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Edited by

Nodar Bakhtadze, Carla Galeazzi,
Bachana Gabekhadze, Vazha Mamiashvili

HYPOGEA 2026

Georgian National Museum

3 Shota Rustaveli Ave, Tbilisi

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Graphic project and layout

Vazha Mamiashvili, Bachana Gabekhadze, Irakli Khutsishvili, Irakli Devdariani

Cover photo

Anzor Mchedlishvili

hypogea2026@gmail.com
book.hypogea2026@gmail.com

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It is a great pleasure to welcome the participants of HYPOGEA 2026 to Tbilisi and to the Georgian National Museum. By bringing together scholars and heritage professionals from different countries and disciplines, this Congress provides an important platform for the exchange of knowledge, the development of new partnerships, and a deeper understanding of artificial cavities and rock-cut heritage as an essential part of our shared cultural legacy.

The Georgian National Museum, the host of this Congress, is the country's largest cultural and scientific institution and the legal successor to the Caucasus Museum – the first collection-based research institution established in the Caucasus in the 1850s. Under the auspices of the Caucasus Museum, the region's earliest archaeological investigations were initiated at Uplistsikhe, the monumental rock-cut temple city of the Classical period. Moreover, in the mid-twentieth century, the first research laboratory in the Caucasus devoted to the scientific study of artificial caves was established within the Museum. Spanning more than a century and a half, this remarkable institutional tradition underscores the important role of Georgian scholarship in the systematic investigation and preservation of rock-cut and artificial-cave heritage.

Alongside the privilege of leading this institution, my own principal field of scientific research is the Stone Age – the earliest and longest period of human history. Much of the evidence for this immense span of the human past has been preserved in natural caves, which provided shelter for successive human populations and retain invaluable traces of their lives, activities, and adaptation to changing environments. My long-standing engagement with these sites gives me a particular appreciation of the importance of caves and other underground spaces – both naturally formed and human-made – as exceptional archives of the relationship between people, landscape, and the geological environment.

I would like to express my sincere gratitude to the Organizing Committee and to all the contributors whose commitment has made HYPOGEA 2026 and the present publication possible, as well as to the Union Internationale de Spéléologie (UIS), under whose patronage the Congress is being held.

I extend my particular gratitude to the Ministry of Culture of Georgia for funding this important initiative, for supporting the study, preservation, and international promotion of Georgia's cultural heritage, and for its commitment to strengthening international professional cooperation.

Professor **David Lordkipanidze**
Director General
Georgian National Museum

HYPOGEA 2026 – An International Congress on Artificial Cavities and Rock-Cut Heritage

Tbilisi, Georgia | 22-26 September 2026

The present volume brings together the contributions presented at **HYPOGEA 2026**, the international congress devoted to the study of artificial cavities and rock-cut heritage, held in Tbilisi, Georgia, from 22 to 26 September 2026. The Congress formed part of the HYPOGEA series, which has progressively established itself as an international forum for the interdisciplinary study of subterranean spaces created, modified or adapted by human societies.

The HYPOGEA congress series originated from the growing need for a dedicated international platform addressing artificial cavities as a distinct field of research within speleology, archaeology, architecture and cultural heritage studies. Previous congresses were held in **Rome (2015); Cappadocia, Turkey (2017); Dobrich, Bulgaria (2019);** and **Genoa, Italy (2023)**. These congresses were conceived and promoted starting in 2015 by the *Hypogea Research and Enhancement of Artificial Cavities* from which they took their name, a federated speleological organization comprising three of the most active groups in the field of speleology on artificial cavities in Italy: Egeria Centro Ricerche Sotterranee, ASSO and Roma Sotterranea, with the support of the *Union* I*nternationale de Spéléologie* (UIS) and the her *Artificial Cavities Commission*, in collaboration with the speleological organizations of the locations where the respective congresses took place. The conference proceedings have often been produced as supplements to the *Opera Ipogea – Journal of Speleology in Artificial Cavities*. These meetings have contributed to consolidating an international scholarly network concerned with the documentation, interpretation, comparative study and preservation of artificial subterranean environments.

HYPOGEA 2026 continued this tradition in Georgia under the patronage of the Union Internationale de Spéléologie (UIS) and brought together researchers and specialists from different countries and disciplinary backgrounds. Held in Tbilisi, the Congress also provided an opportunity to place Georgia's exceptionally rich rock-cut heritage within a broader international and comparative research framework.

The geographical and cultural diversity of artificial cavities is reflected in the wide range of subjects addressed by the contributions gathered in this volume. Among other purposes, artificially excavated and modified spaces have served as places of habitation and worship, funerary and commemorative spaces, refuges and defensive installations, storage facilities, water-management systems, quarries and sites for the extraction of stone and other mineral resources, as well as spaces associated with craft and economic activities. Their functions frequently changed over time, while individual complexes were repeatedly enlarged, subdivided, reused and modified in accordance with changing settlement patterns and social structures.

The study of such environments consequently extends beyond the analysis of isolated monuments. Artificial cavities are embedded in geological formations and topographical settings and often form integral components of wider settlements, territories and cultural landscapes. Their interpretation therefore requires the integration of archaeological, architectural, historical, geological, geomorphological and conservation-based approaches, together with systematic documentation and spatial analysis.

The contributions gathered here reflect this expanding scope of research. They address different chronological periods, geographical regions, types and functions of artificial cavities, while employing a variety of methodological and analytical approaches. They demonstrate the value of comparative research in identifying both recurring patterns and locally distinctive solutions in the creation and use of subterranean and rock-cut environments.

HYPOGEA 2026 strengthened the dialogue between speleology, archaeology, architectural history, geology, heritage conservation and landscape studies, all the while contributing to the further development of an international research community dedicated to artificial cavities. The present publication serves not merely as a record of the Congress, but also as a contribution to the continuing development of this field and to a more comprehensive understanding of artificial cavities and rock-cut heritage as significant components of the world's cultural and environmental heritage.

The studies assembled in this volume are intended to stimulate further comparative research, encourage the documentation and protection of vulnerable subterranean sites, and contribute to a deeper understanding of the complex and enduring relationship between human societies, and geological environments.

Professor **Nodar Bakhtadze**
Chairman of Hypogea 2026 Organizing Committee
Member of the UIS Commission on Artificial Cavities

UNDERGROUND AND ROCKY CIVIL SETTLEMENT WORKS

HYPOGEA
TBILISI•2026

A Comparative Study of Plant-Derived Food Preparation and the Food Storage in Ancient Armenian Subterranean Settlements

Bella G. Babayan
Yerevan State University (YSU), Research Institute of Biology, Scientific Group of Ecological Monitoring
bella.babayan@ysu.am
Samvel M. Shahinyan
National University of Architecture and Construction of Armenia (NUACA), Chair of Geocology
samvel.shahinyan1954@gmail.com
Samvel A. Bagdasaryan
YSU, Research Institute of Biology, Scientific Group of Ecological Monitoring
samvel.baghdasaryan@ysu.am
Tigran A. Yesayan
YSU, Research Institute of Biology, Scientific Group of Ecological Monitoring
tigran.yesayan@ysu.am
Garegin G. Sevoyan
YSU, Research Institute of Biology, Scientific Group of Ecological Monitoring
garegin.sevoyan@ysu.am
Alexander H. Yesayan
YSU, Research Institute of Biology, Scientific Group of Ecological Monitoring
ayesayan@ysu.am

*Corresponding author: Dr. Bella G. Babayan bella.babayan@ysu.am, +37444128815

Abstract

Armenian caves and subterranean settlements such as Khndzoresk and Areni varied significantly in structure and geo-ecology, with some preserving rich archaeological records. Their environmental and architectural conditions strongly shaped subsistence strategies, especially food preparation and storage. This study examines plant-derived food practices in these contexts. Cereals (wheat and barley) formed the dietary basis and were used for bread and porridge, while finds from Areni indicate grain processing and long-term storage. Bio-archaeological evidence, including charred cultivated seeds, reflects stable agrarian systems. Lentils and beans supplemented the diet as protein sources, and plant oils were likely produced from seeds such as flax, as suggested by ceramic residues and tools. Dried fruits (apples, grapes, apricots) also were important. Finds from Areni-1 provide evidence of grape processing and early winemaking, supported by cave microclimates favorable for preservation. Vegetables such as onion, garlic, and wild greens were likely consumed fresh or seasonally dried before storage. Food preservation was highly developed: clay vessels (karas), rock-cut niches, pits, and suspended storage systems reduced spoilage and enabled long-term storage.

Keywords: Armenian caves, bioarcheology, ancient food, subterranean settlements, Khndzoresk, Areni

Introduction

All types of underground dwellings (in natural caves, in hypogeal or semi-hypogeal rock environments) represent remarkable forms of human adaptation to complex environmental, climatic, and social conditions. Throughout history, cave cities and underground habitations developed as sustainable socio-cultural systems integrating architecture, ecology, food-supply systems, ritual practices, and defensive strategies. Archaeological excavations have shown that Dzagidzor and Khndzoresk remained continuously inhabited for more than 3,000 years (Pinhasi et al., 2008). These settlements functioned not merely as shelters but as integrated life-support systems adapted to local geography and natural resources (Lazaridis et al., 2022; Shahinyan et al., 2023c; Groucutt. et al., 2025).

Understanding such settlements requires the study of granaries for cereals and seeds, storage facilities for wine, vegetable oil, and clarified fat, structures for drying fruits, and both cave-based and above-ground food storage systems, alongside the scale of agricultural pro-

duction (Margaryan et al., 2023).

Cave settlements are distributed from the Mediterranean and the Caucasus to Central Asia, the Middle East, China, and South America. The rock-cut complexes of Vardzia (Georgia), Ahlat, Ani, Cappadocia (Turkey), Geghard, and Kobayr (Armenia) illustrate centuries-long religious and cultural trust in subterranean spaces and often preserve architectural similarities with contemporary above-ground structures (Bixio et al., 2023). These complexes represent important medieval cave settlements and religious centers of the Caucasus inhabited from prehistoric times until the early twentieth century (Tejero et al., 2021; Doronicheva et al., 2023).

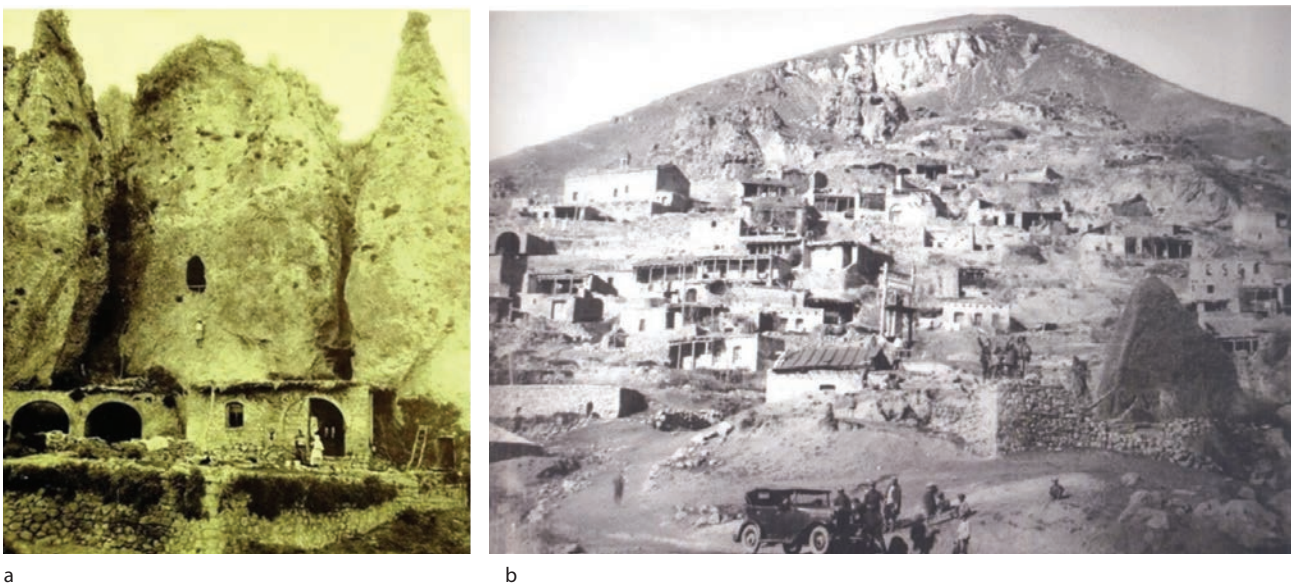
The principal goal of this research was to investigate food preparation and storage practices maintained within subterranean settlements of the Syunik and Vayk regions of RA over time.

The study of subterranean dwellings in Armenia

The various subterranean and semi-subterranean dwellings are found across different regions of the Republic of Armenia and throughout the historical Armenian Highlands from prehistoric times (Haber et al., 2016). Khndzoresk represents a typical cave settlement, whose population reached about 5,000 inhabitants during 1939–1945. Around 2,000 residents participated in the Second World War. Today, fewer than 500 inhabitants remain, while approximately 300 emigrant families have settled in Moscow alone. Archaeological investigations indicate continuous human occupation of the area for more than 3,000 years.

With the development of agriculture and animal husbandry, local communities increasingly relied on the management of surrounding natural resources while ensuring the security and sustainability of their livelihoods. It should be noted that the population of Khndzoresk did not experience famine until the Bolshevik interventions of the 1930s. According to numerous accounts, when severe famines devastated the Ararat Plain and other regions of Historical Armenia during the eighteenth and nineteenth centuries, causing the deaths of substantial portions of the population, such disasters posed no serious threat to the inhabitants of Khndzoresk (Fig. 1). Both fresh and processed plant foods were widely consumed; even toxic plants became edible and palatable after processing, such as salted and pickled the *Polygonatum* spp. also called Solomon's seal, salted and pickled (Luo et al., 2022).

Preserved foods played a crucial role in long-term survival, and many plants also had medicinal uses (Ayvazyan et al., 2024). Common preserved products included ghavurma (meat preserved in oil or sheep fat), motal cheese (brined sheep or mixed goat-sheep cheese aged in animal-skin containers), sujukh, basturma, and choratan/chortan (dried dairy products). More than thirty species of herbs, flowers, and roots were collected for tea and medicine, including loshtak ("Armenian ginseng," bryony). Foods were commonly dried in open air, while cheeses were preserved in brine within clay vessels or sheepskin bags. Wine was stored in large clay containers known as karas, and most preserved products were kept in ceramic and earthenware vessels (Margaryan et al., 2023; Kandel et al, 2017). The RA State Archive contains numerous records illustrating the development and demographic fluctuations of ru-



a b

Fig. 1. The typical constructions in Khndzoresk cave village (a) and the general view of Khndzoresk in early 20th century (b) (Photographs from the archives of Armenian Geographic Society: https://www.armgeo.am/en/khndzoresk/)

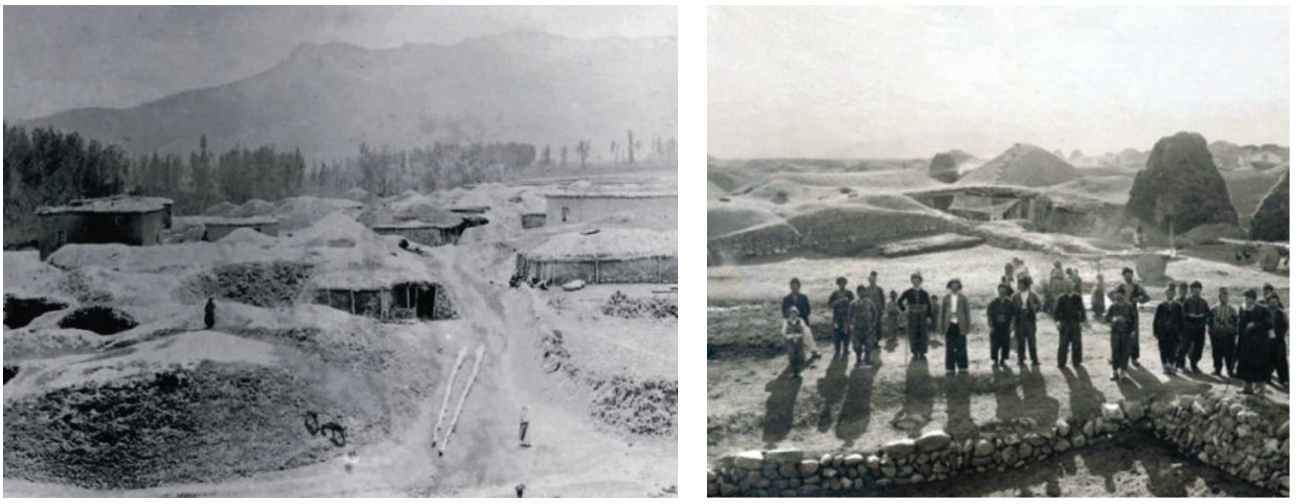


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Fig. 2. Plain dwellings (a) and semi-subterranean houses (b) in Mush (territory of historical Armenia, present-day – Turkey) (Photographs from the archives of Speleological Center of Armenia)

ral settlements. A characteristic example is the Lake Sevan basin, where populations from Bayazet, Muş, and Alashkert were forcibly resettled to territories of the Russian Empire in 1828–1829. Until 1915, villages demonstrated proportional population growth, whereas declines during 1920–1923, 1933–1937, 1941–1947, and 1964–1970 resulted from domestic policies of the Bolshevik state (Richards et. al, 2022).

Residential Comfort, Technologies, and Methods of Food Preservation

A typical cave dwelling consisted of a large chamber divided into functional areas for food consumption, storage, cattle keeping, and sanitation. Toilet facilities were arranged as dug pits that were periodically cleaned, while their contents, mixed with manure, were used as agricultural fertilizer. Evidence for this organization of domestic life derives from oral testimonies of elderly inhabitants of Khndzoresk recorded during interviews in 1982 and 1991, as well as testimonies collected by S. M. Shahinyan in 2020 from residents born in the settlement between 1952 and 1956 who described everyday life in the cave village. Within the territory of the Lake Sevan basin, as well as in Maraş, the Ararat Plain, and other plains of Historical Armenia, dwellings were predominantly constructed in the form of semi-subterranean structures or dugout houses (Fig. 2). Externally, only the dome-shaped wooden roofs of the *hazarashen* type remained visible above the ground surface (Ruggieri et al., 2022).

In subterranean settlements and semi-subterranean communities with hazarashen-type roofs, living conditions were more comfortable and less energy-intensive than in above-ground houses of fortified and commercial cities. Stable cave and underground temperatures during winter and summer required far less fuel for heating and cooling, which was especially important in semi-arid and mountain-steppe regions with annual temperature fluctuations exceeding 40 °C (summer) and -20 °C (winter). Until the 1960s, villages of the Lake Sevan basin largely consisted of semi-subterranean houses with hazarashen roofs according to the models described by Xenophon (Shahinyan et al., 2020).

Nearly 2,500 years ago, Xenophon described subterranean settlements as integrated residential and economic systems with narrow well-like entrances leading to spacious underground chambers. Humans, livestock, and poultry shared enclosed environments, while animals were sustained on stored fodder. These settlements contained reserves of wheat, barley, vegetables, and fermented barley beverages. Their architecture and food-storage systems demonstrate a high level of environmental adaptation and the sustainable character of subterranean life (Rood et al., 2014; Shahinyan et al., 2023a; Shahinyan et al., 2023b; Shahinyan et al., 2023c).

The sleeping, dining, and food-preparation areas formed the principal living space known as the glkhatun ("main house"). Other important components included the cattle stable and livestock enclosure (parakh), where a separate double-section was used for sleeping and guarding; newly married couples also spent their first night there. Similar spatial organization was documented in the cave stables adjoining the dwellings of Khndzoresk. Nearby were the cellar and food-storage facility (maran) (Monnot, 2022; Kandel et al., 2017). Rock-cut dwellings shared many functional similarities with the semi-subterranean houses described in the *Anabasis*, especially glkhatun-type spaces with hazarashen roofs. In both cave and semi-subterranean settlements, cereals such as wheat, barley, and rye were stored in jar-shaped pits up to 220 cm deep, reinforced with stone and lime mortar (Shahinyan et al., 2024; Harutyunyan

a

b

et al., 2022). Large quantities of wine and vegetable oil were kept in large fired clay vessels produced with technologies similar to grain-storage containers (Nikoghosyan et al., 2026; Richards et al., 2022). Products intended for short-term consumption and lighting were preserved in jars, pitchers, and other ceramic vessels. Dried wild and cultivated greens, as well as preserved product: *basturma* (spiced air-dried and salted beef with plant-derived spices), *sujukh* (fermented sausage with spices), clarified butter, *t'khal* (also known as *ghaurma*; salted, boiled, and fried meat preserved in oil or sheep fat in clay vessels), motal cheese (sheep cheese in brine or a mixed goat–sheep cheese), salted trout, and other products–were stored in cellars (Fig. 3).

Tandyr and Kursi

The *tandyr* (or *tonir*), a clay oven partially or fully dug into the ground, was central to medieval Armenian dwellings and was usually placed in the center of a khazarashen or khatsatun ("bread house"). It served both for baking lavash bread and as the household hearth, a concept symbolizing both the physical fireplace and the extended family or lineage in Armenian culture. The tandyr opening was generally level with the floor, although some were raised 20–30 cm and treated with special reverence. Such tandyrs were covered when not in use and ritually consecrated; if polluted by animals or rodents, they were demolished, rebuilt, and reconsecrated before reuse (Manoukian et al., 2022). In cave dwellings, tandyr rooms were typically located near the entrance or connected to angled flues for smoke ventilation. Some cave houses also contained inclined passages leading upward to carved platforms, likely serving as emergency escape routes. The kursi, unlike the tandyr, functioned as a smaller pit for hot ashes and glowing coals removed from the oven, providing warmth during winter, particularly for people returning from outside or for the sick and weakened.

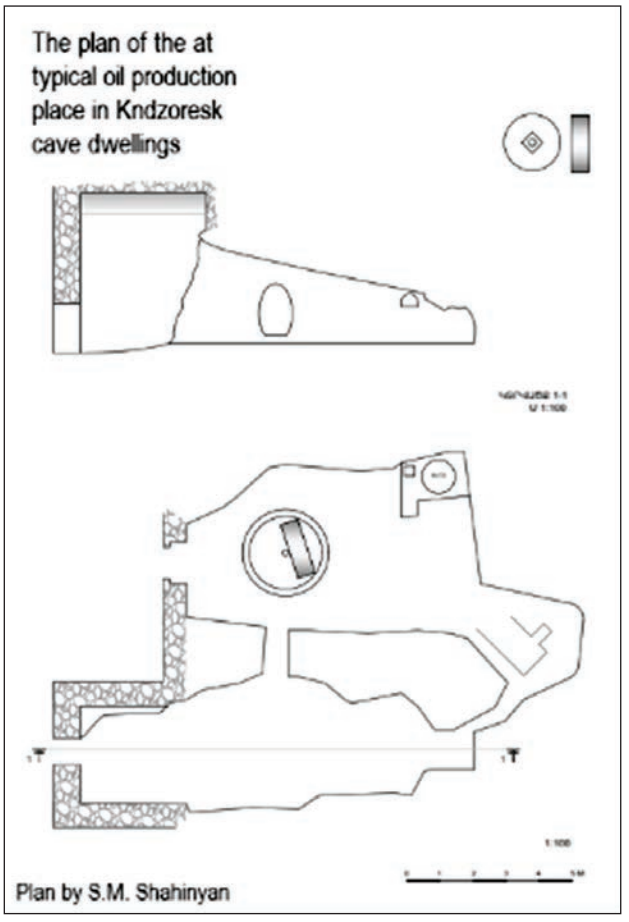

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Fig. 3. View of Khndzoresk in early 20th century (a), the oil production place photograph (b) and plan of it (c). (Plan by S.M. Shahinyan).

Plant species, which were used in traditional cuisine of cave habitants in Khndzoresk

In cave dwellings of Syunik and Vayk of RA the following plants residues were found: Purslane *Portulaca oleracea*; Shepherd's purse *Capsella bursa-pastoris*; Oriental carrot-like herb *Astrodaucus orientalis*; One-flowered mouse-ear or *Cerastium uniflorum* and other species of genus; Goosefoot *Chenopodium album*; Chickweed *Stellaria media*; Chard leaves *Beta vulgaris*; Dill *Anethum graveolens*; Goutweed *Aegopodium podagraria*; Field poppy *Papaver rhoeas L.*; Stinging nettle *Urtica dioica*; Cornmint *Mentha arvensis*; Horse mint *Mentha longifolia*; Parsley *Petroselinum crispum*; Leaf lettuce *Lactuca sativa*; Dandelion *Taraxacum officinale*; Solomon's seal *Polygonatum odoratum*; Hippomarathrum *Seseli hippomarathrum L.*; Small-fruited Cachrys *Cachrys microcarpos M. Bieb*; Stinking meadow-rue *Thalictrum foetidum*; Spinach *Spinacia oleracea*; Scallion *Allium fistulosum*, *A. cepa*; Cilantro *Coriandrum sativum* and Sorrel *Rumex acetosa spp.* (Sevoyan et al., 2024). Many of these plants remain a part of the traditional cuisine in Syunik region, e.g.: zhengyal, which is prepared from wild plants collected and processed using techniques similar to those once applied in cave dwellings. Contemporary biochemical studies show that these plants contain numerous bioactive compounds (vitamins, alkaloids, antioxidants, immunomodulators, anticancer compounds, essential micronutrients, etc.). Many of them are recognized as medicinal plants and are currently used in pharmacology and bioactive food additives (Ayvazyan et al., 2024; Sevoyan et al., 2024).

