to strengthen the defensive fortifications.
In particular, it was the place chosen for the church that created a weakness in the defensive system in Palazzolo, making the protection of the western sector of the plateau more difficult.

The church was then fortified and turned into a fortress in a phase of great changings in the settlements that can be dated, on the basis of historical sources and by the archaeological findings, to the 13th century. Also at that time two more defensive sunken roads and a dovecote were excavated on the eastern sector of the plateau. The study of this kind of production activities related to rock settlements highlights their usual collocation outside human settlements. The hypogeal structures with a partition wall, on the two slopes of the plateu corresponding to the build up sectors of the settlement, could probably be ascribed to this period. These structures are mostly located near the Republic Age tunnel, where later cisterns and basins have been excavated for a water system.

The hypogeal structures at both ends of the tunnel seem to be excavated and destined to a productive function. It is now difficult to interpret the production activity but it can be said that at the time of the construction of the castle they the expansion of the settlement did not stop after the foundation of the *castrum*, that is infact a period when the site sees the highest rate of inhabitants

4.2 Aliano

The medieval settlement of Aliano [Di Lallo & Zannetti, 2013] rises over a plateau on an area extended between the Amerina Road to the West and the Flaminia Road to the East and, even if there are no written sources before the 12th century, the archaeological findings go further back in time. The presence of the Amerina Road, with some findings along its itinerary, testifes the human occupation of the area at least since the Roman Period.

The settlement of Aliano is probably grown starting from the area surrounding the church and the site is characterized by a great differentiation in the type of hypogeal structures, excavated on more level. More or less all the planimetries that have been recorded for the Tuscia Viterbese can be found here [De Minicis, 2003].The structures with mixed planimetry are easier to connect with the building remains on the plateau and, thanks to the direct reading of the stratigraphic relations, it has been possible to state how these cavities were excavated before the building of the masonry structures. Infact, over one of these hypogeal spaces, and on its western side, it is possible to identify what should have been the first enclosure wall of the castrum, dated around the 12th century. The location on this same slope of cavities with central spared pillar, recall other Early Middle Age structures and allows to make the hypothesis of a rock settlement that was preexistant to the *castrum* buildings.
The built-up structures that are still visible today are the church and the bell-tower. Build at more than 10 meters one from another, the church to the West and the tower to the East, the two structures rise on the southern slope of the plateau. The tuff spur on which the *castrum* of Aliano rises is characterized by the presence of many artificial cavities, most of them hidden by deep vegetation and made inaccessible by collapses.

The cavities are located on different levels along the southern slope, while others are situated on the northern side; a total of 44 cavities have been recognised but only 27 have been able to undergo a deep analysis 17 of them are on the southern slope, and 10 on the northern side, while in the western sector the research is compromised by the absence of the original ridges of the plateau.
The settlement, expanded starting from the church, along the southern sector of the plateau, is encircled by the Fosso Carraccio and characterized by the passage of the crest trail that connected Gallese to Soriano nel Cimino. The area shows different kinds of hypogeal structures, often on more levels; there are round planimetries with flat ceiling,

hypogeums with central spared pillar, simple square cavities or cavities with partition wall.
The church, build around the 11th century, was maybe connected with the first rock settlement and only after the foundation of the *castrum* it has been enclosed in the fortifications. Probably the cavities with partition wall, that can be dated to the 11th century, were excavated in a context already deployed for dwellings.
The northern side of the slope is, as seen in the opposed side, characterized by rock dwellings. The western sector still shows a uniformity in the typology of the cavities and in the distribution of the spaces on different levels, while the eastern sector shows a completely different situation; here the spaces seem to correspond to the typology with dividing partition wall (Fig.2). Also on this side thee are the remains of a substructure, that can be dated to the first half of the 13th century, erasingtwo cavities that were excavated in this area.
It is probable, on the light of the data gathered, that the foundation of the settlement was earlier than the encastlement and the fortification works, and that some of the cavities were left outside the enclusure walls; The foundation of the *castrum* seems to have no influence over the expansion of the settlement: infact it keeps on growing in extension and in number of inhabitants.

4.3 San Silvestro

The complex known as "San Silvestro Chapel" [Luchetti, 2013] is situated on the eastern slope of a tuff spur two kilometers N-W from the town of Vasanello. The church is half excavated in the rock, half built, and articulated on two spaces: a larger one as main space and cultural area, and a smaller, probably used for service. The two spaces communicate with a rectangular passage opened in the tuff wall, which is a homogeneous partition wall intentionally and carefully spared during the excavation.
The main room, half-hypogeal, center of the religious activity, is a rectangular space with a length of 8,50 meters and a width of 4,50 meters.
The access, today not visible anymore, can be localized on the southern wall, aligned with the presbitery and oriented towards SE. The walls are straight, orthogonal to the back wall, which is entirely exavated in the rock. The western wall is only partially excavated and is completed by a built section, while the eastern wall is entirely built; the masonry texture is characterized by large tuff blocks, square and flattened (34-40 cm high, 40-120 cm wide), put in orizontal order and kept together by copious mortar.
The ceiling is a semi-cylindrical vault made of square ashlars organised along the generating lines and reaching height of 5 meters; the southern part of the ceiling couldnot be investigated because iti's interested by a cave . On both sides, in corrispondence with the impost point, 2,20 meters from the floor, there is a set-back that runs on the whole perimeter of the room. Near the back wall, 1,20 meters away from it, three recesses testify on both sides the presence of a wooden structure of uncertain interpretation.
The presbitery is defined by a step spared in the rock (50 cm high and 2,5 meters wide); in this area features related to the cultual activities are visible: a rectangular recess, maybe readable as an housing for the altar, and another small trapezoidal recess in the western wall, probably housing the tabernacle (on the surface 0,40 x 0,45 x 0,50 m; on the inside 0,80 x 0,45 x 0,50 m).
There are no traces of painted decoration on the walls, the only decoration is a layer of plaster covering the perimeter of the cavity, with signs of "scratches" used to correct the irregularity of the ashlars.
The second room is completely hipogeal, smaller than the main room (width 4,85 min the entry, 5,80 m in the inside; lenght 4,10 m), the ceiling is 2,35 m high, the planimetry is approximately square, without separation from the floor to the ceiling; the entry on the wall is oriented towards the SE. This room can probably be understood as a service or control space, as suggested by many architectonic features connected with housing. This utilisation has been observed in other examples, but it could not be excluded that this could have been a vestibule for the main religious space.
From the analysis of the architectonic features and of the masonry works, a stratigraphy of interventions can be detected and three different phases of use have been identified.
For the first phase there are unclear elements for a definite date, but following the hypothesis that the complex should be read as a religious building, it could be included in a wider historical context that sees a phenomenon of conversion to Christianity in the countryside led through the foundation of rural parishes, cells and hermitages. The San Silvestro Chapel is a structure aimed at connectng the contryside between Vasanello and Soriano nel Cimino under ecclestiastic management.
A second phase is connected to the building of the masonry walls defining the perimeter of the structure. The built walls encase the tuff walls on the western side and are built from the beginning in the semi-cyrcular vault and in the sounthern section.
In the western masonry wall, it is interesting the analysis of the trapezoidal recess, connected to religious activities; this element has got a depth corresponding to the distance between the tuff wall and the masonry wall, comparable to other cases dated between the 11th and 12th centures.
The third phase is connected with the plaster decoration of the western wall and of the first ashlars of the vault.
On the basis of the comparison with other types already known, it is possible to date this intervention between the 11th and the 14th centures.

4.4 Grotta del Salvatore - Vallerano

Pope Giovanni XII in 962, gives to the monastery of San Silvestro in Capite, as reimbursment for the properties that were alienated by the bull of Agapito II in 955, a *fundus Corilianus* [Federici, 1899], but the complex in exam is mentioned for the first time only in November 1112, when the monk Benedetto, with the license of the abbot Nicola,

constitutus abbas et rector de monasterio Sancti Salvatoris Corilianu, rents a vineyard in the *fundus Corilianu* [Federici, 1899]

Whati's left of the complex, included in the Municipality of Vallerano, is a rock church, once completely painted, excavated on the slopes of a spur and encircled by a stream; the church was part of a wider and articulated rock settlement. The rock facade, towards the North, suffered many events of collapse and erosion, that almost completely erased the upper part of the settlement and the facade of the church, also damaging the paintings.

An interesting description of what remains of the complex is the one made by the Moroni: *"in the suburban district called "*Pantanicchio*", there are two remarkable caves, the first of which is called "*San Salvatore*", because among the many figures of saints painted on the plaster of the vault, today almost completely ruined* (underling here an already precarious situation)*, there was the image of Our Saint Saviour. Nowadays it only shows the effigy of some Apostoles and Saints on the wall opposite from the entry, among wich can be still distinguished the one of Saint Benedictus. The altar is excavated in the same rock and over there is carved the inscription "*Andreas umilis Abbas*".*

The original planimetry should have been approximately rectangular, the walls are slightly arched with the angles rounded off and the vault, probably, flat.

The southern and western walls still preserve traces of paintings about the life of the Christ, during, before and after his death [Fiordiponti, 1899]: the nativity, the Apostles, the crucifixion, San Tommaso and a Christ Pantocrator in the vault.

Studies led at the start of the 20th century proposed to identify in the paintings a greek-bizantine influence, and a date between the first half of the 10th century and the second half of the 11th century [Bertini Calosso, 1907].

A recent analysis of the cycle seems to confirm this hypothesis, dating the paintings to the second half of the 10th century [Piazza, 1999 2006], at the same time of the first mention of the *fundu Corilianu*.

This highlights, probably, that the church was excavated in the first phase of occupation of the countryside by the roman monastery of San Silvestro in Capite.

The upper cavities, over the church, cannot be actually reached, but seem to be of the same typology and could be contemporaneus to the religious structure.

The 10th century coenoby was probably a well structured complex, with a church for religious functions on the lower part and the cells for the monks on the upper part, probably put in communication by steps excavated in the tuff.Recent surveys allowed to identify, in the area near the moat and at the same level of the church, cavities used for dwellings with partition wall, dated from the 11th century.

Morticelli-palazzolo

Aliano

San Silvestro

San Salvatore

Figure 2: Archeological sites (photos Giancarlo Pastura)

5. CONCLUSION

One of the main objectives of the research was to make a census of the monastic structures and properties and the set of their cartography. This work allowed to show a direct relation between the monastic structures, with their adjacent cavities, and theancient buildings. Omitting the subject of the roman viability, frequently these structures occupy territories already densely occupied during the Roman Period. The analysed cases, in particular the settlements of Palazzolo and Aliano, are small examples of a wider phenomenon concerning the documented and clear willing to exploit already existing structures, especially when connected to water supply, crossing of rivers and docks.

The spatial data from the cartography are eloquent, both the properties and the monastic structures are located on plateaus encircled by small streams of water, in accessible parts of the Cimino foothills, or along major rivers, like the Tiber and the Rio Paranza.

The properties of the great abbeys largely consist of land ownership and estates, productive activities, monasteries and castle, or parts of them. In regard to the surviving structures, these first surveys clearly show the close connection between the morphology of the territory and the human occupation, that since its origin uses these characteristics to its advantage. The Cimini Mountains and the Tiber Valley see monastic structures characterized by a rich hypogeal reality, and their study relied on the most recent discoveries in the field of the study of rock and hypogeal cavities in the Middle Ages.

These recent research allow to clearly connect the hypogeal phenomenon during the Early Middle Age to the new foundations of settlements and *castra* over already existing rock dwellings and structures [De Minicis & Pastura, 2015].

Both in the case of religious buildings and of settlements, the rock structures are supplied by buildings and masonry works that allowed the creation of a methodology *in situ* that follows the diachrony between hypogeums and built structures. For these latter a typological classification has been made, also thanks to a copious bibliography on the subject for the Viterbo area, that provides chronological elements supported by punctual archaeological data. In some cases, to deepen the survey in not published contexts, also newly introduced geophysical surveys and remote sensing techniques have been applied. Unfortunately the typological comparison, both of the hypogeal than of the built structures, canno't be applied outside the volcanic territory included between the Bolsena Lake, the Cimino Mountains and the Vico Lake, because the geology of the ground, made of red tuffs with black scoriae alternated by peperino stone, is a fundamental element for the human occupation in this territory, which follows and exploit the characteristics of these materials. The geomorphology of the tufaceous plateaus is also a problematic point for the archaeological research in these areas, because the territory is subject to the deterioration and flaking of the spurs where the abandoned settlements were founded, mostly *castra* connected with articulated and well dated rock dwellings.

Today iti's clear that there is a phase preceeding the *castra*, made of small religious structures with a connected cemetery. The cases of Palazzolo and Aliano testify a process of “restoration of the high grounds” starting from the 8^{th}-9^{th} centuries in places that, with the intervention of the Signorie and with the help of the monastery of San Silvestro in Capite, will find times of great splendor. Concerning the phenomenon of the encastlement, started in the territory in the second half of the 11^{th} century and in the 12^{th} century, the role of the monastery of San Silvestro in Capite seems fundamental for a more effective distribution of the population in the countryside, as testified by the great number of *castra* controlled directly by the monastery. Despite this period is commonly identified with the affirmation of the stone techniques in the buildings, the process of rearrangement of the settlements, mainly in the *castra*, characterized by a new distribution of the spaces, doesn't refuse the negative architecture; infact thanks to its knowledge of the territory it goes through a new period of development in the typology and number of newly excavated structures.

The excavation techniques doesnot change from the previous periods, but keep to be utilised both for urban interventions, to define new settling spaces, and for the creation of new dwellings, pens, storage spaces, production activities and defensive structures. Highly widespread, in this phase, is the dwelling with partition wall, present in all the sites analyzed and usually connected with periods of expansion of the settlement.

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Caves in Italo-Greek Medieval monasticism. New explorations and cultural function.

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Abstract

This paper aims examining the symbolic role of caves in the Italo-Greek Medieval monasticism in the light of the first archaeological surveys undertaken in Southern Italy.

Although Italo-Greek monasticism is a well-established field of study for written sources, it has only recently been examined in order to reconstruct its material aspects. In fact the first archaeological excavations that focus on Italo-Greek monasteries or shrines in Southern Italy were undertaken only in the 1990s.

Overall, the research is shedding light on a very complex picture of this kind of monasticism that have retained Greek traits and have absorbed Roman ones.

Material traces of a monastic use of caves and their large number of mentions in Italo-Greek monks' biographies testify that their highest form of holiness was referring to an eremitic monasticism, with desert and caves as its pillars. In fact where there were not natural caves (for example in cities like Rome), Italo-Greek monks dug artificial ones.

Keywords

Italo-Greek Medieval monasticism, material culture, first archaeological excavations, symbolic meaning.

1. INTRODUCTION

Although Italo-Greek monasticism is a well-established field of study it has only recently been examined in order to reconstruct its material aspects. In fact the first archaeological excavations that focus on these buildings were undertaken only in the 1990s, in monasteries or shrines belonged mainly to the period of the Byzantine Reconquest of Southern Italy, whose main Italo-Greek monastic areas were the Eparchy of Saline (Southern Tyrrhenian Calabria), the *Mercurion* (Northern Tyrrhenian Calabria) and *Latinianon* (Basilicata) [Zagari 2006, 2014] (Figure 1).

On the other hand, art-historical research was carried out in the often rupestrian sites of Salento (Southern Apulia) and Eastern Sicily, in the monasteries of the Lombard Cilento (Southern Campania) and in the Norman Sicilian sites [Zagari 2014].

Although this type of research has developed only recently, there is a long tradition of written sources studies. Among the literary sources the biographies of some of the leading figures of Byzantine monastic phenomenon in Italy stand out, reaching its acme in the ninth and tenth centuries, with Saints Elijah the Younger and the *Spelaiotes* in the Eparchy of Saline, Fantinus the Younger in *Mercurion*, the monastic family from Collesano in *Latinianon* and finally Saint Nilus of Rossano who founded near Rome the monastery of Grottaferrata (1004 AD) and united Italo-Greek monasticism, whence he came, and the cenobitism of Rome [Zagari 2014, 2015].

Figure 1: The main Italo-Greek monastic areas

2. THE CAVE IN THE ITALO-GREEK MEDIEVAL MONASTICISM

Written sources attest to the existence of three forms of Italo-Greek monasticism: the individual eremitism, the eremitism of small groups and the cenobitism. The cenobitism seems to have been the later form of this type of monasticism. It was the result of the correction of a large number of eremitic experiences promoted by secular and ecclesiastical authorities.

The phenomenon is recognizable around the 10th century in all dense monastic population areas of the Byzantine world. The outcome was a cenobitism with eremitic elements, usually rupestrian ones [Follieri 1993; Morini 1999; Zagari 2008].

In the Italo-Greek monks' biographies (*Bioi*), the "rupestrian solitude" defined the highest level of human perfection, the victory in the daily struggle against evil, obtained through the isolation from the world.

It began with the cave purification, as evidenced by the passage of the *Spelaiotes*'s *Bios* where the Saint dug the entrance of the cave to the east to let penetrate the light inside in order to banish the demons that had taken refuge into the cave [Zaccagni 1996; Falla Castelfranchi 2000; Forzatti Golia 2006; Zagari 2008, 2011].

The Italo-Greek monk ideally directed his whole existence toward the cave, transferring to it meaningful values, as we find them in Gregory of Nyssa's writings: the cave in fact represents the material world in which the soul is imprisoned and from which it will come out to see the afterlife light. The illuminating entry of God in the dark cave of the world and the exit of the Christian from that cave as a member of the resurrected Lord's retinue has explicit references to literary themes drawn from Plato's Republic and the cave of Bethlehem [Danielou 1964; Zagari 2011].

Therefore, the cave was the mediator between God and men because the latter, coming out of the cave, would get closer to God and God, by his son, had come among men through the cave [Zagari 2011].

In the cave Italo-Greek monks took refuge from Saracen attacks, but the cave was mainly their remote inhabited place to practice asceticism, where they temporarily followed the eremitic life in order to run away from the fame acquired. Saint Elijah the Younger, from the Eparchy of Saline in the Southern Tyrrhenian Calabria, went in the mountains of Mesobiano, in the north of the same region. Saint Nilus of Rossano spent a period of his life in Saint Michael's cave in *Mercurion*. Saint Vitalis from Castronuovo lived this experience in the heart of Basilicata and Saint Bartholomew of Simeri lived in a cave of Calabria, in Norman times [*Aa. Ss*., *Aug.* III 1867; *Aa. Ss*., *Sept.* III, 1868; Rossi Taibbi 1962; Zaccagni 1966; Giovanelli 1972; Minuto 1977; Morini 1999; Balducci 2004; Forzatti Golia 2006; Zagari 2011].

The hegumen's (the Italo-Greek abbot) stay in a cave was even codified in some *typika*, books that include both the rule of life and the rule of prayer of the community. Although there are a number of major *typikon* traditions, there are many local variations [Zaccagni 1966; von Falkenhausen 1977; Forzatti Golia 2006].

3. MATERIAL FEATURES: NATURAL AND ARTIFICIAL CAVES. SHEDDING LIGHT ON A COMPLEX PICTURE.

As regards material evidence, recent archaeological investigations are shedding light on a very complex framework, with Eastern monastic tradition followed and different monastic uses of the cave depending on chronology and geographical area of Italy [Zagari 2014].

The Italo-Greek monasticism has employed the cave, natural or artificial, for various functions. It has been suggested that remote mountainous caves were used as lavritic cells, with the common monastic buildings placed on a near hilltop. Tombs, different kinds of monastic buildings and especially churches were made into caves. A lavra was in fact a type of monastery consisting of a semi-eremitical settlement [Zagari 2011].

Figure 2: Melicuccà (Calabria), Church of the monastery of St. Elijah *Spelaiotes* (after Zagari 2006)

In the first half of the 10th century, with Saint Elijah *Spelaiotes* – the first native monk of the Greek Calabria – the rupestrian element became the background for a monastery in the Eparchy of Saline (Fig. 2).

This monastery had in fact all its buildings inside caves, sometimes enlarged and regularized by a craftsman who also built there saltworks and a mill [*Aa. Ss*., *Sept.* III 1868; Rossi Taibbi 1962; Forzatti Golia 2006; Zagari 2006, 2011; Morini 2009].

Calabria is the Italian region where caves seem more linked to the Italo-Greek monasticism, especially compared to other regions of Southern Italy, such as Apulia (Figs. 3-4), where the rupestrian churches appear mainly private and funerary [Falla Castelfranchi 1991, 2000; Martino 2003; Zagari 2006, 2011].

Figure 3: Vaste (Apulia), Crypt of Sts. Stephens (photo by the author)

Figure 5: Delianuova (Calabria), Monastery of St. Marina (photo by the author)

Figure 4: Ugento (Apulia), Crypt of Crucefix (photo by the author)

Figure 6: Cosoleto (Calabria), Caves and rock shelters of the Monastery of St George (photo by the author)

In Calabria, monasteries with rupestrian cells located outside the central core have been hypothesized in Locri (on the Southern Ionian coast), in the mountainous inland area of the Eparchy of Saline after Byzantine age and near Stilo (South-Eastern Calabria) in Norman times: the place "Cellia", along the Stilaro river, is perhaps to be identified with the "hill of the cells" mentioned in a Stilo Judge's judgment of 1098 [Cuteri, Iannelli 2000]; the name of "Pietra Cappa", due to the presence of caves, would originally belonged to a rupestrian monastic settlement of 9^{th}-10^{th} centuries.

In the Eparchy of Saline, archaeological excavations found the central core of the "old monastery of Saint Marina" of Delianuova on the top of a hill (Fig. 5) [Agostino, Zagari 2001; Zagari 2006, 2014], while the monastic cells, probably caves, had to be located in the surrounding area, such as in the nearby Saint George of Cosoleto, where caves and rock shelters are opened along the flanks of a hill (Fig. 6), on which lie the remains of the common buildings of the monastery [Minuto 1977; Zagari 2006, 2008].

Caves near Stilo, with burials and 12^{th}-13^{th} century ceramics [Cuteri, Iannelli 2000], have been associated with an eremitic or lavritic monasticism [Zagari 2011].

The only Italo-Greek dependent monastery (*metochion*) that has been dug up at the moment (Saint Marina of Delianuova) had a structure very similar to that of a *lavra*, with buildings arranged around a central open space (Fig. 7), including a small church with expanded floor plan in longitudinal direction and frescoes in the dome that seem to represent iconoclastic subjects. There, the buildings arrangement replaced the lack of a boundary wall [Agostino, Zagari 2001; Zagari 2006, 2014].

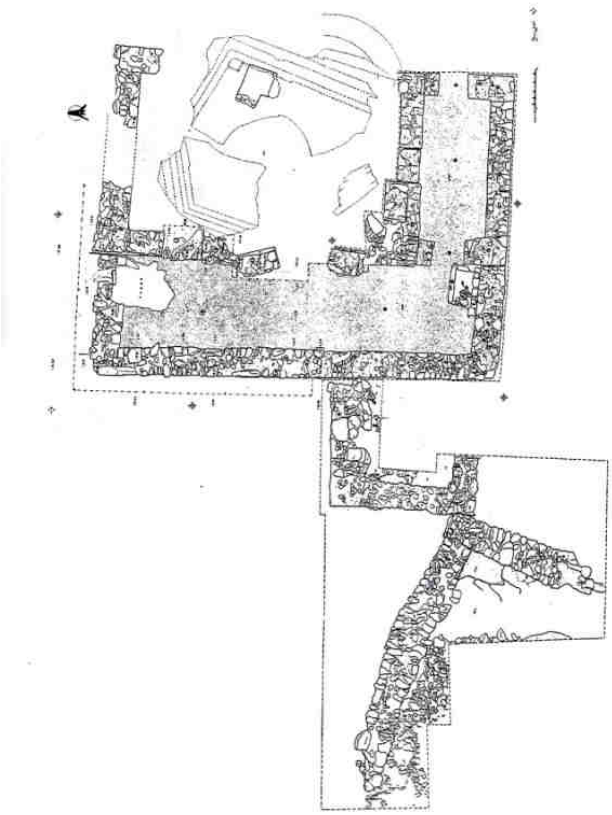

Figure 7: Delianuova (Calabria), Monastery of St. Marina (after Agostino, Zagari 2001)

The rupestrian churches are characterized by floor plans that often reproduce those of the contemporary masonry churches. They had architectural elements such as bench, rainwater tanks or *templon*, whose introduction in the Italo-Greek churches is however dated just before the Norman conquest [Dell'Aquila, Messina 1989].

There is not a single indicator in order to ascribe these remains to a monastery, but rather we have to use different types of sources: written sources that attest to the existence of caves related to greater or smaller monasteries, toponyms (especially agiotoponyms), frescoes, architectural elements, floor plans, as well as artifacts unearthed in archaeological investigations.

Frescoes certainly help to identify the Italo-Greek monastic use of rupestrian churches, both for the theme that they represent and for the position that they have inside the church: are characteristic of the local Greek culture subjects like the last communion of Saint Mary of Egypt, the meeting of Saints Peter and Paul and Saint monks in the niches flanking the apse.

The presence of Saint Fantinus the Younger in the right niche of the so-called "church of the Hospital" at Scalea (Northern Tyrrhenian Calabria) has been considered as an evidence in favor of a monastic destination of this Italo-Greek church, while the lack of a Saint monk in the same position within the Saint John in Vietri di Potenza (Basilicata) has led to doubt that it was a monastic church [Falla Castelfranchi 2001, 2009; Marchionibus 2004].

Saint Mary of Egypt was in fact one of the main female Byzantine hermits, whose cult spread to Italy from the ninth century [Falla Castelfranchi 2000]. The last communion of Saint Mary of Egypt is depicted in a fresco dated from the end of the 10th century to the early beginning of the 11th century (Fig. 8), located in the cave of Monte Stella.

The meeting of Saints Peter and Paul in Rome, or *Concordia Apostolorum*, alluded to the Roman pilgrimage. This theme is attested as monastic churches dedicated to the Chief Apostles (e.g. the monastic church of the *Spelaiotes*) and as iconographic subject of frescoes in rupestrian monasteries, for example in the Angel cave on Monte Consolino (South-Western Calabria) (Fig. 9) [Falla Castelfranchi 2000; Pace 2003].

The pilgrimage to Rome was in fact a peculiarity of the Italo-Greek monks, who tried to isolate themselves from the surrounding world and aspired to be Christlike (*imitatio Christi*).

Therefore the devotion of Italo-Greek monks to the Saints Peter and Paul seems to be referred to an "essentially Roman latitude" of their being Byzantine [Cozza Luzzi 1893; Rossi Taibbi 1962; Burgarella 1983; Stelladoro 1995; Falla Castelfranchi 1999, 2002; Burgarella 2002; Zagari 2006].

In Italo-Greek monasticism, the cave had a so important symbolic meaning that when it did not exist was created artificially. It has been proposed to identify as a monastic cave an underground corridor with four niches on each side that was dug into the s*tylobate* of the temple dedicated to *Mars Ultor* in the *Forum of Augustus* at Rome [Ricci 1926].

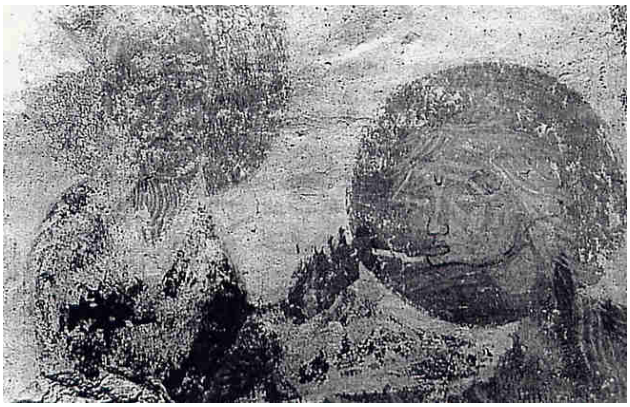

Figure 8: Cave of Monte Stella (Calabria), Communion of St. Mary of Egypt (after Falla Castelfranchi 2000)

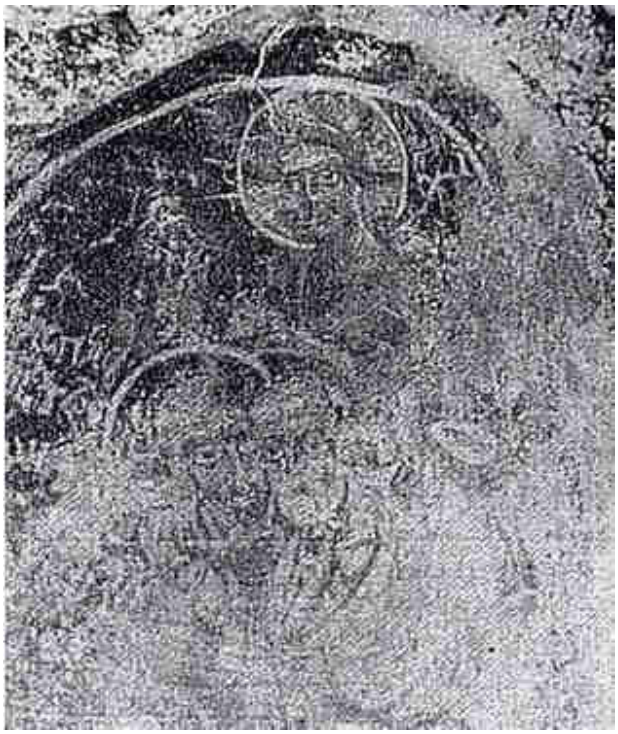

Figure 9: Angel cave on Monte Consolino (Calabria), C*oncordia Apostolorum* (after Falla Castelfranchi 2000)

This corridor (Fig. 10) was certainly made by Italo-Greek monks who built the monastery of Saint Basil *in scala Mortuorum* on the ruins of the ancient temple that was abandoned in the late 5th century or the early 6th century A.D. [Cousì, Felici 2010; Cousì, Ninel Pischedda 2010].