Conclusion

The practices described explain why Armenian cave and subterranean settlements were able to maintain food supplies even during severe and prolonged droughts, unlike earth-built hazarashen-type dwellings. This resilience was linked to greater reliance on wild edible plants in mountainous areas, whereas plain regions depended more on cultivated crops. As a result, crop failures in lowland areas, combined with limited use of wild resources, often led to famine conditions. In contemporary Syunik settlements, these traditional uses of wild plants remain relevant and are being adapted to modern needs. In response to 21st-century challenges, they are increasingly integrated into new approaches, including the development of functional foods based on traditional dishes and plant-derived ingredients.

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Vulnerability and Heritage Issues of Loess Dwellings in North China

Constantin Canavas

Hamburg University of Applied Sciences, Faculty of Life Sciences
Hamburg, Germany
Email: costas.canavas@phl.uoc.gr

Abstract

Cutting in the loess in order to create or modify living space constitutes a multi-layer issue in Chinese cultural history known under the generic Chinese term *yáodòng*. The term can be literally translated as artificial cave or hole dwelling, but is also related to kiln and mining pit. Loess in north China is a soil form that originates from yellow-grey sediment sand carried by the wind from the Gobi desert; it is easily cut, but also highly subdued to erosion processes. In previous presentations the focus was set upon the typology of *yáodòng* variations (cliff holes, sunken yards with lateral cave holes, independent buildings) in its historical, social and technical context. The claim of the present paper is that the particular physical vulnerability and the high demand on maintenance of technical constructions based materially on loess impose not only particular construction and maintenance procedures, but also a derogatory framing that enhances the negative social connotation associated with living in a cave or a cave-like dwelling. The latter assessment should be regarded through the lens of the exodus of the rural population from the central and northern regions of China towards the eastern coast. The abandon of rural housings and entire villages is a general phenomenon in China during the last decades of the 20th and the beginning of the 21st century; however, the higher vulnerability of abandoned *yáodòng* villages shifts the public perception unfavourably towards them, and stabilises the stereotype of *yáod*òng as ephemeral, particularly vulnerable vernacular architecture linked to poverty – thus creating a specific type of dark heritage.
Positive connotations of the *yáodòng* function insofar as they are related to issues that contribute to compensating or overcoming the particular vulnerability. A prominent case is the historical association of these dwellings with reference to the role of the *yáodòng* complex at Yan'an, Sha'anxi province, as headquarters of the Chinese Communist Party under Mao Zedong between 1935 and 1947 – the loess landscape with the vulnerable dwellings serving as background for contrasting with the persistent struggle of the Communist movement to overcome a menacing historical situation. Moreover, the large typological variety of the North-Chinese *yáodòng* becomes itself an instrument of eclectic public perception, touristic promotion, and current economical and political choices regarding a vast region formerly characterised by poor rural population. This is the case e.g. when a particular *yáodòng* complex – after meticulous restoration – is considered as a model case of cultural heritage, touristic re-use, and travel romanticism, or when future-orientated projects suggest ways of overcoming or compensating vulnerability and inconveniences of *yáodòng* housing through technological innovations that enhance the thermic-energetic advantages of living in the loess.

Keywords: *Yáodòng*, cave dwellings, cultural heritage, loess, north China

Introduction: The cave dwellings *(yáodòng)* in the Loess Plateau across the Yellow River in north and north-central China

A particular geological formation of aeolian origin known under the term loess is found at several regions of the globe covering ca 10% of the Earth surface. The formation may follow a wide range of patterns (Pye 1995) and can be found in areas such as the Danube plain in Europe (Evlogiev 2007), in North America (Mississippi Valley), North Africa (Tunisia), Central Asia, and China. In north and north-central China the formation is called *huángtǔ* (*"yellow earth"*) in Mandarin-Chinese, and originates from processes involving yellow-grey sediment sand presumably carried by dry winds from the adjacent desert regions of Gobi and Mongolia. Further proposed explanations account for secondary loess production through alluvial depositing or flooding (Pye 1995). The beginnings of the formation of north and north-central Chinese loess go back to the Pleistocene epoch; in fact, the formation process as such is still going on (Golany 1992a, 14-18). The material has particular advantages for constructing dwellings because of its thermic characteristics, as well as its solidity under dry weather conditions. The latter issue is related to the hard crust that loess forms under the influence of dry wind.

This hard crust is just a surface quality. However, the loess ground is highly subdued to erosion processes. One important side effect of the erosion issue is the relative easiness with which loess can be dug out in comparison to rocky soil – an aspect that has significantly facilitated activities of digging in loess and constructing dwellings known in Man-

darin Chinese under the term *yáodòng* (pit, cave dwelling)[1]. although several other Chinese terms are used to specify variations of the construction, as will be discussed later on[2].

Geographically the loess aria and the distribution of *yáodòng* dwellings cover the Provinces Shanxi, Shaanxi, Gansu, Henan, as well as the autonomous Region Ningxia following a large part of the valley of Yellow River in north and north-central China. In these regions human working with this particular soil has a long tradition documented e.g. in Neolithic sites with *"pocket-form"* shelters dug in the loess.

The role and the typology of *yáodòng* dwellings in China has been an issue of the archaeological research since the beginnings of the 20th century. The most prominent finds till now are certainly those at the Neolithic village of Banpo, located to the east of Xi'an city, capital of Shaanxi, and attributed to the Yangshao culture that can be traced back to 6,000/5,000 – 3,000 BCE (Handbook 1994/2001, 92-106). Similar, perhaps even earlier belowground constructions were found also in other archaeological sites in the Yellow River Valley; they include constructions for which archaeologists describe by the terms vertical as well as pocket-form pits (Golany 1992a, 2-6; Bodolec 2005, 218-219). Although these pit forms are not in use as dwellings any more, the archaeological record has considerably influenced the perspective of looking on and the terminology describing present-day *yáodòng* dwellings.

Conventional typology of *yáodòng* dwellings still in use

The typology of *yáodòng* cave dwellings appears more or less standardised in the literature (e.g. Golany 1992a, 66, Fig. 4.1; Canavas 2021, 42-43).

The cliff-side (lateral) cave dwelling is a type of artificial cave cut into cliffs with a balcony-type flat yard that might link several dwellings dug in the cliff one beside the other (Golany 1992a, 66, Fig. 4.1b). The entrance of the cliff-side cave towards the yard, mostly a vaulted arch, is the only part of the construction exposed to the environment (wind, rain), and is usually reinforced using wood, stones, and/or bricks of loess or clay. In several cases a roofed extension is added outside the cliff cave. The roof is usually covered by loess soil topped with grass. Cliff-side caves can be found in a stare-case arrangement one above the other, with a facade that can comprise many individual caves – with or without extensions.

The type of *yáodòng* that justifies the term underground dwelling is known as sunken courtyard (or pit cave) dwelling. This construction comprises a rectangular pit and a group of cave dwellings dug at the lateral surfaces of the pit (Golany 1992a, 66, Fig. 4.1a). The dimensions of the pit can be between 6 to 12m each side, with a depth of 5 to 10m. The roof of the lateral caved dwellings may consist of existing soil – or may be made artificially and then covered with loess topped with grass (semi-belowground dwellings). In several cases the ground morphology could permit variations of a semi-belowground dwelling, with the entrance giving to the balcony yard and one or two walls in the soil (Golany 1992a, 66, Fig. 4.1d). A factor that shaped the public perception of sunken-courtyard *yáodòng* complexes as an iconic type of vernacular architecture was the publication of photographs of sunken courtyards shot from an aeroplane (e.g. over Shaanxi Province) between 1933 and 1936 by Wulf-Diether Graf zu Castell-Rüdenhausen commissioned by Lufthansa (Graf zu Castell 1938).

Independent so-called hooped dwellings constitute a category of *yáodòng* dwellings built away of cliffs or pits. They are mostly based on a more or less sunken fundament. The reason for which these alone-standing buildings are considered as *yáodòng* is related to the construction material and to the forming of the inner space. Their characteristic outlook is related to their hooped roof made of loess soil or rammed earth, generally structured by wooden beams (Golany 1992a, 66, Fig. 4.1c). Their walls are built with bricks of rammed loess earth. Their specific architecture includes reinforcements of arcs constructed with bricks or/and stones. Since the way of forming the inner space is considered to simulate a cave, several authors call them *"constructed caves"*

The dwelling types described above are mostly found agglomerated in groups forming villages. Typical formations include cliff-side villages dug into the slopes of terraced cliffs, as well as pit villages consisting of several sunken courtyards (Golany 1992b, 151-162).

Vulnerability issues; abandonment of the cave dwellings

The particular physical vulnerability of natural loess formations regarding earthquakes and the implications for the vulnerability *yáodòng* constructions have been studied with reference to various severe historical seismic events (e.g. Xiu 2018). Due to collective collapse of loess hills and massive landslides during severe earthquakes in the past, *yáodòng* constructions have proved particularly vulnerable, a fact that has caused a large number of human casualties. Similar vulnerability considerations regard

1 The Chinese characters imply a kiln-like cave, shaped by human work and used as a dwelling.

2 In Western literature the term "troglodyte" or "troglodytic" has been used in the past for encompassing this type of vernacular architecture (e.g. by Loubes 1988, Loubes 2003). We prefer to avoid this terminology because of the ideological connotations it confers from other fields of use where living in a cave sounds derogatory and implies an inferior evolutionary stage in human civilisation. It should be noted, however, that precisely J.-P. Loubes uses the term in an analytical, purely descriptive, and explicitly non-valorising way when he proposes complex evolutionary models of how human dwellings developed in these regions of China.

technical constructions of walls and arches built with rammed loess soil (Xu 2021).

Though *yáodòng* dwellings were found to have better earthquake resistance than some other types of dwelling common in the region, such as adobe buildings (Luo 1987), unreinforced cave-dwellings remain vulnerable to severe seismic activities. A further risk are earth-slides from uphill that can be caused by strong rains or earthquakes, and can block the entrance of the cave dwellings. These experiences and considerations have motivated local and central Chinese authorities to relocate populations from particularly vulnerable loess regions, and to impose restrictions and special requirements when new constructions are planned.

The abandonment of individual *yáodòng* dwellings as well as of entire *yáodòng* villages is an essential feature of the *yáodòng* landscape in the provinces Shanxi, Sha'anxi and Ningxia (Fig. 1). Beside the geological vulnerability, this is also an effect of the general urbanisation trend in China during the last decades. Moreover, the stronger need of maintenance of *yáodòng* in comparison to other housings has gradually imposed a derogatory framing that enhances the negative social connotation associated with living in a cave. The above features have strengthened the formation of the stereotype of *yáodòng* as ephemeral vernacular architecture linked to poverty. In fact, this stereotype is attached generally to the Yellow Earth region, the valley of the Yellow River and the constructions based on the yellow rammed earth, including caves in the loess soil. Keywords such as *"abandonment"* or *"ephemeral buildings"* have become popular classifications of describing the region in numerous internet sites (e.g. http://ignition.eg2.fr/2016/04/30/ephemeral-buildings-perpetual-architecture*-shanxi*-yaodong/). This perception is enhanced also by the fact that in many cases the old yaodong dwellings are not officially registered as *"houses"*; they are considered just as *"caves"* with no certificates of use, and that may also be one reason why they are not maintained and preserved by some village authorities. In 1992 Golany reported that *"construction of new pit cave dwellings was officially forbidden and currently only aboveground structures are being approved as new dwellings"* (Golany 1992a, 51).

Positive re-framing of the *yáodòng* heritage

Beyond the negative connotations mentioned above, the public perception of *yáodòng* is framed by a specific historical context. In fact, the mainstream national Chinese narrative on *yáodòng* is connoted with the historical focus directed upon sites around Yan'an in Shaanxi, where the leaders of the Communist Party (CPC) under Mao Zedong had installed their headquarters and living spaces during the period 1935–1948 in local yáodòng (Golany 1992a, 52-53). Since many years the Yan'an Revolutionary Site is listed as a protected Major National Historical and Cultural Site. All *yáodòng* constructions related to this historical context have been restored and made accessible to the public giving rise to a type of *"red heritage"* tourism. Through the heroic association to the struggle under the leadership of the CPC against the Japanese invasion, the *yáodòng* landscape has conferred a positive connotation to a vast region formerly characterised by poor rural population.

Recent trends and contemporary considerations

A key aspect that increasingly contributes to a change of current public perception and re-valorisation of the *yáodòng* vernacular architecture is the focus on its thermic qualities and the possibilities of energy conservation an increasing quality of everyday country life (Anselm 2012). Due to the thermic isolating character of loess, the cave dwellings are protected by the extreme summer heat and winter cold. This issue together with a re-evaluation of earth-sheltered architecture have become focus of many recent studies and on-going local, national, and international projects – including projects of touristic development (see e.g. Cao 2013; Genovese 2019). Recently, new cave dwellings have been built in *yáodòng* style as annexes to the traditional ones that have been partially abandoned or adapted to the needs of modern dwelling (Genovese 2019). New concepts such as *"green architecture"* are used as legitimising background for planning new *yáodòng* units (Liu 2002). Following national law and local regulations, a large number of projects intending to protect the value of built vernacular earthen heritage have been initiated in the last years. On the other side, the changing of social needs becomes increasingly an important issue. If one wants to guarantee the use of *yáodòng* as living places, several aspects of the *yáodòng* construction should eventually be modified in order that the new needs can be met. These preoccupations have dominated recent rehabilitation works (Frenda 2016).

In fact, there are several aspects that contribute to a general shift of current public perception and re-valorisation in favour of the *yáodòng* architecture. These aspects become visible and audible in the documentary video by E. Brosseau and C. Bodolec on repairing works regarding existing *yáodòng* in Shaanbei/North Shaanxi (Brosseau and Bodolec 2012). Traditionally, the construction of a new *yáodòng* complex was a collective process in a given community. In the meanwhile local communities (or individuals) undertake only maintenance (if any) or transformation of use (e.g. tourism); new constructions follow new concepts and are conducted by large specialised companies.

An increasingly important aspect that influences the current debates on *yáodòng* is the land use for agriculture and its relation to the specific form of sunken courtyard (or pit cave) dwelling. Whereas in the past, images of *"dwellings below and fields upstairs"* were used for arguing in favour of this

Fig. 1. Abandoned cliff-side yáodòng in Mizhi County, Sha'anxi Province, North China (photo Canavas C.).

particular *yáodòng* type, the rapid mechanisation of agriculture and the tremendously increasing demand for (new) cultivation areas in the Yellow River valley constitute arguments against these underground constructions and explain the reluctant or rejecting attitude of local and central authorities towards this particular type of *yáodòng*. Indeed, current planning priorities of local and provincial authorities, as well as new societal orientations are unfavourable towards the construction of new sunken courtyards. Moreover, in some cases they eventually undermine the preservation of existing ones.

Compared to cliff caves, sunken courtyards are more exigent in technical support and more vulnerable when left out of use. Traditionally, a crucial prerequisite for constructing and inhabiting sunken courtyards was the social solidarity among the constructors and dwellers which is necessary for organising the collective work of construction and maintenance, as well the everyday-life in a strongly shared space. In the past when large families with their strong relation networks were typical for rural North-Central China, this condition was easily fulfilled. The politically organised rural society after 1949 could still support necessary collective works for maintenance. However, the structure of small individual families inhabiting nowadays the cave dwellings around the sunken yard is not comparable to that of the past. Social mobility, especially mobility of labour accompanying the rash urbanisation trends in 21st century China, affect crucially the social conditions of living and working in a sunken-yard *yáodòng* in ways that render its maintenance as well as its adaption to the needs of the evolving society a great challenge.

Heritage tourism

There are several aspects that relate *yáodòng* structures to heritage in China. Some yáodòng constructions, especially some belonging to the independent hooped-roof type (*"constructed caves"*), are already part of ensembles listed by the UNESCO as tangible world heritage such as small fortified towns, e.g. Pingyao, listed since 1997 (Bodolec 2005, 269). Besides, the heritage issue has become a major motif in the tourism discourse and practice. The reference to the Yan'an site, the adaption of the changes in *yáodòng* structures to touristic needs, and the travel romanticism associated with spending some hours or days in a *yáodòng* frame the touristic re-use of cave dwellings as sites of cultural heritage. *"Are you ready for your loess cave adventure?"* is just one of the typical inviting spots. The heritage aspect is increasingly supported by exhibition practices on-site. In Zhangjiata village, Shanxi province, for example, the locals have linked former cave dwellings with tunnels and converted them into an underground folk museum in which tools used by older generations, components of ancient architecture, and photographs documenting the village's history are displayed (Ji 2025).

Conclusions

Traditional *yáodòng* ensembles still continue to serve as living, working, or depositing space for over millions of people in the PR of China, and – because of certain advantageous ecological features (e.g. thermal isolation) – they become increasingly a source of inspiration for modern constructions and large-scale projects. However, the traditionally collective character of constructing and maintaining sunken courtyards and cliff-side caves is increasingly substituted through centralised planning and

new construction materials and concepts, with only small-scale maintenance left in local hands. The new generations of *yáodòng* cave dwellings follow the new social needs in China. Preservation and restoration of older/traditional sunken courtyards and cliff caves are squeezed between new aspirations regarding (local) living conditions and centralised preservation projects. Future-orientated projects suggest ways circumventing the vulnerability and inconveniences in order to enjoy the thermic-energetic advantages of living in the loess. Association of the Yan'an *yáodòng* with a historical frame of resistance and overcoming vulnerability provides with a positive symbolic framing of the traditional architectural issue. Touristic re-use and architectural upgrading conceal poverty past and focus upon exceptional experience of the visitors.

However, the materialisation of collective memory in the sunken or the cliff-side *yáodòng* practically loses its major witnesses if the processes of construction, maintenance and use are not enacted through the local communities. In this context comparisons with similar geomorphological sites in other regions and countries become increasingly interesting. Regarding the debates on sunken courtyard (or pit cave) dwellings a comparison with the considerations on the vertico-lateral cave dwellings in Haddej, Guermessa and Matmata in South-east Tunisia could sharpen the analytical views on social organisation induced by such dwellings, and could yield new insights into possibilities and potentials of heritage preservation and geotourism (Boukhchim, Ben Fraj and Reynard 2018; Boukhchim 2020).

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Historical-Anthropic Hypogean Caves of the Volcanic Area of Goris (Syunik Marz, Armenia)

Rosario Ruggieri[1], Samvel M. Shahinyan[2]

[1]*Hyblean Center of Speleo-hydrogeological Research, Ragusa, Italy*
[2]*Armenian Speleological Center*
info@cirs-ragusa.org

Abstract

As part of an international research agreement, called "Armenia Karst Project", between the Armenian Speleological Center and the CIRS - Hyblean Center of Speleo-Hydrogeological Research of Ragusa, Italy, four research campaigns were carried out from 2016 to 2019. The aim was to study and document both the karst morphologies and the volcanic - hypogean caves in different geographical contexts of the Republic of Armenia. In this regard, 13 volcanic caves were surveyed and documented: 1 in the Lori Marz district, in the northeastern sector of the country; 3 in the volcanic district of the Sisian Region, in the southern sector; 9 in the southeastern part of the country, in the Syunik region, set in a spectacular natural landscape with spires and pinnacles, in the old Town of Goris, excavated in pyroclastic volcanic material, and used since the Stone Age, medieval times, and up to the last decades of the last century, both as dwellings and for animal shelter. This report describes the speleometric and morphogenetic features of the aforementioned caves. For some of these, given their remarkable landscape and historical-anthropic context, an urgent action of recovery, valorization, and safeguarding is proposed.

Keywords: Armenia, Syunik, Goris, Khndzoresk, anthropic caves

The Research

Basically, cave-type residential areas were built not using building materials and binding materials, but rather, volumes were dug out in the "building material" itself. And the karst and denudation voids were adapted for living, while dangerous limestones and debris torn from the ceiling were removed. Thus, geological and geomorphological research becomes a priority.

12 scientific expeditions were organized by NUACA the Armenian Speleology Center to Shinuhayr, Khot, Dzagidzor, Verishen, Karashen, Tegh, Khndzoresk, and elsewhere. Scientific articles were published (Shahinyan, Gunko, Kondratyeva, Rudolf, and others).

Materials preserved in archives were researched, such as the Khndzoresk village parish register of 1905, and the 17th-18th century rural census from the archives of the Armenian Apostolic Church and Matenadaran, according to which the population of Khndzoresk at the beginning of the 18th century was recorded as 17,628 people.We have also used the bibliographic heritage of Armenian medieval chroniclers Movses Khorenatsi, Tatevatsi, and others.

Within the International Conference "Caves as Natural and Cultural Monuments", Campaign of research September 2019, Yerevan, scientific expeditions were organized to Goris (Gunko, Kondrateva, Rudolf) and Khndzoresk (Gunko, Ruggieri, etc.). As a result, several dozen caves, serving residential and production purposes, were studied and measured. For comparative analysis, publications of the results of the research by Roberto Bixio's group from Ani, Khlat, Cappadocia were used.

The Armenian Highland is an aerial plateau framed by high marginal mountains. In the Neogene, the plateau system was broken by discharges onto a number of differently elevated blocks. Along the line of splits, volcanic processes were intensified and continued in the Quaternary period, with solid covers of Neogenic-anthropogenic effusions disseminated over vast areas of the Armenian Highland. In addition to the Armenian Highland, continuous covers and separate "cameo islands" of Neogene volcanic covers indicating the one-time existence of vast area of development of a powerful cover of effusions, which subsequently underwent an intensive process of denudation and erosion, exist in neighboring Asia Minor and Iranian plateaus (Balyan 1969). addition to the Armenian Highland, continuous covers and separate "cameo islands" of Neogene volcanic covers indicating the one-time existence of vast area of development of a powerful cover of effusions, which subsequently underwent an intensive process of denudation and erosion, exist in neighboring Asia Minor and Iranian plateaus (Balyan 1969).

The volcanic cover of the Armenian Highland is represented by two formations: lower, pyroclastic, of Neo-

genic age, with thickness of 200m-300m and upper, actually effusive one (lava covers and flows), of Quaternary Period, having sharply variable thickness from 50 meters to 1 km.

The Armenia Karst Project

As part of an international research agreement between the Armenian Speleological Center and the CIRS - Hyblean Center of Speleo-Hydrogeological Research of Ragusa, Italy, called "Armenia Karst Project", four research campaigns were carried out from 2016 to 2019 (Ruggieri et al. 2022). The aim was to study and document both the karst morphologies and the volcanic-hypogean caves in different geographical contexts of the Republic of Armenia (Fig. 1). 13 volcanic caves were surveyed and documented: 1 in the Lori marz, in the northeast of the country; 3 in the volcanic district of the Sisian Region, in the south; 9 in the southeast, in the Syunik region, set in a spectacular natural landscape with spires and pinnacles, in the old Town of Goris, excavated in pyroclastic volcanic material, and used since the Stone Age, medieval times, and up to the last decades of the 20th century both as dwellings and for animal shelter. This report describes the speleometric and morphogenetic features of the aforementioned caves. For some of these, given their remarkable landscape and historical-anthropic context, an urgent action of recovery, valorization, and safeguarding is proposed.

Caves Surveyed in the Old Town of Goris, Region of Syunik (South-East Armenia)

Nine caves, located in the spectacular natural landscape with spiers and pinnacles, of the old Town of Goris, were surveyed (Figs. 2-3-4). These caves, carved in the pyroclastic volcanic, as previously described, were used since the Stone Age, in medieval times and up to the last decades of the last century, both as dwellings and for the shelter of animals (Figs. 5-11).

Caves in the Neogene Pyroclastic Formation

A pyroclastic stratum is composed of mainly tuffs, tuff breccia, agglomerates, interspersed with sandstones, conglomerates and lava flows. Denudation of this stratum, named in the literature as the Voghjaberd

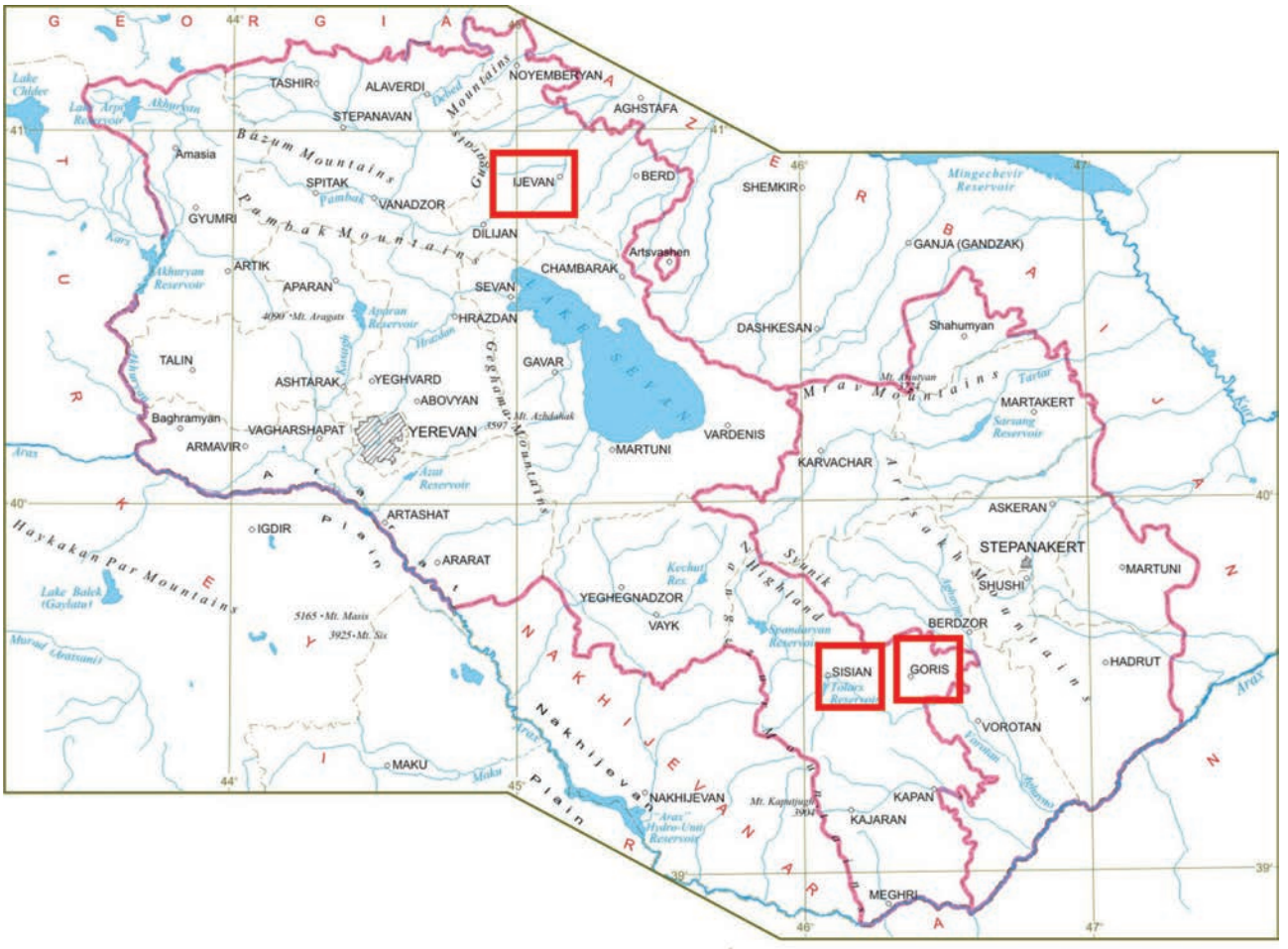


Fig. 1. Map of Republic of Armenia with locations of area of investigation (graphic Ruggieri R.)