The first mention of this monastery in written sources was in a papal bull issued by pope Agapitus II in the 10th century [Ferrari 1967; Hamilton 1979], but the dating of marble fragments found in excavations suggested the 9th century A.D. [Ricci 1926; Sansterre 1988; Marazzi 2015].

The Saint Basil *in scala Mortuorum* was a small monastery with buildings arranged around a courtyard with a water well: the church with a porch was on one side and on the other a two floors building was perhaps the monastic refectory with cells upstairs [Meneghini, Santangeli Valenzani 2004].

The underground corridor was discovered in the 1920s, when it was interpreted as a sort of catacomb (e.g. the *scala Mortuorum*) of the Italo-Greek monastery [Ricci 1926]; a more recent hypothesis proposed that it was a cellar or a warehouse of the monastery itself [Meneghini, Santangeli Valenzani 2004].

The monastery of Saint Basil *in scala Mortuorum* was important because it was connected to the aristocratic family of Alberico. This family was marked out as Rome's super-elite family throughout the whole of this period, up to the middle of the 11th century at the earliest [Meneghini, Santangeli Valenzani 2004; Zagari 2014].

The Italo-Greek monasticism in Rome developed significantly between the 8th and the 9th-10th centuries. These Roman monasteries were mainly male foundations located inside the city walls. They were often built by members of the aristocracy or even by the pope and enjoyed also an unusual spiritual and intellectual autonomy. In this period, the Italo-Greek monks were chosen as technical advisors, counselors and ambassadors by popes, bishops and local lords (also Lombard ones) [Ferrari 1967; Sansterre 1974, 1983; Gribomont 1987; Castelfranchi 2000; Marchionibus 2004a; Zagari 2006, 2014; Marazzi 2015].

4. A SPECIFIC WEBSITE-ONLINE ACADEMIC JOURNAL

Since its establishment the Master TECAM of University of Tuscia has focused on the study of Byzantine monasticism in Italy, Northern Africa and the Near and Middle East: the professors are some of the major scholars of Byzantine monasticism, of its archaeological as well as artistic aspects. This Master's programme carried out a research project on the Exarchic Monastery of Saint Mary of Grottaferrata, which, from its foundation in 1004 AD, has occupied a prominent role in the Byzantine rite monasteries of Italy [Zagari 2014; De Minicis, Zagari 2015].

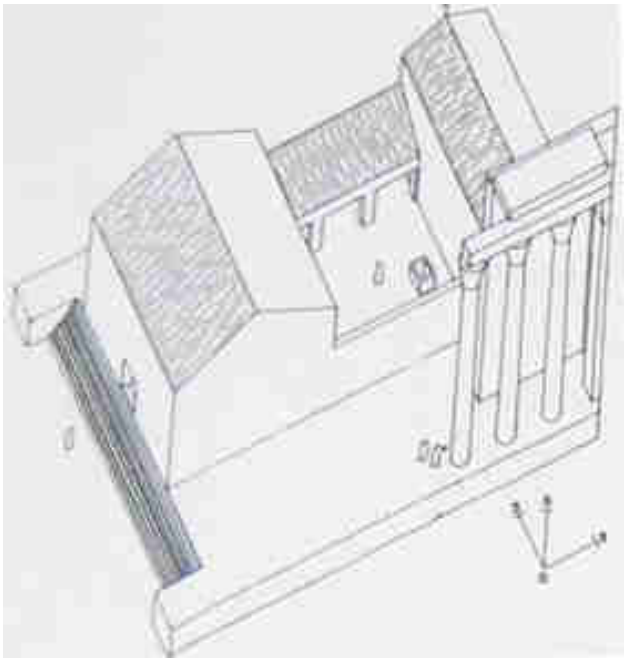

Figure 10: Reconstruction hypothesis of the monastery of St Basil *in scala Mortuorum* (after Meneghini, Santangeli Valenzani 2004)

Figure 11: Hompage of the website "Material Culture of Italo-Greek Medieval Monasticism - Master TECAM" (http://www.monachesimoitalogreco.it)

In the Master TECAM these experts have joined with those of a team that over the years has developed methodologies and strategies of investigation relating to Early Medieval caves, which were so important in the symbolic and material reality of Italo-Greek monasticism.

The website "Material Culture of Italo-Greek Medieval Monasticism - Master TECAM" (http://www.monachesimoitalogreco.it) aims being a meeting and discussion place between scholars with different backgrounds to bring together all the material aspects of Italo-Greek monasteries, to host research proposals and reports on various initiatives in this field of study (Fig. 11).

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SESSION 8

TYPOLOGIES, SYMBOLS, TERMS AND CADASTRE OF ARTIFICIAL CAVITIES

Painting on rock settlements in Cappadocia. A database and a virtual museum for the enhancement of the area

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Abstract
The Cappadocia Virtual Museum originated as part of the multi-year University of Tuscia (Viterbo, Italy) Mission. It provides innovative tools of documentation and communication for the enhancement and development of the Cappadocia site. University of Tuscia has led the project "Rock, rock-carved architecture, painting - Knowledge, conservation, development, at Cappadocia, Nevşehir Province, Turkey" since 2006. The project deals with all aspects of painting in rock-hewn settlements, over the entire history of the rupestrian habitat phenomenon. The project applies an inter-disciplinary methodology, linking the humanities with scientific and technical investigations. Since 2011, the university has joined with partners in devoting significant attention to the rock-hewn habitats of the valleys of Göreme and Kiliçlar, consisting of chapels, churches, monasteries and residential areas. The Italian Mission has provided for the analysis of a large group of sites (80 churches, 20 non-religious spaces). This has led to the design and implementation of a database on Cappadocian rupestrian settlements, churches and paintings. Each site was accurately documented in terms of location, architectural structure, function, decoration, and rock-hewn liturgical and lay furnishings. For the churches, particular attention was paid to recording the data on the pictorial decoration, including the presence of iconographic themes, their dating, techniques of execution and constituent materials, and the scientific analyses conducted. The project has also devoted extensive study to the Cappadocian landscape and rupestrian habitat, the essential context for the painted decoration. Having participated in other project aspects, the Italian National Research Centre played a leading role in the development and production of the Cappadocia Virtual Museum, including the database. The museum serves in the promotion of the area and the monumental sites through the offer of virtual visitation routes suitable to different audiences. The virtual museum visitor is accompanied through the valleys and introduced to specific areas of knowledge and research. The database section of the Virtual Museum permits both browsing and focused consultation using search engines.

Keywords
Cappadocia, Göreme, rock hewn painting, rupestrian habitat, database, virtual museum.

1. INTRODUCTION

The Cappadocia Virtual Museum (www.museovirtualecappadocia.it) originated from the multi-year Italian Mission of the University of Tuscia in Cappadocia, under the direction of Maria Andaloro. The virtual museum is a web application gathering the results of the field research carried out since 2006, and is divided in two parts: a *Tour* and a database titled *Cappadocia – Rupestrian Art and Habitat.* In different forms, these two elements reflect the complex structure of the entire project. The project objectives are to advance the knowledge, conservation and development of the rock-hewn heritage of Cappadocia, proceeding through a harmonic methodology based on inter-disciplinary approaches and integrated organisational forms, under which to direct the multiple themes.

On entering the first section, consisting of the *Tour*, the virtual traveller to the rock sites of Cappadocia can visit the Göreme Open Air Museum. Here they can follow a pathway integrating the rupestrian environments and paintings, stop in wonderfully carved spaces and wander amongst valleys and other-worldly landscapes, rock cones and pinnacles. The tour section offers the choice of over 40 videos illustrating specific themes, particularly the landscape and its morphology; the history; the rock-hewn habitat and its component settlements, and the pictorial decoration, from the palimpsests to the historic figures who commissioned the works. The videos present these themes through the voices of the different professionals participating in the Cappadocia Mission.

The second section, consisting of the *Database*, gathers and archives the many kinds of data and supporting materials (documents, images, drawings, maps) and makes them available for online browsing and research. The aim of the database is to integrate the entire body of knowledge on the mural paintings, considered within their rupestrian context, and to enable new readings based on the studies of their art-

Figure 1: *Tour* home page, with access to different sections

historic characteristics and the results of technical-scientific analyses. The database contains the information emerging from the studies and systematic investigations conducted on the rock-hewn churches and monastic, agricultural and residential settlements of Cappadocia. It currently houses 109 data sheets, 3788 images and 8000 further data sources. The entirety of the materials is available for public use through four search engines, dealing with: i) rock-hewn architecture; ii) liturgical and other furnishings; iii) the painted decorations, with particular attention to iconographic subjects and decorative motifs; iv) the scientific investigations into the materials and artistic techniques with which the Cappadocia paintings were executed. Finally, through access to a reserved area, the museum visitor can download images and obtain further information, such as attached documents. The reserved area can only be accessed by request to:
bancadati@museovirtualecappadocia.it.

2. VIRTUAL *TOUR*

The *Tour* provides the visitor with a graphic navigation system, based on specifically developed vectorial and thematic images, and leads to a selection of more than 40 video clips. The design of the virtual tour home page is based on the illustrations of the French explorer Paul Lucas, who visited Cappadocia between 1705 and 1714 [Lucas, 1714]. From here the virtual visitor chooses one of five sections: Landscape, Rock Habitat, History, Paintings, Project (Fig. 1). Each section offers access to a series of videos of not more than seven minutes each, grouped under different themes.

The first section leads to nine videos, organised in three groups.

1. **The landscape of the land** - The creation and geological evolution of the land, including its remarkable forms and colours, such as shades pink streaked with yellow from the union of volcanic tuff with sulphur. These aspects of the visit are narrated by the geologist Gino Crisci (Fig. 2).
2. **The landscape of man** - The visitor is accompanied by Maria Andaloro, art historian and director of the Italian Mission, to the place where the Kızılçukur and Güllü Dere valleys diverge. Here there await spires and hoodoos, narrow tracks between undulating rock faces, and small grape and garden plots. The landscape is explained as seen through the eyes of the 4th century fathers of the Cappadocian Church, the first explorers of the 18th and 19th centuries, and finally through selections from the most notable 20th century texts commenting on the landscapes.
3. **The landscape of ruin** - The ongoing processes of erosional events and rock collapses demonstrate a landscape that in a state of continuous change, and also in danger of loss [Museo Virtuale della Cappadocia 2016].

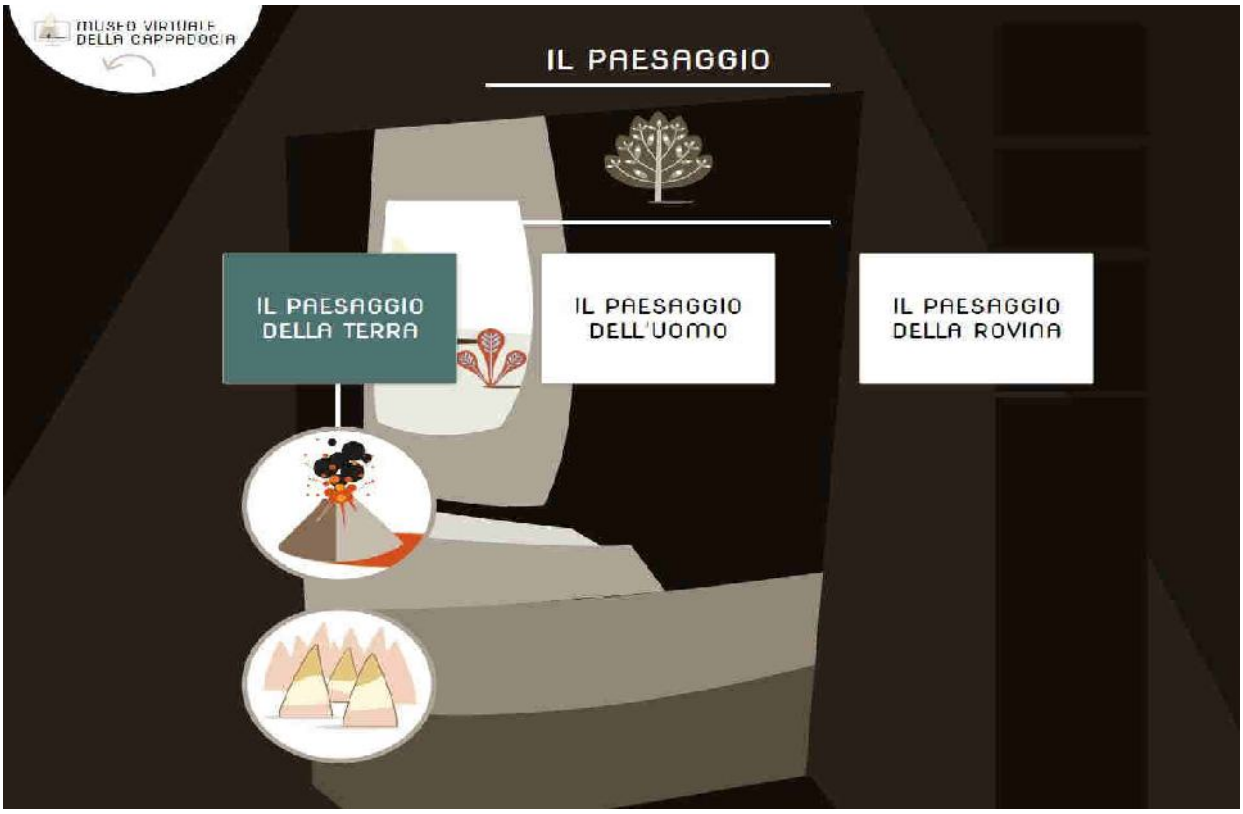

Figure 2: *Tour*. Landscape section with access to videos under the three themes

The second section of the *Tour* offers 17 videos dealing with the rock-hewn habitat and settlements. The members of the University of Tuscia research group address the different habitat types, such as the *palace,* the church and monastery, through examples such as the Beş Parmak monumental complex, near the small village of Şahinefendi.

The archaeologist Giuseppe Romagnoli offers an on-site illustration of this "court-yard" type of settlement, dateable to the 10th to 11th centuries. This site presents a quadrangular space, around which we find a series of excavated spaces, some with ceremonial function and others serving in habitation or utilitarian functions.

This settlement appears related to the habitats inserted in a nearby series of cones, including one which hosts the Church of the Forty Martyrs, and others that are probably related to an agricultural purposes: production spaces for wine-making, including vats for crushing grapes, collecting the juice and storing the wine. There are also stables, with mangers for cattle and horses.

The art historian Chiara Bordino presents the Old Church at Tokalı, with paintings dateable between 913 and 920, as an example of the group of churches identified as pertaining to the "Archaic" period. This is the period when, at Cappadocia, iconoclasm gave way to the so-called "golden century".

The paintings of this time feature extensive Christological cycles and multitudes of saints, and our outstanding for their freshness and vibrancy.

The New Church at Tokalı, perhaps the best-known monument of Cappadocia, presents a different case [Wharton Epstein, 1986; Jolivet-Lévy, 2015]. The rock-hewn interior is coated by a "second skin" of painting of extraordinary quality, worked over an ultramarine blue ground - the most beautiful and costly of all blues.

The foundation of the New Church, as well as its paintings, are datable to the mid-10th century, and can very likely be traced to the noble Foca family, to which the emperor Nicephorus (963-969) belonged [Andaloro, 2011]. The Foca family is again represented in another important rock-carved church a few kilometres away: the Great Dovecote of Çavuşin, dating in its original form to the years of the emperor Nicephorus (Fig. 3).

The second section closes with a video dedicated to a selection of the many monasteries scattered in the area of the Sword and Göreme valleys. The distinguishing element of a monastic settlement is clearly the refectory, or dining hall. Michele Benucci, art historian, accompanies the visitor to the Göreme XXIX monastic complex, showing some of its spaces, and stopping in a spacious hall clearly recognisable as a refectory due the presence of a grand table carved in white tuff, 13 metres long, thus able to host

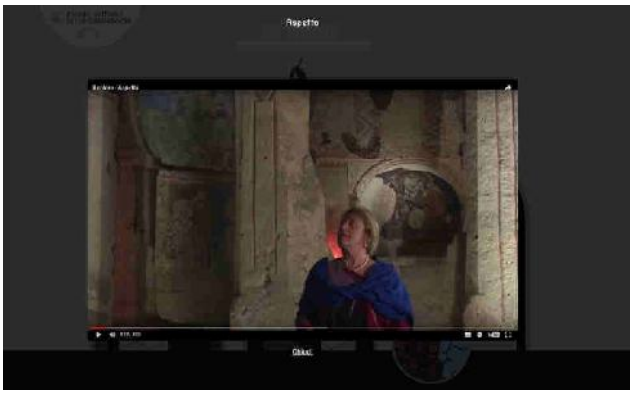

Figure 3: Screen capture of image from a *Tour* video

a community of at least 25 monks [Museo Virtuale della Cappadocia 2016b][1].

Entering the third section of the *Tour*, the visitor finds four clips that lead deeper into specific themes, particularly the histories linked to the fathers of the Cappadocean Church Basil, Gregory of Nyssa and Gregory of Nazianzus, who in the second half of the 4th century played fundamental roles in the origin and promotion of Christian art. After this, the art historian Maria Raffaella Menna, focuses our attention on the advent of Islam in the 7th century, and the subsequent counter-offensive [Haldon, 1999; Kaegi, 1995; Museo Virtuale della Cappadocia 2016c].

The fourth section of the *Tour* offers five videos dedicated to the paintings. The painting of the 6th to 8th centuries is illustrated through the example of the Üzümlü Chapel in Kızılçukur Valley, testimony to the ascetic life of Saint Nicetas of Remesina, and distinguished by the co-presence of a strongly decorative and iconographically dense figurative code. The theme of Theophanes and the Vision of Christ in glory between angel powers is well known to have been favoured for the decoration of the apses[2]. Here, it is analysed by Chiara Bordino through the example of the Haçli kilise, the Church of the Cross in Kızılçukur Valley [Jolivet-Lévy, 2015, pp. 153-154].

This section closes with two in-depth explorations of colour: first, colour as aspect, undisputable protagonist, and structural foundation of Cappadocian wall painting, provided by Maria Andaloro; second, colour as pigment. Here, pigment is analysed in its material composition, for identification of the palette used by painters between the 6th and 9th centuries and highlighting the elements of continuity and change. This research finds voice in the commentary of Paola Pogliani, art historian [Pelosi et al., 2013; Museo Virtuale della Cappadocia 2016d].

The last section of the *Tour* deals with two important sub-projects of the Italian Mission in Cappadocia: *The Church of the Forty Martyrs at Şahinefendi. A pilot project for restoration of the rock paintings*, and *Project Tokalı: Research, restoration and conservation in the New Church at Tokalı, Göreme*. Both of these initiatives have been endorsed by the Republic of Turkey General Directorate for Culture and Tourism, and carried out in cooperation with the Nevşehir Archaeological Museum. In both cases the restoration project is an integral part of a broader plan for the overall development of knowledge.

The Şahinefendi church conserves extensive painting cycles dating in part to the 11th and the early 13th centuries[3]. The dominant iconography of the entire decoration is the vast representation of the martyrdom of the Holy Forty of Sebaste, placed on the vault of the north nave. The first step in the study and restoration of the printed surfaces was 3D recording using laser scanner, accompanied by photographic and graphic documentation, then followed by the study and restoration of the painted surfaces. The objectives of the scientific investigations were to identify the degradation phenomena and analyse the execution techniques and pigments. The works of the years 2007 to 2012 comprised delicate interventions focusing on the restoration of legibility for the paintings, severely compromised by layers of soot. On 28 September 2013, the church and its paintings were once again turned over to the Republic of Turkey in an atmosphere of celebration, with the participation of government and administrative representatives, the local citizenry and the project staff. Today the Church of the Forty Martyrs at Şahinefendi is a monument open for the benefit of all, from the local citizenry to commercial guides and visitors.

The Italian Mission also welcomed the extraordinary opportunity of offering its scientific and operational contributions to the conservation project for the precious paintings of the Tokalı church in Göreme Open Air Museum. In 2011 and 2012 there were a series of photographic, 3D recording and diagnostic campaigns. The mission provided for the mapping of the conservation status and the emergency treatment for the naos walls. In 2013-2015, after providing the definitive conservation plan for the entire church, the works concluded with the restoration of the paintings on the north wall of the naos and in the apses [Museo Virtuale della Cappadocia 2016e].

3. *CAPPADOCIA RUPESTRIAN ART AND HABITAT* DATABASE

The *Cappadocia Rupestrian Art and Habitat* database [Museo Virtuale della Cappadocia 2016f] is a set of organised data, structured and linked under a model of relational logic. The database is organised in terms of catalogue records or “sheets” (Fig. 4).

[1] See Benucci et al. in this proceedings.

[2] Jolivet-Lévy, 1991, pp. 53-56; Rodley, 1985, pp. 184-189; Thierry, 2002, scheda 16.

[3] De Jerphanion, 1925-1942, II, pp. 156-174 ; Restle, 1967, I, pp. 158-160; Jolivet-Lévy, 1991, pp. 205-207; Andaloro, 2012; Andaloro, 2013.

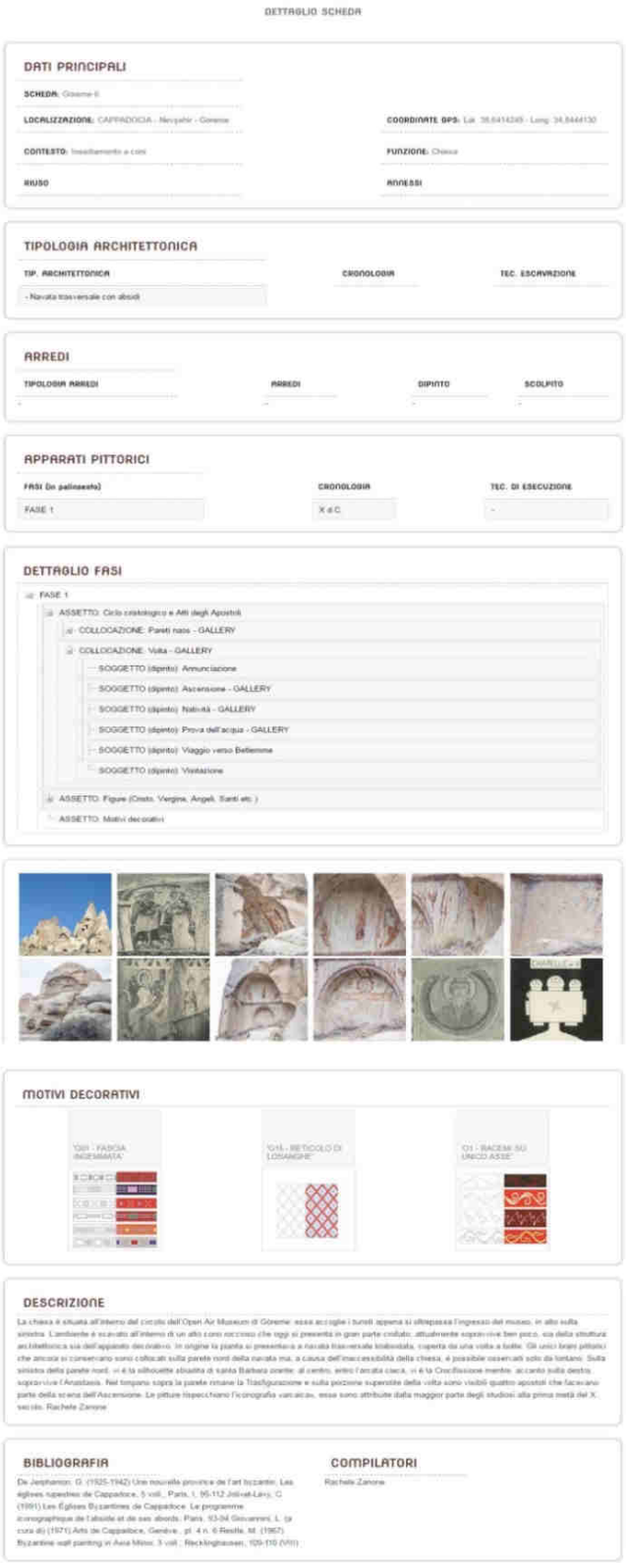

Figure 4: Database: example of a record (catalogue sheet)

Each record corresponds to a single site/area/church or other. The name of the record is that of the current name of the site/ area/church or other under examination (e.g. Göreme 11 - Saint Eustachius; Göreme XVII - Refectory). The record is structured in five sections: 1. **Main data**; 2. **Architectural type**; 3. **Rock-hewn furnishings**; 4. **Painted decoration**; 5. **Notes**.

1. Main data - This first section records the identifying data for the site/area/church or other, organised under the fields *Location (Region, Province, Locality), GPS coordinates, Rupestrian context* (wall settlement, cone settlement, etc.), *Main function* (church, funerary chapel, kitchen, refectory, room, stable, etc.), *Reuse* (dovecote, stable, stone quarry, etc.) and any *Annexes* not catalogued in a separate record (cistern, *parecclèsion*, stable, etc.) [Caprara & Dell'Aquila, 2004; Parise et al., 2013].

2. **Architectural type -** The fields of this section record the features of the rock-hewn architecture: the *Floor plan* (double nave with apses, central plan, single nave with apse, rectangular, etc.), the *Dating***,** and the *Rock-working technique* (roughly hewn, picked; smoothed, use of abrasives; finished, use of chisel and rasp, etc.).

3. Rock-hewn furnishings - This section contains all data concerning the *Furnishing type* (altar, refectory table, parapet, niche, etc.) and the *Decoration* of the features (e.g. sculpted and/or painted).

4. **Painted decoration -** This section of the database documents the paintings and painting cycles. The organisational logic provides for the frequent cases of a number of painting phases, at times with different distributions on the different walls and/or overlying one another in palimpsests. The structure permits the identification of the distinct *Painting phases,* with their relative *Dating* and description of *Technique*. The instances of painting phases superimposed in a palimpsest can also be recorded.

After having summarised the *Painted decoration*, the *Phase details* field is used to specify their *Location* within the rupestrian environment and describe their iconography. The *Iconographic subjects*, after being indicated as to specific *Placement* within the site/area/church, are further identified in terms of *Compositional, iconographic and decorative systems* (e.g. red drawing on hewn surface; non-iconic depiction, Marian cycle, Theophany, Christological cycle; decorative motifs, etc.).

The *Painting phases* and *Techniques of execution* subsections are closely related to the area of the database containing the results from the scientific investigations of the paintings: the stratigraphic analyses for the identification of the plasters and aggregates; analyses for identification of pigments, binders; analyses for levels of soluble salts;

Figura 5: Database. Access to search engines

colorimetric and multispectral analyses, etc. This part of the database can only be accessed through a dedicated interface.

The record then provides for insertion of any photo documentation, and concludes with the **Annotation** fields: *Brief description, Bibliography, Cataloguer* and, finally, *Attached images and documents* (listing the titles and authors of all archived documentation associated with the record).

The records and all their data are available for on-line public access, except for *Attached images and documents*, which are available only on request. The database can be interrogated using different types of searches. The user can also select images and create thematic galleries. The "private" section of the software is accessible to authorised personnel, and is used to carry out data entry, load images, and manage the identifying and other data.

3.1 Public section

The public section of the *Cappadocia Rupestrian Art and Habitat* database can be searched through four approaches: 1) Basic search, by record; 2) Advanced search; 3) Painted decoration, furnishings; 4) Scientific analyses and materials (Fig. 5).

1. **Basic research by record -** This search function lists all the records inserted in the system, on each site/area/church or other that has been analysed and archived. The user can scroll through the list and select a single record for viewing, including all the information and images available to the public. The user can also search for the full or partial name of a specific record, or with the application of filters by *Location* (Göreme, Çavuşin, Güllü Dere, Kızılçukur, etc.) and/or *Function* (church, refectory, chapel, winery, stable, etc.).

2. **Advanced search** - The user can search the database, choosing and combining various filters. The filters available are *Location, Function, Reuse*, (e.g. quarry, dovecote), *Annexes* (e.g. burial chamber, chapel) and *Architectural type* (e.g. single nave, central-plan). As an example, using the drop-down menu, the researcher could choose the locality as Göreme: the current configuration of the database yields 70 results. The researcher then has the option of filtering by Function, and from the different choices could select Refectory. The search then provides a list of four results, for the four records meeting the search requirements.

3. **Painted decoration and furnishings** - The user can also focus their searches on aspects concerning the Rock-hewn furnishings and Painted decoration, once again with the options of the filters described above, concerning *Location* (*Region, Province, Locality*).

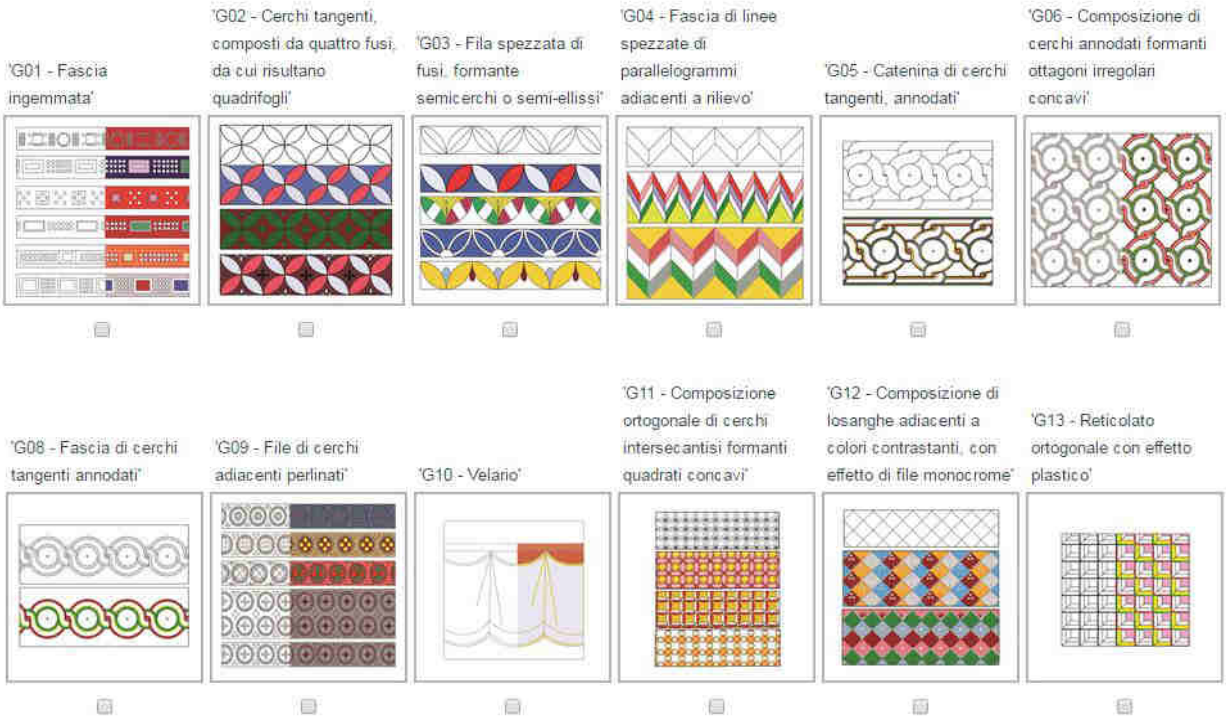

Figure 6: Database. Examples of decorative motifs recorded in the system

Concerning the specificity of features in the rock-hewn furnishings, and their relations to the function of the habitat spaces, the user can distinguish between liturgical uses (altar, ambon, cathedra, parapets, prothesis niche, etc.) and non-liturgical uses (water basin, cupboard, well-shaft, chimney, manger, etc.).

For Painted decoration, the search can be organised by *Compositional, iconographic and decorative systems* (e.g. Christological cycle, aniconic depiction; Decoration in red with geometric motifs and crosses; decorative motifs); by *Dating*; by *Placement* (e.g. apse, naos, narthex), and by *Subject* (e.g. in the case of a Christological cycle, by Nativity, Annunciation, etc.).
Searching by *Decorative motifs* is a specific case, different than for the other fields under Painted decoration. This field does not offer a drop-down menu, but instead a series of graphically represented patterns of the Cappadocia decorative repertoire. In fact, instead of producing a list of records, the searches under Painted decoration typically produce a gallery of photos (Fig. 6).

For example the researcher could call up all the Christological cycles, and within these search for the presence of a scene such as the Baptism of Christ. The search could be further restricted to the area of Göreme, and also filtered for specific dating. The researcher can then select from among the photos presented by the search, and use the Info button to proceed to the complete record. A search by Decorative motifs is different, in presenting a list of places in which the particular motif appears.

4. Scientific analyses and materials - Taking this approach, the user can search for a specific analytical report, or by applying filters under *Location*, *Dating* of the paintings, *Technique of execution* (e.g. an analysis of whitewash, plaster, etc.); *Analytical technique* (e.g. FT-IR spectroscopy, Raman); *Binder* (lime, gypsum, clay binders, etc.), *Aggregates* (sand, gypsum, etc.) and *Pigments* (hematite, azurite, yellow ochre, etc.)[4]. An example of a specific search could be that of a user looking for information on the use of the precious pigment lapis lazuli, in the locality of Göreme.

3.2 Reserved section

The database includes a section accessible only to registered users assigned on the basis of the necessary credentials. This Reserved section is organised in terms of 1. Management of identifying data, 2. Inserting a new record, 3. Searching, 4. User management.

[4] Until the current project there had been realised few study of the execution techniques for the Cappadocia paintings and there had been very little investigation of the pigments and binders. An overview of the studies conducted in this field is in Coşkuner B., 2010. Some of the previous works are Restle, I, 1967, pp. 198-228; Schwartzbaum, 1986; Dangas, 1995, pp. 171-180; Ozil, 1995, pp. 163-170.

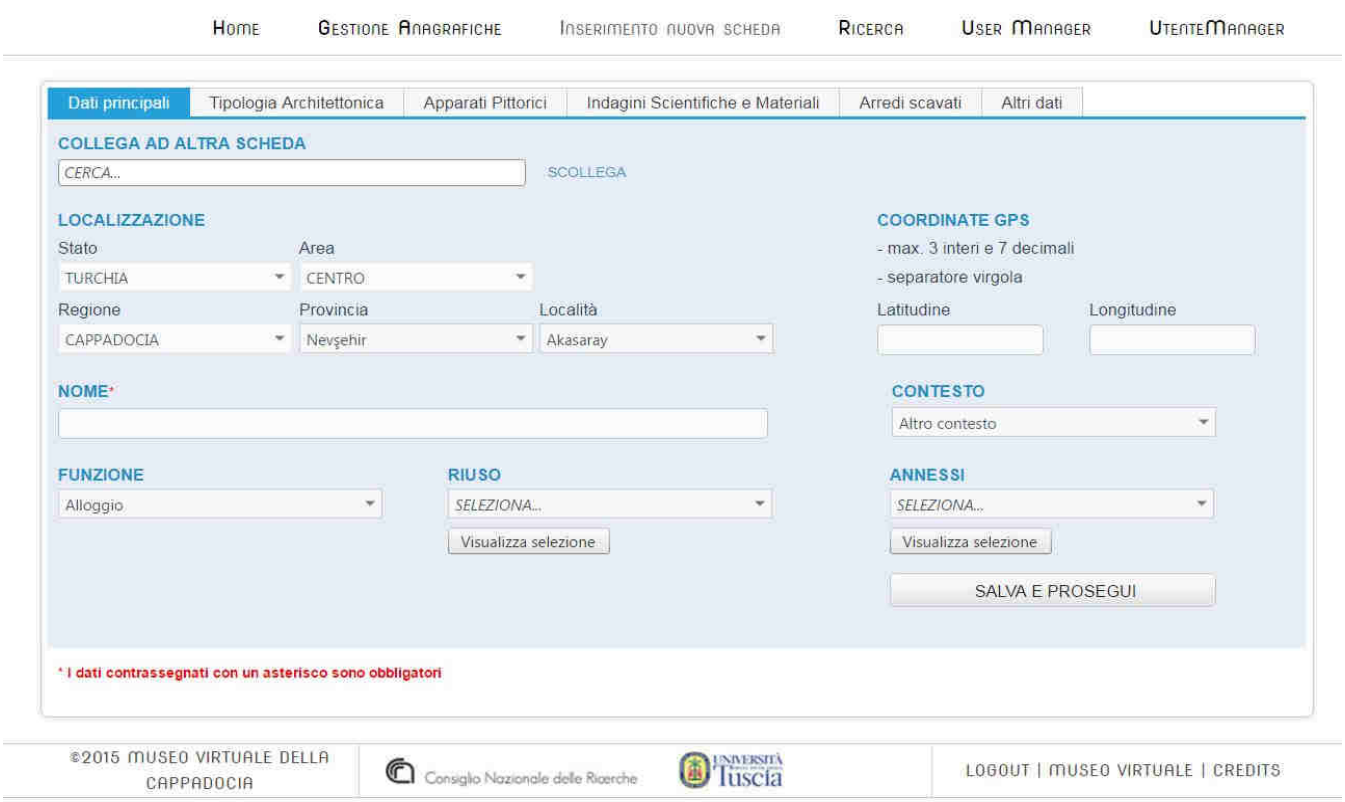

Figure 7: Database. Data entry interface for creation of a new "site/area/church or other" record (detail of the Main Data section)

1. Management of identification data - This section serves for the insertion of all the identifying fields and tables necessary for the compilation of the record, meaning all the standardised lexicons present in the dropdown menus that appear at the moment of compilation. The identifying fields can be incremented, corrected or eliminated. Currently, they cover the identification of **Site/area/church or other**, **Architectural type**, and **Rock-hewn furnishings** (all the data comprising the general sections of the record, including *Location, Context, Function, Reuse, Annexes, Dating, Rock-working technique, Type of furnishings*), and the area of the **Painted decoration**. This last section provides for insertion of the fields concerning *Compositional, iconographic and decorative systems, Placement, Subjects, Techniques of execution, Analytical techniques, Binders, Aggregates, Pigments*), *Decorative motifs* (with the insertion of the graphic illustrations of motifs), and *Attachments*. The attachments section is used to load digital forms of all documentation that complements and provides further information on the record contents. The program also allows for the insertion of high-resolution photographs, which are not normally available to the public, as well as 3D documentation, maps, drawings, etc. For each one of these, the operators can choose whether or not to make the title and author of the work visible in the public area. If the information is made public, the user can make a request to download and view the document by addressing an inquiry to: bancadati@museovirtualecappadocia.it.

2. Inserting a new record - This section permits data entry for the creation a new site/area/church or other record, and the compilation of the record. Only certain data are obligatory, while others can be omitted, modified, corrected or update. The data are mostly compiled using drop-down menus, under the Identification section. The data entry follows the sections of the record as described above, meaning: Main data, Architectural type, Painted decoration, Scientific analyses and materials, Rock-hewn furnishings, and Other data (Fig. 7).

3. Searching - This section provides the list of all the records currently present in the database. From here, the operator can carry out the actions of directly accessing the summary record (Info button), which presents all the data concerning the selected site, and of eliminating a record from the system. Finally, by clicking on the name of the record, the operator can modify its data and image content.

4. **User management** - Each user has an assigned profile, permitting the imposition of certain operations: i) Administrator – Individuals with this profile can

manage the users, access all areas and modify all data; ii) User manager – can access all areas and modify all data; iii) Operator – can modify all data but not access the heart of the database, meaning the Identifying data area; iv) Researcher – can access all areas and download the contents, but cannot modify the data.

4. A SPECIFIC CASE: THE SECTION OF THE DATABASE DEVOTED TO SCIENTIFIC ANALYSES

The section of the database devoted to scientific analyses is an integral part of the entire information system of the project, containing the results of the in-situ and laboratory analyses for the identification of the techniques of execution and the constituent materials of the Cappadocia wall paintings. It is configured as a valid tool for knowledge and presents a double structure. One part is dedicated to the identification of the materials, through the results of the different destructive and semi-destructive analytical techniques, and allows access to specific information on the chemical and physical character of the constituent materials. The other part provides ready access to information concerning the use of mortars, pigments and the identification of the technique of execution. The synergy between the two parts is created in the link that each element has with its contextual provenience through the data on the **location** of the paintings, which connect the scientific investigations to the database sections on the **painted decorations** and **rock-hewn furnishings**. The truly innovative aspect of the Cappadocia paintings database is this connection and integration of the data pertaining to the more scientific sphere with the data on the art-historic context.

The basis of this integration lies in the interdisciplinary work developed in the field, and then transferred to the scientific laboratories, in which the perspectives of the chemists, art historians and conservator-restorers interact in investigating the Cappadocia painting materials. In fact the methodological structure of the scientific section of the database draws on an approach developed in Turkey since 1997[5]. It was at this time, during the survey of the Carian region, that the database structure began to take form, using computerised catalogue sheets on the constituent materials and techniques of execution for the paintings of the region. The fields of the database reflect those of the catalogue sheets, which provide for precise recording of the locations of excavation (using images and/or graphics), a first screening through non-destructive diagnostic techniques, and finally the sampling of the materials, which is itself conducted through an analytical plan varying on the basis of the answers sought in that particular case. This same structure is maintained in the database on the Cappadocia paintings, but now benefits from new methods of communication and is made available on line to a different audience.

The structure is in fact a knowledge instrument for those interrogating the database for purposes of analytical or scientific research, but also for art historians and non-specialist visitors. The integration of the data permits research at different depths, and according to different knowledge objectives.

The "analytical techniques" field contains the list of the investigations conducted. For each investigation, the user can view the quantitative information, but above all this field enables the use of the vast amounts of data contained in the specific scientific databases.

The database structure develops links between the results of the scientific investigations and the contextual provenience of the materials investigated, permitting the broadening and deepening of knowledge on the individual paintings cycles and painting under study at Cappadocia. Following the unifying thread of the use of materials, these elements permit the identification of the original paintings-worksite activities, and of the characteristics of the different workshops active in the region. Moreover, by interlinking the considerations arising from the more traditional art-historic studies with the information on the techniques of execution, is possible to define homogeneous groups of paintings, helping to clarify the dating.

The database is a tool that offers clear advantages in studying the phases of Byzantine painting at Cappadocia, which extend through a chronological arc form the 6th to the 13th century. For example, in investigations following the use of materials, it is possible to circumscribe the use of gypsum mortars, such as those characteristic of paintings executed between VI and IX century, or to analyse the diffusion of precious pigments such as ultramarine blue that is in vast use in the church New Tokalı (mid-10th century), but which also finds application in other contexts of the region.

[5] The project has been conducted in Turkey from 1996 untill today. The first phase was realized on the island of Kűçűk Tavşan Adası and on many other sites in the territory of the gulf of Mandalya (Andaloro, 2007); the second phase takes place in Cappadocia from 2006.

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This paper conceived and authored by Maria Andaloro (particularly Section 1 - Introduction), Valeria Valentini (particularly Sections 2, 3) and Paola Pogliani (Section 4).

From Karalis to Cagliari (Sardinia, Italy). A three thousand years journey inside the artificial cavities of the city

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Abstract
This paper deals with the different typologies of artificial cavities observed in Cagliari, the capital city of Sardinia (Italy), analyzing the historical and spatial development of the urban centre. Since ancient times, the position of Sardinia island, placed in the middle of the Mediterranean sea, attracted people with different origins and cultures, namely Phoenicians (founders of the first urban unit), Carthaginians, Romans, Vandals, Byzantines, Pisans, Spaniards and Piedmontese. Over thousands of years, the city evolved among the coast, the lagoon areas and the limestone hills. The latter deeply influenced the urban spatial distribution. The city underground is characterized by many different types of artificial cavities that follow and sometimes influence the inhabited areas expansion: from limestone quarries to hydraulic-infrastructures (rainwater tanks, wells, aqueducts), from funeral areas to places of worship, from fortification and defensive walls to World War II air-raid shelters, there are many examples of new constructions, reutilization, abandoning and oblivion. Through exploration, research and analysis of the data, hereby the enhancement of the cavities is proposed, in order to recover citizen historical memory to be used for touristic and recreational purposes.

Keywords
Artificial cavities, Cagliari, urban development, enhancement.

1. INTRODUCTION

Cagliari, the main city of Sardinia island (Italy), is located on the southern coast, on the so-called Golfo degli Angeli. Since the Neolithic Age it has been characterized by continuous human presence. The urban area extends from the coast till the close hinterland calcareous hills. Cagliari's hills are around 100 m high, arranged on two rows parallel to the coast line. From north-west to south-east there are on the first row the following hills: Tuvumannu/Is Mirrionis, Tuvixeddu, Montixeddu/Monreale, Bonaria, S. Ignazio; behind them, there are S. Michele, Monte Claro, Monte Urpinu, S. Elia; among them, there is Castello hill (Figure 8). Nowadays, some of these hills have partially or totally disappeared either due to erosion, mining or construction excavation [Terrosu Asole, 1958-59; Stiglitz, 1999]. Cagliari underground is made up of well-known Miocene layers formed in a marine environment. From bottom to top the following layers are observed: clay, quartz-mica sandstone, marly-sandy limestone and, on the top, soft grained limestone [Terrosu Asole, 1958-59; Gandolfi & Porcu, 1967; Pecorini, 1986; Pala & Siriu, 1998]. The urban development was supported and influenced by easy ploughing and mining exploitation. Moreover, the city grew up in a strategic position, between Campidano Valley backcountry and lagoon areas, that were used as safe landing place since the Historic Age.

2. HUMAN SETTLEMENT AND DYNAMICS

Cagliari inhabitants lived in natural caves from the old Neolithic Age (6^{th} - 5^{th} millennium BCE) till early Iron Age (9^{th} century BCE) [Santoni, 2012].

This is shown by cardium potsherd (namely decorated potsherd with *cardium edulis* shell, which was used to impress the fresh clay) found close to Sant'Elia cave, located on the homonym hill and nowadays disappeared [Orsoni, 1879; Atzeni, 1986] and by late Bronze Age elements found close to the cave "Grotta dei Colombi" (end 12^{th} - beginning 9^{th} century BCE) [Taramelli, 1904].

The first artificial caves seem to have been excavated during Eneolithic Age on the northern side of the city. The hypogeous necropolis was composed by graves characterized by sepulchral cells excavated in the rock. These tombs belong to the 3^{rd} millennium BCE and can be accessed by a small well. The settlement is composed by

Recent and Late Bronze Age small sheds (13th - 10th centuries BCE) [Santoni, 2012].
Afterwards the settlement became more and more complex due to Phoenician presence which is documented on the western side of the Gulf, between Tuvixeddu hill and Santa Gilla lagoon, from the 8th to the 7th century BCE [Barreca, 1986; Tronchetti, 1993]. The increase of population due to foreign invasion caused a need for building material, in order to develop bigger houses and a wider urban center. Consequently, quarry exploitation started and rainwater cisterns were built.

These activities went on during Carthaginian age and after it (end of 6th century BCE), when the city, called at that time *Kalaris*, became an important urban center. In this period (between 6th and 3rd centuries BCE) one of the biggest Mediterranean necropolis was created on the western Tuvixeddu hillside (Figure 1). It is characterized by chamber tombs reachable by deep wells [Stiglitz, 1999; Salvi, 2000]. Additional Punic Age hypogeal graves were found on Bonaria Hill. They may belong to another housing unit, associated to the salt evaporation pond exploitation [Mureddu et al., 1988; Stiglitz, 1999].

After the Roman conquer, in the 3rd century BCE, the city moved gradually from Santa Gilla lagoon toward the south hillside close to the sea, to the nowadays city center. In this period the city started to be named *Karales*. Mining exploitation moved to peripheral zones and the water supply, which was till the 2nd century related to pits and rainwater cisterns, was guaranteed from now on by an aqueduct [Salvi, 2004; Salvi & Sanna, 2011]. In its way it intercepts the necropolis area, and several cisterns taking advantage of the exiting excavation and holes and using them as further water catchments [Spano, 1861; Dadea, 1999a]. Tuvixeddu and Bonaria hills were still used for funerary purposes (such as cremation) and graves and chamber tombs were excavated on the rock [Mureddu, 1993; Stiglitz, 1999]. Such sepultures were also found on the north side of the city close to the Botanic Garden and on the Castello rock sidehill [Spano, 1861; Spano, 1873; Ingegno, 1993].

During Vandal and Byzantine dominations (Late Antiquity and Late Middle Age) the city center seemed to keep the spatial distribution observed during Roman Age. The presence of a Christian Community contributed to urban redefinition by renewing the use of already popular places and creating new ones. The northern part of the city was characterized by a cultic caves system related to the presence of eastern monastic communities. From the 4th or 5th century this cave system was interested by reutilization and transformation [Spano, 1861; Taramelli, 1926; Dadea, 1999b, 1999c]. On the western side of the city a crypt that was used for funeral and cultic purposes was found [Spano, 1861; Spanu, 1998] and in Tuvixeddu necropolis chamber tombs could have been readapted for worship uses [Mongiu, 1995].

Figure 1: Tuvixeddu Punic-Roman necropolis (photo: Mattana M.)

During the 8th century *Karales* was abandoned, probably due to Arabs attacks, and the inhabitants moved on a safer place close to Santa Gilla lagoon, in the area that was already populated long before. The presence of Santa Igia/Santa Cecilia *villa* is documented there since the 11th century. The *villa* was the headquarter of the territorial governor of this age called "Judge". The *iudex* were the rulers of the autonomous States in which Sardinia was splitted since the 11th Century, called "Giudicati" (Cagliari, Gallura, Torres or Logudoro, Arborea) [Ortu, 2005; Martorelli, 2013].

Since 1217, the time of the Pisan invasion, Judges and Pisans power coexisted. The latter headquarter is called "Castel di Castro", a fortress built on Castello hill (on Golfo degli Angeli highest and most panoramic point) [Cadinu, 2001]. The Judges age ended in 1258, when Pisans destroyed S. Igia *villa* [Fois, 1986; Martorelli, 2012]. After that, close to Castello district, three new areas were inhabited: Marina, Stampace and lastly, the "rural" Villanova. Each district was equipped with defensive walls and nowadays Cagliari still keep the urban shape defined at that time. The changes underground are a reflection of the changes at the surface, and the artificial cavities followed the needs and the wills of the rulers.

Pope Boniface VIII established *motu proprio* the Kingdom of Sardinia and Corsica, and gave to James II of Aragon the right to invade it (*ius invadendi)*. The king conquered Sardinia and expelled Pisans in 1324. Catalan and Aragon conquerors did not change the *forma urbis*, but built defensive walls.

Afterwards, gun power discovery and the subsequent weapon development changed the defensive strategies. Consequently the walls were downed and had a curve profile in order to change bullets direction and better resist to them. Furthermore the new weapons needed wide space for maneuvering thus first bastions with big walkways were built [Urban, 2000].
After Ferdinand II of Aragon and Isabella I of Castile marriage in 1469 Sardinia became part of Spanish Empire.

Figure 2: Capuchins Garden big cistern (photo: Mattana M.)

Figure 3: Part of roman aqueduct (photo: Mattana M.)

During this Age the fortifications were reinforced and modified since defensive structures were inadequate to support the defense means weight. Military tunnels, often underground, were created in order to move soldiers and weapons. In the Castello district, offensive and defensive underground ways were created, the so called mine and countermine tunnels [Cossu, 2001] (classified as D.03 on the internationally approved classification of artificial cavities [Parise et al., 2013, Galeazzi, 2013]). In order to build them both new tunnels and already excavated water supply cavities were used [Rassu, 2003].
In 1713 Sardinia was annexed to Austria and in 1718 to Piedmont. The defensive structures, mainly the bastions, were extended. Fortifications were improved showing, once more, how defensive needs influenced the urban spatial distribution, restricting the city area and delimiting it by defensive walls [Colavitti, 2003].
Only during the 19th century, with the construction of a main out-of-town road, Cagliari began to expand behind its walls and changed its urban arrangement [Colavitti, 2003]. Its expansion brought to the defensive wall demolition. Nowadays entire defensive walls can be observed only in Castello district. That is due to Gaetano Cima regulatory plan, dated October, 9 1958, that aim at connect the different city areas in order to allow a better communication between them and open Cagliari to the rest of the Island and to Mediterranean commerce. The plan proposes an "open city", destroying the defensive walls, Stampace bastion and the old doors of Castello and Marina districts and connecting Stampace and Villanova districts. The main aim was thus to create an organized city, with new roads and a regular geometry, making breaches in the fortresses that were till that moment a symbol of division [Del Panta, 1983].
During Contemporary Age Cagliari underground use was mainly related to the War World II using cavities as air-raid shelters. Many existing underground places were adapted to this role and some others were constructed. Cagliari was heavily devastated during War World II.
After the war, in the second half of the 1940s, displaced people coming back home and homeless started living underground, readapting many cavities to warehouses and houses.

3. DESCRIPTION OF SOME SIGNIFICANT ARTIFICIAL CAVITIES

Due to the big number of Cagliari artificial cavities, only some of them will be hereby described, more specifically Tuvixeddu necropolis, the big rainwater cistern located on Capuchins Garden, the Roman aqueduct, Santa Restituta Cript, Sant'Efisio Cript, Santu Lemu cavity and Su Stiddiu and La Frana cavities (Figure 8). The ones chosen are considered to be the most significant and explicative and are characterized by many different uses over the course of time.

Tuvixeddu necropolis investigation allows to better understand the old urban spatial distribution. Tuvixeddu (classified as C.02 on the internationally approved classification of artificial cavities [Parise et al., 2013, Galeazzi, 2013]) is well known due to its extension that goes from the homonym hill till the road at the base of it (Figure 1). Its development started in the 6th century BCE and ended during Imperial Roman Age (2nd century BC).
The chamber tombs, belonging to Punic Age, can be reached through deep vertical wells. In some cases astral symbols (depicted or bas-relief) are found on grave doors (i.e. solar disk, moon sickle) [Salvi, 2000]. The graves "Tomba dell'Ureo" and "Tomba di Sid" keep interesting frescos on their walls [Mattazzi & Paretta, 2007].
Some more interesting Roman Age cavities are the " Grotta della Vipera" and the "Tomba di Rubellio". The latter was recently restored, whereas the former is the family mausoleum of the Roman noblewoman Atilia Pomptilla and of her husband Lucio Cassio Filippo. It is dated between the second half of the 1st century BCE and the first half of the 1st century CE [Angiolillo, 2000]. Tuvixeddu necropolis was abandoned for several years and only recently have been again interested by excavation and restoration in order to safeguard it [Paretta, 2012; Salvi, 2012].

Figure 4: Santa Restituta Crypt (photo: Mattana M.)

During the 1980s the Gruppo Speleo-Archeologico "Giovanni Spano" studied and surveyed several graves in this area [Tiddia & Tiralongo, 1984].

The **Capuchins Garden big cistern** (A.4 [Parise et al., 2013, Galeazzi, 2013]) is a Roman Age wide room which was, originally, probably used as quarry (see Figure 2) [Spano, 1861]. It may have been abandoned due to roof collapses caused by incorrect exploitation methods. Subsequently it was covered internally with *cocciopesto* (namely fragments of earthenware or brick mixed with lime and sand used to waterproof the cistern internal side) and the quarry entrance was closed by a thick wall reinforced by the adjacent embankment in order to reuse it as rainwater cistern.

Afterwards it could also have used as a prison. This theory is supported by the presences of rings hanging on the walls and a presumable Early Christian graffito **[**Dadea, 1999a]. During plague in 1656 the big room, which was at that time not used anymore and empty, may have been reused again to dispose the human corpses.

Father Capuchin Giorgio Aleo talks about this use in *"Storia Cronologica di Sardegna" (Chronological Hystory of Sardinia,* but does not give any specific information about the cistern position, thus it is not sure whether he is referring to this or to another site [Aleo, 1926].

The cistern is directly connected to drainage channels in Palabanda valley through Roman aqueduct segments. A Roman Amphitheater, partially excavated in rocks, can still be found on the above mentioned valley [Pala, 2002]. Its suggestive presence offers also the opportunity to trace the old artificial waterways.

The **Roman aqueduct** (A.3 [Parise et al., 2013, Galeazzi, 2013]) is a very important example of artificial cavities reutilization in Cagliari (Figure 3). Many water tanks and catchment made before Roman Age were in fact "recycled" and connected in order to conduct the water to settling tanks and then distribute it. Even so, the water was not enough and during the 2nd century CE an aqueduct intercepting water from a spring about 45 km far away from the city was built. The aqueduct is partially underground and partially above ground and includes basins and waterways that already existed. Its path is still being studied and GSAGS is involved in its surveying and investigation [Ranieri et al., 1995-96; Pani, 2007; Salvi & Sanna, 2011]. Thanks to unexpected finding, mainly due to building activities, part of its underground path inside the city was reconstructed and it is under analysis in order to establish the original waterways. In particular, GSAGS, on Superintendency for the Archaeological Heritage demand, explored in 2003 part of the aqueduct casually found in a construction site on the NW side of the city. During this

exploration, a tank deviating the water flux toward a water lifting plant was found. The conduit was filled by recent debris and empting it about 800 m aqueduct was reconstructed and analyzed [Salvi et al., 2015]. The inspection wells are also very interesting. GSAGS exploration and investigations showed that they were enlarged and waterproofed in order to collect the water from the roofs and to use them as small private tanks. Subsequently, they have been often used as trashes: analyzing the wasting layers, refuses from Early Middle Age to present were found.