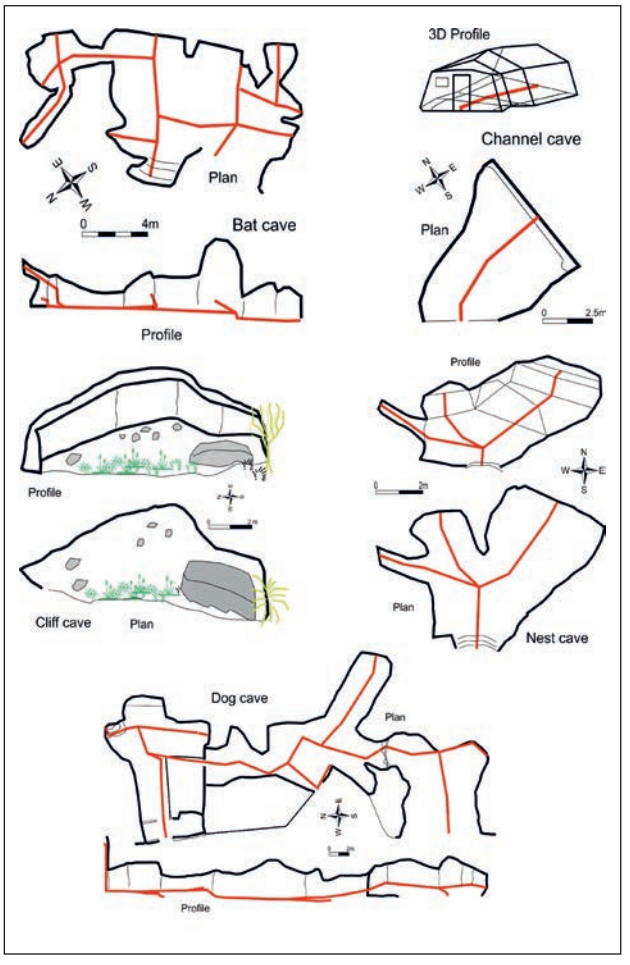
Fig. 2. Panoramic of the new and old Town of Goris (photo Shahinyan S.)

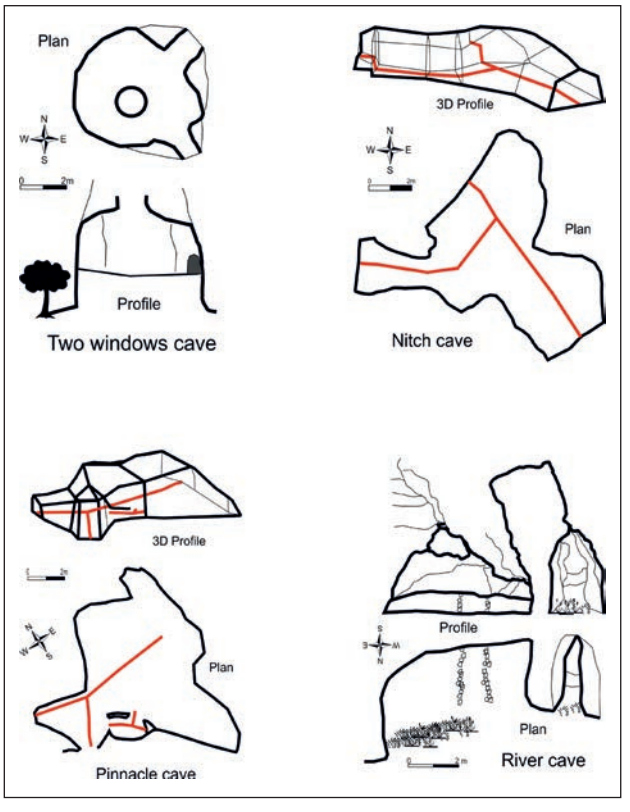
(Geghard, Goderz) Stratum found in the territory of the modern Republic of Armenia (Voghjaberd, Geghard, Yelpin, Syunik Highland, etc.), in the Western Armenia (Byurakn, Basen, Kars, Ani, etc.), in the Southern Georgia (Vardzia), in the Eastern Anatolia (Cappadocia), and in the Northern Iran (Maragha).

The stratum, being almost in horizontal bedding in most cases, composes table-shaped uplands or, as a result of dissection by deep ravines and gorges, appears in the form of outliers of bizarre forms of different sizes (Davtyan 2013). Intensive deep erosion occurs in the pyroclastic stratum, which is associated with the vertical fracturing of rocks as well as with agglomerate composition of large fragments, poorly cemented with pumice-ash material. As a result, the marginal parts of table-shaped plateaus composed of pyroclasts are divided into separate segments by numerous narrow and deep canyon-like valleys. Therefore, on the slopes of the plateau drainage funnels are formed, in which outliers of different sizes and forms are developed. The formation of pyramids is associated with sawing the marginal parts of plateaus with permanent and temporary streams, forming vertical gutters and potholes, with rocky outliers remaining in-between. As a result of further dissection, they turn into separate pyramids or stone mushrooms. (Geologia 1962). Some outliers end with “stone caps”, represented by boulders that protect from erosion the part of the pyramids below them.

Speleological Peculiarities of Pyroclastic Stratum

The topographic and morphological conditions of the Neogene pyroclastic stratum and the degree of its dis-





Figs. 3-4. Maps of the caves surveyed in the Old Town of Goris (graphic Ruggieri R.)

Fig. 5. Cluster of pinnacles with caves (photo Ruggieri R.)

Fig. 6. Sight of the pyroclastic ridge from inside one of the surveyed cave (photo Ruggieri R.)

Figs. 7-8. Singular morphologies with caves in the Neogene pyroclastic formation (photo Mayr F.)

Fig. 9. River cave: natural cave originating from the erosive action along fractures from the river waters (photo Mayr F.)

Fig. 10. Fences cave: cave dug by man and used as a shelter for animals (photo Mayr F.)

Fig. 11. Dog cave: System of multiple connected cavities used for different uses (photo Mayr F.)

section were very favorable for the formation or creation of underground structures. A characteristic feature of this stratum is the wide distribution of underground cavities of natural, semi-artificial and artificial genesis.

The absolute majority of caves in pyroclasts have been created by man. The huge capacities of tuffs allowed the man to create a huge number of cave structures for different purposes. Underground dwellings were cut in the stratum comparatively pliable for processing rhyolite tuffs and lithoclastic pumices (perlites). In a number of cases, for the longevity of the structure (monasteries, tombs, etc.), caves were cut in dense tuffs (ignimbrites).

Natural, semi-artificial and artificial cavities of the Neogene pyroclastic stratum are widespread throughout Armenia, forming secular and cult complexes consisting of cavities, the number of which ranged from several to hundreds. Almost all secular complexes have cult caves, in which residential and industrial buildings also can be found.

Rock structures are cut in the neogenic stratum also in Cappadocia, South Georgia and Iran. The data of archeological research in Neogene pyroclasts have identified three main periods of creation of artificial caves: the Bronze Age, the Urartian period and the Medieval period.

Conclusions, Questions and Answers

Cave houses and settlements are found on almost all continents of our planet, at different times and in different geological formations. There are many more accumulations of cave houses and settlements in the Armenian Highland than in any other place. This allows us to determine the level of man - nature coexistence and to conduct a comparative analysis in terms of construction, the stability and safety of excavations carried out in different places, in different geological layers, in areas with different seismic activity. A settlement or a house must meet a number of natural human requirements. For survival, sufficient temperature inside the room, proximity to a source of drinking water, seismic safety, availability of food sources, necessary separation of housing volumes (bedroom, dining room or section, cesspool or sewer, ventilation, protection from external dangers, and reduction of other risks) are necessary. All this was the case with all medieval houses and villages in Cappadocia, Khlat (Ahlat), and Ani in Turkey, and Shirak, Aparan, Syunik, Vayots Dzor areas in Armenia. Our goal was to discover and research examples of natural historical and archaeological value among cave dwellings and villages and propose turning them into museums.

As part of a more general research project aimed at the study of the karst phenomena present in the Republic of Armenia, 9 caves, semi-artificial, in the Neogenic pyroclastic formation were surveyed. The cavities surveyed in the pyroclastic formation are mostly made by man, some by digging initial natural voids, and used since the Stone Age until the last decades of the last century, as highlighted in the suggestive old town of Goris (Fig. 13-14-15-16-17-18-19-20).

A scientific analysis of the researches results has revealed the following facts:

In Goris and Khndzoresk, no springs emerge in the areas occupied by cave dwellings, nor have any canals or water pipes been laid. This is despite the fact that hydro-engineering technologies were already known to Armenians in the first millennium BC. Proof of this are the Urartian canals, built almost 3,000 years ago and fully functional until the beginning of the 20th century.

There are hundreds of known caves in the territory of the Republic of Armenia, which have been turned into sacred sites, and some later into churches and monasteries. For example, the pagan sanctuary of Geghard Avazan was blessed by Gregory the Illuminator in 302 AD and turned into a church, after which it continued to develop for 800 years and was turned into a monastery. Natural cave sanctuaries of Aghveran and Byurakan (B. Gasparyan and others).

In the areas of villages excavated within the Quaternary volcanic tuff, conglomerate, fine-grained, and ash-textured rocks of Syunik, there are no tectonic faults and fissures. The results of denudational and physical weathering by water (tower-like outcrops) are present.

In cave dwellings of Old Goris, Dzagidzor, Shinuhayr, Karashen, Khndzoresk, etc. no holes for smoke in the ceilings were opened. And in basalt tunnels of lava and cavities formed by gas bubbles, which people used as dwellings – the ventilation, or chimney, is dug on the side, and there is an air duct (Old Herher, and others).

The answer to these questions, regarding the choice to find and exploit a risk-free geological stratum for dwelling or building a house in ancient or medieval Armenia, demonstrates a certain knowledge of nature and geology among our ancestors. From this perspective, the choice of location is rendered meaningful.

Why were apartments dug at a certain distance from the spring sources? Because they saw the destructive power of water and understood that those towers are a consequence of water erosion, the dynamics of which flow at a 35-45 degree slope is already a disaster.

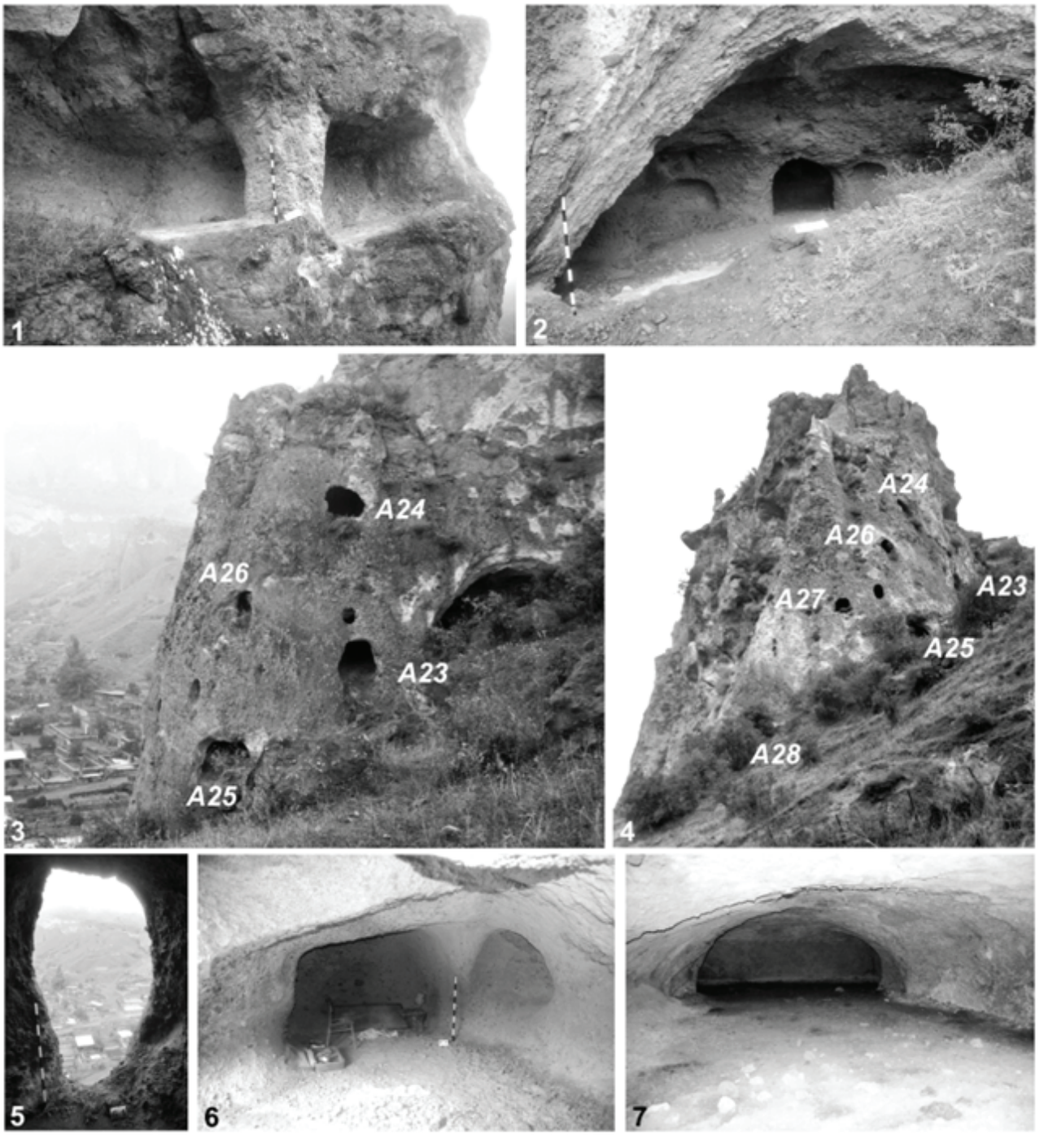
Why are settlements chosen precisely in locations where tectonic fissures and faults are absent? - to again be free from the risks posed by dynamic waters. In addition, in such layer group, underground structures are incomparably more protected from seismic vibrations and earthquakes than aboveground structures.

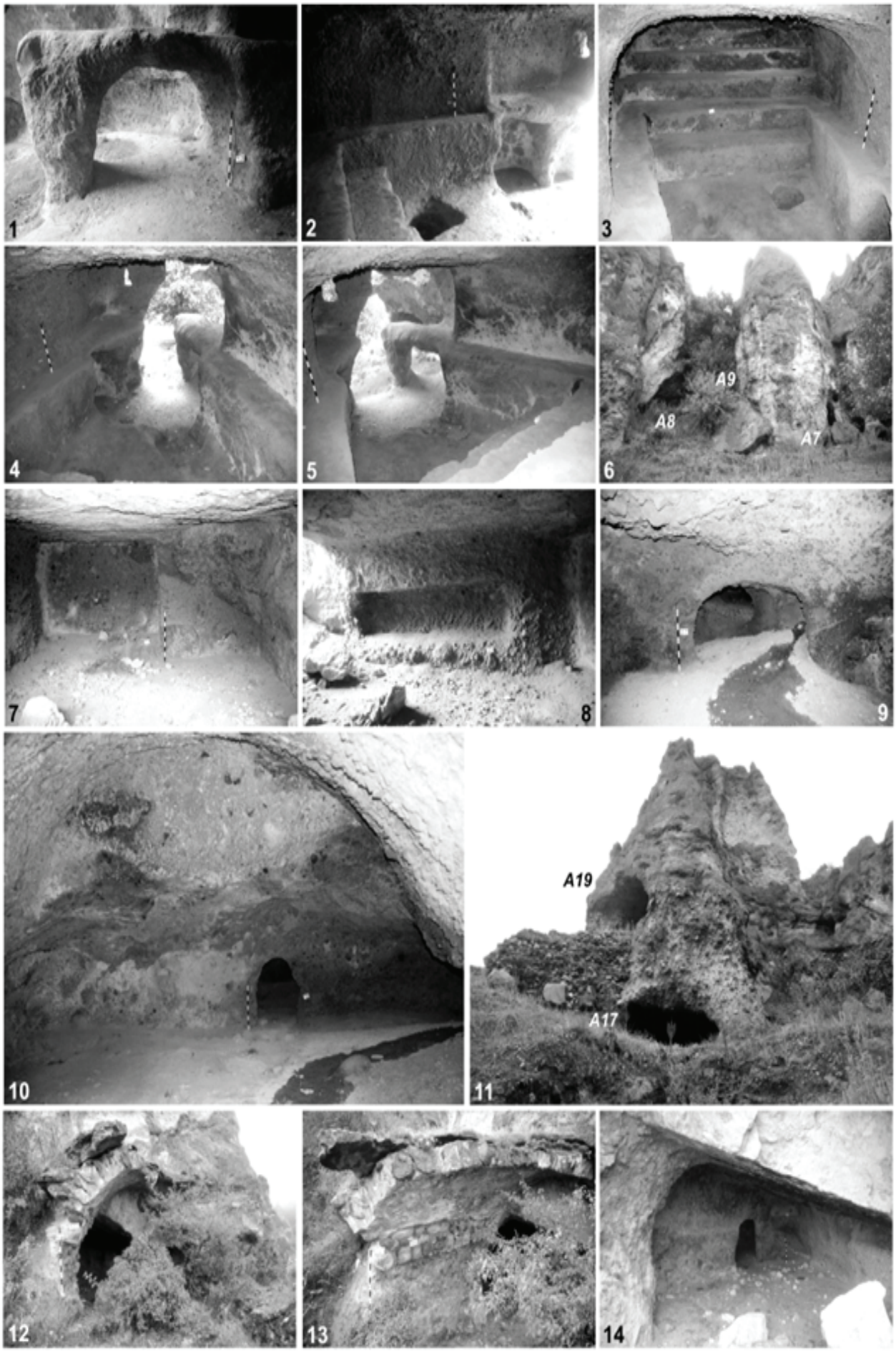
In these structures, significantly less material and energy are expended to maintain a stable room temperature compared to ensuring temperature stability in above-

ground houses of the same volume.

Why do houses built in cavities within basalt flows, even in large caves, have yerdiks (chimneys, holes at the top), while in Khndzoresk and Goris they are absent? Because these geological layers of cliffs absorb soot and toxic compounds from the air, and the entrance crevices supply enough oxygen to regulate the room's ventilation.

In 1992, a summit dedicated to nature conservation took place in Rio de Janeiro, which was attended by the leaders of all the countries of the planet for the first time in the history of mankind. Man, nature and ecologically clean and safe environment are openly exemplified by medieval cave houses and settlements. After that, the ecological state of our planet is getting worse and worse and is already turning into a crisis. The circulation of energy and matter between the environment and humans in cave settlements is so "waste-free" that human biological activity has not lost its qualities. This fact is an important circumstance for the restoration and museumification of a medieval cave village, or at least one house with its auxiliary structures.

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Architecture of the Void: The Settlement Complex of the Hypogea in the Pontrelli Locality

Chiaramaria Spinelli

Polytechnic of Bari, Italy, architecture department. c.spinelli4@phd.poliba.it

Abstract

The Pontrelli hypogea complex, located in the karst area southeast of Altamura, constitutes an articulated system of artificial cavities embedded within a context of exceptional scientific and anthropological value. This site is characterized by an occupational continuity stretching from the Neolithic period to the first decades of the twentieth century. Situated within the broader landscape of Murgian karst–analogous to the rock-cut systems of Gravina in Puglia and the Sassi of Matera–the site represents a significant example of symbiotic interaction between human communities and the geological environment. Its territorial relevance is further enhanced by its proximity to world-renowned landmarks, such as the Pontrelli Quarry, with over 25,000 dinosaur footprints, and the Lamalunga Cave, home to the "Altamura Man."

Excavated into the local calcarenite and adapted to shifting needs, these hypogea exhibit a spatial planning of extreme interest: the cavities are excavated in a strictly parallel fashion, situated just a few dozen meters apart with a uniform orientation. This indicates a precise intentional design rather than fortuitous development. From a documentary perspective, the first systematic records date back to the 17th century; through the analysis of 1600s notarial deeds, property references primarily describe the overlying masseria. This farm complex was a complete architectural organism featuring a two-story residence, stables, a dovecote, and a family chapel. In these deeds, the hypogean spaces are generically defined as "caves" (grotte), without specification regarding their planimetric extent, suggesting a partial perception of the underground complexity. However, material investigation has clarified the dual function of these spaces: they served as warehouses and workshops supporting the masseria, and as rental accommodations for transhumant flocks. The strategic position, intersected by the main Murgian sheep tracks (tratturi), made the Pontrelli hypogea essential staging posts for transhumance. Their characteristic structure allowed for the simultaneous housing of numerous shepherds and herds, establishing the site as a vital logistical hub for the regional rural economy. Despite its historical value, the complex currently suffers from severe degradation. The cessation of traditional maintenance has exposed the cavities to water infiltration, which wears down internal surfaces and compromises structural stability through constant seepage. It is therefore a priority to define a plan for periodic maintenance and rainwater management to halt the decline of this heritage.

In conclusion, the study highlights how these "architectures of the void" are not mere accessories to the surface farmstead, but silent witnesses to a rock-cut civilization capable of integrating private life, faith, and economic pragmatism into a coherent settlement system that deserves full rediscovery and rigorous protection.

Keywords: Pontrelli Hypogea, Karst, Altamura, Apulia, Transhumance, Rock-cut Architecture, Masserie

PREMISE

The study presented concerns a complex of hypogea present within the landscape context of the Alta Murgia, a large area in central Puglia, recently awarded the title of UNESCO Geopark [1].

The system of underground passages borders the aforementioned park but is part of the same geological structure that surrounds it. The study was conducted as part of my master's thesis in architectural and landscape heritage at the Polytechnic University of Bari.

1 https://www.unesco.it/it/unesco-vicino-a-te/geoparchi/alta-murgia/.

INTRODUCTION

Since we are talking about a complex of hypogea, to classify [2] the cavities typologically, we used the Artificial Cavities typological classification - year 2024, National Commission on Artificial Cavities of the Italian Speleological Society (ETS). The chosen site, in particular, is a hypogeal civilian settlement and can be classified into the following subcategories:

Permanent housing settlements

The subtype includes long-term settlements, cave dwellings, and underground houses [3]. Most of these

2 Galeazzi, Germani 2023.

3 Bixio 2012.

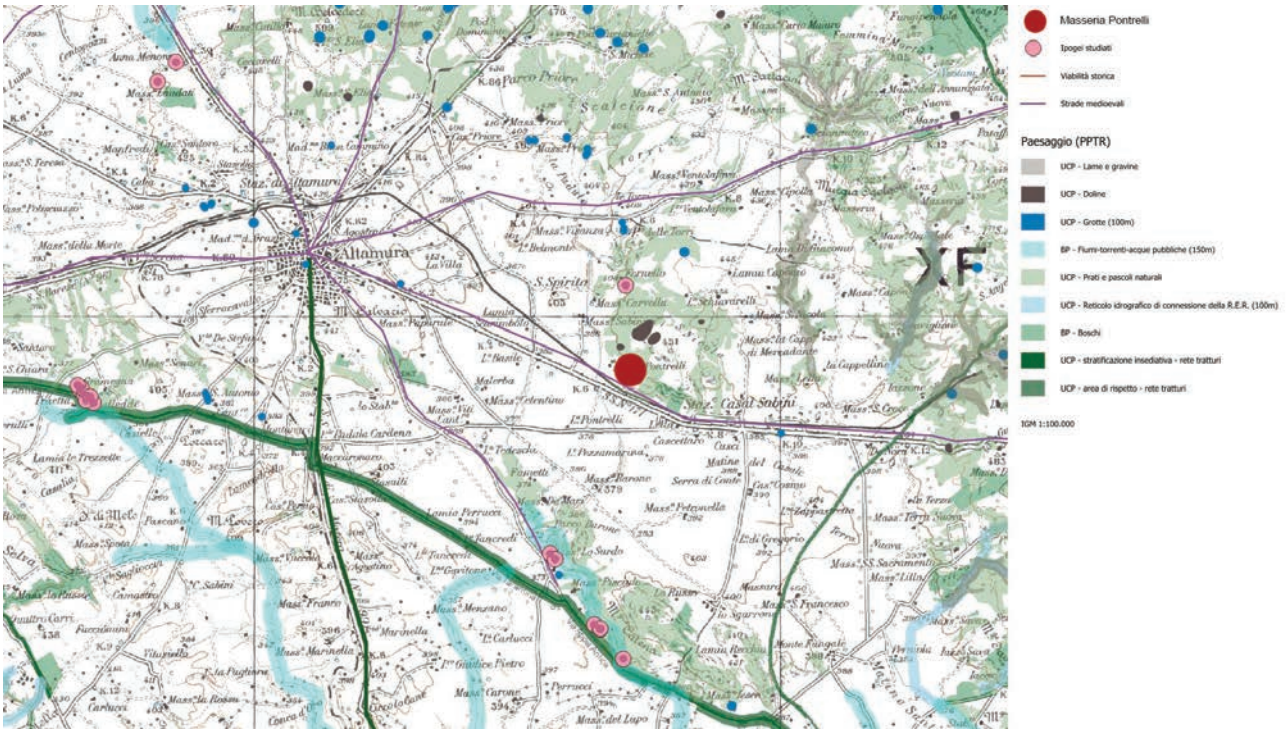

Fig. 1. Masseria Pontrelli and similar comparisons in the area, with identification of the hypogea and caves within the historical and natural infrastructure network. (graphic Spinelli C.)