Santa Restituta Crypt (C [Parise et al., 2013, Galeazzi, 2013]) is located in Stampace district, under the homonym church (Figure 4). Santa Restituta church was built between 1640 and 1645, it has a rectangular plan, three chapels at each side and barrel vaul. There are no elements indicating there was already a building there before it [Angioni, 2002].

Originally it was a natural cave and in the course of time it was used for several purposes [Spano, 1861].
Archeological exploitation in 1973 showed that it was used in six different historical ages: Nuragic, Punic, Roman, Middle Age, Modern and Contemporary Age. Right now it has an irregular shape of about 18 m length and 14 m large and, at most, 6 m high [Lilliu, 1988].

The room was from time to time modified in order to readapt it to different uses, such as limestone quarry, storage room and place of worship [Lilliu, 1988; Usai, 1988; Dadea, 1999b]. More specifically several altars were built, including the one that should host Santa Restituta relics. Traditionally, Santa Restituta was known as a martyr woman in Africa in the 5th century.

During High Middle Age, on the southern part of the Crypt, some seats were excavated in the rock and more recently, in the same area, several human remains were found [Lilliu, 1988].

The Crypt was most probably used by an oriental monastic community that was present at least till the 13th century, as shown by a fresco fragment, probably much bigger originally, depicting John the Baptist [Lilliu, 1988; Dadea, 1999b; Dadea et al., 2000] .

Recently the fragment was studied more in detail and a new hypothesis about it was done, concerning a High Middle Age painting reworked during Early Middle Age on commission or for worship needs [Usai, 2015].

Figure 5: Sant'Efisio Crypt (photo: Mattana M.)

Figure 6: Santu Lemu hypogaeum (photo: Mattana M.)

In 1263 the archbishop of Pisa, Federico Visconti, visiting Cagliari, went also to see S. Restituta area, even if written whether he visited only the above ground church or also the underground crypt. [Tola, 1861].

The hypogaeum was abandoned till 1607, when Saint Spirit Brotherhood, founded at that time, started again to use it (and kept it till 1861). In obedience to archbishop Desquivel, the Brothers started a martyrs corpses research in 1614 and founded several funerary inscriptions and a vase where was written "*Hic Sunt Reliquie Santa Arrestituta*" [Saiu Deidda, 1988].

In order to find a proper place for the relics, a presbytery including a high altar, lateral altars and a pulpit was built (the so called *"capilla mayor"*, pinpointed by a triumphal arch). In 1939 the crypt was converted to air-raid shelter: four big square pillars made by stones and concrete were built; a stone wall was constructed close to the entrance stair for protecting against fragmentation [Angioni, 2002]. The pillars were destroyed in the 1970s during archeological excavation. The GSAGS, together with other Cagliari speleoclubs, studied and surveyed this cavity [Cilla et al., 2012].

Sant'Efisio Crypt (C [Parise et al., 2013, Galeazzi, 2013]) is located very close to Santa Restituta, almost totally under the homonym church (Figure 5) [Spano, 1861; Taramelli, 1926; Dadea, 1999c; Quartu, 1999; Angioni, 2002]. It is excavated in limestone, has an irregular square floor plan and two pillars that support the roof.

On the eastern side there is a small apse with placer trace on it. A decorated marble altar is located in front of it. On the altar right side, into a wood fence, there is an old column at which a legend has it that Saint Efisio, protector of the city, was tied. On the west side, under an irregular recess, there is a two meters deep well. A waterfall gutter that ends on the well can be observed along the wall, above some excavated seats.

Santu Lemu cavity (C [Parise et al., 2013, Galeazzi, 2013]) is located in Fosso di San Guglielmo, at the northern side of the city (Figure 6). Originally this big room was probably a quarry and during Ancient Age was used as a rainwater cistern. During Pisans and Spanish invasions it was partially destroyed and used again as source of material for building the city defensive walls.

An altar built in 1760 highlighting the sacral use of the cavity is documented by Giovanni Spano, an academic interested in many fields, such as history, archeology, glottology, Sardinia ethnology. from which the Gruppo Speleo-Archeologico "Giovanni Spano" takes its name. He wrote that the place was probably used as monastery by San Guglielmo hermits [Spano, 1861]. In the 19th century it was used as an ossuary.

During World War II the cavity was partially readapted in order to be used as a hospital. More than thirty rooms were built inside it, in an area of about 850 m^2. The four big rooms on the lowest floor are flooded during raining periods and emptied again in dry times. The ossuary is located on the left side of the hospital and was studied by GSAGS, that found a relief cross above a recess, confirming the worship use of the cavity [Pani & Bianco, 1990; Rassu, 2011; Vacca, 2011].

Another very well know and legendary place under Cagliari is **Su Stiddiu,** shown in Figure 7 ("the dripp" in Sarde). This was probably a quarry converted to water tank [Spano, 1861] and subsequently, at the end of the 19th century, it was used as beer warehouse by Ferrero – Barisonzo company [Cugia, 1892]. During World War II it was used as air-raid shelter [Rassu, 2013]. Due to urban development it changed very much in the last decades and it is nowadays totally underground. GSAGS was involved in several studies related to it [Mascia, 2011].

La frana cavity (*frana* means landslide in italian) is located nearby Su Stiddiu. It was rediscovered in 1987, due to building sinking. It is a wide room born as quarry, as shown by the evidence of exploitation on its walls.

Figure 7: Su Stiddiu cavity (photo: Mattana M.)

Figure 8: Significant Cagliari artificial cavities and Sardinia overview.
Modern plan (left side) from www.sardegnageoportale.it (©2016 Regione Autonoma della Sardegna)
[old Cagliari maps after Piloni, 1988].

4. CONCLUSIONS

Cagliari history was summarized o the first paragraph in order to show the many typology of cavities that can be found under the city such as residential ones, quarries, infrastructural works (both hydraulic and civil) and worship places.

The analysis showed a continuous use of them during the course of time. The presence of underground places influenced deeply the urban development. The contemporary Cagliari is the result of the ancient one. Artificial cavities presence and the way of using them affected above ground spaces utilizations.

Tuvixeddu necropolis area was reused since old times. During Roman Age, Punic graves were destroyed in order to use them as quarry and to develop two aqueduct parts that passed by hypogeous environments. This area remained at the edge in the urban development, even causing the moving of the inhabited area.

The habit of keeping the sepulchral areas outside the urban perimeter is well shown in this part of the city and highlights how the necropolis presence and its limestone hill conditioned deeply the urban development. During the last century, the same area was interested by exploitation activities that created several kilometers of underground tunnels below the hills, interesting barely the residential zone [Mezzolani & Simoncini, 1995]. Nowadays, the city roadways are on the hill base and enclose the upper part of Tuvixeddu, leaving and highlighting a big limestone park that collect centuries of Cagliari history and culture. Recently, it has been partially restored.

Su Stiddiu and la Frana were originally above ground quarries. The empty spaces resulting from exploitation were hidden and forgot during city expansion after World War II, when buildings and roads covered them. These places were found again in the 1980s and 1990s, due to sinking caused by water infiltration.

Old big water catchments areas, such as the Botanic Garden and the Capuchins Garden, are nowadays green spaces keeping traces of their history.

The aqueduct, the most important hydraulic work of the old roman *Karales*, is mainly underground and partially unknown. The parts already accessible are still waiting for enhancement in order to be seen by non expert people.

Concerning the worship places, even if they were used in many different ways during the course of time, they are nowadays considered sacral places related to devotion memories and traditions. Churches were built above Sant'Efisio and Santa Restituta crypts. The presence of worship hypogea influenced the urban development during centuries and around them squares that mark the sacral zone can be observed.

As concerns the civil infrastructural works, this paper dealt with air-raid shelters. This utilization was very limited in time, bringing to a temporal change of cavities use and without changing the city spaces.

The complexity and the diversity of Cagliari underground places has always interested its citizens. In the past decades many cultural and speleo voluntary associations studied Cagliari artificial cavities and broadened its knowledge.

These activities lead to raise the awareness about the city underground and the local administration started several actions in order to restore and make some cavities available for visitors. Hypogeous areas are becoming more and more accessible and we hope that soon itineraries promoting their comprehension and knowledge will be available.

In conclusion, this paper analyzed a small part of the wide Cagliari artificial cavities heritage and highlighted the connection between above ground and underground, even if in a very general way. At the moment these results can be considered a preliminary study from which a deeper research could be developed.

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Rock-cut roads in the Middle Ages: reuse, new elements and "service" roads

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Abstract
Aim of this paper is to present an excursus about rock-cut roads in Latium (central Italy), with a special focus on the area of Tuscia (Viterbo), in which it could be possible to observe different solutions inside the group of roads that put in connection settlement with the main road network (rock cut and not). Geomorphology in this area allows these kind of streets and roads with different functions: e.g. ancient roads known as *"tagliate"*, multi-functional rock cut roads (not just roads but also moats in connection with the fortification system of castle sites); new streets that show innovative elements in the "building techniques". Inside these samples it could be possible to identify roads cut along the median part of the stone banks; roads that present huge cutter races or narrows cut space for walking, realized on slopes as dugout technique and in with the most exposed side has also a defensive role. Another aspect is the road network inside cave settlements, that is in relations with the different kind of housing solutions: within this group it could be possible to observe roads with specific hydraulic drainage systems or in connection with common areas as squares for networking. Further, a net of streets and roads that are part of urban project in the new settlements, and the "service roads" all around settlements putting in connection housing areas with productive areas, have to be mentioned. Another group finally is that concerning streets and roads for peculiar situation, e.g. roads to connect isolated religious sites and settlements. In this case we have a road network that is function of the religious places; sometimes it is a ceremonial road with *aedicules*, stations and religious symbols. The present work aims at classifying this very complex typology.

Keywords
rock-cut roads, middle ages, “service streets”.

1. INTRODUCTION

Aim of this paper is to present an excursus about excavated roads in Latium (central Italy), with a special focus on the area of Tuscia (Viterbo), in which it could be possible to observe different solutions inside the group of excavated roads that put in connection settlement with the main roads.[1].

Geomorphology in this area allows these kind of streets and roads with different functions; these excavated structures are in general long life artifacts, and for this they need of an accurate method to clarify their use, chronology, and transformations.

In line with this assumption, the long experience, acquired during a research project on medieval rock cave settlements in Latium [De Minicis 2003, 2008, 2011a, 2011b], has underlined how roads network in the Middle Ages is a condition of the political, economical and material situation.

In this paper I will point out elements from three different historical moment De Minicis 2011a:

- the high Middle Ages (6^{th}- 9^{th} centuries): when it could be possible to notice in many cases the so-called “upland restoration” in the historical evolution of landscape;
- the real *encastellation* (10^{th} – 12^{th} centuries);
- the late Middle Ages (12^{th} century - modern era).

Undoubtedly it is not simple to understand chronology and phases of these artifacts [Giannini 2012], but an accurate analysis of some elements (dimensions, shapes, and landscape connection) allows to propose hypothesis about their function and chronology.

2. ROCK-CUT ROADS AND MOATS

In Tuscia there are many examples of rock-cut roads. Within this sample it could be possible to identify the following types: excavated streets dated back to Etruscan or Faliscan times, based on the presences of Tombs and inscriptions, visible yet on the long faces of these

[1] This kind of roads are known as " tagliate" or "vie cave" in all the Italian bibliography without any difference. They are passages cut as open galleries along the plateau slope or in specific points of the plateau. They are multi-functional roads and for this it could be possible identify some different solutions about cutting technique, space organization, topographic and functional relations with settlements and landscape. Because of it is a very specific kind of roads in this paper we decide to use sometimes the Italian word to identify them, according this explanation.

"tagliate"; curve trend, the deep cut in the soil and stable slope are all elements that could be put in relation with the use as street for carts. These latter typically use natural depressions, are bottled-shaped and have in their central part the presence of a drain. All the samples have different dimensions [Giannini 2012].

Figure 1: Palazzolo (Vasanello), excavated road in Roman time (author Pastura)

Excavated roads are in use still in Roman times, when several cases of reuse, but also new excavations, had to be recorded. Elements of this period are a reduced slope in connection with a largeness of the roads, that sometimes is with stone slabs and vertical sides [Giannini 2012].

Before to analyze artifacts of the Middle Ages, it is important to underline how the Faliscan, Etruscan or Roman *tagliate*, are in general part of the great roads network (e.g. excavated segments are in the via Amerina, Clodia or Cassia), and also they put in connections settlements, thus being part of the group of service roads [Mannoni 1983], because their use was completely different in the Middle Ages.

The reuse of ancient *"tagliate"* or of their segments is a situation that need to be value in all its different kind of variations[Giannini 2012; Pastura 2012; De Minicis, 2014]. In some cases in fact it is possible to notice as the organizations of settlements in the first upland occupation is in connection with the presence of this artifacts, as if they were a condition, in a certain way, for choosing the settlement site. Further, they have a defensive role when in connection with them, on the vertical sides, there are protecting walls.

Thus, losing their role of roads they become moats, a really important element during the encastellation, when new moats will be dug in connection with settlements. This is the case of Torre dell'Isola, on the Amerina closed to Nepi, where a road/moat (2-4 m wide), was dug in connection with the buildup area at least in the 10th century - when it is remembered as *castrum* in written sources [Digiuseppantonio Di Franco, Orazi 2008; Digiuseppantonio Di Franco 2011] - as a defensive element. In other cases about the 13th century it could be possible to notice an additional defensive strengthening with other moats in connection this time with the fortifications [towers and castles - De Minicis 2011b, 2014; Giannini 2012]. This last element is really important because of the association moat/tower or moat/castle as a unique project is a focal point in the interpretation, chronology and comprehension of these artifacts. An example of such solution is Castel Torena, on the Teverina closed to Montecavallo, where it could be possible to identified the two rock cut roads/ moats as boundaries of the buildup area, while another moats was dug in connection with the defensive tower (12th – 13th centuries), in the last part of the plateau [Regni 2003; Romagnoli 2006, 2012]. In the site of Palazzolo, closed to Vasanello, a series of parallel new moats are cut in along the stone bank,- with a clear defensive function - in connection with another ancient rock cut road that allows to arrive directly from a side to the other of the land.

Figure 2: Torre dell'Isola (Nepi), excavated road/moat (author Digiuseppantonio Di Franco)

Also in this case a new moat was dug to increase the defensive system that allows to preserve and close off the church, transformed in fortress and located on the western side of the plateau [Pastura 2012, 2013]. In the case of Norchia, on the Clodia between Vetralla e Viterbo, four

moats are dug packed with all the fortress built to defend the settlement between the 12th and the 14th centuries. All these case study show how one of the element to increase the defensive settlement systems is one of the most used in military building during the late Middle Ages and Renaissance; fortress with moats: a kind of solution that find a huge field of experimentation in rural landscape with a geomorphology as the volcanic Tuscia.

These samples are all in relation with important transformations that involved both a reuse of ancient rock cut roads and a planning of new ones, and could be considered as high quality level buildings. Despite Medieval moats, in connection or not with fortress or other defensive buildings, are a kind of elements with a lower quality level(Architectural design and economic burden).

Figura 3: Parco Regionale Silente-Velino (L'Aquila). Roman road [Montagnetti, 2015]

3. A SYSTEM OF SERVICE ROADS

Inside the group an important cluster is composed by secondary rock cut roads that from the main road network move to settlements. These are dug with a completely different system and technique, that allows to create a complex system of service roads.

In light of the fact that the analysis consider a wide sample group, it is possible proposesame new methodological considerations in order to discern typological element inside this group based on a codification that consider first of all structure and function. It's important mention that this tentative to organize a complex typology arises from a group of considerations and observations made in the past by another author [Giannini 2012] and from a new study that amplified our knowledge. So in this study we clustered the results of this new study and compared them with previous tests.

A first division is discriminating between roads for people only, and those also used for animals. This is an important division because of commerce is in connection with roads in which it could be possible animal use (Dimension, Architectural design).

Due to importance of the commercial routes, all the settlements in Tuscia located on plateaus in the middle of deep gorges needed to be inside projects that put in connection villages with the major roads. Inside this group it could be possible to consider: rock-cut roads deeply dug in the median part of the hillside and streets on rock cut terraces. In both of them it could be possible notice the same wideness (1,50m), that consent to suppose the use of animals with truckload.

This important function is in connection with long trip roads. From the analysis carried out, it is possible note that roads dug deeply in the hillside are in connection sometimes with terraces or face walls. This association is in use in Roman times in general in connection with crossing place. An interesting case is in Abruzzo[2], a site recently studied, in which there are huge segments of a roman road in use for all the middle ages. This road is 2 m wide and reaches the breadth of 4,20 m near to the focal point of the hairpin turns, expedient useful also for carts passage (Montagnetti, 2015).

A sample of this kind of solution in Tuscia is in the road that from the area of Vitorchiano move to Corviano, flanking the ditch Martelluzzo (Di Calisto, 2003; Romagnoli 2006; Giannini 2012). This road, that conserve lots of traces of the cutting technique, is wide enough for animal passage, , and on its sides it is possible to observe some cave productive places, dug along all the path. Their presence is in line with a function as service road in connection with the Martelluzzo, the main important water source.

Figure 4: Tarquinia.Porta del Fiore and the *via coperta* [Serchia, Maggiore, 2012]

[2] It's an excavated road that put in connection the area of Monte Secino with Monte Etra and the Arano Valley, closed to the plateau of Rocche. All this land is inside the Parco Regionale Sirente-Velino (L'Aquila).

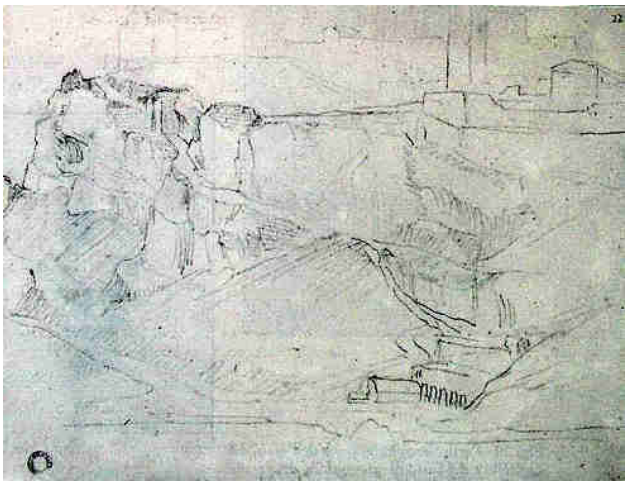

Figure 5: Tommaso Minardi (1835). The *via coperta* [Serchia, Maggiore, 2012]

Another important case study is a road carved out on the north - western hillside of Corneto (Tarquinia) , overlooking the valley of the Marta, which , over a gap of 40 meters , linked the town from Porta del Fiore (13th c. .) with Fontana Nuova.

The road is an open air rock cut, but in some part it was dug as a gallery (as a *via tecta*). It possible to observe buttresses in connection with these voults , while, along the open air parts fortifications and sentry boxes The road is depicted clearly in some sketches of Tommaso Minardi (1835) (Serchia, Maggiore, 2012).

Inside the cluster of roads on rock cut terraces it's possible count as well a lot of mule tracks in which there is this kind of solution (rock cut terraces) just in steeply points and for short segments however an important sample group are pedestrian itineraries..

Pedestrian roads on rock cut terraces differ, but in general it's possible notice some common elements: they are in general narrow paths (1mt wide) stretched on the most exposed hillside in which the settlements extends.

On this basis is possible identify two subgroups: roads on narrow rock cut terraces, similar to the other already mentioned and roads dug as a dugout. In this last sub-group the most exposed side of the dugout has also a defensive function for the road itself. Streets on rock-cut terraces are in general in rock cave fortified sites (rock cave *Castra)* and put in connection the castle with rural areas, water springs and sources. Sometimes in the same place there are mills or laps for hemp and flax maceration Considering what has been highlighted up to this point, it's possible consider them as the real service roads for *Castra* that in a lot of cases move out not from the main gateways, but from secondary gate opened on the walls in strategic position and away from the main gates (*posterulae*).

In light of the above is possible identify inside the group of service roads a sub-type with a completely different function: rock-cut roads in connection with worship sites and conditioned in their route by ritual (processions, ceremonies). For example places where the local population buries its dead , if not in direct contact with the settlement, remains a point of reference for centuries; hermitages and sanctuaries, are pilgrimage and procession destinations or stations and are testified by the presence of *stationes*, *edicolae* and religious symbols along the way. All these roads according to an anthropological point of view are furthermore in connection with special and private moments during the life of a person and of a community and for this devotion needs to be consider as the main important element in these samples, sometimes in relation with penances and atonements. According to this it's possible suggest that the steepness in all these case study is a choice in connection with the sacredness. A sample is the road that move to the church of S.Cecilia in the area of Soriano nel Cimino, that is the unique access to the church: a rock cut road very steep and narrow (0.70m in the widest point), that in the last 30 meters is a stairway; an offset for wooden beams guaranteed the use in case of heavy rain, covering the steps with a kind of planking; the necropolis around the church was in use from the 6-7th century to the 13th century, after an interruption of use (Poma, 2015).

Another case in connection with processions is the pilgrimage way for the hermitage of S. Vivenzio, the patron of Blera, a little town closed to Norchia (Viterbo). This road, in part in line with the ancient *Via Clodia*, flanking the Etruscan necropolis move to Norchia. Closed to the hermitage there is a rock cut segment of the road narrow and steep, that move to the hermitage in a sheer drop on the ditch of Acqua Alta. Frescos of 12th-13th century inside the sanctuary are witness of the medieval use, but certainly the steep access is more ancient.

Finally, in the group of roads dug as dugout it's possible consider all those with a defensive function. These roads are in general on the flanks of cliffs on which settlements lay and, in some cases , the presence of specific elements confirm our interpretation.

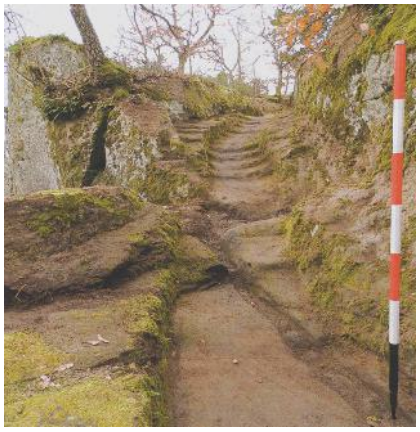

Figure 6: The road that move to the church of S.Cecilia (Soriano nel Cimino) (authore Poma)

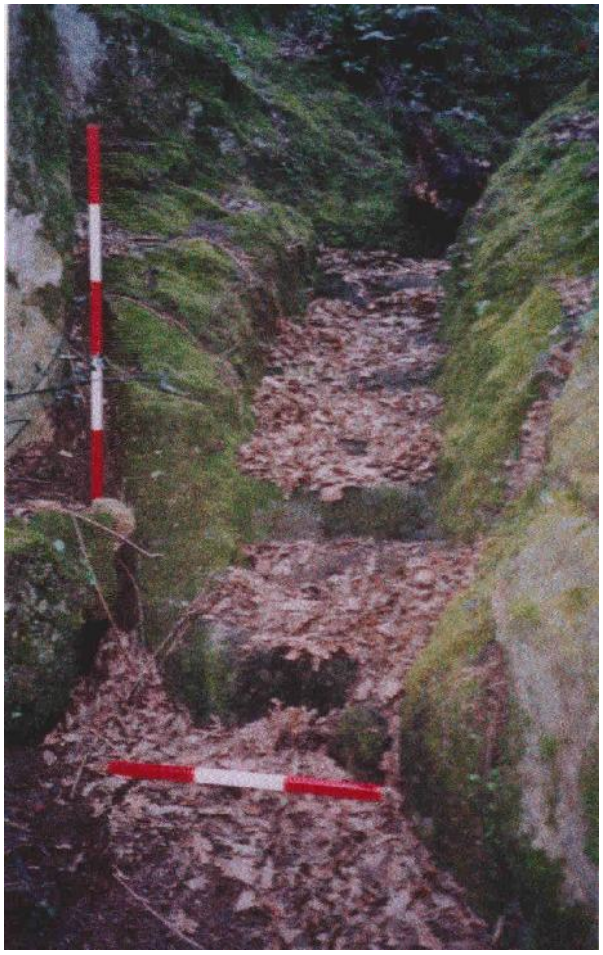

Figure 7: Castel d'Ischi. Streets cut into steps narrow (author Mariani)

Interesting samples are the two roads of Castel d'Ischi, a castle in the Treja valley, and the one of Torre dell'Isola. In one of the roads of Castel d'Ischi there are a lot of element that recall the presence of defensive structures as housing for wooden beams and embrasures and a sentry box. (Mariani 2008)
In Torre dell'Isola is the road in the Nord side that present element of a rock cut road dug as a dugout characterized along the path by a bend, and really interesting for the presence of a *posterula* to which the road leads.

This element is in connection with the tower, the first fortification, and the stronghold, that was the unique entrance to the settlement since the 10th century with a clear military and strategic function . The entrance (1,50mtx1,60mt) was cut in the rock, that in this side was a natural protection, even supported by walls inside. The gate, furthermore, "si trova ad una quota notevolmente elevata rispetto al camminamento coperto…per facilitare la salita, infatti, erano utilizzati una serie di appoggi (pedarole) ricavati nel tufo" (Di Giuseppantonio Di Franco, Orazi, 2008).

In this case it is evident that the access roads for the settlement, in the phase of full encastellation, provided, on the opposite side,, a path wider and easier then the one in dugout, for the use of animals, transport and truckload.

4 . STREETS INSIDE SETTLEMENTS

One last observation concern roads inside settlements. Although it is a bit out of topic, we believe that it's not possible produce an essay on roads network without introducing the inner organization of the living space, organized usually , in function of settlement morphology and of the different kind of activities *in loco*.

In another paper (De Minicis 2011b[3]), I told about the main elements involved in the great settlement transformation that from the 12th century it's possible to notice in the new foundations. To summarize in broad terms what I said there, I'll highlight in the last part of this paper all the elements involved in the internal space *reorganization* of the *castra*. I'll consider *castra* that received great defensive system, with new fortification and building up of new walls and gates; the inner space start to be strengthened with the building up of the *ecclesia castri,* new houses with space for domestic life divided from stables and warehouses, new space for production (near to the walls or out of them). In this general process of reorganization of the space it could be possible also speak about a kind of urban intervention that pay attention to the main infrastructures, object of this last part of the paper. Samples are the regular roads of S. Giuliano (Barbarano Romano), in which a linear long road limited a part of the settlements (Guerrini 2003) and of Filissano, already mentioned, in which it is possible to notice a kind of allotment, with the building up of new houses, according to a style common in the new foundation settlements.

Another recurring element is the planning and building of new squares as places of trade along the main roads, closed to churches above all, when it's possible as in the case of Torre dell'Isola. A group of new common space is obtained also, for example, by the use of excavated road/moat, not useful anymore for defense owing to the settlement development and transformed digging new space with different function (common space, space in connection with other houses or for productive activities). In this rock cave settlement there is a large diffusion of staircase and *pedarole* (excavated steps) that are involved in the inner roads network (from a level of the settlement to a another, so they are part of a connection between roads) but also they are used to move from downstairs to upstairs inside the houses.

[3] A conference with the title "Insediamenti rupestri di età medievale nell'Italia centrale e meridionale", edited by me had a subtitle "L'organizzazione dello spazio nella mappatura dell'abitato". Every reference could be control in my paper inside this conference.

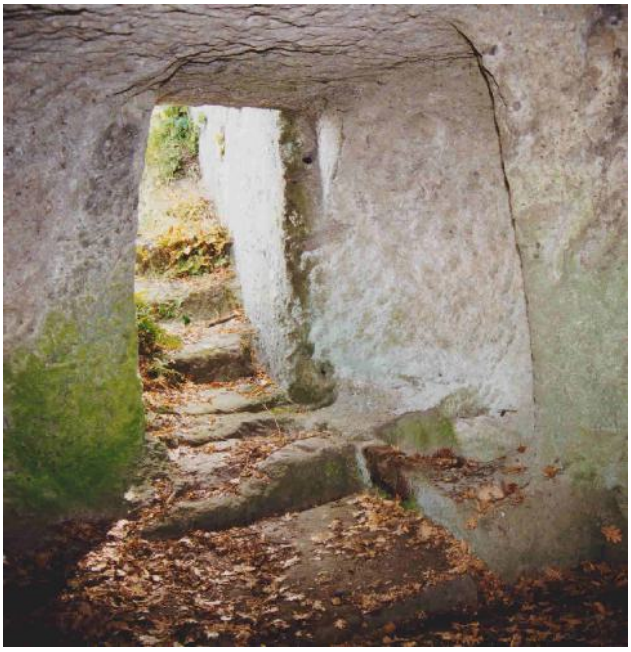

Figure 8: Corviano (Soriano nel Cimino). A staircase of four steps (author Di Calisto)

So in this case staircases are the main element in the urban organization and transformation and also an important comfort inside houses. Sample is the case of Corviano, where houses with an entrance on the face, put in connection with the main road throughout a wooden walkway(I phase), start to have, from a specific moment, staircase that move directly from the plateau, and so they become houses with different rooms also well connected to the main road networks.