Fig. 2. General plan of the hypogea superimposed on the aerial photogrammetric survey with contour lines. (graphic Spinelli C.)

Fig. 3. Access dromos to three underground chambers (photo Spinelli C.)

caves are now abandoned, but in some cases, such as the *Sassi di Matera*, they have been the subject of a process of reevaluation and recovery since the 1980s.

Temporary settlements

Seasonal settlements, shelters for shepherds during the transhumance, hideouts for brigands, places of temporary detention.

THE PONTRELLI HYPOGEA COMPLEX

Historical and geographical context

The term "complex" defines a system of artificial *sub-divo* cavities connected to each other underground. The study area, called "*Pontrelli"* or "*Punturillo*"[4] is located ESE of *Altamura* in a karst landscape characterized by sedimentary rocks. The site is adjacent to the well-known *Pontrelli quarry*, where one of the largest deposits of dinosaur footprints in the world (approximately 25,000 footprints over 12,000 m2), dating back to the Upper Cretaceous, was discovered in 1999.[5] In addition to its paleontological value, it also holds paleoanthropological significance linked to the "*Altamura Man*", a complete Paleolithic skeleton discovered in 1993 in a karst well in *Lamalunga*. The favorable conservation of the lithotypes and the environmental conditions have preserved the stratifications of the past, allowing, on the one hand, the study of evolutionary phases and, on the other, favoring a continuity of settlement that, however, has often erased the traces of previous eras. Continuity of settlement characterizes the hypogea in the *Pontrelli area*: the only historical documentation present are notarial deeds that document the transfer of ownership of the agricultural lands. The events described date back to a chronological period that began in the late 1600s, and caves and wells present in the area covering sixty-six *tomoli* (26,829 hectares) have already been documented[6]. Although there is no information regarding the specific site, it is known that the Altamura area and the *Murgia* area have shown continuous settlement starting from the Neolithic and continuing into the Peucetian, Greek, Late Antiquity, and Medieval periods [7].

Fig. 4. Geometric and topographic survey with laser scanner point cloud overlay. Western hypogea. (graphic Spinelli C.)

The *Alta Murgia* region is steeped in natural and human influences that reflect the richness and complexity of human spatial organization over the centuries: extensive networks of dry-stone walls, underground villages and necropolises, rock churches and rural chapels, as well as cisterns and snow pits can be found. *Trulli*, post houses, and rest areas further enrich the landscape, while countless farms and sheep farms, known as '*jazzi'* stand along the ancient transhumance tracks.

4 Notarial Register of *Altamura* 46, Mendolla C. 1854, State Archives of Bari.

5 *Altamura* Limestone „ quarry. The footprints date back approximately eighty million years. The area was acquired by the Municipality of *Altamura* in 2016.

6 For a more complete examination of the transfers of ownership see: Ferrante, Pupillo, 2020, *La masseria pontrelli* in *Le masserie di Altamura, unpublished stories of patrimoni and owners.*

7 Document 5 of the PPTR (Regional Territorial Landscape Plan), area 6 (*Alta Murgia*).

Fig. 5. Entrance to the central hypogeum complex. (photo Spinelli C.)

Fig. 6. Central hypogeal chamber of the second western hypogeum. (photo Spinelli C.)

The road system

The rural structures support intense agricultural and pastoral activities, and therefore, in the same way, a road structure, consolidated over time, has allowed these rest sites to be reached within a large inter-regional network; in fact, the area is clearly and naturally characterised by two ancient and important transhumance routes, the so-called *tratturi*, which run almost parallel in a WNW-ESE direction, represented respectively by the royal *tratturo* n°19 Canosa-Ruvo and by the section of the royal *tratturo* n°18 Barletta-Grumo. On the Fossa Bradanica side, the Tratturo Regio n°21 retraces the route of the Appian Way, furthermore, it is cut transversally by two other ancient roads[8] (Fig. 1). It is in this context that the hypogea developed; a context partly dug by water, and which gave rise to the ravines on whose sides the caves and the first human settlements were dug, partly a vast agricultural area in which the hypogea served as dwellings, stables, and shelter so as not to compromise the fertile soil dedicated to cultivation. Furthermore, it is no coincidence that these dwellings or fortified farmhouses are located either along the main roads or along the grassy paths of the area precisely to support shepherds and flocks during the transhumance periods. In particular, the Pontrelli hypogea complex extends below ground level at an intermediate distance between Altamura and Santeramo in Colle; their location is close to the Melfi-Castellaneta sheep track that runs alongside the stretch of the Appian Way between Gravina in Puglia and Taranto[9].

Description of the environments

The four hypogea discovered[10] are three complexes of cavities placed next to each other to the west and a larger one to the east (Fig. 2). They all follow the same orientation, slightly inclined towards ENE/WSW and with the West-East arm, or the longitudinal one, tending to be more developed; In fact, in three out of four cases, they appear to have a “cross” plan. For simplicity’s sake, and given the complexity of the system, the group of three smaller hypogea is called the West Hypogea, while the East Hypogeum is the largest main hypogeum. After carrying out the drone and laser scanner survey campaign, several site visits were conducted to study the site, which is currently in a state of abandonment for the West Hypogea, but still contains furnishings and rural materials that recall a past life and allow us to reconstruct the intended use and type of settlement; while the East Hypogeum has been cleaned and is located beneath a farmhouse that is still in use today. The plan was created by superimposing the ground plan onto the section made at -386.5 m above sea level and therefore, approximately two meters below a hypothetical average elevation plan that considered the different orography of the soil. They are all found to have been excavated to the same depth and were certainly used in the past. as animal shelters, storage areas, and dwellings. The excavated rooms were separated from the outside by wooden doors, some of which still have the metal hinges visible, or by dry stone walls that divided the rooms into multiple spaces. Since all of them

8 PPTR Puglia (approved with Regional Council Resolution no. 176 of 2015).

9 Piepoli, 2017.

10 The survey of a rural area with a complex of underground tombs required the combined use of laser scanning and LiDAR techniques, each with specific characteristics and applications. For the survey of the underground tombs, the terrestrial laser scanning (TLS) technique was employed, which involves the use of fixed devices capable of emitting laser pulses at surrounding objects and measuring the time taken for the beam to return.

were *sub divo* constructions, they were lit by vents positioned centrally with respect to the vault above; on average, a longitudinal room, in the cases analyzed, had two or three vents, while in the quadrangular rooms, only one was found.

The Western Hypogea

All the hypogea of the site are accessible from a *dromos* (corridor) leading to a central open space, which distributes the surrounding rooms (Fig. 3). The first, starting from the left, of the western hypogea (Fig. 4), is composed of three rooms, two of which are quadrangular, each measuring approximately 5x5m, with low niches, and a rectangular room measuring approximately 11x6m with a barrel vault and a cross engraved on the entrance architrave. This detail does not necessarily indicate the presence of a place of worship but may be an auspicious inscription; in fact, no traces have been found that could suggest a sacred use. Access to the rooms was managed by wooden portals with a counter frame built into the internal side of the room and with, probably, a beam blocking the door. Continuing to the right, at a distance of 22m, is the other *dromos*. which leads to a more complex system of rooms. This hypogeum has suffered a clear collapse of the quarry ceiling, making the space appear airier and more open, but it can originally be imagined as the one described previously (Fig. 5). The interior has an average size of 15m x 7.5m, has a vent and a few niches in contact with the ground. The central chamber is longitudinal, also measuring 15m and 6m wide, and is accessible through a wooden door whose fixed frame is still preserved; it is barrel-vaulted and has two vents. It is richer in niches for the storage of objects and has holes at mid-height, probably for the insertion of beams that crossed the room and allowed objects to be hung. Some barrels placed on ‘ *tufelli* ‘ and some demijohns are still preserved, suggesting that it was used as a storage room (Fig. 6).

The final chamber is divided into three rooms and has a ‘fan-shaped’ layout [11], meaning the rooms are carved out in a radial pattern around an imaginary central hub, with protruding end walls dividing the spaces. This construction technique allows the rooms to be arranged in a favorable position for maximum light.

This spatial organization reflects a clear functional distinction: the rooms intended for storage are oriented to remain cool and dark, while those oriented toward the light were likely intended for daily activities. The recurrence of modular dimensions and the perfect alignment between the western and eastern complexes suggests the intervention of a single *team* of specialized builders.

11 Masini 2003.

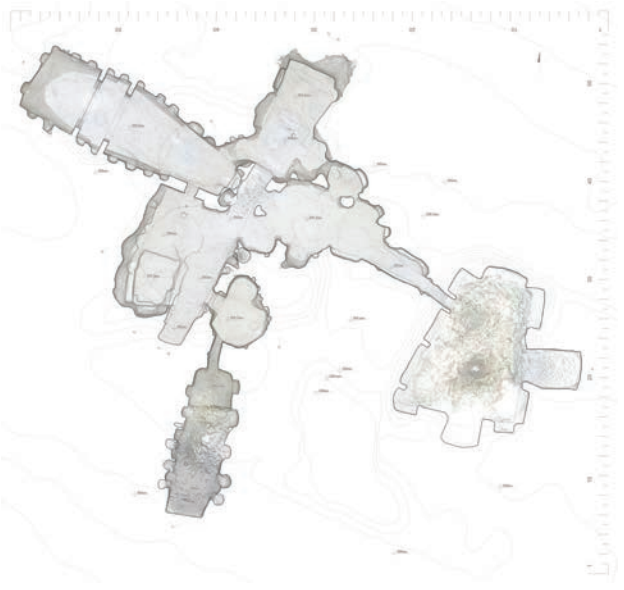

Fig. 7. Geometric and topographic survey with laser scanner point cloud overlay. Eastern hypogeum. (graphic Spinelli C.)

The eastern hypogeum

The complex has a cruciform plan with overall dimensions of 48m x 31m, with an annexed arm (total length approximately 25m), parallel to the transverse, connected to the *dromos* on the right, and an uncovered *jazzo* to the east (Fig. 7). Although part of the roof is now lost, the same construction methodology is discernible as in the hypogea already investigated; the excavation technique is the shaft with subsequent excavation of the *dromos* and opening of the entrances to the rooms overlooking it. In the area between the entrance corridor and the *jazzo*, the farmhouse is constructed, consisting of two masonry construction units and reinforced concrete perimeter walls topped with sheet metal covering the work area and the chicken coop. Proceeding into the *dromos* (Fig. 8) On the right, there is an entrance to a lower circular room, approximately 5.5 m in diameter, accessed via two steps. What is immediately noticeable is a cross carved on the ceiling before a stone ‘hourglass’ ring used to hang a lamp. During the day, the room was lit by a vent, now blocked by the construction of the wall of the building above. The side walls, made of fossiliferous calcarenite, have numerous niches and holes due in part to the degradation of the material, and in part to the insertion of nails and metal or wooden hooks, which are still visible today. To the side, on the left, there is a larger niche with traces on the ceiling indicating the past presence of a partition, perhaps wooden, separating it from the main room. The room was intended to be closed due to the permanence of the holes in the door frame and others used to place a beam

Fig. 8. Entrance to the eastern hypogeum (photo Spinelli C.)

Fig. 9. Excavated area near the dromos (photo Spinelli C.)

to block the entrance. On the right, a narrow corridor leads to a long barrel-vaulted room with lateral niches; access to the back of the room is blocked by a pile of stones lowered from the vent. It is hypothesized that this was due to the need to create a sturdy foundation for the farmhouse, built above and in a false position with respect to the vault of the hypogeum.

To the left of the *dromos* There is a room measuring 16m x 6.40m, part of which is lowered by half a meter compared to the previous floor level. Standing in front of the *dromos* We can therefore observe a large quadrangular concavity carved into the calcarenite and composed of steps which have rectangular cavities of various sizes (Fig. 9). At the bottom, on the wall, the presence of a pseudo-apse niche is evident, and the wall surface is covered with a biological patina due to humidity and a black crust attributed to soot. To the side, on the right, there is a platform approximately 0.50 m high that runs along the entire wall and is characterized by a series of triangular notches that suggest recesses; a stone element measuring 78 cm x 68 cm x 51 cm remains *in situ*, with a 22 cm deep cavity and a lateral disposal hole.

Leaving this space, one is welcomed, through a masonry entrance made of calcarenite blocks, into a barrel-vaulted room with two vents (Fig. 10); on the right, there are traces of a fireplace with a masonry back wall and set between two rock walls, which were dug out to create niches used as a pantry and holes to create recesses for beams (often used to hang objects). The back wall of the fireplace, which overlooks the central well, has three alternating vertical black bands (Fig. 11), which suggests that there were strings inside the hood to prevent convective motion of the smoke, which was then expelled from a chimney above.

The position of the fireplace next to the entrance is also documented in other cases[12] On the left, however, there is a vaulted room with lateral niches, and the space is ideally divided by two masonry arches detached from the walls, therefore certainly not load-bearing, and with recesses for beams still present and also used to hang objects or to divide the space (Fig. 10). Next to the fireplace and directly corresponding to the excavation shaft, an irregular circular pit has been dug into the calcarenite. It has an average diameter of 1.80 m, a minimum depth of 86 cm and a maximum depth of 1.13 m, and contains a slight incision in the floor, perhaps a small channel of which almost nothing remains. Opposite the pit, a small oven is set into the rock with a cooking surface made of *chianche* (a floor block made of local stone) and a mouth underneath for the insertion of wood. The oven has a mouth regularized by calcarenite ashlars and reveals the presence of a wrought iron hook to which the door would have been attached. This too has a flue that passes through the stone ceiling via a perforation.

Facing the fireplace and taking the left entrance, you find yourself in another room connected to the excavation shaft. On the left, there is a raised, carved niche, indicating that the floor level was likely lowered over time; in fact, the floor would have been at the same level as the entrance. What is unique about this space is the evident junction between the Altamura limestone and the Gravina *calcarenite*, demonstrating the presence of the hypogeum straddling two geological sediments. Continuing along the path, you find yourself in a space punctuated by arches carved into the rock with equally low, concave niches, likely used for feeding troughs. Between each arch are stone rings or hooks that would have allowed the various sections to be closed with ropes. Finally, after having completed the described route, on one side you find yourself at the *dromos*, on the other, crossing a 9m long corridor you enter the *jazzo*, the place where the livestock were kept. The *jazzo*, also dug into the calcarenite bank, has nine niches of different sizes but with a width between 3 and 5m and a depth between 80cm and 1.50m except for one which

12 R. Caprara, F. Dell'Aquila, 2004.

Fig. 10. Room with stone arches and vents (photo Spinelli C.)

becomes a room as it is 6m deeper than the external edge of the perimeter wall; these were used to shelter the animals in case of rain or during the hottest hours (Fig. 12).

The construction phases

Due to the critical issues analyzed (see below), a relative chronology of the underground work was defined rather than an absolute dating. The construction phases were identified through excavation traces and signs of workmanship. In the region between Puglia and Basilicata, two methods are distinguished: vertical wall attack (on slopes or ravines) and shaft excavation on flat terrain. [13]Both coexist in the Altamura area, but in the Pontrelli hypogea the latter, typical of the Bari area, prevails. It generates tabular morphologies in which the shaft evolves into a central courtyard around which the rooms are arranged [14]. Although erosion hinders the analysis of the tools (chisels, picks, wedges), the persistence of the excavation "teeth" in cross-section has allowed us to identify the construction sites in the intermediate or final phases.

It is therefore hypothesized that the first construction nucleus was the central western sector with the excavation of the vertical shaft, the access ramp, and the surrounding rooms, therefore rooms I, II, III, IV, and V. Generally, the excavation phase is easier to identify by observing the marks on the quarry ceiling, which, in this case, is indeterminate due to the collapse of the quarry. Furthermore, the floor to the west was lowered over time, probably to extract construction material and/or due to a change of function. However, looking carefully at the edge of the *dromos*, a roughly hewn section with

Fig. 11. Detail of the fireplace (photo Spinelli C.)

two steps is visible; the rest has been lost due to the excavation. Eight meters further on, the floor is smooth and shows a curve to the left. The same construction technique can also be found in rooms IV and V; in room III, it is no longer detectable because, in this case too, the entire floor level was subsequently lowered. Room I, therefore, can be reconstructed in its original phase as a closed space, vaulted or flat, with two entrances separated by a rock wall that either curved or had a rock door of which a slightly outlined base still remains.

A second hypothetical phase is the expansion of room II-III (probably in other distinct sub-phases), the implementation of room V and, it is not possible to know whether at the same time or later, room VI was built, in the past, accessible from another ramp now obliterated.[15]

It would probably have been a space, used as a manger, separate from the settlement context, and used to shelter the flocks during the night; not far away, moving east, there is the rock *jazzo* which would confirm the hypothesis of a stable and also of the large number of niches dug into the walls. Finally, the spaces, thought to be separate, are joined by corridors and arches, generating a single large construction complex and it is hypothesized that the pre-existing spaces were enlarged with the excavation of further niches (Fig. 13).

The difficulty in identifying the phases, especially in the eastern sector, is due to the varying lithotype: the

13 Masini 2003.

14 Dell'Aquila, Messina 1998.

15 The hypothesis comes suggested by the owners of the site who, during their inspections, found the roots of a fig tree located a few metres away from the back wall of room VI.

Fig. 12. Rupestrian Jazzo (photo Spinelli C.)

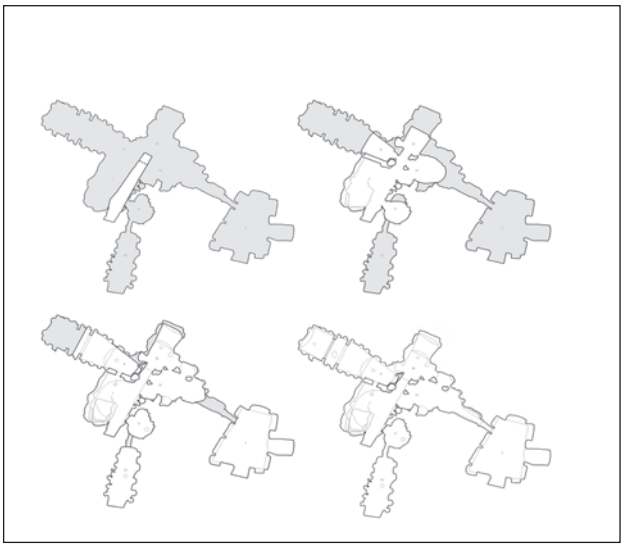

Fig. 13. Reconstruction of the construction phases. In order from left to right, the four excavation phases (graphic Spinelli C.)

fossiliferous calcarenite, roughly divided into three balsas, has undergone such an erosion process that it has erased the signs of workmanship on the walls, making them difficult to read. However, the construction of this hypogeum, in the phases subsequent to the first, appears to be attributable to a time period in which a specific workforce was employed; in fact, the orientation of the rooms and the nearly identical orientation to the western hypogea, as well as the similarity of the construction techniques, suggest a team of specialized builders who also left their mark on the surrounding area.

Functional distribution

The eastern hypogeum complex appears significantly more remodeled than the western ones, which were primarily used for housing and storage. If the site was originally intended for religious and funerary purposes [16], it would fit into a practice documented in the Altamura area from the Neolithic to the Hellenistic period. On the contrary, evidence of occupation during the Roman and early medieval periods is scarce, except for the sites of *Belmonte* and *Montedoro* [17].

Before the urban foundation in the 13th century, the territory of *Altamura* was described in legal documents as a deserted place [18], although by 1243, human settlements and pre-existing roads were already mentioned. The foundation of Altamura by Frederick II (1232-1243) gave impetus to a territorial reorganization aimed at the economic and fiscal control of rural areas. In this medieval context, rock-cut architecture flourished, with the construction of numerous churches, often frescoed, between the 14th and 15th centuries and closely linked to the system of *masserie* [19].

Returning to Room I, a burial function could be supported by Room V, interpreted as a cult space due to the presence of a relief cross and votive niches; alternatively, the small size and thermal protection would suggest a use as a dormitory. Regarding the stone containers, the lack of certain evidence that they were used as sarcophagi and the presence of drainage channels indicate their eventual reuse as drinking troughs [20]. A second hypothesis for Room I is that of a wine press [21]. Although the porosity of the rock excludes the use of the cavities as collection tanks for liquids, the use of wooden containers for the must is likely. Over time, these spaces were adapted as fireplaces or stables, as evidenced by the soot and mangers [22], a transformation that perhaps occurred after the collapse of the quarry roof. Other interpretations suggest a factory for grinding cereals or dyeing fabrics, given the proximity of the well to the hot water chimney. The last phase of certain use is that of a stable, perhaps also intended for the seasoning of

16 At the *Pontrelli* quarry and in nearby locations such as *Masseria Jesce* and *Casal Sabini*, funerary hypogea and necropolises from the Bronze Age to the Classical Age are documented (D. VENTURO 1994; F. COLVICCHI et al. 2004), confirming the millennial sepulchral use of these cavities.

17 Round, Donvito, 2009.

18 A. Giannuzzi, *The Altamura Papers* (1232-1502), in Codice Diplomatico Barese, XII, Bari, 1935, doc.89, pp. 93-220.

19 Round, Donvito 2009.

20 Hypothesis confirmed by the historical memory of the site owner.

21 A historical piece of information that would confirm the existence of an area intended for milling is that in the *San Tommaso area* there were vineyards belonging to the same owners.

22 Olcese, Breed, Surace 2020.

manure for fertilization. [23] The rooms feature mangers, cuspated niches for horses, stone rings and recesses for the "*varroni*" (beams closing off the entrances) [24], confirming a deep-rooted agricultural-pastoral vocation [25].

The hub of underground life was the central nucleus near the well, equipped with a kitchen with a fireplace, niches for food, and a small bread oven. An irregular pit near the fireplace, unsealed, may have served as a dump or grain storage area.

Finally, the external *jazzo*, connected by an underground passage, was used for seasonal shelter for flocks. During periods of inactivity, thanks to natural fertilization and protection from the wind, the space could be converted into a vegetable garden, like well-known examples such as the *jazzo Nunziatella in* Matera.

Conclusions

In conclusion, one might imagine a permanent rural settlement for production and storage purposes serving the farm, which could also have been a resting place for shepherds and their flocks during the transhumance. The extreme versatility of the spaces allows it to be used on a rotational basis for different purposes, even shared by sharecroppers or neighboring residents.

Altamura area, many hypogea carved out of limestone can be found, with a history even older than that found at Masseria Pontrelli (Fig. 1). This confirms a deep-rooted knowledge and practice in the use of this construction typology and in the intended uses of the rooms[26]

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23 This would be confirmed by the notarial register of notary *Mendolla* kept at the ASB, from the year 1854, in which, in the deed of donation, the use of the fields used as manure heaps to produce fertilizer for sale is explicitly described.

24 CRESCENZI 2012.

25 The proximity to important roads such as the *Appian Way* underlines the logistical value of cave settlements in the rural context.

26 For further information see the illustrated catalogue of the exhibition of the rock settlements of Altamura created on the proposal of the CSREC in 1982.

The Rock-Cut Village of Nicosia (Sicily, Italy)

Roberta Varriale
(CNR-ISMed), Napoly, Italy
roberta.varriale@cnr.it

Abstract
Nicosia is a village in the province of Enna, the inner area of the Italian Sicily Island. The city centre developed on the upper basin of the Salso River, a tributary of the Simeto River and its geomorphological conformation has favoured, since the beginning of its history, the phenomenon of cave dwellings. Those caves, carved into the sandstone rock, were initially excavated by first settlers, then reused during the subsequent periods and adopted for civil and rural uses: houses, stables, ovens, wine presses, silos, WW2 shelters, parking facilities, warehouses etc. Today, these structures are a sign of the ability of local population in maximizing natural resources and are perceived as elements of identity and part of the local cultural heritage, both in terms of their tangible and intangible values. Although Nicosia's troglodytic heritage is impressive in terms of the number of caves and historical reuses, it is poorly recognised at regional level and even ignored at international level. A contribution to their recognition was carried out, in 2017, by the Eco Museum Petra d'Asgotto to enable their nomination, in 2017, to the UNESCO tentative list. This attempt, which unfortunately was unsuccessful, was followed by a series of regeneration projects carried out by the municipality involving several buildings in the town centre. Progress has also been made in terms of promotion: today, the caves of Nicosia are listed by the Italian Environment Fund (FAI), host several events and they are also included in some cultural itineraries. However, there is still much work to be done, starting with a careful archaeological survey that can lead to complete mapping, dating of the construction of individual elements, measurement of spaces and reconstruction of various historical uses and reuses. Considering that, to date, the territory of Nicosia is excluded from both the boundaries of the UNESCO Madonie Geopark and those of the Nebrodi Regional Natural Park, the local Municipal body, supported by the Madonie Local Action Group (GAL), have entered into an agreement with the National Research Council (CNR) to carry out joint projects aimed at completing the census operations for the definition of regeneration plans for the socio-economic well-being of the local community. The research illustrates the methodological approach identified within this framework at a theoretical level and tests it based on data from selected case studies.