In closing what I want remember is a special care for water systems with the building up of cisterns and laps (De Minicis 2006[4]) but also a special care to the hydraulic drainage systems especially where there are important gaps and slopes. In a lot of roads on rock cut terraces it is possible to notice this kind of solution with the use of drainage accommodations dug on the road surfaces. In some cases in association with them it is possible to notice the negative traces of wooden elements that cover the drainage and consent a better use of the road level (as in the case of S. Cecilia, *supra*). Drainage systems are also present along the two side of the road level in a lot of cases of roads network inside and out of the settlement Samples are often in connection with s gates and *posterulae*. Bearing in mind the presence of vegetation in all *castra* sites, gate places are the point in which, also for the different slope and gap, is possible to observe these elements (e.g. Norchia, Castel Torena, Castel d'Asso); an interesting comparison is with the settlement of Zungri (VV) in Calabria, in which in the main N-E gate it's conserved a staircase with a lateral drainage system distinguishable for the presence of a partition (dug in the rock) that divided it from the main part of the road. A gate of the 13th century located in a strategic point, from which it could be possible control docking and mooring in the Tyrrhenian sea but also control enemy arrivals (Coscarella, Bruno, 2011).

5. CONCLUSIVE REMARKS

In order to close this essay, in line with all the elements exposed it could be possible say that rock cut roads network, are a kind of roads network organized in function of *castra*. The ancient excavated roads (Estruscan, Faliscan, Roman), the so called *vie cave* or *tagliate*, although they are reuse, are not used for network, but as a part of the defensive system during the Middle Ages - except few samples. The "new" medieval artifacts, instead, are: roads dug along the median hillside, roads on huge rock cut terraces or narrows cut space for walking, on the more exposed slopes, in connection with *castra* and with an important defensive function(roads in dugout)).

This "technique", if we can call it in this way, is undoubtedly a method for not long way roads, while the main roads for long distance are built in stone or mixture yet, although with a new concept.

In contrast with ancient time in fact there are a great change in roads network and in the building technique in line with the most common means of transport (animals and carts) and with a different (not highways but shorter trunk and secondary roads).

Figure 9: Corviano (Soriano nel Cimino). A staircase. (author Di Calisto)

[4] The sentence is referred to an article which takes in review , for the rock field , use of hydraulic systems in household.

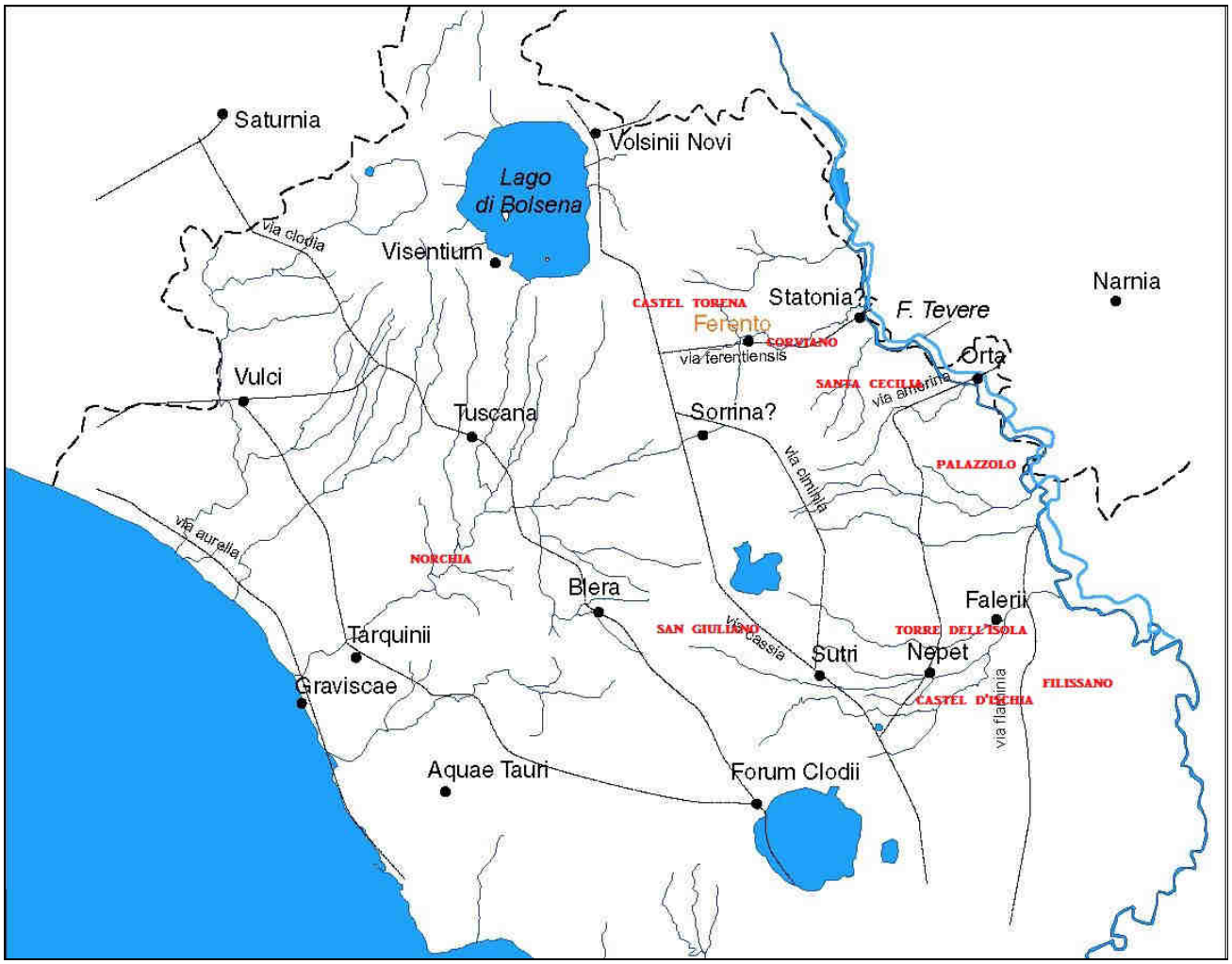

Figure 10: Sites localization

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Principles of spelestological zoning

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Abstract

A spelestological zoning scheme, based on the six-level hierarchic classification, is proposed in this paper.

The artificial underground cavities, being the subject matter of the spelestology, are known as the signs of the technological influence on the geological environment, and the underground space development technologies are described as part of the culture.

The principles of distinguishing spelestological taxon units of the two higher levels (spelestological lands and provinces) are also described. How to deal with underground objects construction is mainly determined by civilizations and local cultures mentalities. It can be seen in specific methods of underground space development and the history of mining. The spelestological lands borders are mainly determined by civilizations development areas. Either local cultures development borders studying (which are shown as culture elements stable combinations, connected with underground space development and geographical and ethnographical landscape) or historical processes studying inside these borders allow us to distinguish them into spelestological provinces.

It is suggested to use zoning methods of cultural geography to find out the borders of spelestological lands and provinces, as the spelestological zoning is a special case of cultural-geographical zoning describing the territorial development of such material and intellectual culture element as spelestological objects, its expressivity in the landscape, the local culture and geographical environment interconnection, the territorial organization and differentiation of a human society with stable mentality and behavior stereotypes.

All 10 spelestological lands and 83 provinces are briefly described.

Keywords

Artificial underground cavities, spelestological zoning, cultural-geographical zoning, spelestological lands, spelestological provinces.

1. INTRODUCTION

Spelestology is a science that studies the underground macro cavities created or changed as a result of intelligent beings activities, and nowadays it is in its early stage of phenomenology and statistics collection period.

The value of the information already gathered requires analysis, especially zoning development, i.e. data structuring in physical space which can help in clarifying common factors of spelestological objects distribution.

Curiously enough, that there are some classification schemes based on the technique of construction; the function (or purpose); the shape and development of the underground structure; the spatial correlation with the surrounding environment; the temporal correlation with the general historical events on a general, regional and local scale [Parise, Galeazzi, Bixio and Dixon, 2013], but it seems that nobody has still tried to create any zoning scheme, however there are a lot of rather elaborate ones in the related studies such as speleology and karstology.

The spelestological zoning scheme based on the six-level hierarchic classification is used in this paper.

The classification scheme is proposed in Table 1. The spelestological substratum element itself, called the spelestological object, is on the lowest 7th infra-level. Its existence is the main generative factor of a *spelestological block*. The *spelestological block* term was proposed by A. Vyatchin [Parfenov, 1997]. We describe the spelestological block as a locality, i.e. a primary complex cell of the geospace including terrain, technology and society features. The main attention was paid to the higher taxonomic categories of the proposed hierarchy (spelestological lands and provinces) in this paper.

We have distinguished 10 *spelestological lands* and 83 *provinces* (Fig. 1; Table 2).

№	Taxonomy unit	Definition	Separating principle	Activities semantics
1	Spelestological Land (**SpL**)	A territory within which historically a characteristic relation to mining and underground architecture (terratecture) as an aspect of civilization is manifested	Uniformity of underground environment development ideology (cultural and civilizational factors)	What for they are doing?
2	Spelestological Province (**SpP**)	A territory that has a characteristic history of mining and underground architecture (terratecture) development and a historically formed complex of artificial underground cavities	Uniformity of historical tradition (cultural and historical factors)	Who (and when) is doing?
3	Spelestological Division (**SpD**)	A territory that is characterized by a complex of interests and needs of the population that are satisfied by the production of a specific complex of mining works and by the construction of underground architecture (terratecture) resulting in artificial underground cavities	Uniformity of motivation (cultural and economic factors)	Why are they doing?
4	Spelestological Regions (**SpR**)	A separate part of geological engineering environment that is auspicious for the conducting of specific complex of mining works including construction of underground architecture (terratecture) objects in the conditions of relative lithological uniformity, restricted by the availability of the corresponding rock for mining	Uniformity of technology (economic and technological factors)	How are they doing?
5	Spelestological Sites (**SpS**)	A system of adjacent or located not far from each other congenerous spelestological blocks that is characterized by the uniformity of the underground cavity set	Uniformity of environment (relative) and technology (depending on geomorphological and geological conditions)	What are they doing?
6	Spelestological Block (**SpB**)	Elementary geological and geomorphological structure characterized by a relative uniformity of enclosing geological environment and restricted by geomorphological or geological boundaries that prevent the expansion of the artificial underground cavities	Uniformity of geological and geomorphological environment (geological and geomorphological factors)	Where they are doing?

Table 1: Zoning classification structure.

2. THE SOCIAL SYSTEM AND CULTURES

The human being tends to create system intercommunications with other people by nature. It leads to the human society organization. The human society in whole can be considered to be an adaptive social system [Markaryan, 1975],[1] being an evolutionary adaptation mechanism which helps the specie to survive and succeed.

The social system provides its own existence and the existence of its elements processing information into other resource forms with the help of the technologies combination (*technologies* are the ways, dependent on knowledge and social abilities, in which goals are realized, goals chosen by the community as well as those which nobody had in mind initially [Lem, 1964]). The social system supports several basic processes featuring operations on information, interconnected with social institutions and being of historical (i.e. temporary) nature [Pereslegin, 2009].

The structure of basic processes supported by the social environment forms culture, i.e. the way how a social system interacts with the environment which can be shown as a combination of social used technologies and boundary conditions of these technologies. (A good example of the subjective technology limitation is the taboo based on religion. Hunter and cattle peoples of Central Asia have a taboo of ground digging and rock cutting connected with the cult of ground [Potapov, Shagzhiev and Varlamov, 2000]; it is forbidden by traditional beliefs to disturb the subsoil for many African peoples [Kulik, 1972]. Surely, the underground space exploitation by such cultures usually didn't go out of natural caves usage.) Large local cultures agglomerations having pronounced singularity and combined with general mentality, i.e. traditional supercultures (cultures of superethnoses) are usually called civilizations in modern languages [Pereslegin and Stolyarov, 2003].

[1] A social system is an integral unity that consists of people, their social bonds, interacting and attitudes [Primush, 2004].

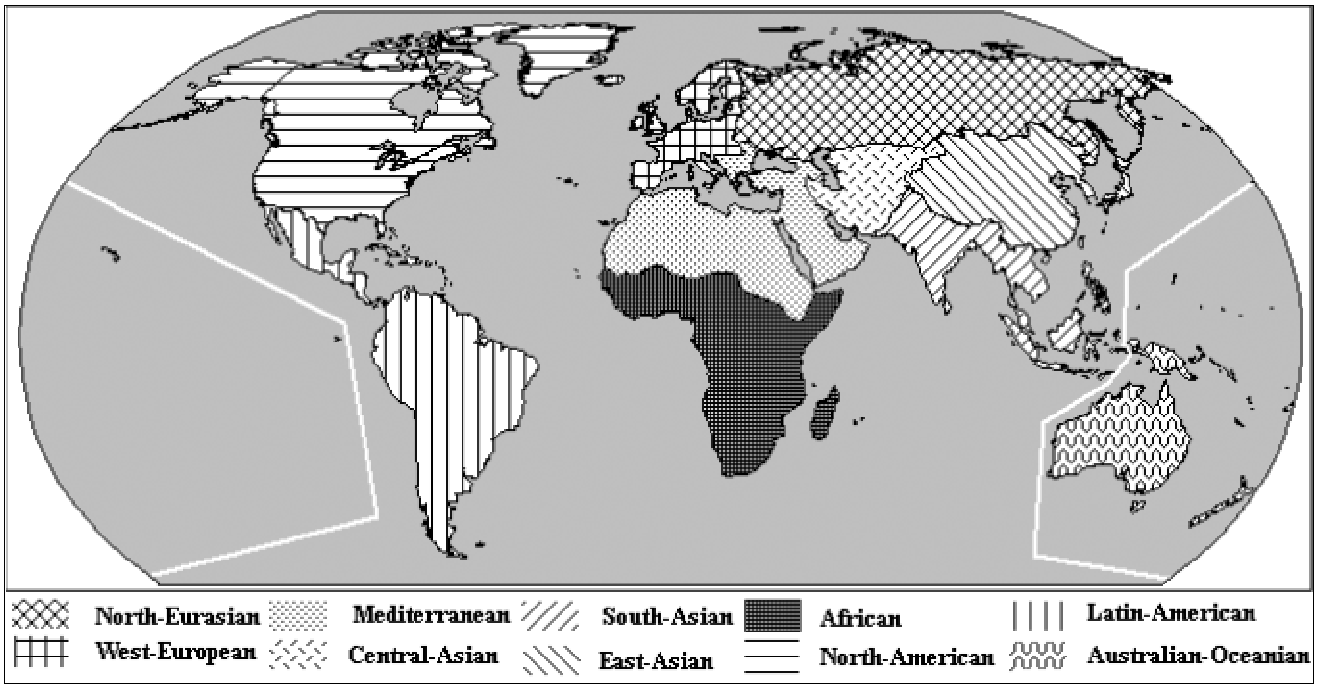

Figure 1: World division into spelestological lands

There are four founders of the civilizations doctrine: N. Danilevsky, K. Leontiev, O. Spengler and A. Toynbee. Later works on this problem poorly developed the fundamental ideas [Emelianov-Lukianchikov, 2008]. The best civilizations theory adaptation to the modern moment was created by S. Huntington [1996].

The vision of different civilizations (or cultural phyla) interacting on the Earth was introduced into scientific use by Danilevsky. He understood a civilization as a large socio-cultural community of people that was formed on the basis of certain unique universal values. He showed that civilizations are not mixed together and are changed only in a historical scale. Danilevsky saw in the cultural-historical type, the highest expression of social cohesion.

In this approach, civilizational traits and characteristics are manifested in four main activities: religious, cultural (science, art, production), political and socio-economic [Danilevsky, 1895], contributing to the semantics of civilization and its archetypes depicted on the level of the collective unconscious.

Danilevsky's ideas were developed by Leontiev [1876], who described the civilizations historical dynamic. Later Spengler came to similar conclusions [1918]. At first, their theories are unified by methodological reducibility of civilization to the three functions: religious, state and cultural, the three-stage historical development of civilizations: youth (religion development), puberty (state development) and old age (culture development). They defined the maximum duration of civilization existence as 1000-1200 years.

The term “civilization” was introduced into scientific use by Toynbee [Toynbee, 1934-1961]. After Spengler, he noted a close association of civilization with a particular religion, i.e. identified the role of religion as a system civilizational criterion. According to A. Toynbee, the unity of religion defines the commonality of the historical development, customs and institutions and creates a sustainable regional type of high culture.

Toynbee considers civilization as a response to the challenge of the external environment. He put forward the evaluation criteria of a civilization: stability in time and space, in situations of challenge, and interaction with other peoples. The development of a civilization is determined by the ability of its creativity to find answers to these challenges. (We use Toynbee's term of a civilization in this paper.) Toynbee believed that each civilization passes in its development several stages: emergence, growth, breakdown, and decay and then gives way to other civilizations.

L. Gumilyov introduced the concept of a super-ethnos to denote the major ethnic and cultural systems of their respective civilizations. Super-ethnos as a higher taxon of ethnic hierarchy is system composed of several ethnic groups [Gumilyov, 1993].

There are different opinions on the total count of the existed civilizations. Making a literature review M. Melko

[1969] concludes that there is "reasonable agreement" regarding the twelve major civilizations, seven of which have already vanished (Mesopotamian, Egyptian, Cretan, classical ancient, Byzantine, Central American, Andean) whilst five continue to exist (Chinese, Japanese, Hindu, Islamic and Western). It is useful to add Orthodox (the successor of the Byzantine), Latin American and possibly African civilizations to these five ones [Huntington, 1996].

3. UNDERGROUND SPACE DEVELOPMENT IN THE HISTORICAL PERSPECTIVE

It is possible to stratify the development of the social system on development phases characterized by the dominant form of economic life, types of activities, man's place in the trophic pyramid, the relationship between social and environmental systems, dominant social institutions and transcendence, the specificity of population dynamics, collective psychology, the basis of the economy (the resource, the possession of which is vital for the society), characteristic of the used energies and speeds. The development phases are separated by phase crises. To date, there are known three phases of development: low-tech archaic (primitive), mid-tech traditional (agrarian), high-tech industrial and it is expected the emergence of a fourth cognitive postindustrial [Pereslegin, 2009].

Many regions were successively occupied by a number of cultures leaving heterogeneous in origin layers of monuments, including spelestological objects (in Turkey, for example, underground monuments of the Neolithic, Hittite, Urartian, Persian, classical Hellenistic and Roman, Byzantine, and Turkish eras are known). However, there is often a relative continuity and cultural traditions of successive civilizations in sequence, for example: Minoan – Hellenic – Western civilization, the Minoan – Hellenic – Orthodox civilization, the Minoan – Syrian – Islamic civilization, the Sumerian – Indian – Hindu civilization [Toynbee, 1934-1961].

Mining history is indirectly reflected in the specificity of spelestological object ensemble on the spelestological province territory.

People yet in traditional phase began to adapt the environment to their own needs and requirements [Gumilyov, 1989]. One of the usual human methods of space development is the development of mining and underground architecture which leads to the formation of spelestological objects as the variety of traces of technological impact on the geological environment.

It is possible to identify, indirectly depending on the level of technology development, three stages of development of the surrounding (in this case, for example, underground) environment.

I. *Adaptations*: the technology is aimed at the adaptation to the environment, protection from it – in the case of mining it is a step of the use of natural caves without any reconstruction.

II. *Developments*: transformation of environment by technical methods – the use of natural caves, which are adapted for the required tasks, first by backings, coating walls, etc., and then by notches, underminings, excavation of artificial sites.

III. *Exploitations*: creation of an artificial environment – excavation of special underground workings to meet emerging needs.

Underground environment development has begun since the emergence of the mind.

However, the technically primitive, based on hunting and gathering cultures could not redirect a lot of energy and time from work for the production of food. Small communities of collectors couldn't afford non-productive members, even chieftains and specialists (craftsmen and shamans) get their food and lived in the same conditions along with all. Therefore, they mainly remained at the level of the adaptations and developments of underground environment, but at least at the beginning of the Upper Paleolithic they excavated large (for the instrumentation of that time) mine workings for the extraction of flint and pigments as well as constructed underground dwellings (dugouts, etc.). [2]

Even high-performance cultures based on nomadic animal husbandry could not change the situation. The way of life of nomads is not conducive to specialization, as well as bounding to a particular place. Therefore, in the area of nomadic people only small underground places of worship are known, and the necessary metal was obtained from the sedentary tribes (such as the Urals Kargaly in ancient times [Chernykh, 1997]) or groups (e.g., slaves or semi-slaves of the Tuaregs of the Sahara [Lhote, 1984]) specialized in the mining field.

The turning point in the development of mining occurred only in settled agricultural societies, allowing to upkeep orders of magnitude more population than hunters and gatherers in the same area. The larger community of farmers built a complex social structure, they could afford to have not producing anything material kings, bureaucrats, priests and soldiers, as well as professional craftsmen [Diamond, 1997], including miners of different kinds. There appears state, writing system, and culture in the modern sense of the word. People are moving away from the use of natural materials to create new materials. The establishment of the state as a system of governance was accompanied by a synchronous significant technical innovations, in particular large-scale irrigation, the use of metals, brick, glass, multi-storey stone buildings, which required more active development of underground resources. Already in Neolithic and Bronze age people

[2] The culture as a knowledge reproduction system probably appeared at the beginning of the Upper Paleolithic [Markov, 2011].

began to use underground structures for various purposes and massively excavate minerals.

The heyday of mining was achieved in the industrial time, i.e. the era of widespread use of machines that allow excavations in difficult conditions at previously inaccessible depths, in the conditions of high watering, etc., produce huge amounts of minerals.

4. CULTURES AND SPELESTOLOGICAL ZONING

Culture manifests itself not only in the material space (like technosphere, a set of material atributes of civilization, i.e. physical bodies), but also in the information environment (the infosphere as a set of signs) and in social space (sociosphere as a system of stable relations imposed on a society) [Pereslegin, 2010].

It draws attention the unity of technosphere (the differences in ways of obtaining food, housing, manufacturing goods are mostly decorative in nature) as well as the unity of the historical development (even strictly isolated from each other different ethnic groups form a similar social and economic structures with remarkable tenacity). This unity is based on the universality of the world, that is, the generality of the laws that are represented at all ontological levels [Pereslegin and Stolyarov, 2003; Stolyarov, 2004]. However, there is evident originality of local cultures.

They are partly due to geographical determinism, objective differences in geographical living conditions of different societies. It is known that people adapt to environmental conditions by changing the pattern of behavior, i.e. culture, first and foremost archaic low-technology culture that adapts to the enclosing landscape, is derived from the geographical conditions (landscape) [Gumilyov, 1989]. To a similar conclusions came D. Forde who expressed the idea that the main demarcation lines of cultures are predetermined by the character of natural landscape zones [Forde, 1963].

The objective conditions of the natural environment and geographical location (including landscape, climate, flora, fauna, minerals, etc.) occupy a special place among the reasons for the diversity of cultures. In the past, the natural environment gave people the means to live and survive. Actions that were rewarded by success became customary and were the basis of system of values, norms and rules of conduct different from other groups.

The system was fixed in the mind, passed to new generations and regulated the behavior of each member of a society [Stefanenko, 1999] persisting even when conditions change.

The last is due to the fact that the cultural paradigm protects from excessive erosion the information structure of the society or its layer allowing to focus energy on particular goals. But at the same time it inhibits all the new [Nalimov, 1989].

Thus, the divergence of cultures is generated largely by random, chaotic processes the results of which are fixed in the information matrix. Here by the information matrix the totality of the transcendental and scientific ideas about the world that are absolute for this culture is referred. The matrix usually has a religious nature – Christianity, Judaism, Buddhism, Confucianism, and Islam are the universal matrixes that determine the parameters of different civilizations [Stolyarov, 2004]. It is agreed by all the researchers using the civilizational approach that the essential element of a civilization is the dominant religion that is marking well its area [Emelianov-Lukianchikov, 2008].

However, the matrix can have a secular form of social (ideological) doctrine although any of these systems necessarily have a transcendental component. Creating the ultimate idea of good and evil, purposes and meanings of existence of the whole society and each individual, the matrix structures the beingness of the civilization, transforms it from chaos into a system. In its turn, actualization of the matrix, conversion of its transcendental content into a particular philosophy, worldview, ideology, state laws, dominant household morals and standards creates those behavioral patterns, basic understandings, rules of life which are usually defined as a national character (mentality) [Stolyarov, 2004].

From the aforesaid it must be concluded that any culture in addition to a deterministic component (due to the geography, human biology and the biosocial programs of its behavior, and other objective reasons) has a chaotic (informational – random or spontaneous) component.

Consequently, the proposed classification should reflect the presence of two kinds of factors that provide the basis of structuring, objective (mainly natural / physical) and subjective (mainly cultural / informational).

The bigger the community of people we consider, the weaker is the manifestation of objective component in a generalized culture. First, with the increase of the area of socio-cultural community there is an increase in distance from the landscape that formed the original local culture.

The occupied territory spreads to the areas with heterogeneous landscapes, and therefore decreases the number of natural factors common to it. Second, the larger and more complex is a social structure, the greater its activities (including technical) are defined by information processes.

Features of development of architecture and underground mining at the lower levels of the taxonomic hierarchy are almost wholly dependent on geographical and geological conditions, but the higher the level, the greater the significance of cultural factors in the allocation of spelestological taxonomic units. At the level of *spelestological lands* the construction of underground facilities is determined largely by a mentality of civilization, and it's necessary to make structuring primarily on cultural factors. Exactly the specific features of local

culture expressed in its mentality define the boundaries of an area with a distinctive relation to mining.

Another consequence of the nature and stages of the historical development of social systems is a limited in time applicability of the proposed spelestological zoning scheme. The lower limit corresponds to the Neolithic revolution (approximately VIII-VI BC) which led to the emergence of severe imbalances in the level of development of regions [Diamond, 1997] which led to a rapid accumulation of diversity of local cultures (in social structures, identity, everyday life, etc.) and accordingly to the existence of various approaches to the development of underground environment.

The development of such modern processes as globalization [Stolyarov, 2004] and postmodernism [Panarin, 2002; Stolyarov, 2004] sets an upper limit (around 1970). The development of a global economic and information communications, development and induction of technologies,[3] the increase of the disseminated information, its inflation and noise pollution – dramatically leveled or made difficult to note the differences between regions in the modern historical perspective.

It should be also noted that environmental ideology requires reclamation of disturbed areas of nature including the elimination of exhausted mines, so in technically advanced countries the number of spelestological objects actually decreases.

5. SPELESTOLOGICAL ZONING METHOD

For the problem of determining spelestological taxa boundaries important is the conclusion Forde [1963], that in determining the areas of cultures it is necessary to consider not the individual elements of cultures, but their complexes representing stable combinations. Therefore, despite the fact that as a classification criterion we use only one set of technologies, methods of development of the underground environment, and therefore the boundaries of spelestological taxa of higher levels do not necessarily match with the generally accepted cultural divisions, however, it is an interconnected element of the cultural complex, the scope of which should also be considered at zoning.

Spatial cultural differences are studied by a special branch of geographical knowledge, cultural geography [Sushchy and Druzhinin, 1994; Streletzkiy, 2001]. Cultural landscape concept which was introduced to geography by L. Berg [1915], considering two main layers, natural and cultural, the latter being a complex historical formation having many layers [Saushkin, 1946]. The most important methods of cultural geography as a geographical discipline are mapping and zoning. Cultural-geographical taxa are distinguished by the totality of the features used in particular cultural zoning. The system these features according to I. Beloborodova [1999] may include the following feature packages: natural geographic, historical-genetic, cultural, traditional, ethno-social, ethno-religious, political, regional identity [Manakov, 2002].

Therefore, applying the method of integral zoning proposed by Forde for the solution of spelestological zoning problems it is possible to use the experience and methodology of cultural-geographical zoning because spelestological zoning is a special case of cultural zoning, describing (using various techniques: usually by zoning method is meant a set of practical methods and techniques of selection zoning units of different ranks which provide homogeneous and comparable results corresponding to the theoretical principles of zoning [Isachenko, 1961]) the spatial distribution of one of the elements of material and spiritual culture (spelestological objects), the expression of this element in the landscape, connection of local culture with geographical environment; territorial organization and differentiation of communities of people with stable patterns of thinking and behavior [Manakov, 2002].

Cultural-geographical zoning is a set of rather complex methodological procedures and is based on the developments in zoning in different directions of geographical science. Methods of cultural-geographical zoning is markedly different depending on the level (scale) of zoning. Combining at the same time in the framework of comprehensive cultural-geographic zoning the principles of natural, cultural, and socio-economic zoning requires handling of a significant number of criteria for isolation of zoning units of different rank. In the process of integral cultural-geographical zoning, we must consider a whole set of factors.