Keywords: rock-cut architecture, troglodyte, historical uses and reuses, regeneration, enhancement

Introduction

Nicosia is a small village (12400 ca inhabitants in 2025) in the province of Enna, in the inner area of Sicilian Island, Southern Italy. Its convenient location on the upper basin of the Salso River, a tributary of the Simeto River, has contributed to its urban development throughout its long history. The presence of a cliff valley from one side, and the geological composition of the soil on the other, meant that excavations have always been a significant part of its urban experience: more than 300 dwellings can be found, both in the city centre and in the suburbs. Today, some of them have been partially or completely incorporated into subsequent stone, brick or concrete buildings but many have retained their original troglodyte façade.

Although there is no doubt that Nicosia can be considered one of the most significant rock-cut Italian villages, both in terms of the number of caves and historical functions and reuses, its troglodytic heritage it is poorly recognised and little has been done to transform this unique aspect of the village it into a social and economic regeneration factor. This is a very critical issue since the area is today affected from all the typical problems of inland areas: demographic issues, such as depopulation and ageing, economic issues, such as low per capita income and closure of commercial and business activities, social issues, such as very high unemployment rates, and the subsequent abandonment of several historical buildings the city centre.

One of the problems of the status of the rock-cut village may be the fact that Nicosia is not included in any of the surrounding protected areas surrounding: Madonie UNESCO Global Geopark (Madonie Geopark, 2026), the Regional Nebrodi Regional Park (Parco Nebrodi, 2026) and the National Etna Volcano Park (Parco Etna, 2026) (Fig.1). Anyway, it is also true that the village is underestimated because of the absence of structured and solid research capable of enlightening all the tangible and intangible values connected.

To date, although a definitive date for the village has not yet been established, it is matter of fact that all attempts carried out were based precisely on the functional relationship between the caves, initially excavated to be adopted as burial chambers. Some scholars dated the foundation of village in the Prehistory (2000

Fig. 1. The rock- cut village of Nicosia, Sicily (photo Varriale R.)

BC) (Valbruzzi et al., 2016), some hypothesized, based on the evidence of a necropolis dated IV-VI century BC, that Nicosia could have been the Hellenic mythologic city of Herbita (Collura, 2016), some placed the troglodyte village in a broader regional and national context, attempting to reassess the current state of research and enlightening how the main focus have always been rupestrian castles and churches rather than the complex phenomena of the rupestrian habitat (Patti, 2013). Even if all the above-mentioned studies focused on the fundamental role of dwelling, however, the main issue appears to be the lack of a structured stratigraphic survey that, in the absence of archival historical data, can provide a topographical interpretation of the village (Macchione & Mastroianni, 2024).

To investigate on the complexity of the relationship between local geology - defined as a geo-resource - and the urban development expressed by the troglodytic village, an archaeological site was opened in Monte Altesina in 2020. The project is still ongoing, first results were published in 2025 (Labisi et al., 2025) and new updates were divulgated at the beginning of 2026 (Monte Altesina, 2026).

However, even if the linkage between the excavations of dwelling and the dating of the village has been confirmed, subsequent uses of those spaces could provide information regarding the development of the settlement. In fact, even if mostly of them were initially excavated as burial places by the first settlers of the area, they were then reshaped and reused in the subsequent historical phases to host several new functions: rural dwellings, rupestrian churches, stables, ovens, wine canteens and presses, silos and even tanneries. In this perspective, the reconstruction of historical reuses of those caves could support the reconstruction of subsequent phases of the history of the village.

However, to date, in the absence of comprehensive speleological surveys, significant exhaustive archaeological research, measurements and analysis of the historical functional classification for each dwelling, the reconstruction of the historical development of the rock-cut village is still an open question.

First steps towards the systemization of existing information were taken by Petra d'Asgotto Eco Museum in 2016 (Ecomuseo Petra D'Asgotto, 2026) with the signature of a Memorandum of Understanding (MoU) with the Municipality of Nicosia and the external support from the Madonie Local Action Group (GAL) (GAL, 2026). Based on this MoU, the elaboration of a preliminary survey addressed to the description and the classification of representative Nicosia's dwellings was carried out. This survey supported, in 2017, the application for inclusion, in combination with the nearby rock-cut village of Sperlinga (Scalisi, 2004, 2005, 2008), in the UNESCO Tentative List in 2017 (UNESCO Tentative List, 2026). Even if the application (Dossier Nicosia Municipality, 2017) was not successful, this first attempt provided the collection of data regarding 37 cavities which were organized in 10 complexes as follows: Medieval castle of Nicosia, Montetto and Santa Caterina rocks, Vaccarino rocks, Rocca Palta rocks, San Cono rocks, S. Paolo rocks, Itria grotto and church,

Cappuccini rocks, Saint Anna rocks, Saint Agata rocks and the complex of Petralunga, Mercadente and Castagna rocks. That survey provided the descriptions of the properties under consideration, it included pictures, results from onsite inspections and some historical details. Even if data collected are not exhaustive, this first attempt played an important role in raising awareness of the value of Nicosia's rock art heritage. In fact, from that moment onwards, a series of events focusing on the rock-cut village of Nicosia were carried out. First, in 2018, architects Domenica D'Amico and Tiziana Pugliese were commissioned a technical report regarding the rock-cut dwelling spaces in the city centre (Determina Nicosia Municipality, 2018). Then, in 2021, Sicily Region, almost 40 years after the project was approved, finally funded the reinforcement of the rocky face where the main urban rock-cut complex is carved (A Nicosia si consolida Monte Sant'Elena, 2026). From the enhancement point of view, today the caves of Nicosia are included in some touristic itineraries managed by the Italian Environment Fund (FAI) (FAI, 2026) and by local Eco Museum (Ecomuseo Petra D'Asgotto, 2026).

Even though some progresses have been made, both with reference to the analysis of Nicosia's rock-cut environment and its enhancement, there is still much to be done in terms of raising awareness and of monitoring and preservation.

With a view to continuing scientific research, including through the submission of projects for funding, in 2025 the Municipality of Nicosia signed a MoU with the Institute of Studies on the Mediterranean (ISMed) from the National Research Council of Italy (CNR) (MoU CNR-ISMed/Nicosia Municipality, 2025) within the scope of the research project "Underground Space for Territories Knowledge and Enhancement" (Underground space for territories knowledge and enhancement, 2026). The MoU was supported by the Petra d'Asgotto Eco Museum (Ecomuseo Petra D'Asgotto, 2026) and the Madonie Action Local Group (GAL) (GAL Madonie, 2026).

This article is the first outcome of that MoU and describes the methodological approach carried out also introducing and testing a new theoretical tool for the classification of Nicosia's cavities.

Materials and methods

Today, troglodyte villages, as well as being the subject of numerous academic studies, are recognised as elements of cultural heritage and have often become very popular tourist destinations. The analysis of various success stories – such as the UNESCO properties of Sassi of Matera in Italy, inscribed in the UNESCO list in 1993 (Matera's Sassi, 2026), the Cappadocia troglodyte habitat in Turkey, inscribed in the UNESCO list in 1985 (Cappadocia, 2026) and the villages of Matmata in Tunisia, included in the tentative list (UNESCO Tentative List, 2026) – demonstrate, however, that this transformation is not without risks and that tangible and intangible values connected to those assets are very fragile (Varriale, 2019).

In such a promising yet equally risky context, the aim of the research was to draw up an action plan that would provide tools addressed to the classification and the enhancement of the village as an element of local cultural heritage supporting the preservation of the troglodyte habitat as well.

The research consists of the following four phases: definition of boundaries of the rock-cut village to adopt as a case study, state of the art: documents, bibliography, results from archaeological research and inspections, theoretical approach and test on selected case studies, conclusions. In the first phase, the area of interest was defined, both urban dwelling and those in the suburbs were included. In the second, results from previous studies, data from the cadastral register, maps and data and pictures resulting from inspections by the author were collected and classified. In the third, the list of information to be organized in the tool was elaborated and tested on selected case studies. The conclusions set out the next steps to be taken.

Discussions and results

In application of the MoU CNR-ISMed/Nicosia Municipality (MoU CNR-ISMed/Nicosia Municipality, 2025), three maps of the rock-cut village were provided. The first map shows the boundaries of the rock-cut village and caves included in the cadastral register from the 40s (Figure 2a), the second is the aero photogrammetry of the city elaborated in the 90s (Figure 2b), the third enlightens only the 10 groups of dwelling listed in the dossier carried out for the inclusion in the UNESCO Tentative List (Figure 2c). The paper is about cavities included within the boundaries as shown in Figure 2a and Figure 2b.

The collection of publications about the History of Nicosia revealed that cave dwellings, even if always described as fundamental in the process of dating, have never been at the centre of dedicated studies. It has emerged that most of these publications, very often produced by local historians rather than academics, lack international standing and consist of conference proceedings rather than scholarly articles in journals recognised by the international scientific community. However, there are many first-hand sources that have not yet been investigated, such as those derived from the municipal land registry and the report prepared for inclusion on the UNESCO Tentative List, which pro-

a

b

c

Fig. 2. Maps of the rock-cut village of Nicosia: a) from the municipal cadastral, b) the aero photogrammetric view, c) case studies included in the application for inclusion in the UNESCO tentative list (©Municipality of Nicosia)

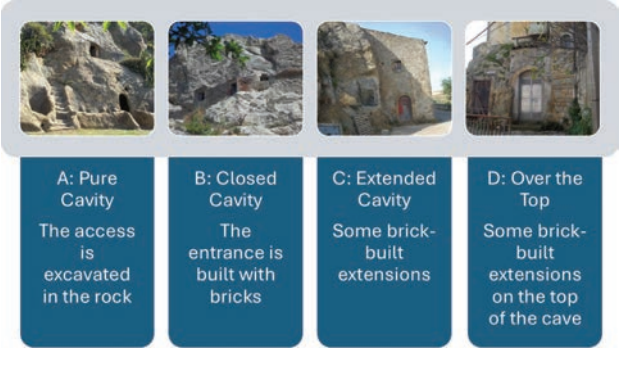
vide a basis for scientific research. To facilitate the planning of future activities, available data have been collected, classified and implemented with results from inspections carried out by the Author in March 2023 and October 2025.

Based on results from the previous phase, a summary table to be adopted as a tool for the analysis of Nicosia's cave dwellings was realised. Data collected are: name of the property, location: urban or extra urban, type of entrance of rock-cut elements: pure cavity, closed cavity, extended cavity, over the top (Varriale & Genovese, 2024) (Fig. 3), UIS classification (Parise, 2013), UBH functional classification (Varriale, 2021, 2025) (Fig. 4), historical reuses, state of the art and level of enhancement.

With reference to the of re-use of historical rock-cut architecture according to the following scale:

Abandoned: mostly rock-cut architectures are abandoned; very often they are undivided inheritances, sometimes the owners have emigrated abroad.

Re-interpreted: transformed into exposition halls or museums.



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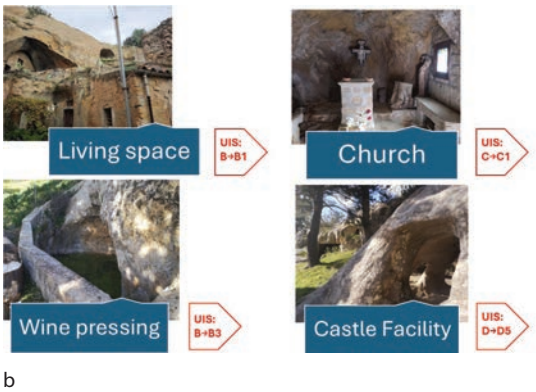


b

Fig. 3 a) Types of caves in Nicosia: pure cavity, closed cavity, brick-built cavity, over the top, b) UIS and UBH classifications for Nicosia's Dwellings (graphics Varriale R.)

Re-invented: adopted parking, urban or rural facilities.

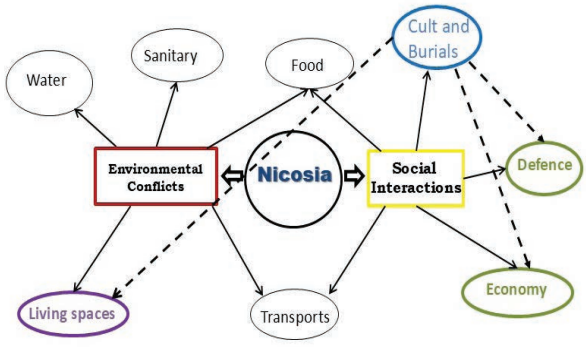
Inhabited: some troglodyte dwellings are still inhabited.

Results are collected in Table 1 (Table 1) that analyses 10 case studies in the suburbs (Extra Urban) and 9 case studies from the city centre (Urban). The table can be adopted as a tool for the classification and the analysis of all cave dwelling in Nicosia in the future.

The rock-cut village of Nicosia could be a resource for the regeneration of the village and, together with other elements of local cultural tangible and intangible cultural heritage, be the focus point of future projects. However, to be effective, future actions must be supported by solid academic research able to reconstruct the primary functions of dwellings and their transformations throughout the history as well.

Table 1. The analysis of rock-cut dwellings in Nicosia: the test on selected case studies (R.V.).

URBAN/EXTRA URBAN	NAME	UIS	UBH (included historical reuses)	STATE OF THE ART	TYPE	USE
Extra urban	Caratia Graita	B1, D7	Living Space, Defence (WW2 Shelter)	In use	1	Abandoned
Extra urban	Castagna Giacobbe	C1, B3, D7	Cult and Rituals (Church), Economy, Defence (WW2 Shelter)	Abandoned	2, 3	Abandoned
Extra urban	Cocuzza Modica	B3, D7	Economy, Defence (WW2 Shelter)	Abandoned	2, 3	Abandoned
Extra urban	Masseria San Paolo	B3	Economy	In use	2, 3	Re-invented (educational farm)
Extra urban	Mercadante d'Alessandro	B1, B3	Living Space/Economy	Abandoned	1, 2, 3	Abandoned
Extra urban	Mercadante Rossignolo	B1, B3	Living Space/Economy	In use Abandoned	1, 2, 3	Abandoned
Extra urban	Pianmartino Russo	B3	Economy	In use	3	Re-invented (rural tourism)
Extra urban	Pieralunga Casalotto	B1, B3, C1	Living Space/ Economy/Cult and Rituals	In use Abandoned	1, 2, 3	Abandoned
Extra urban	Salveregrina Agozzino	B3	Economy (Oven)	In use	1	Abandoned
Extra urban	San Marco Speciale	B6, C1	Economy (Stable), Cult (Church)	Abandoned	1	Abandoned
Urban	Borgo dei Vicoli Cappuccini	B1	Living Space	Abandoned	1, 2, 3	Abandoned
Urban	Castle	C2, D, B1, D7	Cult and Rituals (Burial Places), Defence (Middle Ages), Living Space	In use Abandoned	1	Re-interpreted (Local Cultural Heritage)
Urban	Montetto and St. Caterina	B3, B4, B6	Economy (Stables, Wine Presses, Warehouses)	Abandoned	1	Abandoned
Urban	Vaccarino	B	Economy, Living Space	In use Abandoned	1, 2, 3	Re-invented (car parking)
Urban	Roccapalta Settlement	B	Economy, Living Space	In Use Abandoned	1, 2, 3, 4	Re-invented (rural facility, car parking)
Urban	St. Cono Settlement and Church	B, C1	Economy, Living Space, Cult and Rituals (Church)	In Use, Abandoned	1, 2, 3	Re-invented (car parking)
Urban	Itria Settlemenet and Church	B, C1	Economy, Living Space, Cult and Rituals (Church)	Abandoned	1	Abandoned
Urban	St. Agata Settlement	B	Economy, Living Space	In Use, Abandoned	1, 4	Re-invented (rural facility)
Urban	St. Anna Settlement and Church	B	Economy, Livisn Space	In Use	1, 2	Inhabited (contemporary troglodyte)



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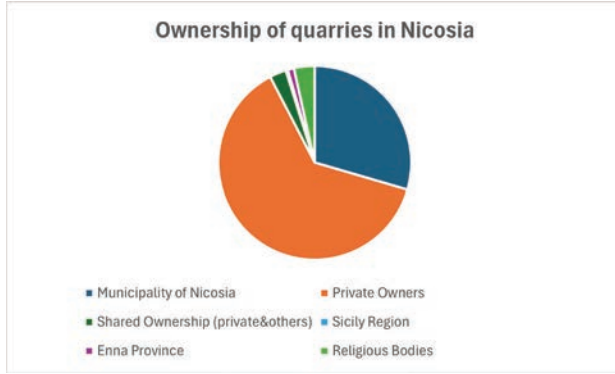

b

Fig. 4. a) Re-uses of historical burials in Nicosia according to the UBH approach, b) Cave dwellings in Nicosia: articulation for ownership in the municipal cadastral (R.V.)

Results from archaeological investigations could support the analysis of all the passages from one function to the other by adopting the UBH theoretical approach (Fig. 4a) (Varriale, 2025) thus implementing the cultural values of those artefacts.

In addition, future actions addressed towards the protection of the integrity of the rock-cut village and its enhancement, should also take in attention the fact that, as it comes out from the analysis of the cadastral register from the municipality of Nicosia, based on 288 cavities, 63% of the dwelling are private owned (Fig. 4b) and that only the definition of a new Municipal Regulation of urban Decor and Furniture of Nicosia, with a special focus on local cave dwelling, could provide shared rules for the safeguard of the rock-cut habitat and its sustainable enhancement.

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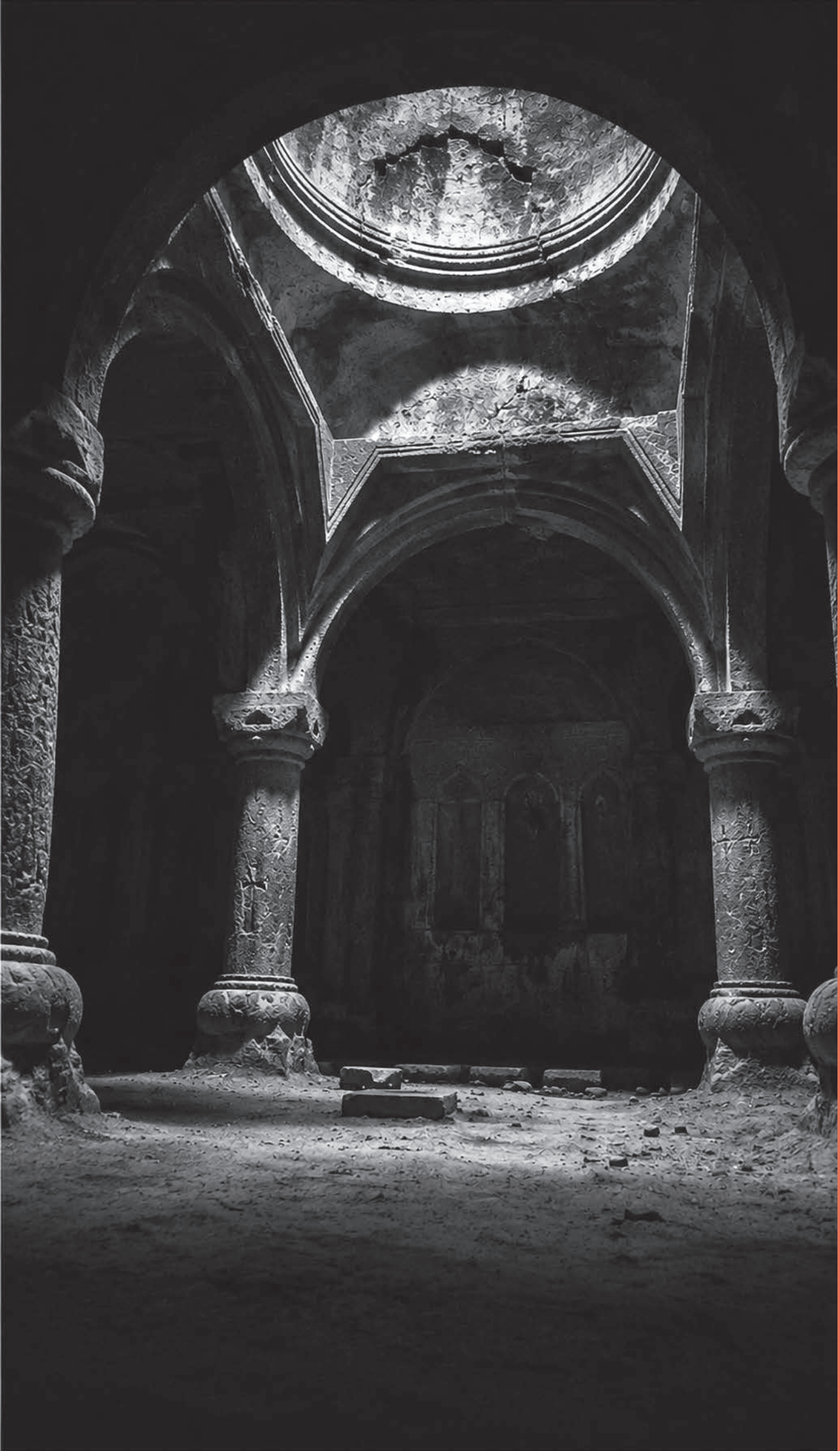

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Two Important Rock-Cut Monuments in Historical Tao-Klarjeti (Turkey)

Giorgi Bagrationi
Researcher of architectural monuments, Tbilisi, Georgia
g_bagrationi@yahoo.com

Abstract

This article examines two important rock-cut monuments that became known to the scientific community several years ago. Both are located in the historical Tao-Klarjeti region of Turkey.
In 2012, a fairly large rock-cut complex was discovered in the Khanaki region of Artaani Province, in the Erusheti River gorge, two kilometers from the historical Khodureti. It consists of seven tiers and extends for approximately 200 meters. In its lower, right-hand section is a rock-cut church, with a tunnel leading to the refectory. The church's façade collapsed as a result of an earthquake, revealing the remains of an aisle. An prothesis is carved north of the central portion of the church itself. Judging by its architectural features, the monument must have been built in the 8th-10th centuries.
In 2016, in the historic Solomonia, district of Erzurum Province, near the Kalmakhi Fortress, a small church with a unique architectural form was discovered in a cliff. Several years ago, local residents excavated its entrance from the ground. The monument is a small chapel with a memorial function, parallels to which we find in the early Christian tombs of the Roman catacombs. Considering a number of factors, this monument is undoubtedly one of the first Christian structures in the territory of historical Georgia.

Keywords: Harosman Caves, Nokalakoi, earthquake, Solomonis, Kalmakhi

Our field of interest includes two important rock-cut monuments that became known to the scholarly community only a few years ago. Both are located in historical Tao-Klarjeti, on the territory of modern-day Turkey.

In 2012, a fairly large rock-cut complex was discovered by scholars in the Hanak district of Ardahan Province, a few kilometers from historical Khoshureti (modern Dilekdere), in the valley of the Erusheti River (Hanakçay), near the left bank. The complex consists of seven levels and stretches for approximately 200 meters, containing churches, halls, tunnels, and faced walls whose masonry has survived to this day. Based on architectural features, the monument was likely constructed between the 8th and 10th centuries.

Fig. 1. Location of "Nokalakoi"

The local population calls this place "Nokalakoi," which is obviously derived from the Georgian word "nakalakari" (ancient settlement). The modern official name of the monument in Turkish is "Harosman Mağaraları" – the Harosman Caves.

In the eastern part of the complex, a fairly large rock-cut church with a northern pastophorium has survived. The hall space (13.5 × 7 m) terminates in a deep sanctuary with a bema, along the base of which runs a bench almost around the entire perimeter. The front part of the bema projects significantly beyond the apse. The hall reaches a height of up to 6 meters and is covered by an arched vault. The floor level of the bema and apse is raised by one step. In the western section of the northern wall of the hall, a tall niche about one meter deep has been carved. To its right, at the beginning of the bema, is the entrance to the prothesis chamber. This chamber can also be accessed from the apse through an arched doorway cut into the northern side. A small rectangular altar niche is arranged in its eastern wall. Most likely, a freestanding altar stone once stood in the main sanctuary.

On the southern side, the church preserves five windows, the easternmost of which is cut directly into the sanctuary. Like the next window, it is deeply recessed and widens several times toward the interior.