In the concept of cultural landscapes, there are isolated 11 specific types of cultural spaces – ethnic, confessional, political, historical, linguistic, decorative (professional art), folk art, domestic culture, economic (household) culture, political culture, scientific and philosophical. Each of them can be represented as a layer of the cultural landscape with its own net of boundaries. The layers of natural factors (geological, topographical, paleogeographic, etc) must be added [Manakov, 2002; Vampilova, 2005; Vampilova and Manakov, 2012; Manakov, 2014].

L. Smirnyagin identifies five sequential stages in the practice of zoning: 1) evaluation of territory zoneability (including consideration of the experience of predecessors); 2) region recognition; 3) drawing borders; 4) reviewing and assessment of the grid of areas; 5) iteration (revision of the grid of taxa based on new knowledge) [Smirnyagin, 2011]. Zoning on the upper and middle levels of zoning are usually built top-down, i.e. from the highest units to lowest. However, already at the middle level, refining of the

[3] In particular, the revolution in mining in 1950s [Moses, 1989] – the increase of power, the cheaper drilling, the emergence of new ways of drilling, fastening of excavation, supporting, and transportation etc.

boundaries from the "bottom" is required. This means that zoning for the middle and lower levels should be simultaneously performed both top-down, and bottom-up. At the lower level, a more fruitful way is the zoning "from below", from the actual material to the identification of system of taxa [Manakov, 2014].

Applying this approach to spelestological zoning, you can see that the boundaries of higher taxa level (*spelestological lands*) mostly determined by the area of spreading of civilizations. Both recognition of the boundaries of local cultures and ethnoses-carriers, and the study of historical processes in these boundaries allows to divide them into *spelestological provinces*.

On the other hand, at the lowest level, the borders of *spelestological blocks* are determined by objective geological and geographical conditions, the only problem here is the incomplete knowledge, and in some cases the diversity of natural conditions.

By joining of *spelestological blocks* into *spelestological sites*, an element of subjectivity is manifested since the terms of the joining (similarity of technology) is not parameterizing and determined to a large extent by qualifications (experience and intuition) of an observer, and you have to apply the "volitional decisions" regarding to the extent of the area study. At the level of *spelestological regions* the value of objective conditions increases again because the borders of *spelestological regions* are mainly controlled by geological structures.

At the level of *spelestological division*, delimitation is possible to carry out from two sides – "bottom" by grouping *spelestological regions* and verifycting the results of the merger from the point of view of the complex of existing dividing lines, primarily economic, administrative, natural, etc. and/or from the "top" when *spelestological province* is divided into *spelestological divisions* if possible along the existing dividing lines of cultural-geographic regions with the result verification for the compliance with the principles of that spelestological zoning.

The resulting taxa net must be constantly reestimated from the point of view of fragmentation, contrast of zoning borders, nesting in the units of higher hierarchical level. Based on the results of the zoning performed, you may need to change the concept about the very process of zone forming at the given territory, i.e. to modify the principles of zoning and revise the taxa net (make iteration) [Manakov, 2014].

There are two main methodological procedures when drawing boundaries of the areas which follow one another – the separating, when each district is contrived separately regardless of the boundaries of neighboring districts and the separation, when a mutual (compromise) boundary between the two neighboring zoning units is determined [Smirnyagin, 2011]. On the lower level of spelestological zoning, due to dispersion of classified substrate, separating is mainly used (*spelestological block*, *spelestological site* and *spelestological region* often do not have common borders with other taxa). Starting from the *spelestological division* level and above separation is mainly used; from the same level, the techniques of cultural-geographical zoning are also applicable.

In the delimitation of taxa, you should rely largely on the net of the boundaries that are identified within each layer of the cultural landscape. It should be noted that the natural boundary is a marker of the historical-geographical area if it repeatedly show itself in the formation of political and administrative units.

The latter, in turn, show stability when they coincide with ethnic and cultural boundaries. Within the political-administrative units themselves, there usually dominates a tendency toward erasing ethnic and cultural differences [Vampilova and Manakov, 2012]. The situation of coincidence of heterogeneous boundaries is called superposition [Smirnyagin, 2011].

For the recognition of cultural-geographical taxa of different level and drawing their borders L. Smirnyagin proposed [1989] a method of floating signs zoning. It is based on zoning "from bottom up" – first a taxon is recognized by means of a rather complex and often unparameterizable procedure, an idea of its character is formed, and then the specific to the taxon characteristics are identified that are compared with the characteristics of neighbors, followed by a stage of carrying out the district boundaries. More traditional methods of zoning are also such methods of border drawing as overlay method and leading characteristic method [Manakov and Andreev, 2011].

The overlay method is based on the isolation of integral zoning units by juxtaposition of the nets of the boundaries of sector-specific zoning schemes (physical-geographical districts, the boundaries of the historic and modern administrative-political formations, territories of compact residence of ethnic and religious groups, dialectal zones, ethnographic, cultural, economic areas, etc.).

Formal in nature, overlay method often leads to random results and requires control. The leading characteristic method is aimed at the isolation of zoning units by some single component. After determining which characteristics are leading at that level of zoning you can move on to the understanding of zoning in general and, in particular, the system of zoning hierarchization [Manakov, 2014].

6. SPELESTOLOGICAL LANDS BORDERS DESCRIPTION

It seems that the best way to determine the *spelestological land* borders is such:

6.1 Mediterranean spelestological land

In Europe on the Balkans the western and northern border of this country passes along the division between the

Orthodox and Muslim peoples at the east and the Catholics at the West, i.e. approximately along the eastern and south-eastern borders of Croatia, then through Vojvodina and Romania along the crest of the Carpathians to the Ukrainian state border, then to the east along it to the Dniester river and along the edge of the left side of the valley of the Dniester to the Black sea.

On the Crimean peninsula the border of the spelestological land runs along the Outer (Third) ridge of the Crimean mountains.

In the Caucasus the border runs along the edge of the Big Caucasus Northern piedmont, i.e. in the historical border between valley farming and plain nomad cattle breeding. The border between the Caspian Sea and the Indian Ocean runs upstream of Kura and Araks, than it goes southwards along the Kurdish ridge and along the Zagros piedmont up to the Persian Gulf.

In Africa, the boundary of the **SpL** runs along the ethnic division between Semitic, Berber, and Cushitic Christian peoples to the north of it and Negro (Western Bantoid, Mande, Songhai, Sudan, etc.) peoples, to the west of the Nile this line mostly corresponds to the southern limit of the Sahara and to the east of the Nile is runs along the south-western frontier of Ethiopia and then across the Ogaden desert to Djibouti.

6.2 Central Asian spelestological land

The northern border runs between the Caspian Sea and the Aral Sea over the northern slopes of Mangystau mountains ant the Ustyurt plateau, through of the Bolshie Barsuki Sands, along the western side of the Turgay hollow, over the heights of Zhylandytau and Saryadyr, then near the edge of bogen structures of Kazakh Uplands area to the western side of the Balkhash lake; to the east of the Balkhash – along the Tarbagatai ridge to the Chinese state border and than approximately along the Chinese-Kazakh state border to the Mongol Altai.

The Eastern border of the **SpL** runs along the Mongol-Chinese border to the Eastern Tyan-Shan foot, than along its piedmont to the Chinese state border and to the south along it. The eastern border of the **SpL** runs along the edge ridges of the Plateau of Iran (Makran, Braguch, Tobakakar) and southern piedmont of Gindukush; than to the east along the Khinduradzh ridge up to the Chinese border.

The western border of the **SpL** runs along the western side of Zagros mountain system (except plain Khuzestan but including Iraqi Kurdistan), than along Iraqi-Turkish state border up to the river Araks, at the south-west its border runs along the Araks and the Kura to its outflow.

6.3 African spelestological land

The northern **SpL** border runs along the ethnic division between Christian Cushitic, Semitic and Berber peoples from one side to the north of it and Negro (Western Bantoid, Mande, Songhai, Soudan, etc.) and Muslim Cushitic (Somali) peoples to the south. To the west from the Nile this line is mostly similar to the southern border of the Sahara and to the west from the Nile it runs along the south-western state border of Ethiopia, than across Ogaden to Djibouti.

6.4 South Asian spelestological land

The eastern border of the **SpL** runs along the edge ridges of the Plateau of Iran (Makran, Braguch, Tobakakar) and southern piedmont of Gindukush; than to the east along the Khinduradzh ridge up to the Chinese border. In the south the **SpL** includes islands of Indonesia and the Philippines.

6.5 East Asian spelestological land

The **SpL** land borders are nearly similar to modern Mongolia and China state borders. Also the **SpL** includes Korean, Japanese and Kuril islands.

6.6 West European spelestological land

We traditionally line the Western Europe eastern border (after A. Toynbee, U. Wallis, S. Huntington, etc.) along Western Christianity (Catholicism and Protestantism) distribution limit in Europe [Huntington, 1996]. It seems this borderline splits the territories with different approaches to develop the underground space.

The land border runs along the Russian border with Finland and Baltic states, across Belorussia and the Ukraine, dividing their western outskirts, than it goes across Romania between Transylvania and Moldova with Walachia (along the Carpathian ridge), than across Vojvodina and than approximately along the Croatian south-western state border (along the line where the Croatian population dominates over the Bosnian and Serbian one).

The foundation of the Western civilization itself probably took place in the 8th century. Later the North-American and the Latin-American subcivilizations were based on it [Huntington, 1996].

6.7 North Eurasian spelestological land

The western **SpL** border runs along the Russian border with Finland and Baltic states, across Belorussia and the Ukraine slightly deviating to the east from their state border.

In the south the border runs through the Crimean and Caucasian mountains piedmont, between the Caspian Sea and Aral Sea the border runs over the northern slopes of Mangystau mountains ant the Ustyurt plateau, through of the Bolshie Barsuki Sands, along the western side of the Turgay hollow, over the heights of Zhylandytau and Saryadyr, than near the edge of bogen structures of Kazakh Uplands area to the western side of the Balkhash lake; to the east of the Balkhash – along the Tarbagatai ridge to the Chinese state border and than along it. At last it runs along the Russian state border to the Pacific ocean.

6.8 North American spelestological land

Its Southern border can run along the southern border of the USA.

SpL	SpP	Approximate characteristics of the territiory
Medi-terranean	Mountain Crimean	mountainous part of Crimea
	North Caucasian	northern slope of Greater Caucasus
	South Caucasian	Georgia, Armenia, north Azerbaijan and areas of north-eastern Turkey
	Bessarabian	between the rivers Danube, Prut and Dniester, including the left bank of the latter
	Eastern Balkanian	Bulgaria, Serbia, Montenegro, Macedonia, Albania, most part of Bosnia-and-Herzegovina, southern and eastern Romania, north-eastern Greek and European Turkey
	Grecian	most part of the Greek State, and Cyprus
	Minor Asian	The Asia Minor peninsula: most part of modern Asian Turkey
	Mesopotamian	roughly corresponds to Iraq, including the plain of Khuzestan and except Iraqi Kurdistan
	Levantine	Syria, Lebanon, Jordan
	Palestinian	The historic region of Palestine (modern Israel and Palestinian territories)
	Arabian	The Arabian peninsula: Saudi Arabia, Yemen, Oman, UAE, Qatar, Bahrain, Kuwait
	Nilotic	Egypt and Sudan
	Maghrebian	Libya, Tunisia, Algeria, Morocco, Western Sahara, Mauritania, northern Mali, northern Niger, northern Chad
	Canarian	Canary Islands
	Maltese	Maltese Islands
	Abyssinian	Ethiopian highlands: Eritrea and most part of Ethiopia
Central Asian	Ustyurtian	Mangystau mountains and Ustyurt plateau
	Turkestanian	most part of the territories of Turkmenistan, central Uzbekistan, southern Kazakhstan and northern Xinjiang Uygur AR of China (Dzungaria)
	Pamir-Tianshanian	Tajikistan, Kyrgyzstan, eastern Uzbekistan, south-eastern Kazakhstan
	Afghani	Afghanistan and western part of Pakistan (Tribal Areas and the north-western Baluchistan)
	Iranian	approximate territory of Iran (except plain of Khuzestan and including Iraqi Kurdistan) and southern Azerbaijan
African	East African	Djibouti, Somalia, eastern Ethiopia (Ogaden), Kenya, Uganda, Tanzania, Madagascar and other East African islands
	South African	South Africa, Lesotho, Swaziland, Botswana, Namibia, Angola, Zimbabwe, Malawi, Mozambique and the Copper Belt: Southern Democratic Congo (Shaba) and Zambia
	West African	historic regions of Upper Guinea and Sahel
	Central African	historical regions of Lower Guinea and the Congo Basin: Central African Republic, South Sudan, both of Congo (without Shaba), Gabon, Rwanda and Burundi
South Asian	Western Indian	plain part of the Indus Basin: most part of Pakistan and outskirts of western India
	Himalayan (North Indian)	southern Himalayan slope and the marginal basin: northern half of Pakistan's North-West Frontier Province, northern Kashmir (Azad Kashmir and Gilgit-Baltistan); Nepal; Bhutan; Bangladesh; Indian states Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Delhi district

	Middle Indian	Hindustan Highlands: states Maharashtra, Goa, Madhya Pradesh, Chhattisgarh, Jharkhand, Orissa, eastern Rajasthan, Gujarat, and Diu-Daman and Dadra-and-Nagartaveli Territory
	South Indian	Dravidian India: Karnataka, Andhra Pradesh, Kerala, Tamil Nadu states and Puducherry territory
	Ceylonese	Sri Lanka island
	Burmese	territory of modern Myanmar
	Indochinese	Thailand, Cambodia, Laos, Vietnam, Singapore and continental part of Malaysia
	Avstraloasian	Indonesia (excluding Irian), Philippines, East Timor, east Malaysia, Brunei
East Asian	North Chinese	north provinces: southern and central Hebei, Shanxi, Shandong, Henan, north Anhui, northern Jiangsu, Shaanxi, Gansu, Ningxia Hui and Beijing and Tianjin Municipalities
	South Chinese	southern provinces: Hubei, southern Anhui, southern Jiangsu, Zhejiang, Fujian, Jiangxi, Hunan, Guangdong, Hainan, eastern Guangxi Zhuang, Shanghai municipality, Hong Kong and Macau, and Taiwan
	West Chinese	south-western provinces: eastern Sichuan (Basin), Yunnan, Guizhou, Chongqing Municipality and western Guangxi Zhuang
	Manchurian	northeastern China (Manchuria or Dongbei) provinces: Liaoning, Jilin, Heilongjiang, outskirts of northern Hebei and eastern Inner Mongolia AR
	Tibetan	historical Tibet: Chinese Tibetan AR, province Qinghai, western Sichuan (Mountain), Indian Little Tibet and Bhutan
	Kashgarian	southern part of Xinjiang Uygur AR (Kashgar)
	Mongolian	Mongolia and China's Inner Mongolia AR
	Korean	territory of Korea
	Japanese	Japan and Kuril Islands
West European	Apennine	Italy and Corsica (France)
	Iberian	Spain, Portugal and Gibraltar
	Gallic	France, Luxembourg, eastern Belgium and Germany west of the Rhine
	British	British Isles: UK and Ireland
	Central European	most part of modern Germany (excluding the land to the west of the Rhine and areas of north-eastern country), Austria and Denmark
	Prussian	historical regions Pomerania and Prussia: north of modern Poland, north-east areas of modern Germany, Kaliningrad region of Russia and the area of Klaipeda in Lithuania
	North Carpathian (West Slavic)	southern Poland, western Belarus, Czech Republic
	South Carpathian	Hungary, Slovakia, Zakarpattia region of Ukraine and the north-western Romania (Transylvania)
	Western Balkanian	Slovenia and Croatia and western Herzegovina in Bosnia-and-Herzegovina
	Scandinavian	Finland, Sweden and Norway
	Icelandic	Iceland Island
	Baltic	approximately territory of Estonia, Latvia and Lithuania
North	Western Ukrainian	Lviv, Ivano-Frankivsk, Chernivtsi, Ternopil, Khmelnytsky, Rivne and Volyn regions

Eurasian	Slobozhanshchyna-Kuban	Russia: Orel, Kursk, Lipetsk, Belgorod, Voronezh, Tambov regions, eastern part of Bryansk region, southern outskirts of Ryazan, Tula and Kaluga regions, western part of Volgograd region, and main part of the Rostov region, Krasnodar and Stavropol regions; Ukraine: northern part of Kharkiv, Lugansk and Donetsk regions, as eastern outskirts of Sumy region
	Krivoy Rog - Donetsk	most part of Dnepropetrovsk, the southern parts of Lugansk and Donetsk regions of Ukraine, the western part of Rostov region of Russia
	Novorossia-Tauride	Ukraine: Odessa (east of the Dniester River), Kherson and Mykolaiv region, Zaporizhia region, as well as most part of recognized Transnistrian republic and plain Crimea
	Belarusian	middle and eastern parts of Belarus and western outskirts of Smolensk and Bryansk regions of Russia
	Middle Russian	west regions of Russia
	North Russian	north of European Russia
	Fennoskandian	Karelia, Murmansk region and northern outskirts of Leningrad region
	Average Volga	lower part of upper and middle of reaches of Volga: Yaroslavl', Kostroma, Ivanovo, Gorky, Kirov, western half of Tatarstan, Mari El, Chuvashia, Ulyanovsk and Samara regions
	Lower Volga	lower reaches of the Volga: Mordovia, Penza, Saratov, eastern part of Volgograd, Astrakhan' regions, Kalmykia, plains Dagestan and Chechnya (Russia), Atyrtau region (Kazakhstan)
	Ural - South Siberian	territory of the geological formations of Ural and Cis-Ural, Kazakh Uplands, Altai, mountains of southern Siberia and Transbaikalia (Dauria)
	North Siberian	territory of West-Siberian Plain, Central-Siberian Plateau and East-Siberian Mountainous
	Far East	approximately territory of Jewish autonomy, Amur, Primorsky, Khabarovsk, Magadan, Kamchatka and Chukotka regions
North American	Atlantic	territory of eastern and midwestern states of USA and provinces New Brunswick, Nova Scotia and Prince Edward Island of Canada
	Pacific	western states of the USA
	Arctic	most part of Canada and Alaska state of the USA
	Greenlandic	Greenland Island
Latin American	Caribbean	Caribbean Islands
	Mesoamerican	territory of Central America
	Northern Andean	Colombia, Venezuela, Guyana, Suriname, French Guiana
	Central Andean	Peru, Ecuador, Bolivia, and northern outskirts of Chile and Argentina
	South Andean	most part of the territory of Chile and Argentina as well as Uruguay and Paraguay
	Brazilian	Brazil
Australian-Oceanian	Australian	Australian continent
	New-Zealandian	New Zealand Islands
	Polynesian	Polynesian islands, including New Zealand
	Micronesian	Micronesian islands: Mariana, Caroline, Marshall and Gilbert Islands and others
	Melanesian	Melanesians islands: New Guinea, Bismarck, Solomon, New Hebrides, New Caledonia, Fiji.

Table 2. Spelestological provinces territories characteristics

6.9 Latin American spelestological land

The **SpL** includes Latin and Southern America also including the Caribbean islands. Its land border can run along the southern border of the USA.

6.10 Australian-Oceanian spelestological land

It includes Australia and Oceanian countries (including Indonesian Western Irian and American Hawaii).

Approximate characteristics of the configurations of *spelestological provinces* are shown in Table 2.

7. CONCLUSIONS

Creating the approach to the spelestological environment structuring we used several methods of system methodology: going from the whole to its part (distinguishing elements) and to the opposit, from the elements to their combinations (generalization) and presenting the spelestosphere as multilevel object systems combined into hierarchical interdependent communities. The use of the system approach helping to find the links of the spelestological objects with the other sciences objects seems to be perspective.

For example, the found regularities show that there is correlation among the territory population mentality and the set of underground structures situated there. this lets to talk about a new purpose of the spelestological environment research – to search and arrange the ethnopsychological aspects of the mining art. This work can help to distinguish the taxon units and determine their borders. It is necessary to hold out detailed research on the lower levels of the spelestological zoning scheme. It will help understand the mining and underground architecture history and how the spelestological objects spread in space and time.

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20 centuries of excavations in Laon (France)

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Abstract
Some 140 km to the North East of Paris, France, lies 'Lugdunum Clavatum' nowadays known as Laon. Encircled by 5.5 kilometres of city walls, one of France's finest cathedrals at its centre, Laon was home to 10.000 inhabitants as early as the 13th century…. a direct consequence of the geological ridge the town sits on.

Indeed, the particular topography and geology are a critical factor in the expansion of the town, its subsoil providing natural construction materials. As a result of excavation works, Laon houses many diverse underground spaces: rock quarries, underground sand quarries (arènes), storerooms, cheese cellars, military galleries, etc.

Nowadays, the 77 hectares of the intra-muros medieval city, are built on 3 levels of excavation, the result of 2000 years of underground activity : from the first extraction of building materials during Antiquity to the military use during World War II. This presentation, resulting from 20 years of surveying underground spaces, aims to provide an overview of how 20 centuries of excavation in the heart of the city, have shaped the ground under Laon.

Keywords
Valorisation du caractère patrimonial des cavités souterraines – MEDDE
Mise en valeur des espaces souterrains, Ministère de l'Ecologie, du Développement Durable et de l'Environnement

1. GEOLOGY AND GEOPOLITICS

Some 140 km North-East of Paris, lies the city of Laon, capital of the Aisne region (French department 02). Due to the particular geological and geographic characteristics, combined to the anthropic occupation, the city played an influent and important geopolitical role. This town has had a strategic position since the Antiquity, until the last world war.

Geologically situated in the Parisian basin, it figures at the edges of the Lutetian deposits, since it is placed on a hillock just in front of the natural border of the coast of the Ile de France region.

Travelling from the actual Northern and Eastern borders through the large plains of lime, it is a natural bastion before the "march" of the 'cuesta Ile de France" on top of limestone banks. It controls one of the major axis towards Paris.

Sitting on limestone, the 77 Ha lime plateau forms a crescent on which the town is built, cumulating at 80 m a.s.l. Geologically it is successively formed by layers of sand of the 'cuisien' and the 'thanétien' a layer of clay 'of Laon' of 7 or 8 meters, 3 meters of greenish sand of glauconite, to end with 7 or 8 meters of limestone banks and rocks.

Leaving aside the possible uses of the rocks, the presence of a layer of clay in the final stratum results in a reserve of water of more than 150.000 m^3/year. Sources situated on the summit of the hill or in the interior via 12 or 13 meters deep wells give access to the water reserve.

In the Antiquity, this particular element was a decisive factor in establishing a *castrum* on the eastern side. For more than 2000 years, this geological particularity strengthens the natural topographic qualities of the place, as it is autonomous for its water supply. As a consequence 'outside' water arrives to the taps only in 1869.

This French acropolis, as some authors designate Laon, has gained over the years a strong symbolic and cultural value caused by this water coming from the heights. Starting with the sources and votive wells, followed by the development of Christianity and the waters of the christening, Laon became a renowned intellectual center of the medieval religious thoughts, culminating with the construction of one of the first gothic cathedrals.

2. THE ANCIENT TIME

Surveying the top layers is impossible, as the archeological and historical data are missing However, the areas under the surface have been less impacted or destroyed by the urban transformations and providea complete picture. Three different tracks of three different kinds: excavation, the wells and pits, the silos. However the chronological appreciations have still to be clearly defined by archeological surveys.

These three markers can be observed in the medieval underground quarries. Indeed, with the widespread excavations of limestone for construction purposes during the medieval period, the tracks of the ancient excavation can be observed in the very first layers of the quarry,

Figure 1: Denis Montagne

Figure 3: Quarry face (photo D. Montagne)

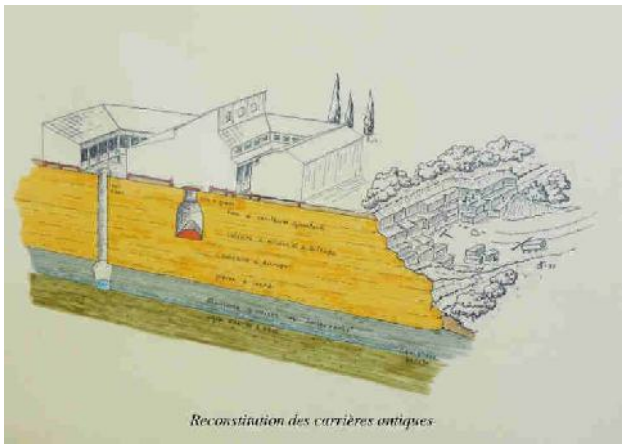

Figure 2: Reconstruction of the antique quarries (drawing D. Montagne)

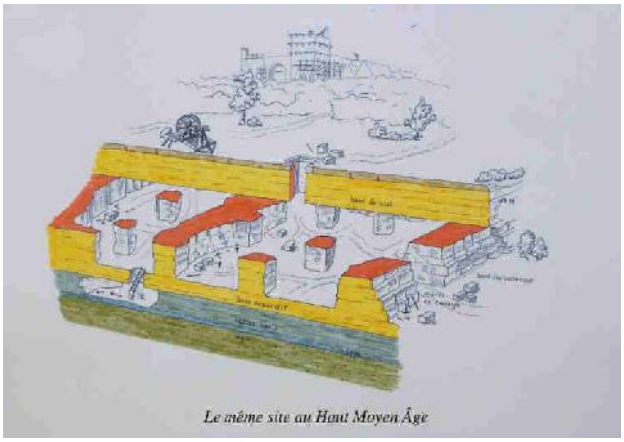

Figure 4: The same site in the Medieval Period (drawing D. Montagne)

technical and chronologic interface between the excavation in open air dating from the Roman and the post-roman excavation. In the Antiquity, excavation was horizontal, executed with a particular tool with two twin points : the '*escoude*'.

Some marks of vertical excavation are also to be noticed, always on a small surface and continuing the excavations in open air.

The wells and pits are probably ripped open due to the progress of the medieval quarries.. They can be identified as wells of water when they connect with the aquifer layer some meters beneath. It is more difficult to know their origin and their use when they end at one or two meters in the limestone layer. They are always filled with decomposing organic materials or ceramics (broken amphoras and other usual objects) *in sigillée*. Those vertical openings (pits with waste) of diameter 80 cm max, are localized in majority in the supposed limits of the ancient *castrum*.

The wheat silos are also present within the same limits of the city (Figs. 1 and 2).

3. MEDIEVAL PERIOD

The quarries in the rock

The urban development , evenly spread over many centuries, impacts the demand for construction materials. With the exception of the Late Empire, construction materials were needed from the beginning of the 6th century and the creation of the diocese of Saint-Remy (who was born near Laon). With the arrival of the Capetian dynasty, Laon turns into a royal residence. Due to the demographic, economic and intellectual growth, the impact underground has been as significant as the impact above ground. Indeed, the local geology offered all the materials that were needed to develop, the civic, military and religious architecture. on top of the 83 m-high hill.

The medieval fortifications are made up of 55.000 m^3 of stones and almost the same quantity of mortar.

The quarries during the Carolingian period are smaller (2,50 m), with small pillars (Figs. 3 and 4).

Over four centuries, the size of the blocks changed, progressively decreasing in width and depth. The quarries themselves become higher, up to one meter more than in

previous periods. West of the city, in the center, it is rather common to find old small open pit quarries recycled into cellars. A second level of quarry-cellar perpendicular to the first, shows the medieval plots. The building activity was self sufficient in construction materials, drawn on the bottom and subsoils, leaving residual empty spaces ready for future uses.
The pickaxe with a rather short handle and blade is the common tool, with scissors and a peak at both ends. Its shape will remain the same all over the centuries, almost until the second millennium, as the last stones are excavated just outside the during the reconstruction period of the twenties.

Underground sand quarries *(arènes)*
Under the lime bank, in contact with the aquifer on clay, a layer of green glauconite sand locally known as *"arènes",* is 2 or 3 meters thick. It was almost completely harnessed on the total surface of the old town and spreading out from the wells and galleries.
As an element of the mortar, this sand was used more or less in an anarchical way depending on the needs over the centuries. Unqualified workers were employed. Therefore, that kind of activity has often been forbidden or strictly controlled due to potential stability problems.
Since the end of the Medieval period, particularly during the 16th 18th and 19th centuries, consolidation works and creation of pillars all over the city, have been undertaken.

The *creutes*
The troglodytic habitat is quite unique. It is localized in the southern part of Aisne, and is very much linked to the quarries of the Chemin des Dames. It was destroyed during World War II.
Nevertheless, in the city of Laon which was saved from the bombings, a street and an area is named *'rue des creutes'* This word refers in general to the troglodytic habitat in the region. This area outside the city walls consists of rupestrian houses dug in the dolomitic limestone unsuitable for construction. The housing existed still at the beginning of the 20th century. The German soldiers during World War I were so surprised that they made postcards of these particular houses.

4. MODERN PERIOD

The military quarries
If we do not take into account the regular consolidation works, the underground world of Laon is the same since the end of the 13rd century (Fig. 5).

Six centuries later, a network of of huge galleries was opened on the level of the *"arènes"* for military purposes. These arrangements began in the middle 19th century, went on till the latest modifications Seré de Rivière after the 1870 Franco-Prussian war. They aim at transforming Laon into a stronghold at the center of a system of forts and batteries on the *cuesta*. For that purpose batteries were built on the Eastern, Western and Southern ends of the plateau,

Figure 5: the outfitting post excavation (drawing D. Montagne)

with three underground gunpowder storerooms. Galleries were dug on that occasion and equipped with an optical telegraph, for communication with the other forts and batteries in the South and the West.
This system became outdated due to the development of artillery and the arrival of new explosives, especially the melinite in 1885, used for the first time the year after in the fort of Malmaison (15 km south of Laon). The underground areas will be forgotten until the First World War.

Some improvements will be made by the occupying forces: namely, water reserves, telephone network, etc.
More than 20 years later, civilians will shelter in the underground galleries during World War II. Some larger tunnels, with multiple accesses, were electrified aiming at serving as collective shelters. Some underground tunnels will be recreated or dug in the rocks to serve as emergency exits avoiding to be trapped in case the buildings should collapse. Most of these tunnels will be closed again after the war, because robbers found their way to the caves.

Yesterday and tomorrow
Almost 50 years of oblivion and darkness will then follow. Population misused the underground. Indeed, water was not longer drawn in the aquifer. Since 1869 it was pumped out of the layers of limestone aiming at supplying the water towers and the houses. This progress in supplying drinking water has not been linked to the creation of an urban sewerage system. The wells out of use have been used for waste water, in a uncontrolled way. The rise of the water consumption since world war II resulted in the eighties, in the yearly discharge of 150.000 m^3 of waste water in the underground of the historical center of the city of Laon.

Penetrating all the layers right to the level of the *"arènes"*, this huge quantity of water has been at the origin of the erosion and of more than 90 collapses and landslides in the period 1950s to 1990s.

In order to handle this situation, the State developed a Risk Exposure Plan *(loi Barnier – Barnier law* in 1991.

Furthermore, an agreement between the Regional Direction of Cultural Affairs and the city of Laon, established a department for the survey of the underground on November 2nd, 1993.

Since then, the underground has been surveyed, and part of it mapped. Policy actions for protecting and valuing this precious heritage have been taken as follows:

1995: creation of a sewing system in the historical city, introduction of the underground during the *'journée européennes du patrimoine (European Heritage Days)'*;

2001 approval of the Action Plan on Preventing the risks of landslides (cave collapse) the department of the survey of the underground conceived a guided visit of the underground;

2004: opening to the public, visits managed by the Tourism Office; 2016: updating of the visit circuit.

Since more than 20 years of surveys, observations, controls and works, the underground world of the city of Laon, in its diversity is nowadays better protected and maintained.

We hope that this policy and planning could be maintained. During the two thousand last years, the underground of Laon has made it possible to build, to eat, to defend. Now it is part of the cultural and historical heritage.

Tomorrow other uses will certainly be added. Promising research has been conducted. This contribution brings up some items that still need to be surveyed and discovered.

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The anthropogenic caves in Finalese (northern Italy) during historical age

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Abstract
This contribution illustrates the first results of an archeological research aimed to survey and study the caves used by man during historical ages in Finale, domain of Del Carretto's Marquis. The caves in this area are well known in the prehistoric presence but this particular phenomenon of employment and occupation in Middle Age and Modern Age has never been deepened.

The choice came from the observation that there is no specific study to merge the archeological data (data- survey and data from excavations) with historical and geological data. The Finalese is a karst area located in Savona, region of Liguria, North Italy in the municipalities of Finale Ligure, Spotorno, Noli, Bergeggi, Vezzi Portio, Orco Feglino, Calice Ligure, Rialto and Borgio Verezzi.

This study has examined more than 250 natural caves of which 116 have traces of historical frequentation. The sites were classified into 7 different types according to the Commission on Artificial Cavities (A,hydraulic underground works- B, hypogean civilian dwellings-C, religious structures-E, mining works).

Keywords
Anthropogenic caves, Middle Age, Modern Age, reuse.

1. INTRODUCTION

The caves have always been used by man as dwellings, warehouses, barns, cemeteries and places of worship (pagan and christian), with stable or temporary frequentation that vary depending on the occupants' needs. In the Past, the Man has been able to use the environment where he lived, finding simple and practical solutions.

Living in a cave and spending there many times, it means making changes to satisfy the primary needs of human life. Today we are surprised because modern Man lost this ancestral capacity.

The vision that in historical times (Roman Age and Middle Age) the underground space was not used it is a vision not correct; it is true that always, in the collective imagination, the caves are considered refuges of devils and witches but it is necessary to distinguish that mainly these beliefs relate to deep caves and not to less deep caves or rock shelters but in fact sometime it is possible to find archaeological evidences but these evidences present a series of problems: lack of written documents and elements not dated.

2. THE ARCHEOLOGICAL RESEARCH

Archaeological research has proposed to survey and study the caves used by man in medieval and modern times in the Finale area. The caves in this area are well known and studied in the prehistorical and protostorical period but there was no specific study on historical frequentation.

The choice of this type of research was dictated by the lack of a specific study in this area, aiming to unify the archaeological data (obtained from stratigraphic excavations and occasional findings), historical data (from archival research and place names) and geological data and caving (Cadastre Caves) on the phenomenon of attendance and use of the underground environment.

Archaeological studies and ongoing research in the area have allowed to initiate a first historical and archaeological documenta-tion of these sites known through the caving.
The identification of these sites has highlighted that natural caves used and inhabited in historic times are more numerous than previously believed.
The data collected also allowed to have a more complete picture of the settlement dynamics in the analyzed territory. It should be noted that in studies of this type it is essential to have a multidisciplinary approach and the figure of the archaeologist is essential in the identification of human traces.

The archaeological research can be summarized in three phases:
1. field search (survey): detection of known and unknown caves and location via GPS coordinates;

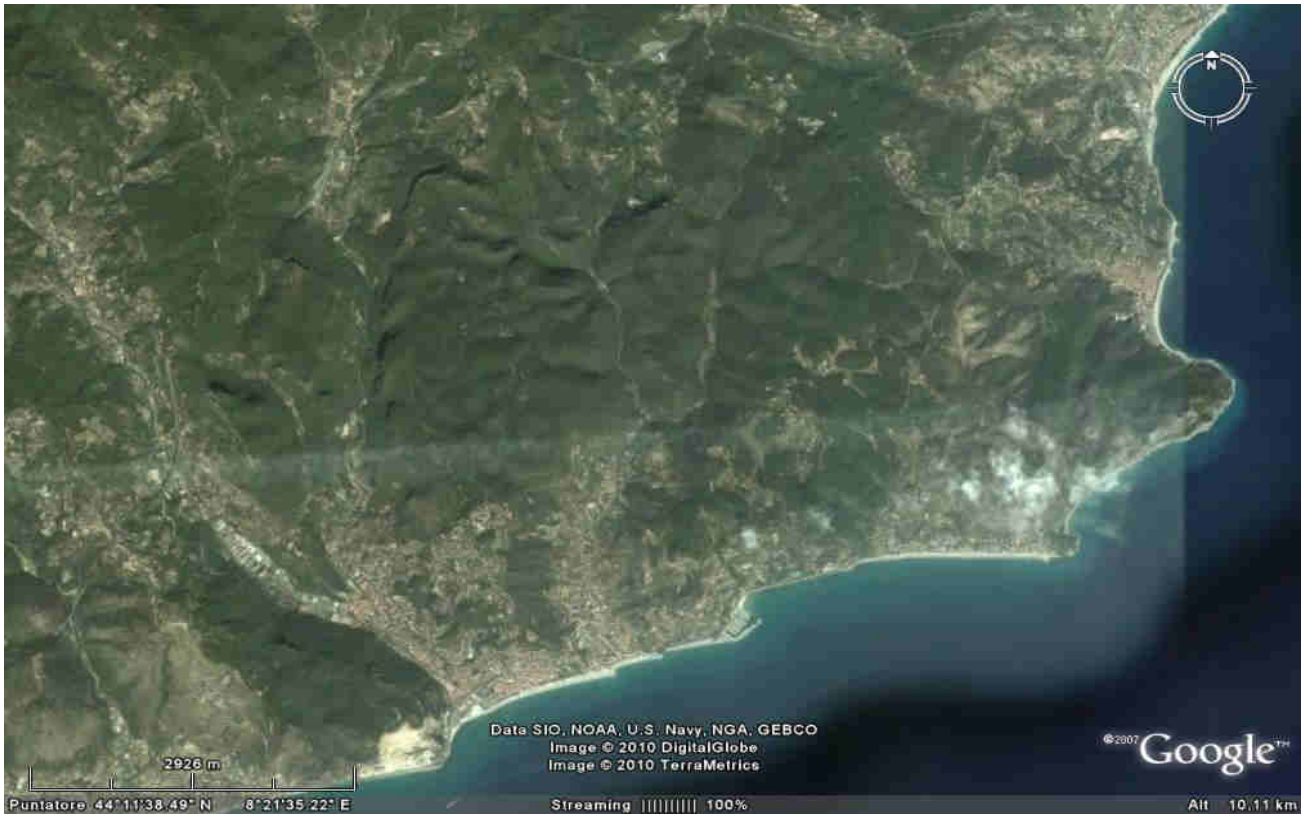

Figure 1: Map of Finalese area[http://www.google.it/intl/iy/earth **]**

2. bibliographic research, archive, place names and use of oral sources.The archival research was mainly carried out in the Civico Archivio Storico di Finale Ligure to find information and references to the use of the caves. About twenty years ago [Murialdo, 1996] had been identified a notarial document of 1541, in which it was sold to Perti, in locations Pianmarino, a grassy land with *arma* (cave) for stable use.

This bill of sale is the written testimony of everyday and "historical" of these natural shelters so numerous in the Finale. It has been possible to identify the rock shelters thanks to some place names, present in written documents. Localization is also occurred thanks to oral sources;

3. study of archaeological materials (from the studied caves). The study of archaeological materials (both from stratigraphic, both collected from surface excavations) was carried out on items stored in warehouses of the Soprintendenza Archeologia della Liguria in Genoa and at the Museo Archeologico del Finale.

Most of the exhibits come from collections of surface or from nineteenth century excavations; but also the latest scientific excavations have shown that certain archaeological deposits have been upset. Therefore the study of archaeological materials, in particular that of ceramics, is considered one interim study, not detailed, which is addressed to the kinds of the individual classes of materials, separate productions and for vascular forms.

3. TERRITORY AND GEOLOGY

The research focused and limited to the area of the Finalese (region of Liguria, province of Savona, in the municipalities of Finale Ligure, Borgio Verezzi, Calice Ligure, Rialto, Vezzi Portio, Orco Feglino, Noli, Spotorno and Bergeggi). The Finalese [Giuggiola & Imperiale, 1970] is a geographic area that includes the river basins of the Pora stream, its tributary Aquila, Sciusa stream and finally a few streams in the short course and the steep slope of the coastline between Mount Finalpia and Capo Noli (Fig. 1).

The term Finale identifies the historical territory, which during the Middle Age it was the domain of the Marquis of Del Carretto, Lords of Finale.

This area is geologically characterized by the Miocene formation called *Pietra di Finale*, which is a carbonate rock of sedimentary marine origin that formed about 20 million years ago and consists of conglomerates, sandstones, marl and bioclastic limestones with rich macro and microfossils lenses. The *Pietra di Finale* was deposited on an existing topographic surface consisting of old rocks, of quite different nature and origin. Dated back to Permian-Carboniferous (about 330 million to 250 million years ago) those continental sedi-ments *Scisti di Gorra* that are associated with interbedded lava material, *Formazioni di*

Eze and volcanic material, *Porfiroidi del Melogno*; while about 245- and 150 million years ago (Triassic and Jurassic periods) quartz coastal sediments were formed (*Quarziti di Ponte di Nava*) and also marine dolomitic sediments (*Dolomie di San Pietro ai Monti*,*Calcari di Val Varatella*). [Bonci M. C., Firpo M., 2013].
Most of the land is hilly and consists of valleys perpendicular to the coast, deeply incised by rivers of torrential character.
The territory is characterized by thick forests that make research very difficult in field. The province of Savona is one of the most forested provinces of Italy with an estimated coefficients around 64% against the national average of 30 % of woods [http://www.provincia.savona.it/allegati].

4. THE CLASSIFICATION OF INVESTIGATED SITES

The classification of the investigated sites it is the result of a complex analysis that tried to be as complete as possible, but it cannot be said, however, exhaustive. In this study it was considered appropriate to adopt definitions developed and provided by the Commission of Artificial Cavities of the Italian Speleological Society [Galeazzi, 2013] that have also been approved and used at international level by the International Union of Speleology (UIS) [Parise et al., 2013]. The classification has taken into account different aspects, ranging from the size, the activities and elements of human settlement, the study of building structures and the presence of archaeological remains.

For many caves it continues to remain uncertain which was the first and original function and the first phase of occupation in historic times. In many cases it is obvious that these cavities have undergone more transformations, so that it is not easy even to lay down a specific period. Also, if for some sites it is quite clear immediately to understand its function, such as small rock shelters or binder, which due to their limited size could certainly not be used as stables, for others it is much more difficult, due to lack of objective data. It added that the progressive abandonment of the countryside and the farming and pastoral activities has as main consequence that within a few generations the collective memory linked to the use of the territory has been almost completely lost. In recent years, the Commission of Artificial Cavities [AA.VV.,2009; Galeazzi ,2013; Parise et al., 2013] tends to distinguish the subterranean cavity in the following way:

1. natural caves
2. artificial cavities
3. mixed artificial cavities
4. natural caves modified by men = anthropogenic caves

The aim of this work has been to make an inventory of the anthropogenic caves till now surveyed. The list is reproduced in Table 1, at the end of this article. In Fig. 2 the distribution of the cave types in Finale territory is presented in a graphic.

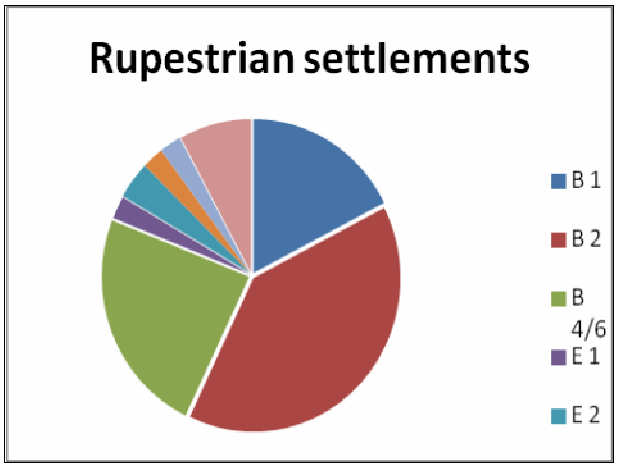

Figure 2: Pie chart of rupestrian settlements

5. CONCLUSIONS: CHRONOLOGY AND FUNCTION OF ANTHROPOGENIC CAVES

The research is to be considered as an initial study which sees the identification and classification of over a hundred anthropogenic caves, but cannot be considered exhaustive and complete. At present the studies cannot provide an accurate history of the occupation of natural caves in the Finale. The motivation is due to several factors: first, the total lack of archaeological deposits *in situ* making it possible to study the stratigraphic sequences and provide datings. Second, most of the archaeological materials coming from or gathered by surface and/or 19th century and prehistoric excavations that are not occupied by any medieval remains or not post-medieval. In some caves (Caverna della Matta, Arma delle Manie, Caverna marina di Punta Crena, Arma dell'Aquila and Caverna delle Arene Candide- for this cave) has already been dealt one typological study of materials, especially ceramic, which provided data on use of the site in a given period or time frame [Mannoni,1982, 2005; Biagini, 2002].

In Caverna Le Pile and in F 29 shelter two coins have been collected which indicate a frequentation in the 15th century, under the rule of the Duke of Milan, Filippo Maria Visconti (1421-1435). It comes from the first half *petachina* of Savona and the second was a *minuto* of Filippo Maria Visconti.

Caverna dei Passi Cattivi, in the locality of Sanguineto has been identified as the cave, which was used as a hospital during the plague of 1631-32 that appears in some documents, kept in the Municipal Historical Archive of Finale Ligure. The discovery of two artfacts of graffita monocroma should confirm the attendance and use.

Type from B1 to B7: hypogean civilian dwellings

The man-made caves in the Finalese have suffered over time a partial or total emptying of the archaeological deposit. Emptying is related to agro-pastoral activities that have affected the sites themselves. In 1956 in Arma della Moretta was performed an archaeological dig near the

Figure 3: "Grotta di Montesordo", an example of permanent dwelling, with entrance portal in "Pietra di Finale" (photo Mordeglia S.)

walls, for a possible stratigraphy in connection with the rock carvings inside the cave [Giuggiola, 1979]. The excavation brought to light two layers that returned modern ceramics and covering prehistoric levels with fragments of *Ursus* (not further specified).

Emptying of Arma della Moretta can be dated based on the findings that were found in the upper layers and allow to place the event between the 16th and 17th century. Even in the most ancient cave Adriana levels, containing remains of *Ursus Spelaeus,* are covered by levels with modern ceramic materials (from the 17th to the 20th century).

Grotta del Principà (Fig. 4), for example, is still handed down by the old farmers the custom to gather inside the cave to fatten the rich clay soil. The emptying of the archaeological deposit is to also connected with the construction of terracing walls in front of the cavity. Near Caverna dell'Acqua o del Morto , the presence of some concretions routes, re-used in the walls and the presence of a fragment of engraved pottery on cue, testify to the construction of the walls took place between the 16th/17th century, following the deposit emptying stored in the cave [Del Lucchese,1987].

Even in the Arma delle Manie internal clay deposit was exploited to realize the partition walls of the cave. During the excavation [Giuggiola, 1982], it was noticed that paleolithic levels were covered directly by medieval levels (pottery from 13th century); it is highly unlikely that there has been no further prehistoric attendance: Neolithic and proto-historic and Roman times, as in many other sites of the Finalese. Furthermore in the clay used as a binder, there were Mousterian lithic materials so this means that in the Middle Age someone took the ancient clay to built the walls.

The use of clay binder in dividing walls of Arma delle Manie does not appear to be a single and isolated case.

Figure 4: "Arma du Principà" (photo Mordeglia S.)

During this study, focusing on building structures (natural input closing walls or partition walls) and their construction technique, it was possible to document the use of clay as a binder in at least 11 caves. This simple and effective technique requires that each row of stones is nestled in a clay layer, in the same way as with way mortar. The advantage is to have a more compact and thermally isolated structure.

The use of this technique has currently no direct comparisons with other Ligurian sites. In the Finale there are examples of walls of stone and earth but it cannot be compared to those identified in the caves. In the excavation of the *castrum* of S. Antonino [Cagnana,2001] in Perti, are located the remains of the so-called "wooden houses", having any concrete base, made of stones connected by dirt, dating from 4th- 5th century to the first part of middle age; in Rialto, many houses are built of stone and mud, because the use of lime was more expensive. Of these houses, the oldest of Cà Prinzipi in Zenda township and Ca du Marquis in Calvi, has been offered a dating from the 16th and 17th centuries, based on archival research [Caneto, 1997]).

In some sites (Caverna delle Fate, Arma delle Manie and Riparo di Pian del Ciliegio) masonry, defined "a secco"[Del Lucchese, 2009], from previous studies, they have proved really bonded with clay. It should be added that the majority of the caves with structures linked with clay belong to the stable settlement type and is the input closes the wall to be made with this technique. Moreover, these caves have a clearly defined access and more than half have a stone portal with threshold. Unfortunately in these caves where there are well-defined walls no archaeological materials were found.

Another technical aspect, although minor, has detected the extraordinary capacity of the builders to adapt to where they had the most of the space rock. In some caves it was observed that the input is closed, the wall was not going to

Figure 5: "Riparo c/o bivio della Croce" (photo Mordeglia S.)

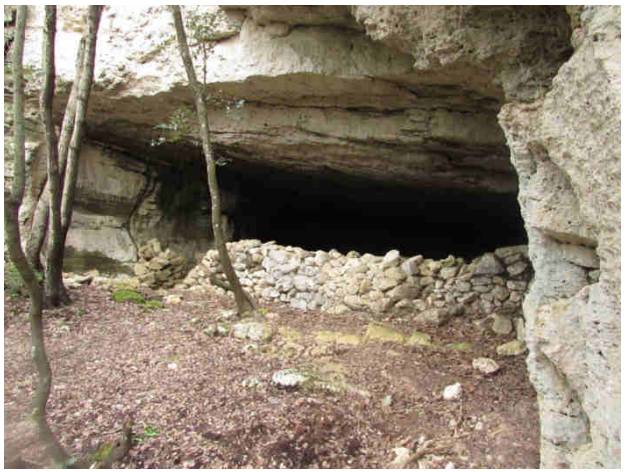

Figure 6: "Arma dei Ponci" (photo Mordeglia S.)

completely seal the structure and so it was necessary to create an artificial partial coverage.

The examples are offered by the parish priest cave that still has three thin slabs of stone embedded in the rock face and in Tana della Volpe and "Riparo c/o bivio della Croce" (Fig. 5) where you can see the grooves in the rock wall, used to insert elements roof.

Type E1: Mining works: quarries and mines

In the quarries of Val Ponci ("Grotta inf. di Ponci" (Fig. 6), and 3rd quarry of "Cave romane"), said roman because are near the bridges of the roman route " "*Julia Augusta"* (between the 1st century BC and AD) were found two fragments of medieval pottery (glazed, archaic majolica). This surface –discovery combined with the lack of written records about the mining activities it does not give an exact dating for these works.

The silver mines of the Bric Gettina, in Rialto, have not been the subject of an archaeological study, to clarify from when he started mining, yet. According to local tradition, the mines were opened by the Del Carretto Marquises to draw from gold and silver chalices and the churches of S. Biagio and S. Caterina in Finalborgo have accrued with this local metal. In a late 18th century document it was reported that the cultivation was terminated at that time.

Type A: the hydraulic works

The works of arrangement and water use of the caves:Grotta del Rio Mortà, Arma del Buio and Grotta dei Ponci can be traced back to the early decades of the 19th century.

Type C1: religious structures (rupestrian churches and chapels)

Grotta di S. Antonino (locality Perti), the rupestrian chapel named "Colpo di Orlando(locality Val Sciusa) and Grotta dell'affresco (locality Val Sciusa) are three sites linked to religious structures. They cannot be compared with each other because besides representing three religious types, they also belong to different age.

Grotta of St. Antonino is located within the homonymous romanesque church and therefore it is clear not only his attendance from the time of the erection of the religious building, which took place between the 10th-11th century, but it is also possible that there was a non-random desire to incorporate it in the church [Testa, 2015].

For the rupestrian chapel "Colpo di Orlando" (Fig. 7), recent studies , propose a dating back to the 17th century, not excluding an older building. The date of 1873 engraved on the rock wall is likely to be referred to a phase of restructuring or expansion.

Grotta dell'Affresco was one of part of the processional route *Rogazioni* of which was also the stage shrine built on the "Colla di Ponci". This last is marked in a paper of 1799 (geometric Card G. Gustavo where is outlined part of the territory between Savona and Finale) and in the 1812/13 cards of the Napoleonic cadastre.

Figure 7: "Cappelletta del Colpo di Orlando" (photo Mordeglia S.)

Table 1 LIST OF SURVEYED ANTHROPOGENIC CAVES IN FINALESE TERRITORY

Abbrevations: A1 = hydraulic drainage works
B1 = durable dwellings - B2 = temporary shelters - B4 = warehouses - B6 = stables - B7 = dovecotes
C1 = religious structures: D1 = war defensive structures; E1 = stone quarries

Name In western Liguria they are used the terms "balma, barma, arma" to indicate caves, caves and rock shelters. "Tana" indicates a smaller cave	**Municipality**	**Regional Caves Cadastre** Li/SV is the code of Ligurian Cadastre, while "F" is a sort of local Cadastre nam-ed "Catasto Borbo-nese".	**First Phase (original destination)**	**Other Phases (reuse)**	**Notes**
Arma do Principà	Finale Ligure	Li/Sv 26	B1	B4 /B6	presence of wall made in stones and clay
Arma del Parroco	Finale Ligure	Li/Sv 204	B1	B4	presence of wall made in stones and clay
Grotta di Montesordo	Finale Ligure	Li/Sv 454	B1	B4/B6	presence of wall made in stones and clay
Grotta del Mulo	Finale Ligure	Li/Sv 476	B1	B4/B6	presence of wall made in stones and clay
Caverna di S. Eusebio	Finale Ligure	Li/Sv 23	B1	B4/B6	
Caverna della Matta o del Sanguineto	Finale Ligure	Li/Sv 96	B1	B4/B6	
Arma dei Rucà	Finale Ligure	Li/Sv 1824	B1	B4/B6	presence of wall made in stones and clay
Arma delle Manie	Finale Ligure	Li/Sv 231	B1	B4/B6	presence of wall made in stones and clay
Riparo Pian del Ciliegio	Finale Ligure	F 3	B1	B4/B6	presence of wall made in stones and clay
Grotta del Pungitopo	Finale Ligure	F 217	B1	B4/B6	
Riparo della Cà Vegia	Finale Ligure	/	B1	B4	presence of wall made in stones and clay
Riparo Casa del Prete	Finale Ligure	/	B1	B1	
Riparo Casa dell'Armetta	Finale Ligure	/	B1	B1	
Grotta inf. dei Frassini	Finale Ligure	Li/Sv 769	B1	B4/B6	
Caverna delle Fate	Finale Ligure	Li/Sv 33	B1	B4/B6	presence of wall made in stones and clay
Grotta della Ruggetta	Finale Ligure	F 167	B1	B4/B6	
Riparo sopra Calvisio	Finale Ligure	Li/Sv 447	B1/B4/B6	B1/B4/B6	presence of wall made in stones and clay
Grotta Adriana	Orco Feglino	Li/Sv 450	B1	B4/B6	
Riparo di Camporotondo	Finale Ligure	F 44	B1/B4/ B6	B1/B4/ B6	
Grotta casa del Vacchè	Finale Ligure	F 20	B1/B4/B6	B2/B4/B6	
Riparo del bivio Vacchè	Finale Ligure	F 18	B1/B2	B4/B6	
Tana della Volpe	Calice Ligure	/	B1	B4/B6	presence of wall made in stones and clay

Caverna del Galluzzo	Borgio Verezzi	Li/Sv 94	B1/B2		
Arma dei Passi cattivi	Finale Ligure	Li/Sv 203	B2	B4/ B6	
Arma dei Gi	Finale Ligure	/	B2	B4/B6	
Grotta dell'Angelo	Vezzi Portio	Li/Sv 412	B2	B4/B6	
Grotta dell'Aurera	Finale Ligure	Li/Sv 360	B2	B4/B6	
Arma della Moretta	Finale Ligure	Li/Sv 332	B2	B4/B6	
Caverna dei Parmorari	Finale Ligure	Li/Sv 198	B2	B4/B6	
Caverna dei Tre Solai	Finale Ligure	Li/Sv 178	B2	B4	
Arma di Perti	Finale Ligure	Li/Sv	B2	B4	
Arma delle Anime	Finale Ligure	F 71	B2	B4/B6	
Arma du Rian	Finale Ligure	Li/Sv 25	B2	B4/B6	
Arma Pollera	Finale Ligure	Li/Sv 24	B2	B4/B6	
Caverna delle Arene Candide	Finale Ligure	Li/Sv 34	B2	B4/B6	
Caverna degli Zerbi	Finale Ligure	Li/Sv 255	B2	B4/B6	
Caverna dei Pipistrelli	Orco Feglino	Li/Sv 211	B2	B4/B6	
Caverna inf. degli Orsi	Orco Feglino	F 191	B2	B4/B6	
Grotta dei Banditi	Noli	Li/Sv 101	B2	B2	
Arma do Pilin	Finale Ligure	Li/Sv 214	B2	B4/B6	
Arma della Strapatente	Orco Feglino	Li/Sv 210	B2	B4/B6	
Grotta dei Balconi	Orco Feglino	Li/Sv 438	B2	B4/B6	
Riparo Cian da RueII	Finale Ligure	F 109	B2	B4	
Grotta a Ipsilon	Finale Ligure	Li/Sv 482	B2	B2/ B4	
Riparo del 1860	Finale Ligure	F 122	B2/B4/B6	B2/B4/B6	
Grotta dell'Uccelliera	Finale Ligure	Li/Sv 199	B2	B2/B4	
Riparo del sentiero di Ciappo delle Conche	Finale Ligure	F 29	B2	B4/B6	
Caverna di Rocca degli Uccelli	Vezzi Portio	/	B2	B2/B4	
Riparo c/o "Vecchie Beline"	Finale Ligure	/	B2	B2/B4	
Riparo c/o "Consolando Consuelo"	Finale Ligure	/	B2	B4/B6	
Riparo c/o bivio Croce di Perti	Finale Ligure	/	B2	B2/B4	
Riparo di Perti	Finale Ligure	F 231	B2/B4	B2/B4	
Grotta del Corno	Finale Ligure	Li/Sv 908	B2	B4/B6	
Arma dei Tecci	Borgio Verezzi	/	B2	B4/B6	
Riparo c/o ex cave Escomarmi	Orco Feglino	/	B2	B4	
Caverna Le Pile	Finale Ligure	Li/Sv 210	B2	B4 e B6	
Grotta marina di Bergeggi	Bergeggi	Li/Sv 32	B2		