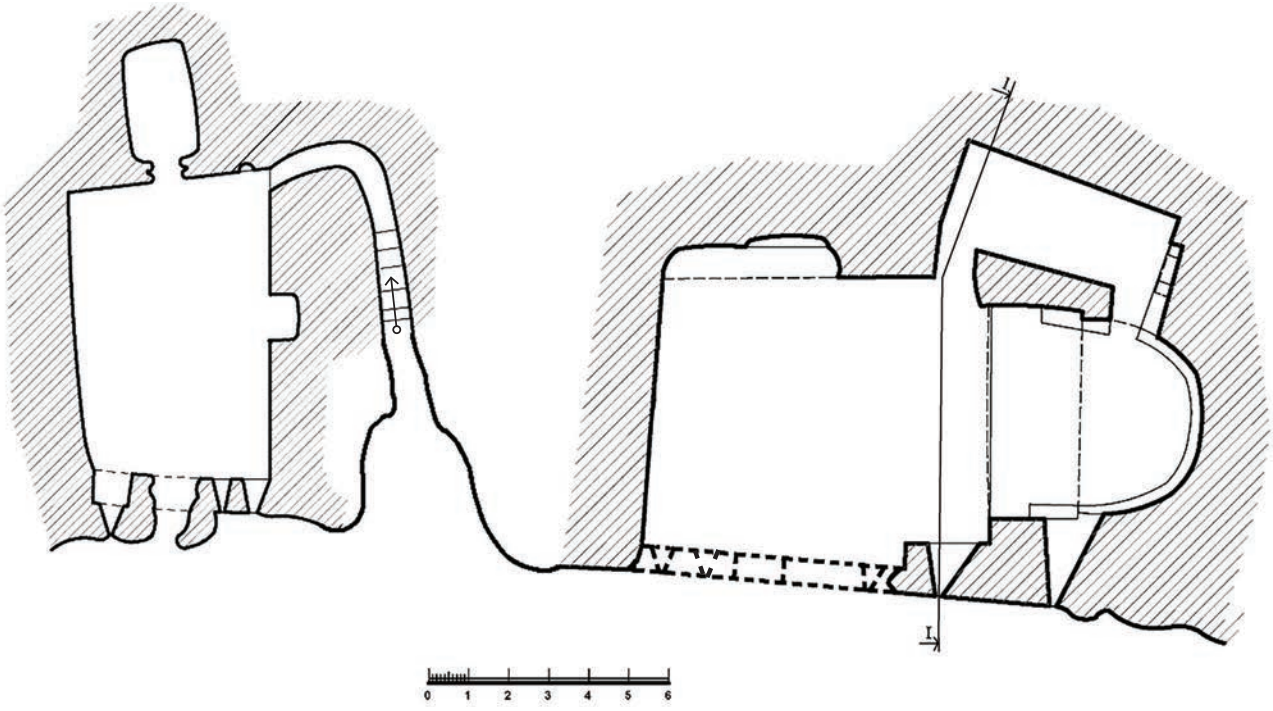

Fig. 2. Plan of the church and refectory of "Nokalakoi"

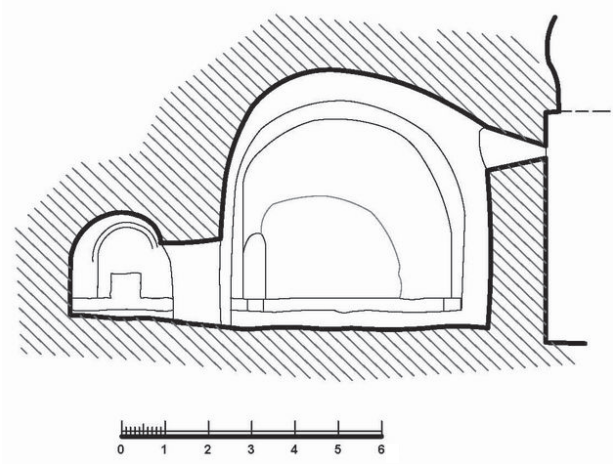

Fig. 3. Section of the church of "Nokalakoi"

Fig. 5. "Nokalakoi" Church, view toward the prothesis altar

Fig. 4. "Nokalakoi" Church, view toward the altar

Fig. 6. "Nokalakoi" Church, view of the western wall

Fig. 7. "Nokalakoi" Church, view of the north wall of the annex

This abundance of windows was apparently intended to compensate for poor lighting; however, even this was probably insufficient, since the church also had a large southern annex that further blocked the light. The lower part of the cliff where the entrance was cut has collapsed, though traces of plaster and painting survive in the corner of the semicircular tympanum.

Apparently, the church was entirely painted, as indicated by the plastered and heavily smoke-blackened western wall (this is also explained by the fact that the dark hall was effectively illuminated by candles, while today shepherds use it as temporary shelter). It is possible that traces of frescoes may be revealed after cleaning. A large portion of the western wall surface, closer to the ceiling, is recessed within an arched outline, likely intended to emphasize the importance of the painting.

As already noted, remains of the southern annex, which collapsed as a result of an earthquake, are visible in front of the church. In general, traces of earthquakes can be seen throughout the complex; however, in this particular case there was also a structural flaw. As seen in photographs, the roof of the annex had been cut in a flat horizontal form, making it far more vulnerable to earthquakes than a conical or even arched vault would have been.

It should be noted that historically three major destructive earthquakes have been recorded in this region. Concerning the first earthquake, 18th–19th century authors (Vakhushti Bagrationi and Niko Dadiani), relying on the historian of David the Builder, date it to 1088. According to Vakhushti Bagrationi (1696–1756), the earthquake occurred in 1088:

"…on the day of Easter the earth shook so violently that rocks, cities, fortresses, and buildings were destroyed, and many people perished…"

The second major earthquake, which occurred in Samtskhe-Javakheti on Easter Day, was described by an anonymous 13th-century chronicler in the "Centennial Chronicle" as follows:

"…countless souls perished in Samtskhe; not a single cathedral, church, or fortress remained standing; immeasurable mourning and weeping ensued."

The same earthquake is mentioned by the Armenian historian Mkhitar Ayrivanetsi (1230/35–1297/1300) in his chronographic history:

"…an earthquake occurred in Georgia and caused great destruction. The Egyptians invaded Cilicia for the second time. The earth shook in Khlat and throughout its borders."

The third earthquake occurred in 1319, when Ani, located about 90 km away, was destroyed and ceased to exist.

Approximately 10 meters from the church, a tunnel leads into a large hall (presumably a refectory). Its main space (5 × 7.5 m) is elongated along the south–north axis and is illuminated from the south by one wide doorway and three windows. The ceiling forms a slightly tent-shaped vault. A large niche is carved into the eastern wall, while a doorway cut into the north side leads into a small chamber.

Between the church and the refectory, the facing masonry of a wall has survived, the character of which re-

Fig. 8. Tunnel connecting to the refectory at "Nokalakoi"

Fig. 9. Interior view of the refectory facing south

Fig. 10. Interior view of the refectory facing north

Fig. 11. Preserved masonry of the wall

Fig. 12. View of the complex

sembles building techniques of the 8th–10th centuries.

At present, access to most of the remaining chambers of the complex is difficult. The tunnels connecting them are largely blocked by collapsed stones. Some of the chambers contain small scriptoria; many others served residential or utility purposes.

Since 2020, the Köroğlu HES hydroelectric power station has operated near the complex, and the flooding zone created by its dam nearly reached the base of the monument. Fortunately, the lower level of the complex lies above the waterline and escaped inundation. In recent years, the complex has become an attractive tourist destination visited not only by Georgian travelers but also by Turks.

* * *

In 2016, in the Şenkaya district of Erzurum Province, near historical Solomonis (now Evbakan), 400 meters from Kalmakhi Fortress and 80 meters northwest of the rock-cut three-church complex known locally as "Kaya Kilise" ("Rock Church"), a small church of original architectural form was discovered. Several years earlier, local residents, motivated by "treasure hunting," had cleared its entrance from the earth. Before that, only an amorphous circular opening above the doorway was visible above ground level, its outer surface framed by a semicircular arch.

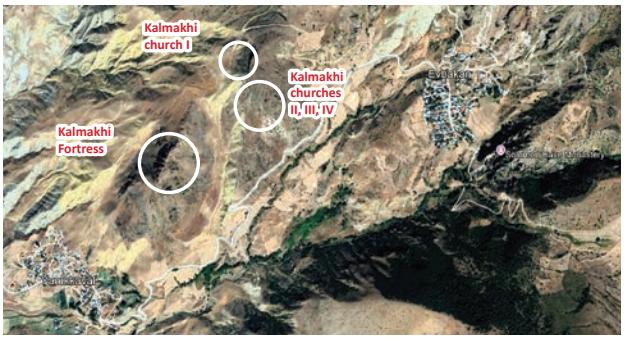

Fig. 13. Location of Kalmakhi churches

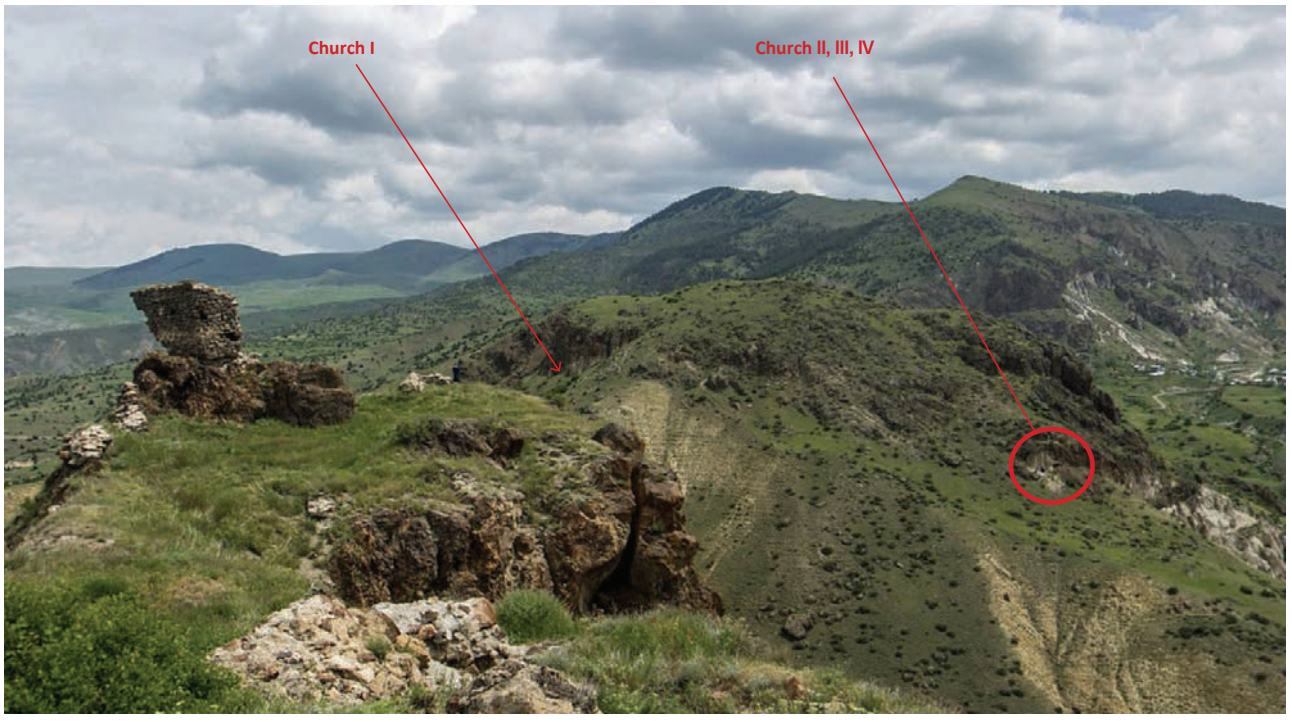

Fig. 14. View from Kalmakhi Castle toward the Kalmakhi churches

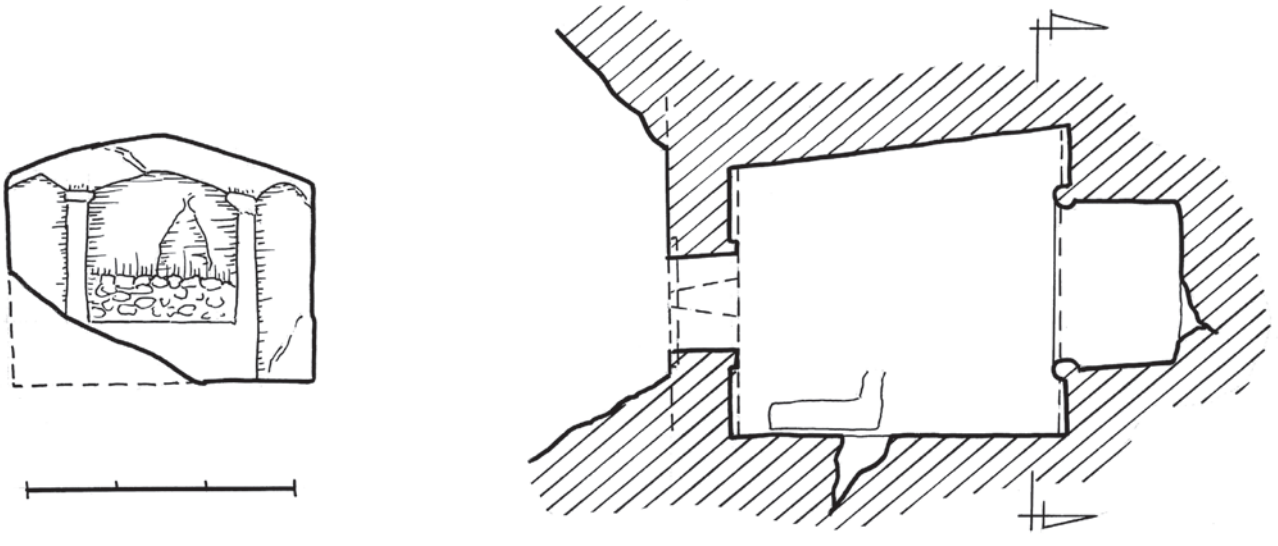

Fig. 15. Plan and section of Kalmakhi Church I

The interior space of the monument is designed in a highly original manner, especially in the context of Georgian architectural thinking. The main chamber is an almost square space covered by a gabled tent-like vault. The rock in which the monument is carved is difficult to work with, consisting of layers of various soils alternating with hard stone and limestone, making it difficult to carve regular architectural forms. Nevertheless, distinctive architectural features of the walls can still be discerned.

On the eastern side, the wall surface is divided into three sections, the central one being twice as wide as the side sections and forming a deep rectangular niche with a gabled covering, raised 70 cm above floor level. The sides of the niche imitate half-columns ending in highly exaggerated Doric-style capitals. The side sections of the eastern wall also form narrow niches, the southern one ending in a semicircular arch and the eastern one in a gabled arch. The western wall is arranged according to a similar scheme. Here, the central section contains the doorway, above which a semicircular arch is carved, and higher still an interior arched window. The side sections also form narrow niches ending in semicircular arches. Their divisions likewise imitate half-columns.

The southern and northern walls are plain; only a deep geological fissure runs along the wall and ceiling. Near

Fig. 16. Kalmakhi Church I, exterior view

Fig. 17. Interior of Kalmakhi Church I, view toward the altar

Fig. 18. Interior of Kalmakhi Church I, view toward the west wall

the southern wall, a small rectangular cut in the floor was discovered, possibly serving as a burial chamber.

The lower surface of the eastern niche is covered with stones and earth fill. Its size suggests that a burial chamber may have been carved beneath it, paralleling pre-Christian and early Christian rock-cut tombs. The overall spatial arrangement also recalls early Christian memorial monuments. Clear parallels may be drawn with the famous Roman catacombs illustrated in the accompanying photographs: the Catacombs of Domitilla (2nd–3rd centuries), the tombs of Via Latina (2nd–4th centuries), and the Jewish catacombs of Villa Torlonia in Rome (1st–3rd centuries). In Georgia, certain parallels may be found with the Kaspi crypts (1st–3rd centuries).

Considering numerous factors, the monument likely represents one of the earliest Christian cult structures on the territory of historical Georgia.

The nearby “Kaya Kilise” complex mentioned above is also an interesting monument. In this case as well, large portions of the southern walls have collapsed. If one describes them from west to east, a kind of chronological sequence can be observed in the architectural solutions of the churches.

Conventionally, Church IV is the simplest and smallest, with a rectangular sanctuary and an altar stone built into the rock and adjoining the eastern wall. Church III, the next in sequence, is the largest; on the eastern side it terminates in a semicircular apse, while the northern wall (and probably the similarly divided southern wall) consists of arcades of varying sizes. Church II, which follows, is more refined: the arcade of the northern

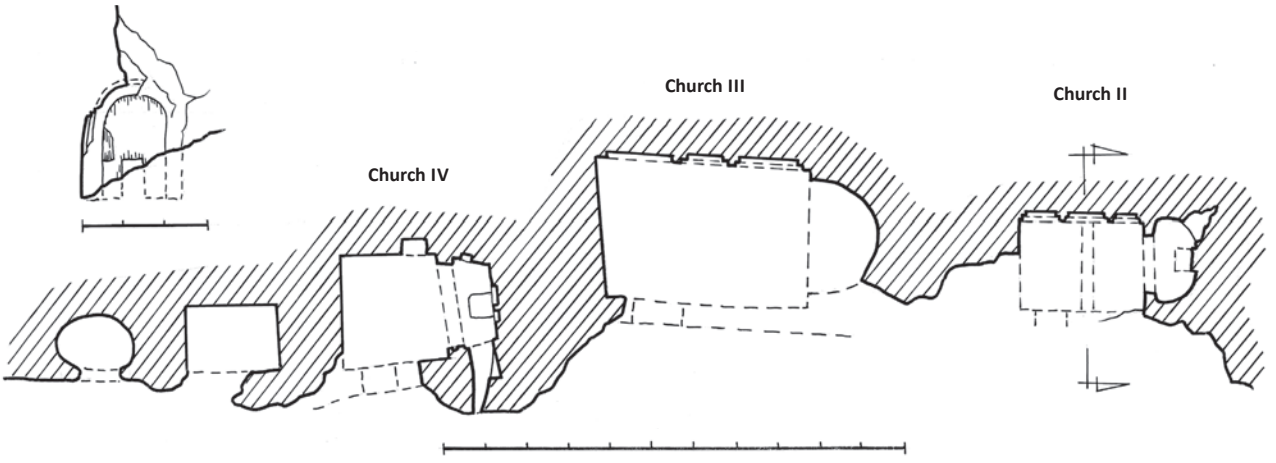

Fig. 19. Plan and section of Kalmakhi Churches II, III and IV

Fig. 20. Solomon-kala

wall has a two-stepped profile, and much of the plaster intended for painting has survived. In the sanctuary, an altar stone adjoins the semicircular apse, while the junction between the sanctuary and the hall is sharply emphasized by wall projections.

Together with the well-known Solomon-Kala complex near Evbakan, described by Ekvtime Takaishvili in 1907, these churches and Kalmakhi Fortress form an interesting destination for visitors.

Fig. 21. Plan of Kalmakhi Fortress

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The Architectural Structure of the Medieval Cave Monasteries of David Gareji within the Framework of Byzantine and Eastern Christian Monasticism

Nodar Bakhtadze[1,2], Bachana Gabekhadze[1]
nodar.bakhtadze@iliauni.edu.ge
1 Georgian National Museum, Tbilisi, Georgia
2 Ilia State University, Tbilisi, Georgia

Abstract

In the southern part of Georgia's Kakheti region, in an extensive and almost uninhabited area, lies the ancient Christian monastic centre known as David Gareji. It comprises 21 relatively large independent medieval cave complexes. According to historical sources and ecclesiastical tradition, the first monasteries were founded here in the sixth century by Holy Fathers who came from a tradition of Syrian monasticism. Thereafter, monastic life continued uninterrupted within these complexes until the High Middle Ages. Naturally, as they expanded and developed, they also underwent substantial reconstruction and during this period, new complexes were also established.

In recent centuries, all these monasteries were abandoned and severely damaged, and they are currently under threat of destruction. The urgent preservation of David Gareji's cultural heritage requires their comprehensive scientific study using modern methodologies; however, owing to a number of constraints, only a small part of them has been adequately investigated to date. For example, the analysis of the architectural planning of these cave monasteries in relation to the development of the liturgical practices conducted within them is still at an early stage. Furthermore, the uncritical acceptance of previous scholarly opinions remains problematic, since a substantial body of previous research was carried out during the period of Soviet occupation, when in-depth studies of monastic structures from the perspectives of theology and the history of Christianity were considered inappropriate by the official authorities.

Over the past decade, we have conducted significant architectural and archaeological research in order to address this situation. We have evaluated the validity of newly developed hypotheses primarily against the results of international scholarly studies on the historically and stylistically closest analogues to the Gareji-type monasteries – namely cave monasteries created within Early Byzantine and Eastern Christian monastic traditions.

Our research provides a well-reasoned basis for proposing that the majority of the cave monasteries of Gareji were organised on the lavra model, at least during the eighth–tenth centuries (and some throughout their entire period of functioning). They consisted of groups of residential units of a relatively standardised form, carved at varying distances from one another for ascetic monks living in isolation, while at the same time constituting components of strictly centralised monastic life.

Keywords: Georgia, David Gareji, rock-cut monastery, cave Church, architecture

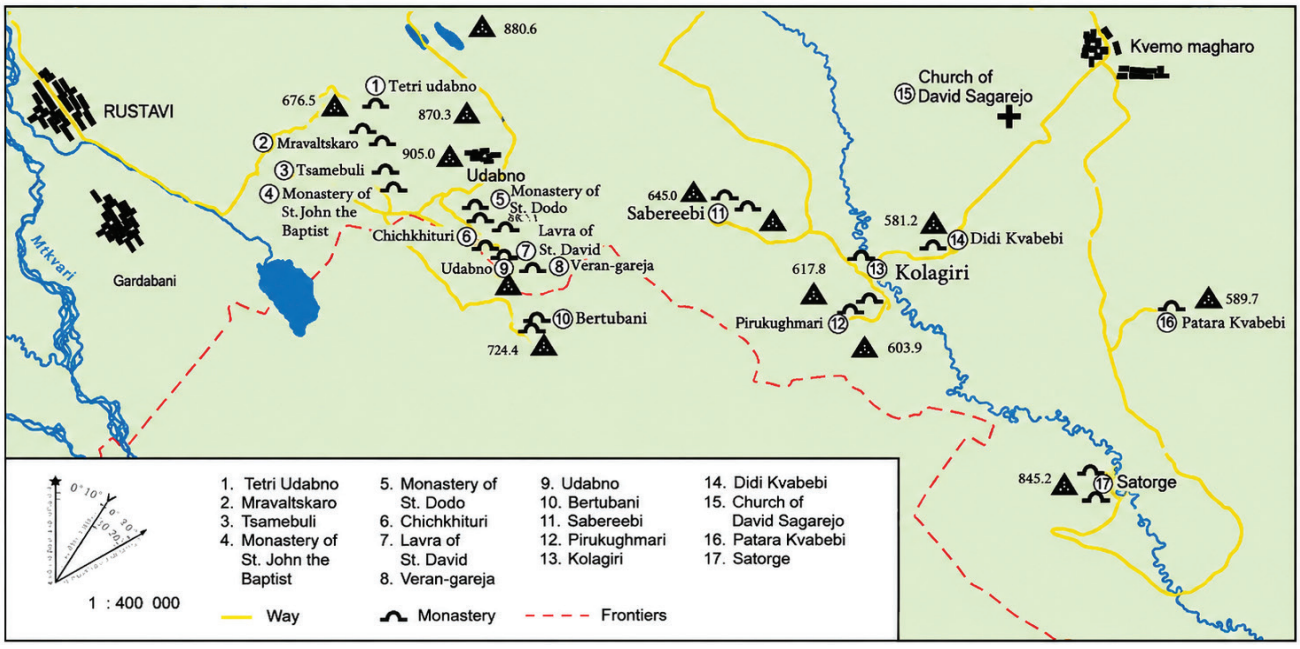

Fig. 1. Map of the David Gareji Monastic Region Showing the Rock-Cut Monasteries

Introduction

In the southern part of Georgia's Kakheti region, on an extensive and almost uninhabited plateau situated between the rivers Mtkvari and Iori, lies the region known as David Gareji. Its significance is immense not only for the study of the history of the Caucasus region, but also more broadly for the history of the Byzantine and Eastern Christian worlds. The region is renowned for its cave monasteries, masterfully carved into the rock, as well as for the outstanding examples of mural painting preserved within them (Fig. 1).

According to historical sources and ecclesiastical tradition, the first Christian monastery was founded here in the sixth century by one of the Thirteen Holy Fathers who came to the Kingdom of Kartli (Iberia) from the world of Syrian monasticism – St. David Garejeli (Mroveli Leonti 1955, 209; Bagrationi 1959, 117). During the lifetime of St. David himself, his disciples carved two additional monasteries in the surrounding rocky massifs. Thereafter, the expansion of the network of cave monasteries and their reconstruction in each historical period continued uninterrupted until the High Middle Ages.

Fig. 2. David Gareji. Monastery of St. John the Baptist (photo by V. Mamiashvili)

Fig. 3. David Gareji. Sabereebi Monastery (photo by N. Bakhtadze)

Despite the political and economic crises caused by the expansion of neighbouring empires into Georgia during this period, monastic life continued in some of these complexes into the Late Middle Ages, although on a considerably reduced scale. By the nineteenth century, only three monasteries remained active, whilst in the twentieth century, under Soviet occupation, monastic life in the region ceased entirely.

The scholarly identification and historical investigation of the ancient cave monasteries of the Gareji region has been a focus of attention for a century and a half, although it has often been fragmentary and episodic. Today, 21 monastic complexes in various states of preservation have been identified in the region, containing approximately 5,000 artificially carved cave chambers. In addition, numerous isolated hermitages still exist within this area, whose affiliation with one or another monastery has not yet been definitively established.

Among these cave monasteries, only about ten complexes have been the subject of systematic research during the last few decades, and even these have been studied unevenly from the perspectives of different scholarly disciplines. For example, whilst comparatively more data has been accumulated in the fields of historical source studies, mural painting, and epigraphy (Fig. 3), the archaeological investigation of the same monasteries is still at an initial stage (Fig. 2). The multidisciplinary study of these unique monuments, which represent part of world cultural heritage, through modern scientific methods, as well as their protection from the threat of physical destruction, requires considerably greater efforts from the Georgian authorities and relevant international organisations.