Arma dell'Aquila	Finale Ligure		B2	B4 e B6	
Caverna dell'Acqua o della Fontana	Finale Ligure	Li/Sv 29	B2	B4 e B6	
Grotta dell'Antenna	Borgio Verezzi	F 25	B2	B4/B6	
Edificio c/o Grotta dell'Antenna	Borgio Verezzi	/	B2	B1/B2	
Arma della Rocca di Perti	Finale Ligure	Li/Sv 98	B2	B4	
Grotta marina di Punta Crena	Finale Ligure	F 125	B2		
Arma del Frate	Finale Ligure	Li/Sv 99	B2	B4 e B6	
Grotta II del Vacchè	Finale Ligure	Li/Sv 408	B2	B4	unlocated
Grotta-Riparo del Bric Reseghe	Finale Ligure	F 41	B2	B4	unlocated
Arma di Cornei	Orco Feglino	Li/Sv 212	B2		unlocated
Caverna Simonetti	Orco Feglino	Li/Sv 213	B2		unlocated
Riparo c/o sorgente Selasca	Finale Ligure	/	B4 e B6	B4/B6	
Arma sopra Crosa	Borgio Verezzi	Li/Sv 239	B4/B6	B7	
Riparo di fronte Martinetto	Finale Ligure	/	B4	B4	
Riparo Fascette I	Orco Feglino	/	B4/B6	B4/B6	
Riparo nuovo Val Nava	Orco Feglino	/	B4/B6	B4/B6	
Riparo circolare con fori	Finale Ligure	F 224	B4	B4	
Riparo con pozzo scavato	Finale Ligure	/	B4	B4	
Primo Riparo del Vacchè	Finale Ligure	F 14	B2	B4	
Secondo Riparo del Vacchè	Finale Ligure	F 16	B2	B4	
Terzo Riparo del Vacchè	Finale Ligure	F 17	B2	B4	
Riparo del pozzo ovale	Finale Ligure	F 45	B4/B6	B4/B6	
Riparo di Rio fine	Finale Ligure	/	B4	B4	
Tana dei 5 cinghiali	Orco Feglino	F 234	B4	B4	
Riparo vicino alla Grotta delle stalattiti	Orco Feglino	/	B6	B6	
Riparo di Sant'Antonino	Orco Feglino	F 138	B4/B6	B4/B6	
Riparo a N della Caverna della Matta	Orco Feglino	F 57	B4/B6	B4/B6	
Riparo sottoroccia Cornei	Orco Feglino	/	B4/B6	B4/B6	
Grotta c/o la caverna delle Fate	Orco Feglino	F 50	B4/B6	B4/B6	
Riparo sotto Ciappa	Finale Ligure	F 120	B4/B6	B4/B6	
Riparo c/o "Falesia del Gorilla"	Finale Ligure	/	B4/B6	B4/B6	

Riparo degli Asinelli	Orco Feglino	/	B4/B6	B4/B6	
Riparo c/o Rio dei Frassini	Finale Ligure	/	B2	B2	
Arma dei Buoi	Finale Ligure	F 27	B4/B6	B4/B6	
Tana du Mortou	Spotorno	Li/Sv 102	B4/B6	B4/B6	
Grotta di Rio Fine	Finale Ligure	F 240	B2	B4/B6	
Cavità 1 delle miniere di argento	Rialto	CA 14 N	E2	E2	
Cavità 2 delle miniere di argento	Rialto	CA 14 N	E2	E2	
Cavità 3 delle miniere di argento	Rialto	CA 14 N	E2	E2	
Cavità 4 delle miniere di argento	Rialto	CA 14 N	E2	E2	
Cavità 5 delle miniere di argento	Rialto	CA 14 N	E2	E2	
Arma dei Ponci 2 °Cava ponti romani	Finale Ligure	Li/Sv 100	E1	E1	
Grotta inf. di Ponci 1°Cava ponti romani	Finale Ligure	Li/Sv 139	E1	E1	
3°Cava ponti romani	Finale Ligure	F 21	E1	E1	
Grotta del Rio Mortà	Finale Ligure	F 173	A1	A1	
Arma del Buio	Finale Ligure	Li/Sv 27	A1	A1	
Grotta dei Ponci	Finale Ligure	/	A1	A1	
Grotta di S. Antonino (cripta)	Finale Ligure	Li/Sv 30	C1		
Cappelletta rupestre	Vezzi Portio	/	C1		
Grotta dell'Affresco	Vezzi Portio	F 38	C1	C1	
Riparo con croce del Rio Fine	Finale Ligure	/			presence of graffito cross
Riparo della Dea Madre	Orco Feglino	/			presence of graffito cross
Riparo c/o "Falesia Antro delle streghe"	Orco Feglino	/			presence of graffito cross
Riparo inferiore Cà Cerisola	Finale Ligure	F 34	B4	B4	
Riparo superiore Cà Cerisola	Finale Ligure	F 35	B4	B4	
Casella di Bric Reseghe	Finale Ligure	F 42	B2/ B4/B6	B2/B4 /B6	
Riparo del Buio	Finale Ligure	F 39	B4	B4	
Cunicolo di S. Bernardino	Finale Ligure	F 164	B2 e B4	D1	discovered in 1931
Grotta della chiesa di S. Bernardino	Finale Ligure	F 73	B2 e B4	D1	discovered in 1931

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7. ACKNOWLEDGEMENTS

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I thank also Dr. Roberto Ricci for having confirmed that currently there are no studies or even reports on the use of clay binders in masonry (personal communication).

Southern Italy underground space: from the history to the future

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Abstract

There are numerous manufactured structures and objects to be found in the underground in Southern Italy. Representing ways to manage natural resources, to confront the risk of conflict or simply goods and objects stored underground and consequently having survived the test of time, these artifacts allow us to extend our studies of design plans for sustainable growth based on cultural heritage valuation. In fact the underground presents a parallel world, the analysis of which, in its darkness, helps throw light on many of the more obscure areas of Southern Italy urban development, the analysis of the relationship between over-ground and underground urban development reveals many yet-unexplored realities and surprising possibilities of intervention following the roles of "best practice in architecture". According to this approach in fact, the cultural heritage of negative building practice can be used for a contemporary approach to urban regeneration. The paper analyses two ideas of projects based on the valorization of underground space in Southern Italy within two different networks of European and extra-European countries. CUBRe and HURN

Keywords

Underground, cultural heritage, valorization, Southern Italy, projects.

1. INTRODUCTION

In Southern Italy underground space is a parallel world, the analysis of which, in its darkness, helps to throw light on many of the more obscure areas of its urban development in a historic perspective. But the relationship between over-ground and underground urban development is not only linked to the past, it also reveals many surprising possibilities of intervention following the roles of "best practice in architecture" and sustainable urban development, combining perfectly two of the main guidelines in urban planning and historical centers regeneration:

- Use of the underground to enlighten the pressure on the aboveground urban space;
- Reconversion of abandoned cultural heritage sites to allocate contemporary urban functions.

Southern Italy is the perfect place to match both these guidelines. First, in this area negative building culture has a dominant role within its cultural heritage; second, these spaces were neglected and abandoned; third, the underground space is now considered a resource to stimulate a sustainable approach to local urban development.

In Southern Italy underground culture became very popular in order to resolve problems caused by common social and environmental conditions, such as harsh climactic conditions, communication, religious practice, scarcity of resources. In these cases, the dominant local building know-how was reconsidered and new underground building skills were adopted. The relationship between underground and urban development was so special that sometimes it was also brought to extremes: in fact while generally underground was the place where environmental conflicts were settled, sometimes it was quite simply the place chosen for urban settlement by reconverting natural canyons of the area.

Far long from being considered an early approach to sustainable urban development, at the opposite, for a quite long period the use of underground space for urban purposes has been considered as the symbol of hygienic and social degradation of this area.

The abandonment of the ancient underground settlements was therefore considered the solution and new anonymous aboveground residential areas were built. Dismissed and inhabited underground spaces have been forgotten for years causing their physical degradation, the collapse of many structures and damages to the aboveground settlements [Parise, 2012, 2015].

The recent valorization of underground cultural heritage inverted this approach giving to underground space a communicative role of cultural values and a multidisciplinary approach to this process was considered by a consortium consisting of five institutes from the National Research Council of Italy (IBAM, IRPI, ISSM, ICVBC, IMAA) the best way to deal with all the problems connected to its management [Varriale, 2015; Lapenna et al., 2017]. The consortium "Undergrounds in Southern Italy" generated a series of operative proposals in order to finance research and development strategies based on underground cultural heritage valorization. In the following pages two ideas are described: CUBRe and HURN. The first was elaborated to apply to a HORIZON 2020 call, the second to participate to a INTERREG one.

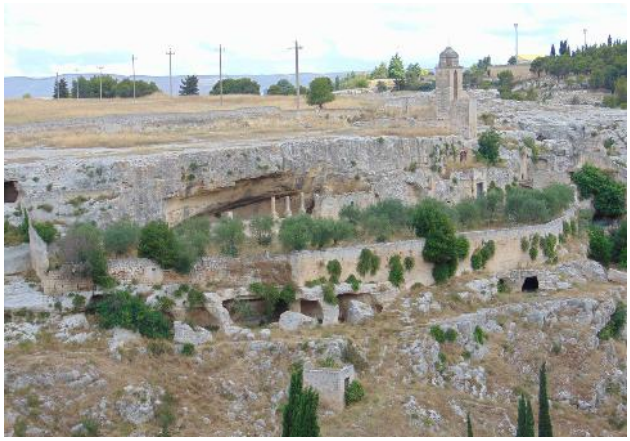


Figure 1: Gravina di Puglia (southern Italy) (photo by the author)

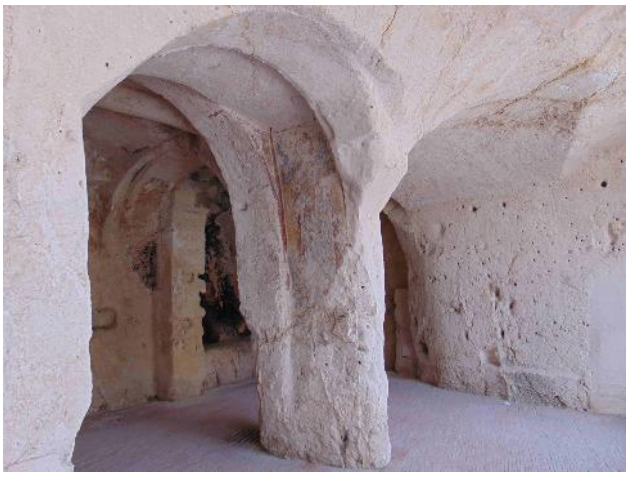


Figure 2: The "Sassi" of Matera (southern Italy) (photo by the author)

2. THE CUBRE PROJECT[1]

The idea of the project CUBRe (Culture of Underground Building as a driver for urban Regeneration) is based on the acknowledgement that underground space is not just a challenge, but also a valuable resource to celebrate, protect and use again in urban contests. CUBRe aims at providing a balanced and sustainable methodology for supporting the conservation of the underground heritage − such as natural and anthropogenic caves, dismissed infrastructure, and human settlements − and realizing the potential of underground space in urban areas for regeneration policies at the same time.

By combining wide multidisciplinary competencies, CUBRe aims at guaranteeing continuity of use and significance to the underground historic fabric, revitalisation of the public realm and skills development for townspeople. In particular, it aims at disseminating knowledge on underground culture and supporting local communities' decision-making with adequate cultural, scientific and technical knowledge of the underground building from many different aspects (i.e. archaeology, geotechnics, history, urban planning, cultural anthropology, economics, architecture, cultural tourism).

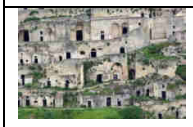
The idea is based on a multi-disciplinary and interactive approach which points out on the individuation of seven Role Models and four Replicators chosen among the cases of urban underground regenerations or abandonments (waiting to be valorized) in the countries of the partners. It aims at investigating the strategies of Role Models, in terms of governance mechanisms, planning framework, stakeholders' involvement management, financing mechanisms, technical needs, and their direct impacts on the underground built environment preservation, environment, society and economy, as well as potential negative externalities (i.e. 'gentrification', hard-branding, mass tourism, recreational villages, underground degradation, etc.) to provide a catalogue of approaches and context-specific practices, collected and made available on an interactive digital platform, the Underground Heritage Platform (UHP) and to be used, at first, in Replicators.

The platform will manage data, providing knowledge on main technical and organizational barriers to the underground regeneration and correlated solutions. In particular, it will analyse new potential functions, seen as evolution of the historical ones – with a particular attention to their divulgation – maintaining a conservative approach of their historical value as part of the European Cultural Heritage. At the end of the project, the platform, which will represent the main tool for communication and dissemination, will be managed by other CUBRe follow-up: the Heritage-Led Underground Regeneration Network (HURN), chaired by the Matera Municipality, which will be based on the consortium partner and the Network *"Sottosuolo Antropico Meridionale"* composed by 14 Italian municipalities.

The produced knowledge is based on the analysis of the following Role Models and Replicators.

Southern Italy is included both among Role Models and Replicators within CUBRe because in this area underground space has always been influent on the urban management and sometimes the *below 0 level* was itself the place where urban life took place. In this type of underground situation, the traditional building concept is inverted, based on quarrying and removal rather than construction. Instead of the mass of rock being used to build spaces of habitation, it must be removed in order to create the required space. This strategy became necessary in various areas of the basin in order to solve problems of safety, adverse climatic conditions or lack of water [Del Prete & Parise, 2013]. The urban functions of the underground vary from one area to another [Galeazzi, 2013; Parise et al., 2015] but nearly always provide solutions for dwellings and shelter and always prove to be among the most environmentally friendly models of urban development and management of water and energy resorces.

ROLE MODELS

	Naples (Italy): Modern Ages tuff quarries having recently been reconverted into a multi-piano public parking to promote the passage from private to public urban transport, an underground exhibition hall and a fashion lounge bar. Avant-garde in underground urban planning and regeneration [Varriale, Esposito & Miano, 2013].
	Postojna (Slovenia): A post office, retail area and an exhibition hall in a cave; the project's green building features include a unique heating and ventilation system and a sophisticated environmental monitoring [Šebela, Prelovšek & Turk, 2013].
	**Matera** (Italy): The caved city was dismissed in the late 50s, and inhabitants moved to new quarters. In 1993, the site entered in the UNESCO's World Cultural and Natural Heritage List and used as an open-air museum. Matera will be "European Capital of Culture 2019", as exemplary of the underground building big potential [Laureano, 1993].
	Wieliczka (Poland): From the Middle Ages 13th to the 2007 this salt mine was in almost continuous operation, also housing a subterranean community who transformed the mine into a cathedral with salt sculptures, a concert hall, a sanatorium, etc. Since 1978, it is included in the UNESCO's World Cultural and Natural Heritage List.
	Granada (Spain): Gypsy communities from the Middle Age to 1960, when Spanish government deported them, have inhabited the Sacromonte caves, built during the Arab period. Periodic inundations and poor maintenance caused the gradual abandonment of the area. In the late '90s, the valorisation of flamenco dance culture inversed the process [Urdiales Viedma, 2003]..
	Goreme - Cappadocia (Turkey): Located on the central Anatolia plateau, the region is settled in a moonlike landscape of giant rock cones, housing historic cave-dwellings and Byzantine churches. Listed by UNESCO in 1985, thanks to many successful regeneration interventions, it offers a sustainable balance between heritage conservation, cultural tourism development and the local community empowerment.
	Maastricht (Netherlands): Used since the lower Paleolithic period, the limestone quarries are a vast network of subterranean corridors. One of Maastricht's main tourist attractions, they have ancient inscriptions, drawings and other art-works. Some of them, after being abandoned for long, have new functions and for others there are new plans of regeneration [http://www.marres.org/site/assets/files/1162/121-023_undertones_plattegrond-eng-def3.pdf].

REPLICATORS

	Gravina di Puglia (Italy): Its heritage is a real underground city, made up of cellars, subterranean granaries, passages, aqueducts, cisterns, drainage systems, rocky churches and rocky habitats, all created by cutting and digging into the "calcarenite" [Bixio et al., 2007; Parise & Sammarco, 2015] .
	Gaziantep (Turkey): During a conservation project in the Gaziantep historic bazaar, new caves and tunnels have been recently discovered. Excavation will start soon for bringing the underground city into light.
	Almanzora (Spain): This Almeria town owes its name to the caves that can be found there and is characterised by numerous historical archaeological sites (e.g. Villaricos, Fuente Álamo and Almizaraque).
	St. Sozomenos (Cyprus): Abandoned village near Nicosia is an important case of medieval ascetic practice in Cyprus, born around a large cave chapel dedicated to the monk Sozomenos's, decorated with wall paintings dating from the Byzantine period. Chapel and village are the focus of an interdisciplinary research project led by CYI, in partnership with Cyprus Department of Antiquities and Cornell University.

They are indeed study cases for our modern bio-architecture and simultaneously places of enormous potential for tourism, as they belong to the cultural patrimony of the area.

In Matera − Role Model in the project − the site of the Sassi originates from a troglodyte village, considered to be one of the first human settlements in Italy [Laureano, 2001; Lionetti et al., 2015]. The construction of the Sassi reflects the progressive transformation of natural caves into closed caves and then into *lamiones.* The various levels of these single dwellings has over time created an urban landscape of underground habitations and cisterns, the complexity of whose structure can only be fully appreciated when observed in section. These caves are believed to have been inhabited since Paleolithic times and the earliest findings date back to the eight century BC. In the ninth to eleventh centuries AD, they were occupied by peoples from the East, followed by the Norman Swabia peoples in the eleventh to thirteenth centuries and a baroque period from the seventeenth to eighteenth centuries. In the year 1000, Basilian monks from Anatolia and Syria brought their culture to the area and the cave churches in Southern Italy are perhaps the most striking example of this influence [Fonseca, 1970]. The demographic rise and the socio-economic decline of the area turned these dwellings into the socio-environmental disaster described by Carlo Levi in his famous book *Christ stopped at Eboli.*

Following the success of this work and much consequent political pressure, the Sassi were finally, definitively evacuated. In the 1980s, recovery of the site began and in 1993 the *Sassi di Matera* were granted UNESCO status as a World Heritage Centre. The successful passage from having being for a very long period the physical sign of the supposed moral, social and urban decline of Southern Italy to the nowadays protection as a significant part of Cultural Heritage is the proof that the inversion of the decline is possible. Matera will be the European Capital of Culture in 2019, this investiture is the confirmation that underground cultural heritage regeneration can generate a virtuous process.

In Gravina di Puglia − Replicator in the project − only a few kilometers from Matera, there is another series of caves of particular interest. Once exploited for residential and defense purposes, this is a complex series of caves along the sides of a canyon, through which flows a river of the same name. The complete history of this site has yet to be entirely reconstructed, but its topographical position and the fact that natural caves already existed there suggests that they were most likely already used in Neolithic times; however without their having been subject of in-depth study, it is difficult to date the beginnings of their residential function. It is, however, a fact that in the year 456, the above-ground urban development was destroyed by a Vandal invasion and the inhabitants took refuge in the caves of the Gravina river, most certainly reviving the concept of cave 'dwellings' here. To the early shelters, religious buildings dug out of the tuff were soon added, along with various other infrastructures for everyday existence. Over the centuries, layers of different structures were added, often hiding the original ones. The recent interest of a local historian and a sad incident[2] have thrust this site into the limelight but there is yet much to be done to give it the full attention it merits.

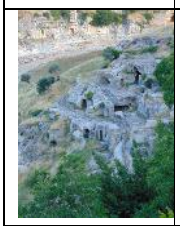
Even if really innovative, the CUBRe project is not exhaustive with reference to the wide underground world in Southern Italy; it gives a methodology to follow in the approach to the reconversion process in the selected cases but in this area underground cultural heritage is so significant as an expression of a cultural character that many more sites could be used as Role Models and as Replicators as well. To give a more complete and exhaustive vision of the tribute given by Sothern Italy to the underground world and its implications, HURN has pointed out a list of 14 municipalities interested in setting up a cooperative approach to the reconversion planning based on this typology of cultural heritage. They have been selected because of the relevance of their underground heritage but their significance is also linked to their logistic location since the creation of a dedicated touristic route is one of HURN's goals.

3. THE HURN PROJECT[3]

HURN (Heritage-led Underground Regeneration Network) is the first EU-wide project in the field of Cultural Underground Heritage (CUH), still largely unexplored in terms of market-oriented valorisation. Many EU initiatives and projects focused more on the potential reuse or exploitation of the Cultural Heritage, than on a specific context-related typology of heritage. Abandoned underground spaces have always represented a significant cost for the local authorities in terms of safety and hygienic control and for the risk of collapse [Parise, 2015], and influenced the aboveground urban management.

The HURN approach aims at transforming CUH from a negative space, also from the financial point of view, to a positive one at local and regional level, guaranteeing significance to the underground historic fabric, revitalisation of the public realm and skills development for townspeople. By making available good practices and defining new methodologies for CUH exploitation, HURN will favour new demand for reuse by users. This would satisfy the need for job creation, bringing the private sector and entrepreneurs to play an increasing role, not limited to tourism, as well as attracting investments and stimulating knowledge creation and research. HURN exchange of experience will not only support local communities' decision-making with adequate cultural, scientific and technical knowledge from many different aspects (i.e. archaeology, geotechnics, history, urban planning, cultural anthropology, economics, architecture, cultural tourism), but also activate a learning process on the CUH.

The list of the selected cities − with the exclusion of Matera and Gravina, already included in CUBRe − is the following, they can stimulate several other proposals in accordance with the guidelines of the upcoming calls.

	Grottaglie (Taranto province). The Gravina di Riggio [Marangella & Parise, 2008] is a caved settlement inhabited from 2000 BC to Middle-Age. Several historical underground oil factories [Monte, 2003], pottery ovens and chemistries testify the role played by underground space in the economy of the area
	**Ginosa (Taranto province).** Two different caved settlements completely abandoned and degraded for the *poor sister* of Matera (all potentially dangerous movies scenes in Pasolini's *"Il Vangelo Secondo Matteo"* were played there). Recurrent collapses [Parise, 2007, 2015] and floods, underground space must be restored and given back to population for reconversion programs.
	Massafra (Taranto province). The Gravina Madonna della Scala hosts a caved Neolitic village: more than 200 structures with different urban functions connected by a complex system of stairs, partially used to host the animated scenes of the crib at Christmas. Farmacia di Mago Greguro and several underground churches complete the underground scenario.
	Castellaneta (**Taranto province**), Gravina of Coriglione and Gravina of Santo Stefano are two perfect examples of Middle Age negative building culture. The most important underground churches are: Santa Maria del Pesco, Santa Maria del Soccorso, Santa Lucia, Santa Maria di Costantinopoli, Mater Christi, Padre Eterno, Santo Stefano, San Michele Arcangelo, Ovile Vecchio and Santa Maria del Porto.
	Palagianello (**Taranto province**). The rock-cut settlement is located under the Middle Age castle; paths and stone stairs allow visitors to get inside the multi-storey underground spaces. Several underground churches: San Girolamo, Sant'Andrea, San Nicola, Santa Lucia, Iazzo Rivolta.
	Laterza (**Taranto province**). Laterza is well known as the pottery city and this activity was based on the use of underground ovens but also the bread tradition and leather manufactories had their roots in the underground. A spectacular Spanish wine canteen and a caved settlement complete the underground scenario.
	Fasano (Brindisi province), In the area of Egnatia underground stratifications preserved a roman village for contemporary visitors, the harbour area and the necropolis. Lama d'Antico is a well preserved and the caved church « Lama d'antico » a perfect example of virtuous use of underground cultural heritage.
	Monopoli (Bari province). Significant stratifications reconstruct the urban history of the city from the Massapic Era up to the present, mummified bodies of medieval monks and underground churchs complete its underground world.
	Palagiano (Taranto province). The underground oil factory in XIX century and the collapse risks (2003 flood): two faces of the role of underground space in the management of aboveground conflicts [Parise, 2007].

	Taranto. Taranto is one of the oldest city in Italy, its history is written in the underground of the old, and abandoned, city. Depicted as the symbol of the unsustainable city (the steel factory ILVA generated one of the most controversial case of urban pollution in Italy) the *resilience* approach is based on the evaluation of the narrative role of underground space as for the very first time achieved in the MARTA museum exposition.
	Altamura (Bari province). In the undergrounds the remains of the umankind history: a concretioned scheleton of a Neanderthal (50000-65000 years ago) men was descovered in 1993. Its unicity was the reason why this case took part to the Science Museum of New York exibition on menkind evolution.
	Mottola (Taranto province). Very popular for the magnifecent caved churches and rock-cut settlement once used by religious pelgrims.

Another HURN innovative feature is its capacity to answer to regional policies addressed to urban regeneration, sustainable development, knowledge growth, cultural heritage valorisation and to generate diffuse positive effects on local economies, environmental protection and preservation of local culture signs.

HURN is supported by Region Apulia, Region Basilicata, Generalitat Valenciana, Visit Flanders and Cyprus Department of Antiquities, Ministry of Transport, Communication and Work in order to set up a long lasting and largely replicable approach to urban and regional development, by providing new spaces in congested urban areas. The capacity of developing a convincing methodology and producing a visibility to the project will guarantee a relevant durability. In addition, the project will benefit greatly from the participation of Matera, European Capital of the Culture 2019, which will become a primary visibility channel and will support the establishment of a permanent European Heritage-Led Underground Regeneration Network (E-HURN).

HURN project will have significant effects on sustainable development and cultural heritage valorisation and addresses regional policies. The approach supported is: “new urban functions, no new building”. The idea of “a better city environment for future generations” is based on the valorisation of underground cultural heritage sites as a cultural value itself but also as a place for reinterpretation of degenerated urban spaces according to new urban needs. The action combines: diffusion of Regional cultural issues (historical aboveground urban and social development) and urban development (the perfect place to allocate new invasive functions in congested urban realities). Further, the reinterpretation of dismissed underground spaces gives the opportunity to geo-monitor these often forgotten spaces and prevent urban collapses. Sustainable paradigm: security, best practice in architecture, performing cities, cultural valorisation.

HURN activity aims at introducing a paroxysm in regional planning based upon the regeneration of cultural heritage: the transformation of the less visible, the most forgotten and degenerated urban space into a resource for urban, social and economic development.

The innovation of the theory approach strongly influences the expected results and the overturning roles in urban spaces. Abandoned underground spaces represent a significant cost for the correspondent administrative bodies in terms of safety and hygienic control and the risk of collapse influences the aboveground urban management.

The approach of HURN overturns this hierarchic order, so that the regenerated underground space is transformed from being a negative item in the municipality budgeting into a positive one at both local and regional level.

The innovative character of the proposed action is due to its capacity to answer to three coexistent and not inevitably coherent urban management priorities in historical cities:

- decline of urban underground sites as an effect of their abandonment or of the exhaustion of their historical function: in all European case studies the location underground seems to have accelerated their removal from the urban aboveground experience and their physical degradation;
- valorization of historical underground sites as significant signs of local cultural heritage;
- need of space to allocate cultural and urban functions in observance of local building limitations and bonds.

HURN contemporary intercepts regional policies addressed to urban regeneration, sustainable growth, cultural divulgation, cultural heritage valorization and to generate diffuse positive effects on local economies, environmental protection and preservation of local culture signs in the respect of underground building original historical functions and nowadays urban and regional planning.

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NOTES

[1] The CUBRe project was elaborated by the author in cooperation with Giuseppe Pace. Partners: National Research Council of Italy, Matera Municipality, Chamber of Commerce of Matera, Gravina Municipality, Game Universidade de Santiago de Compostela, TEI of Crete, METU Middle East Technical University, ILIANI State University, CYI the Cyprus Institute, ASM Institute of History, Katholieke Universiteit Leuven, University of Ljubljana, Universidad de Murcia, Gaziantep Metropolitan Municipality, Gaziantep Silk Road Development Agency, Gaziantep Chamber of Commerce, Eurocrea Merchant, EURICUR.

[1] The incident concerned two brothers, Ciccio and Tore Papparlardi, who disappeared in one of the cisterns of the historical centre on 5 June 2006. Initially, the two boys seemed to have completely vanished and the case created such commotion that the investigators examined many and various hypotheses which threw light upon difficult family relationships, among other things, exciting strong public interest. The bodies of the two brothers were only found on 25 February 2008 at the bottom of a well in a disused area. The discovery of the bodies concluded the unhappy story of the brothers but attracted attention to the underground of Gravina, to the dangers of its abandonment and ultimately to the potential of the area from a cultural and touristic point of view.

[1] The HURN project was elaborated by the author in cooperation with Giuseppe Pace. Partners: National Research Council of Italy, Municipality of Matera, Municipality of Taranto, Chamber of Commerce of Matera, The Cyprus Institute, University of Murcia, Municipality of Bocairent, University of Leuven.

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