Previous Studies on the Architectural Structure of the Cave Monasteries of David Gareji: Achievements and Limitations

Despite difficult political and economic circumstances, the architectural features of individual spaces within the cave monasteries of Gareji – primarily churches and chapels, refectories, and other distinguished chambers – as well as questions concerning their chronology and typology, have repeatedly been the subject of scholarly investigation over the last century, ranging from travellers' accounts to academic articles and monographs (Chubinashvili 1948; Gaprindashvili 1977; Gaprindashvili 1987). Prominent art historians and architects have even proposed a number of original hypotheses concerning these issues, including comparative analy-

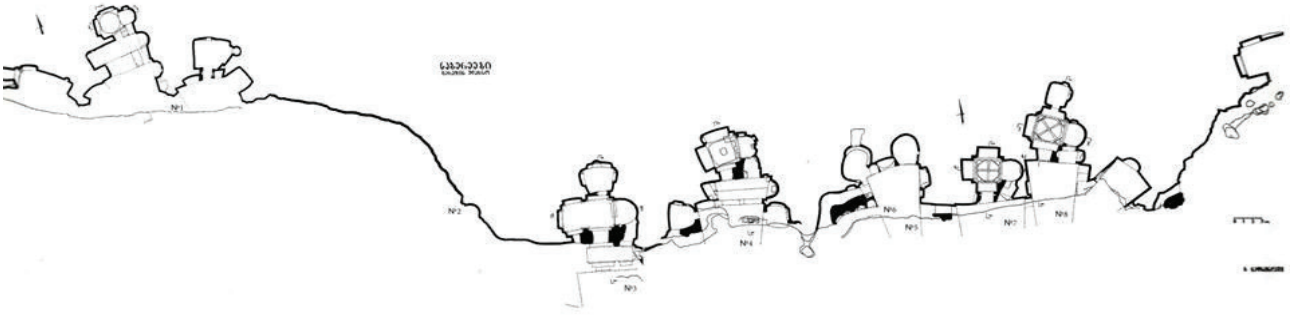

Fig. 4. David Gareji. Sabereebi Monastery. General plan (G. Gafrindashvili and N. Bakhtadze)

ses with analogous monuments in Cappadocia.[1]

However, the same cannot be said about interpretations concerning the typological architectural structure of these cave ensembles or the factors governing the functional division of spaces within individual monasteries. Until very recently, the prevailing view among Georgian scholars was largely the following: since these complexes represent accumulations of chambers gradually carved out in different periods and under different socio-political circumstances, any attempt to perceive the cave monasteries as consciously conceived architectural ensembles, or to identify unified principles of spatial planning, was considered futile. Indeed, the

Fig. 5. David Gareji. Monastery of St. Dodo. The westernmost group (photo by N. Bakhtadze)

monasteries of Gareji do not display the kind of "precise unification" of the planning details of cave spaces that later emerged, in the twelfth century, at the apogee of Georgian rock-cut monastic architecture – the world-renowned cave complex of Vardzia Cave Monastery (Bakhtadze 2024).

However, this does not mean that we should reduce the emergence and gradual development of new cave monasteries in Gareji throughout the Early Middle Ages to the opposite extreme – namely, to view it as an almost organic process dependent solely on the will and aesthetic preferences of individual patrons. It should not be forgotten that one of the most widespread forms of Christian asceticism – life and spiritual practice conducted wholly or partially within cave monasteries – was part of ancient international traditions based on ecclesiastical norms, extending from the origins of Christianity in the Holy Land to the magnificent Byzantine-type cave monasteries of Cappadocia (Rodley 1985; Kostof 1989; Hirschfeld 1992).

The present paper is devoted precisely to this specific and highly problematic aspect of the study of the cave monasteries of Gareji – namely, the architectural and functional differentiation of these complexes, the identification of the styles of monastic life practiced within each monastery during different chronological phases, and the reconstruction of the typikon-based rules established by their inhabitants.

It is universally recognised that the architectural structure and appearance of any historical religious monument is largely determined by the religious practices and rituals performed within it. However, it appears that during the twentieth century a considerable proportion of Georgian historians viewed Christian asceticism as a phenomenon that was far more conservative than it actually was in reality – as something unchanging in both time and space. Consequently, the first generations of Georgian art historians did not develop clearly formulated views regarding the styles of monastic life practiced in the cave monasteries of Gareji during either the earliest or later stages of their existence.

A clear example may be cited in support of this statement. As is now widely accepted, two principal forms of monastic organisation were developed in the Holy Land and Egypt:

Fig. 6. David Gareji. Monastery of St. Dodo. Hermitage of the central group (photo by N. Bakhtadze)

Lavras – that is, communities of hermits. Within them, groups of individual "eremitic" monks lived in isolation from one another throughout the week and performed their religious practices separately. They gathered only on Saturdays and Sundays in the "heart of the lavra" (the communal centre with the main church) for the Eucharist, communal liturgy, and meals.

Cenobitic monasteries (coenobia), where monks lived and prayed together according to a common daily regime within a compact communal environment.

There were also monasteries of mixed type; however, I still consider them essentially lavras – with the qualification that within the "heart of the lavra" a certain part of the monastic community followed a cenobitic way of life (Bakhtadze 2007).

1 Among these issues, N. Bakhtadze have also presented and published a paper at the 2nd Congress of the Hypogea series, in which I discussed the circumstances of the origin and the problems of dating of a specific type of rock-cut churches identified in the monastic complexes of David Gareji, considering them in the context of analogous chapels in the monasteries of Cappadocia (Bakhtadze 2017, 395-403).

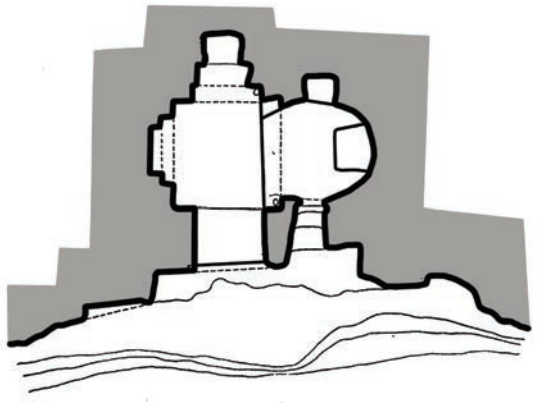

Fig. 7. David Gareji. Mravaltskaro Monastery. Hermitage chapel. Plan (drawing by N. Bakhtadze)

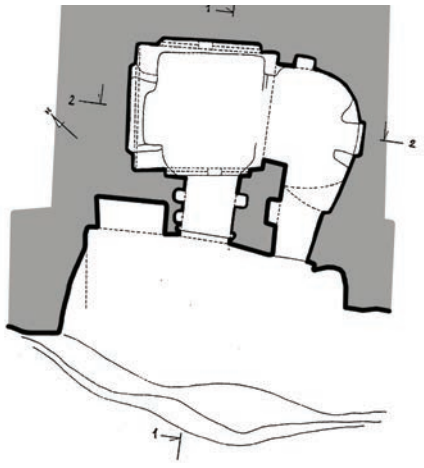

Fig. 8. David Gareji. Tsamebuli Monastery. Hermitage chapel. Plan (drawing by N. Bakhtadze)

These two canonical forms of monasticism continued throughout the Middle Ages, and in places even into the modern period, within the Byzantine and broader Eastern Christian worlds. Despite the differences in their liturgical organisation, the overall spatial structures of these two types of monastic institution are today often difficult to distinguish from one another – especially since the vast majority of them were abandoned, partially destroyed, or reoccupied for different purposes over the course of centuries (Hirschfeld 1992). The scholarly differentiation of these monastic structures by European archaeological, art-historical, and theological schools during the twentieth century required extensive field research and prolonged work with historical sources.

However, our predecessors did not examine the architectural structure of the cave monasteries of Gareji within the broader context of these varieties of Byzantine and Eastern Christian asceticism, which led them to certain misconceptions. The nature of these discrepancies may be illustrated as follows: Any visitor will immediately notice that some of the cave monasteries of David Gareji are carved in a relatively compact manner, whereas the majority consist of groups that appear, at first glance, to be quite deliberately separated from one another by considerable distances. The reason for the creation of these monasteries as dispersed groups cannot simply be explained by a desire to locate more convenient rocky formations for carving – the geological structure of the rock slopes here is entirely uniform. Therefore, if these groups of caves had simply been created gradually over time as a result of the increasing number of monks, new chambers could have been carved directly adjacent to the earlier ones, in a continuous arrangement. What then does the fragmented and sometimes considerably dispersed structure of these cave groups forming the monasteries indicate?

The recognised leader of the Georgian school of art history in the twentieth century, Academician Georgi Chubinashvili, in his foundational 1948 monograph on the cave monasteries of David Gareji, proposed the following regarding the structure of one such "dispersed" complex – the monastery of Dodorka (Fig. 4): According to him, this complex was characterised by its unusual disposition of space containing groups of caves carved on several levels, of different sizes and forms, together with various types of cave churches. Both the monastic cells and the churches, he argued, were carved without a deliberate plan. In his view, this apparently represented a "degradation" (or even "collapse" – the term he himself used) of the monastic order. He suggested that, by the time these groups were being created, the monks inhabiting the cells had already begun to carve their own churches next to their living quarters in a spontaneous and chaotic manner. In other words, he interpreted this phenomenon as a reflection of the feudal fragmentation of the country, representing decentralisation and a certain disobedience of monks towards higher ecclesiastical authorities – he even used the term "separatism" (Chubinashvili 1948, 47-48).

Thus, Chubinashvili failed to notice during his brief field excursion that these groups of caves consisted of structural components serving the same functions and, in many cases, even of cave chambers with clearly identifiable typical attributes. As a result he did not consider the possibility that these separate yet structurally homogeneous groups of caves might have represented hermitages subordinated to a lavra-type monastery. On the contrary, he argued that the cave structures of Dodorka must have been created in the thirteenth–fourteenth centuries, at a time when hermits no longer existed within the Dodorka monastery. According to him, the complex had probably been transformed into a cenobitic monastery, since "we no longer observe separate dwellings of hermits there" (Chubinashvili 1948, 49).

Discussion: What additional data and corrections have our studies contributed to the resolution of this scholarly problem?

An initial, tentative classification of early Georgian monasteries in general, and of the rock-cut monasteries of the Gareja desert in particular, considering the liturgical practices believed to have been carried out within them, was undertaken by our research team – the Laboratory for the Study of Artificial Caves at the S.

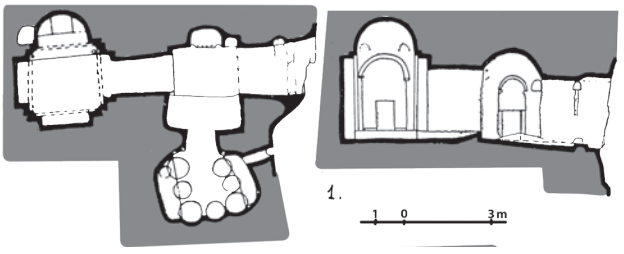

Fig. 9. David Gareji. Berebis Seri. Hermitage plan (drawing by G. Gafrindashvili)

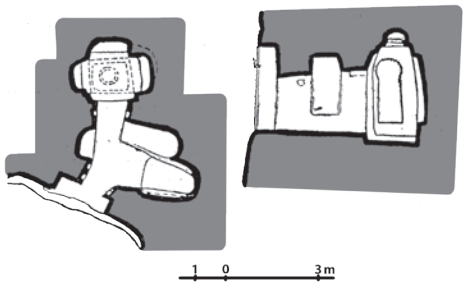

Fig. 10. David Gareji. Kotsakhura Hermitage. Plan (drawing by G. Gafrindashvili)

Janashia State Museum of the Georgian Academy of Sciences (Bakhtadze 2001; Bakhtadze 2003). However, overcoming the decades-long lacunae in this field required considerably more in-depth multidisciplinary research. It was clear that the research had to be carried out gradually, beginning with the less thoroughly studied monasteries of the Gareji region. For this reason, our interdisciplinary research team (composed of researchers from the Georgian National Museum and the Scientific Foundation "Udabno," with funding from the Swiss National Science Foundation) conducted a study of one of the outstanding complexes of Gareji – the Dodorka Monastery – between 2005 and 2008. The results of these art-historical and archaeological investigations enabled us to define more clearly questions pertaining to the architectural structure of the cave monasteries of Gareji, taking into account the style of religious and ideological activities practiced there during the Middle Ages.[2]

From the outset, we should emphasise that, regarding the architectural style and typology of the cave structures in the rock-cut complexes of Gareji, we can only discuss the extant data from the eighth–tenth centuries onwards. No definitive conclusions can be drawn regarding the relatively typical architectural structure of the Gareji monasteries in the sixth–seventh centuries, because the planning of the overwhelming majority of these complexes was later completely erased as a result of extensive reconstruction. However, we have no grounds to doubt the references preserved in written sources – namely, in the hagiographic literature dedicated to the life of St. David Garejeli – indicating that the first ascetic inhabitants of Gareji lived in natural caves, slightly enlarged caves, or spaces carved out through their own efforts. The same sources also mention the

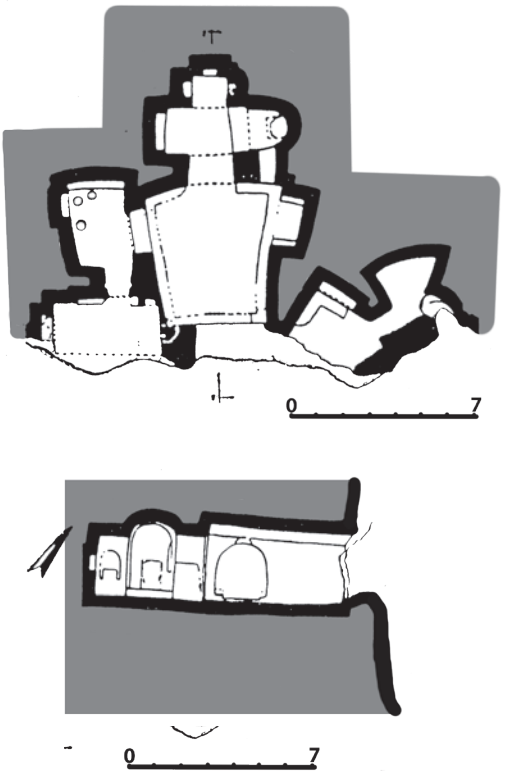

Fig. 11. David Gareji. Beris Seri. Hermitage plan and section (drawing by N. Bakhtadze)

2 Within the framework of this project, following the explanations N. Bakhtadze provided in parallel with the architectural surveys of individual hermitage groups (with references to relevant scholarly literature and parallels from Near Eastern monasticism; Bakhtadze 2001; Bakhtadze 2003), some members of the research team revised their earlier view that Dodorka constituted a purely coenobitic monastery as a unified whole (Mirianashvili 2001; in fact published in 2003, N.B.), and accepted the significance of the individual hermitage units of this monastery as group dwellings of monks operating within a lavra-type system – a kind of "unified" architectural system (Mirianashvili 2011). It is somewhat more surprising that, even after the same discussions, another member of our project, D. Chikhladze, was unable to move beyond the influence of G. Chubinashvili's aforementioned interpretation. In a work published quite recently, he appears to come closer to the correct understanding – in his own words, he attempts to reveal the "dominant architectural structure" of the groups comprising this complex and even discusses the "self-sufficiency" of the cave groups. However, at the same time, he still fails to generalize these groups as architecturally strictly defined ensembles of residential and sacred spaces created for solitary monks within the organizational framework of a lavra-type monastery. In his conclusion, he explicitly states: "It is to be noted that neither 'Grigol's complex' nor any other cave complex (the author, for some reason, refers to such groups as independent complexes – N.B.) within the monastery can serve as a general model for other complexes: the variables – such as geographic and geological conditions, the different stages of development, the donor's demands and personal taste, etc. – influenced the architectural style of each cave complex" (Chikhladze 2020, 88).

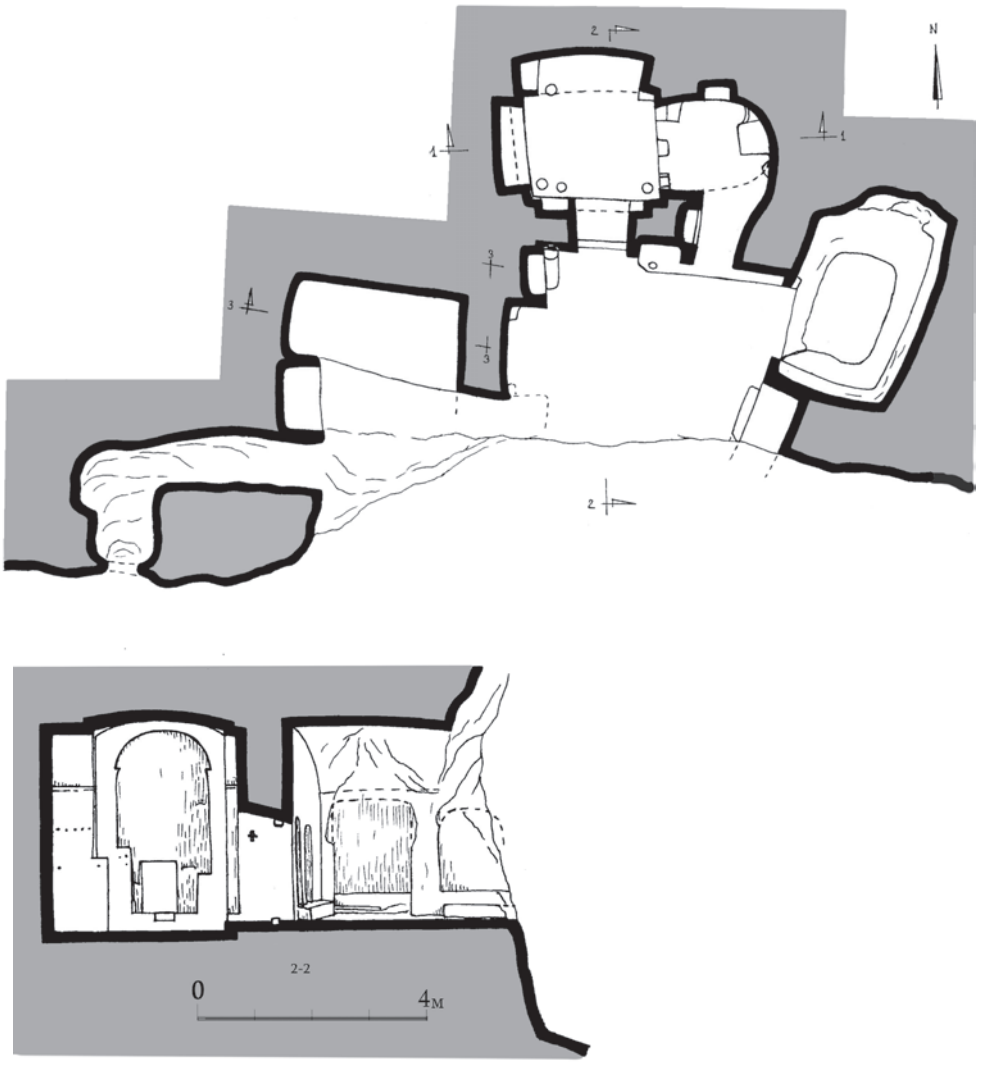

Fig. 12. David Gareji. Monastery of St. Dodo. Plan and section of the westernmost hermitage (drawing by N. Bakhtadze)

carving of the first church. Nevertheless, the degree of refinement and canonical architectural character of these earliest cave structures remains unknown to us. If we consider the analogies of the first Christian monastic cave structures in the Holy Land, it is possible that the cave chambers of these earliest Gareji hermitages had entirely accidental or highly primitive forms and layouts, and that they were therefore lost during later reconstructions of the monasteries, carried out in periods when more elementary aesthetic requirements for the monastic environment had become established. It is known that both in the countries recognised as the birthplaces of Eastern Christian monasticism (Egypt, Syria, Palestine, Cappadocia, Mesopotamia) and in Georgia, monasteries during the Early Christian period frequently combined rock-cut components with above-ground masonry structures (Hirschfeld 1992, 18-58; Bakhtadze 2003; Bakhtadze 2007, 81-122). However, even in the monasteries of these regions, during the fourth–seventh centuries refined cave chambers of sophisticated architectural form and "copies" of the interiors of canonically shaped above-ground churches were not yet being created on a large scale. According to the data available to us, the turning point came at the transition between the eighth and ninth centuries, when in Cappadocia the practice became established of accurately reproducing, to a greater or lesser degree, the interiors of stone-built liturgical and residential spaces in rock-cut architecture (Rodley 1985, 12-90; Kostof 1989, 88-127). The factors that stimulated this phenomenon have not yet been precisely determined[3]; however, it is clear that from this period onwards, and continuing through the High Mid-

3 Some scholars seem to associate this tendency with the end of the Iconoclastic period – arguing that, during the dominance of this theological movement, monasteries of the Byzantine world more often supported the position of traditional worship, and that the triumph of the veneration of icons was expressed through their placement within renewed and deliberately embellished sacred spaces (Kosttof 1989, 105-108).

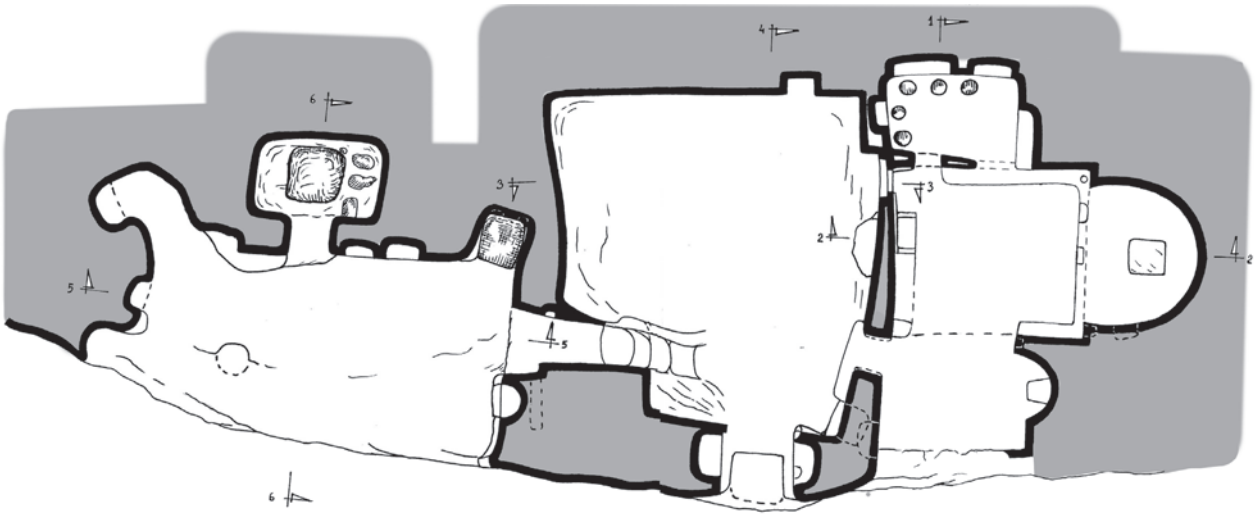

Fig. 13. David Gareji. Monastery of St. Dodo. Plan of a hermitage in the western massif (drawing by N. Bakhtadze)

dle Ages, the art of carving cave monastic complexes in Cappadocia reached new levels of creative mastery. It is noteworthy that monasteries functioning according to both the coenobitic model and the lavra model were created there through a variety of spatial and decorative techniques (Rodley 1985, 15-108). The slight difference was that in lavras – whose very structure implied monastic cells and often chapels of ascetic monks living at a certain distance from the central core of the monastery – these spaces were often carved using more modest methods than the compact, monumental, and architecturally elaborate coenobitic monasteries. In our view, we are dealing with an echo of the same cultural and architectural phenomenon in the Gareji deserts, which is entirely natural if we take into consideration the particularly close relations of Georgian Christian institutions with North Syrian (Antiochian) and Cappadocian ecclesiastical institutions.

Nevertheless, a local specificity can still be observed: due to certain historical circumstances, in the Gareji monastic region the lavra model of monasticism clearly predominated during the eighth–tenth centuries and, to some extent, in later periods as well. Below, we will present arguments supporting the validity of this hypothesis.

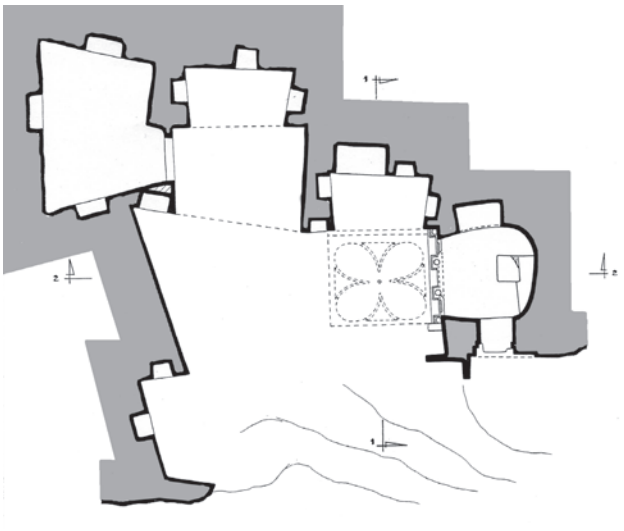

Fig. 14. David Gareji. Monastery of St. Dodo. Plan of a hermitage in the central massif (drawing by N. Bakhtadze)

We have examined both the general structure of dozens of cave groups belonging to several monastic complexes of the Gareji region and the architectural features of their constituent chambers in the light of the typological variations characteristic of Early Byzantine and Eastern Christian monasticism, and we have identified a number of consistent patterns. In particular, the repeated occurrence of chambers located in analogous positions within the spatial organisation of these groups and probably serving identical functions has provided us with substantial evidence to argue that the planning of practically all these groups was based on the same general ideological concept (Bakhtadze 2001, 21, 22; Bakhtadze 2003, 15, 16; Bakhtadze 2007, 86, 108, 116, 130-132).

First and foremost, it is striking that the principal sections of such cave groups intended for habitation and liturgical purposes are, as a rule, carved out in the elevated zones of rocky cliffs. Beneath them, directly along the edge of the earthen slopes, are located auxiliary cave structures at the first level, which have survived either as open spaces or buried under fallen rock debris (Fig. 3, Fig. 5, Fig. 6).

A highly characteristic and seemingly indispensable element of these isolated groups (which, in our opinion, should be identified as hermitages) are small or miniature individual cave chapels, which are predominantly located at the extreme northern edge of the rock massif (Figs. 4, 7-12) and, more rarely, along its eastern side (Fig. 13). The vast majority of them reveal an intention to imitate the interiors of stone-built churches. In most cases, they follow a free-cross plan with “atrophied arms” (Figs. 7-10). A significant proportion of their ceilings are decorated with various types of domeless

vaulting forms (hemispherical, truncated pyramidal, truncated conical, and others), or with imitations of vaulted architectural coverings. It is particularly noteworthy that these small churches, which constitute separate groups of the cave monasteries of Gareji, are very close both in scale and stylistic character to individual churches of isolated hermitages within the lavra-type cave monasteries of Cappadocia, which specialists date to the eighth–tenth centuries (Kostof 1989, 49, 108; Rodley 2010, 184-205)[4]. The miniature chapels of the Gareji hermitages are often replaced by small prayer niches, namely apse-shaped niche-sanctuaries. In such cases, the private chapel church does not continue deeper into the rock from the main room, or "vestibule" (see below), but rather an apsidal niche – approximately 2 m wide, or a slightly corner-rounded rectangular space with a conch – is carved into the eastern wall. As a rule, it is provided with a rectangular altar table (trapeza) carved directly from the rock itself and placed in the centre. Good examples of such halls are preserved in Hermitages Nos. 2, 4, and 7 of the Dodorka Monastery (Figs. 15, 16).

The vast majority of the monastic complexes of the Gareji region, including the Dodorka Monastery, are carved into the southern slopes of elongated rock formations orientated along an east–west axis. Accordingly, the hermitage groups of Dodorka and many other cave monasteries are also orientated with their façades facing south. The ideological focal points of these hermitages – the cave churches – are, in most cases, carved deeper into the rock mass than any other chamber belonging to the group, at the extreme northern points, that is, in locations most protected from natural destruction (e.g., the Berebis Seri, Natlismtsemeli, Tsamebuli, Udabno, and others). This concern for safety was entirely natural as the administrators of the monasteries were well aware that the limestone–conglomerate structure of the Gareji ridges could not provide complete assurance that large spaces carved within them would not eventually collapse. Naturally, placing these chapels deep inside the rock – accessible only through two or three chambers or through a large vestibule – created serious problems for the illumination of their interiors; however, their creators appear to have prioritised safety above all else. The lack of light was compensated by means of wide openings made in the southern part of the sanctuary, leading towards the vestibule, which are found almost in all such chapels (Figs. 7-8, 11-12). It should be noted that some researchers consider such openings to be elements reflecting an original and unfamiliar liturgical practice carried out in this type of church (Gagoshidze 2013, 70, 71; Tumanishvili 2013, 50, 51). However, our simpler explanation would appear to be more logical. It should also be noted that the fact that liturgy was rarely performed in the individual chapels of the hermitages, and that they were used mainly for prayer (without communal readings of the Gospel or sacred books), may be indirectly supported by this very circumstance – namely, the deliberate, even if forced, abandonment of good illumination. Naturally, the same principle could not be applied to the main churches of the Gareji lavras. There, in addition to the large dimensions of the naves and sanctuaries, proper lighting was also of great importance for the performance of the Divine Liturgy. Therefore, such churches were constructed close to the surface of the rock, usually immediately behind a narrow entrance passage, and broad openings leading to the exterior were created to provide illumination. This was probably one of the main reasons why the southern rock walls of such churches frequently collapsed, and why the façade sides of most of them were restored with masonry walls during the High Middle Ages.

A clear structural regularity can be observed in the cave groups of the Gareji monasteries, undoubtedly resulting from a conscious understanding of the geological structure of the local rock formations. The first "wall" located immediately behind the entrance from the rock surface is relatively narrow, while the floor plan of the chambers gradually expands inwards, forming a shape similar to the broad base of a trapezoid. Similarly, the height of the vast majority of these spaces is lower near the outer surface of the rock and increases towards the interior (Figs. 11, 15, 16). Thus, thanks to these seemingly inconspicuous devices, the pressure exerted by the weight of the rock mass on the side surfaces of openings near the rock face and on the ceilings of the caves is reduced. It is also noteworthy that both the churches and even the somewhat larger chambers of cave groups generally have ceilings approaching vaulted forms (mostly pointed-arch shapes), with the exception of churches featuring imitations of domes. This solution contributed to the redistribution of gravitational forces towards the outer masses of the chamber walls.

Virtually every such group possesses a central vestibule or main hall, considerably larger in area than the church itself – a spacious and high cave chamber through which one enters both the church and the auxiliary rooms arranged to the right and left. These chambers most probably served communal and ceremonial (receptive and ceremonial) functions. It was likely here that the hermit monks residing in the group spent most of their time: they performed practical and economic tasks, as well as cultural and educational activities; received members of the clergy; held theological discussions; and instruct-

4 N. Bakhtadze have published a separate study on the stylistic similarities between these types of churches and the synchronous individual churches of the cave hermitages forming part of Cappadocian monasteries in the proceedings of the Hypogea 2017 Congress (Bakhtadze 2017, 395-403).

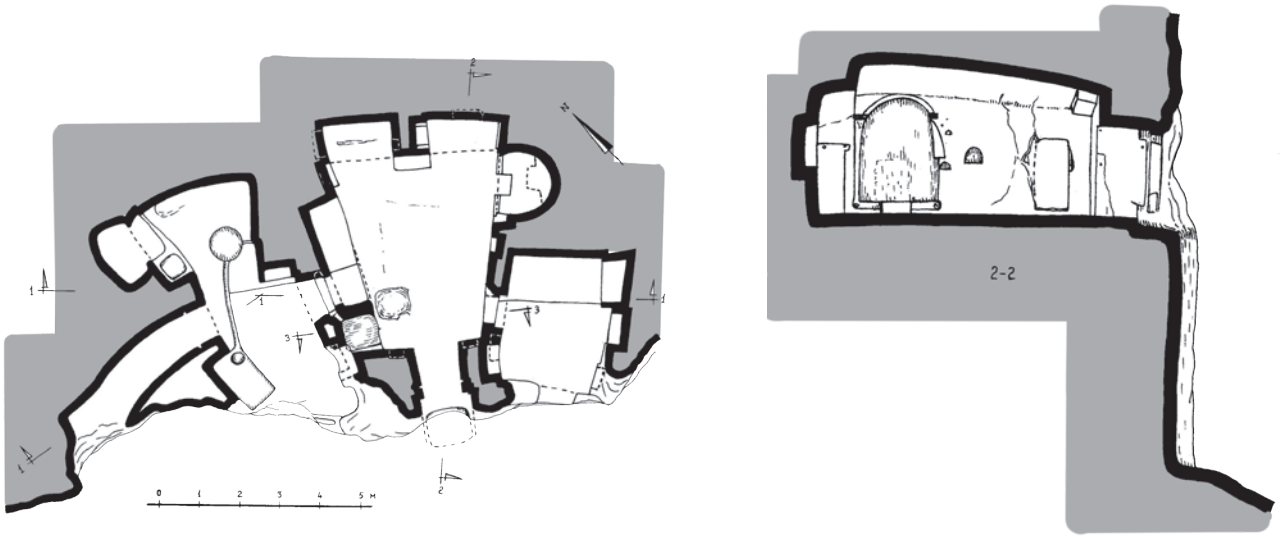

Fig. 15. David Gareji. Monastery of St. Dodo. Plan and section of a hermitage in the central massif (drawing by N. Bakhtadze)

ed younger monks. This process was undoubtedly supervised by the spiritual father of the group – the most experienced and authoritative monk of the community. As the structure of the complexes indicates, the head of this autonomous community probably lived in a relatively comfortable small chamber carved near the communal hall and slept on a specially carved stone bed-bench. Ordinary members of the brotherhood likely slept either on the floor of the communal chamber itself or, quite often, on elevated platforms formed within broad specially carved niches.

Both the communal chambers and the dwelling chambers of the spiritual fathers frequently contain wide shelves carved into the walls, as well as smaller niches intended for storing household objects (for example, bedding mats), and recesses for attaching pegs on which personal belongings could be hung. From this communal chamber, through passages or simply through door openings in different directions, one reaches several additional, smaller and lower rooms that appear to have had a more utilitarian character, resembling kitchens. Indeed, during our archaeological excavations, the cleaning and study of such caves revealed large reservoirs carved into the floors, storage pits, and sockets for placing large domestic ceramic vessels – kvevri and jars. Some of the pits carved into the floors contained hearths. The water reservoirs are often interconnected by channels, depending on their type: in rainwater collection systems, excess water flowed through channels into other (usually smaller) cisterns, or was discharged outside altogether. Rooms appointed in this manner were undoubtedly food-preparation areas. Usually adjacent to these chambers, deeper inside the rock, narrow and low rooms were carved with narrow entrances and numerous pits in the floors for placing vessels. Their function is even easier to identify: these were certainly storage rooms for food supplies, where provisions could be preserved in a cool environment (Figs. 13, 15). On

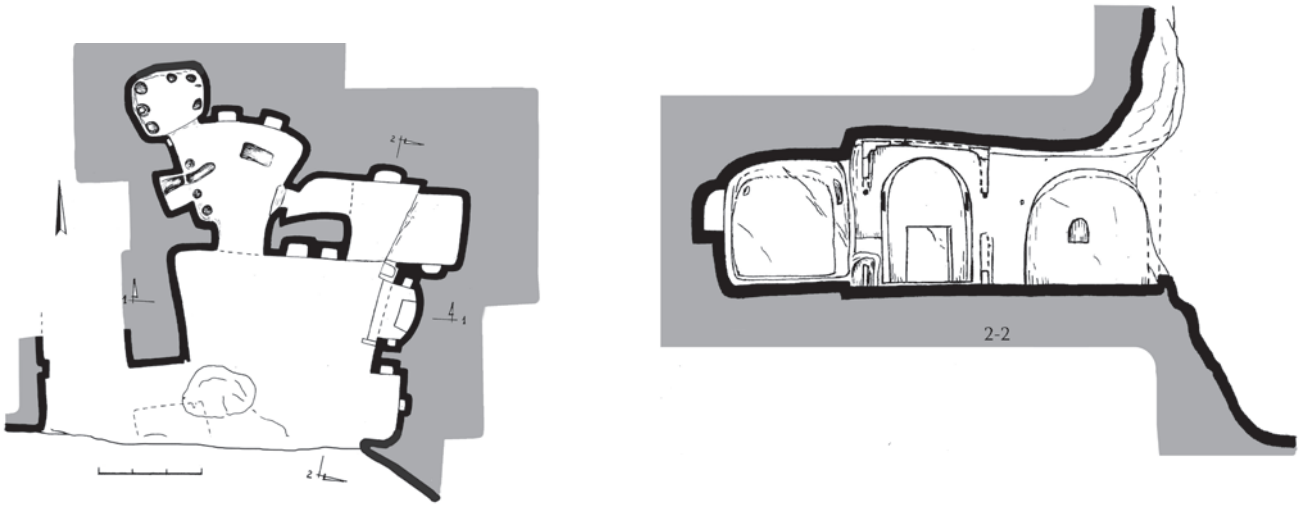

Fig. 16. David Gareji. Monastery of St. Dodo. Plan and section of a hermitage in the central massif (drawing by N. Bakhtadze)

the same side of the service block there are usually elongated corridors, slightly widened at the end and equipped with latrines provided with vertical ventilation openings (Figs. 12, 15).

The communication systems connecting these residential groups with the outside world also appear to have been highly standardised. Practically every major residential and monastic group of caves – both at Dodorka and in the majority of similarly segmented monasteries – is elevated approximately 3–5 metres above the ground level. The façade sections have not survived everywhere, but where they are preserved to some degree, one can usually visually identify a system of vertical communication shafts and tunnels, or their remains. In some cases, traces of such access openings have been revealed through archaeological research (for example, in the group containing the burial church of St. Dodo). These tunnels, designed according to a rectangular plan with rounded corners and intended for the passage of a single person, were most probably created primarily for the safety and defensive protection of the inhabitants of these groups. Depending on circumstances, wooden ladders may have been installed there, but more often ropes or rope ladders were probably suspended, which could be raised when necessary (for example, at night or when suspicious circumstances were detected). Near the upper ends of these shafts, one frequently finds rope attachments carved into the rock or sockets for wooden beams, which would have allowed ropes and possibly even systems of baskets and pulleys for lifting loads to be attached more conveniently. Such tunnels and shafts began in the ceilings of smaller lower-level cave chambers (which themselves would have had wooden doors opening towards the exterior space), while on the upper level the openings were probably covered with additional protective wooden shutters (Fig. 6, 13, 15).

We should assume that such tunnel-like shaft entrances, besides serving as protection against "uninvited guests," also emphasised the limited connection of isolated residential and prayer spaces with the outside world, representing an architectural expression of the principle of ascetic seclusion. Obviously, due to the considerable damage to the façades and the burial of the lower levels beneath collapsed debris, we cannot yet speak with certainty about the universal character of the "shaft-and-tunnel" communication system. However, it is already evident that the hermitage groups were largely arranged on two levels: in the overwhelming majority of cases, at least a few auxiliary chambers are found on the lower level, directly at the edge of the ground surface (for example, a stable has also been documented in the Veran-Gareji hermitage). From one of these chambers, monks would have reached the second, residential level through a shaft of the aforementioned type.

In the lavra-type cave monasteries of the Gareji region, we naturally cannot exclude the existence of other forms of communication – for example, stairways carved into the inclined surface of the rock (either temporary ones, created before the excavation of tunnels, or conversely, emergency solutions made after the collapse of the façade and tunnel sections). Alternatively, the two-level organisation of the hermitage groups may indeed not have been strictly standardised (for instance, depending on the characteristics of the landscape, the cave chambers could have developed horizontally, only slightly elevated above the ground surface). However, based on preliminary evidence and the statistical analysis of well-preserved façades, we believe that future archaeological research will confirm the typical character of elevated hermitages arranged on a second level.

What is the situation in this regard in Cappadocia? In the rock-cut monastic complexes there, the vertical organisation of space – the two-level arrangement and the use of vertically connecting openings (shaft-type tunnels) between them – represents a common architectural phenomenon directly connected with the practice of lavra-type monasticism (Rodley 1985, 65; Kostof 1989, 17, 71). However, Cappadocian hermitages were often carved into rock formations resembling cones, where the organisation of the main spaces was not limited merely to horizontal development along the "façade" of the rock. Rather, they also expanded vertically, resulting in multi-level complexes connected to each other by narrow vertical shafts climbed with ropes, or by tunnel-like stairways (Rodley 1985, 66, 185, 189). Such structures are particularly clearly represented in lavra-type hermitages, for example in Göreme Valley and Paşabağı (Monks Valley), where cells and chapels located one above another are connected by narrow vertical shafts carved into the rock or by steep internal passages. There, too, numerous traces of removable ladders or devices for attaching ropes have been documented.

Thus, the two- and multi-level organisation and the use of vertical shafts in the relatively isolated groups of practically all cave monasteries of David Gareji should not be regarded merely as technical or topographical solutions. Rather, they should be understood as essential components of monastic life, where physical separation was closely connected with the principles of ascetic seclusion, discipline, and controlled communication.Together with the evidence indicating isolated living conditions and individual prayer practices of small groups of monks, if we also take into account that all these groups of chambers possessed their own food storage rooms and kitchens, it becomes clear that we are dealing with hermitages of the lavra type – places where monks were required to care autonomously for their physical needs throughout the entire week except Sundays.

In general, the hermitages forming part of the cave lavras of the Early Byzantine world (also known as hesychasteria (ἡσυχαστήρια or sketes) were arranged in markedly varied spatial configurations (within reasonable limits

Fig. 17. David Gareji. Monastery of St. Dodo. The church with the tomb of St. Dodo (photo by B. Gabekhadze)

a **b** **c**

Fig. 18a, b, c. David Gareji. Monastery of St. Dodo. Stages of the archaeological excavation of the lower tier of the church containing the tomb of St. Dodo (photos by B. Gabekhadze)

of distance from the heart of the monastery). There are examples of hermitages located only 5–10 metres from one another, as well as those separated by distances of 500–1,000 metres. Written descriptions even preserve extreme cases – apparently, some hermit monks walked for several hours in order to attend the Sunday liturgy in the central church of the lavra (Hirschfeld 1992, 20). In the deserts of Gareji, too, these distances probably did not have any fixed or critical limits.

An excellent example of a lavra consisting of even more widely dispersed hermitages in the Gareji region is the complex known as "Berebis Seri" ("the Ridge of the Monks"). Its constituent sketes are separated from one another by distances exceeding one kilometre. However, in the central part of this monastery (which some researchers identify as an independent monastery and refer to as "Sabereebi"), the situation is completely different: along a single rocky massif groups of hermit monks' dwellings (with individually carved chapels of high artistic quality) are arranged extremely compactly – separated from one another by only 5–15 metres[5] (Fig. 3, 4). The extremely dense arrangement of these church-containing groups has for decades complicated the proper understanding of the liturgical and typological structure of the entire monastic complex. A large number of scholars have connected this unusual clustering of churches with some unknown liturgical system (Tumanishvili 2013, 50, 51). In our opinion, however, before the collapse of the façades, the hesychasteria here were carved according to exactly the same general planning scheme as the hermitages described above in other Gareji monasteries. Indeed, in front of some churches, quite extensive vestibules and remains of communal spaces have survived to the present day.

Furthermore, it is highly probable that each of these cave sketes of Sabereebi also possessed additional lower-level caves, connected with the main spaces by shaft-like vertical entrances – similar to those found in the hermitages of Dodorka. As a result of the collapse of the extensive façade sections of Sabereebi, the entrances of some lower-level caves covered by fallen debris can still be clearly identified. As we have noted, in the lavra-style cave monasteries of Gareji (including the Dodorka complex), the almost standardised two-level organisation of hermitages had remained unnoticed until very recently. Consequently, no one had undertaken a systematic search for lower levels in the clustered hermitages of Sabereebi (nor had the same aspect been examined in Veran-Gareji or in the other hermitages of Berebis Seri).

After recognising this structural pattern, we began intensive investigations aimed at locating the lower-level caves

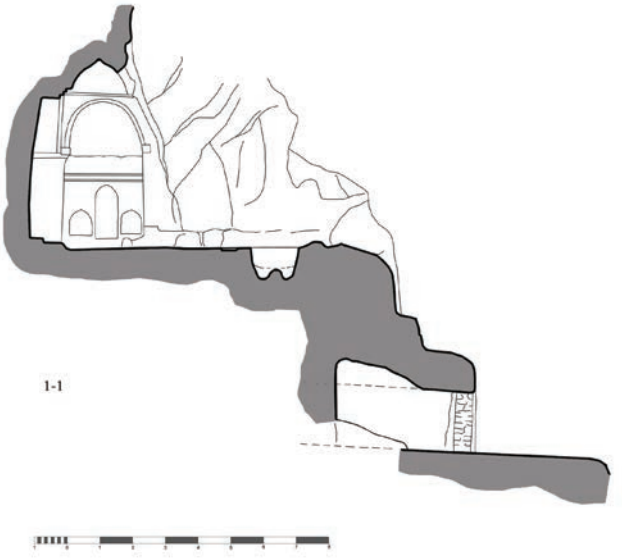

Fig. 19. David Gareji. Monastery of St. Dodo. Section through the two tiers of the church containing the tomb of St. Dodo (drawing by N. Bakhtadze)

and connecting tunnels in such hermitages. In the group containing the burial place of St. Dodo, this system immediately became physically evident: on the lower level, a carefully carved chamber was revealed, from which a vertical opening led upward into the vestibule of the monks' dwelling spaces on the second level (Figs. 7, 18, 19).

Finally, the fact that hermit monks inhabited the isolated hermitage groups of Dodorka and other cave monasteries of the Gareji region which we identify as lavras is also indicated by another circumstance. The typological classification and analysis of pottery fragments collected from the slopes in front of the caves also demonstrate that the monks living in these groups received their daily meals within their own hesychasteria throughout the week. In the floor depressions of the groups and on the slopes in front of them, a particularly large quantity of ceramic vessels has been preserved, discarded after becoming unusable through long-term use (and possibly also scattered during enemy raids). These include both large storage vessels for long-term food preservation, such as kvevri and jars, and a considerable amount of tableware (bowls, trays, plates, jugs, pitchers, and drinking vessels).

Conclusion

As a result of the architectural and structural analysis presented above, I believe that we have identified a sufficient number of characteristics to enable us, with a high degree of certainty, to recognize groups of hermit monks' dwellings within newly discovered or still in-

5 It should not be forgotten that later, during the renaissance period of Georgian rock-cut monasteries in southern Georgia (against the background of the renewed flourishing of the doctrine of Hesychasm), in the 12th century, the world-famous monumental rock-cut lavra of Vardzia was created, where nearly two hundred hermitage groups, each equipped with autonomous individual chapels and food-storage facilities, were carved across nine levels according to a simultaneously conceived architectural plan. These hermitages are separated from one another by only 2–3 meters or even merely by thin rock partitions (Tumanishvili 2013, 50,51).

sufficiently studied medieval cave systems associated with Christian monasticism in the Gareji region – provided that all or at least several of the essential components described above are present.

Even in cases where a significant part of the rock-cut chambers belonging to such systems has not survived, we will attempt to locate them archaeologically within the collapsed rock debris. And if certain elements have disappeared permanently due to destruction, we can still undertake their approximate theoretical reconstruction.

Furthermore, when discussing the function of similar, previously unexplored religious groups discovered in the future, we should probably abandon the term "independent hermitage." Such a phenomenon, in my opinion, never existed as a widespread and canonical form – not only in the Gareji desert, but even throughout wider regions influenced by Byzantine monasticism.

Near any such site, or even at a distance of more than a kilometre, one will certainly find the remains of other hermitages with more or less similar structures, as well as a larger monastic cluster equipped with a substantial church and refectory – that is, the "hearts" of the lavras whose components these hermitages represented.

We do not wish to claim that all cave monastic complexes of David Gareji where we have identified this typical general structure of hermitages functioned as lavra-type organisations continuously from the eighth–tenth centuries until the Late Middle Ages. It is possible that in some of these monasteries, after the adaptation of monks' residences, worship was conducted according to a coenobitic monastic model for a certain period or even for a considerably longer time.

Nevertheless, our data clearly demonstrates that during the Early Middle Ages, the lavra form of monastic organisation predominated in the vast majority of cave monastic complexes of the Gareji monastic region, and that many essential components of the hermitages created for the ascetic life of solitary monks have survived to the present day within their dispersed or relatively compact structures.

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Sant'Angelo in Criptis Cave (Santeramo in Colle, Bari, Italy): Cult and Nature
Knowledge, conservation protocol and heritage value

Mariagrazia Cinelli
Soprintendenza ABAP per la città Metropolitana di Bari
mariagrazia.cinelli@cultura.gov.it
Valentina Gaudio
Soprintendenza ABAP per la città Metropolitana di Bari
valentina.gaudio@cultura.gov.it
Antonio Laselva
Archeoclub d'Italia, Santeramo in Colle "Don Ignazio Fraccalvieri"
antonio.laselva@libero.it
Lorenzo Orsini
Soprintendenza ABAP per la città Metropolitana di Bari
lorenzo.orsini@cultura.gov.it
Marcello Turci
Soprintendenza ABAP per la città Metropolitana di Bari
marcello.turci@cultura.gov.it

Abstract
Apulia is an Italian region characterized by the widespread presence of natural and anthropogenic caves. Among these, the Sant'Angelo cave in Santeramo in Colle (near Bari) represents a significant example in which the natural space of a karstic cavity and the anthropogenic space of a rupestrian church coexist, forming a complex cultural and environmental system.
The cave constitutes one of the most important testimonies of the cult of St Michael the Archangel in Apulia. It is located along the ancient route connecting Bari and Matera (tratturello no. 93, Grumo–Santeramo), near a small basin identified in medieval sources as Lacu Travatu. Closely associated with the cult of water, the site was continuously frequented by pilgrims, probably from the 5th century AD and certainly during the Lombard period, until the 15th century, as evidenced by numerous rock inscriptions engraved on its walls.
In the 12th century, likely following the incorporation of the site into the Monastery of Sant'Erasmo, a church was built above the cave, now partially incorporated into an 18th-century rural structure. From this phase onwards, the hypogeum was progressively decorated. A niche, aligned with the entrance axis and framed by carved columns, houses a fresco depicting St Michael slaying the dragon. Between the late 13th and mid-14th centuries, additional frescoes were executed, including Christ Pantocrator among the Apostles and the Descent of the Holy Spirit on the entrance lunette, and a Madonna and Child flanked by St Michael and St John the Baptist within the cave.
The primary conservation challenge posed by the Sant'Angelo cave stems from its intrinsic environmental characteristics. Conservation problems frequently arise when a substantial amount of water interacts with an artwork, causing both deterioration of the binding media and widespread microbial colonization. Considering that Sant'Angelo's cave is both an anthropized environment and a karstic grotto, establishing and maintaining a balance between the natural features of the cave and its preservation requirements will play a pivotal role in the conservation practices to be carried out.
To ensure the site's future accessibility, it is crucial to determine how human presence might disrupt this delicate microclimatic balance and whether tourism could act as a catalyst for microbiologic decay.
Consequently, a comprehensive campaign of scientific analysis will precede all planned restoration interventions and public access protocols.
More broadly, the study of the Sant'Angelo cave highlights the deep connection between the landscape, shaped by productive and devotional practices, and the rupestrian environment. This perspective calls for an integrated approach to valorization, based on the reconnection of natural and cultural components. The protection and enhancement of this site should therefore rely on a balanced integration of conservation measures, controlled access, and digital technologies, ensuring both long-term preservation and wider cultural recognition.

Keywords: Saint Michael Archangel cult, karst anthropic caves, wall paintings, environmental monitoring, contemporary conservation

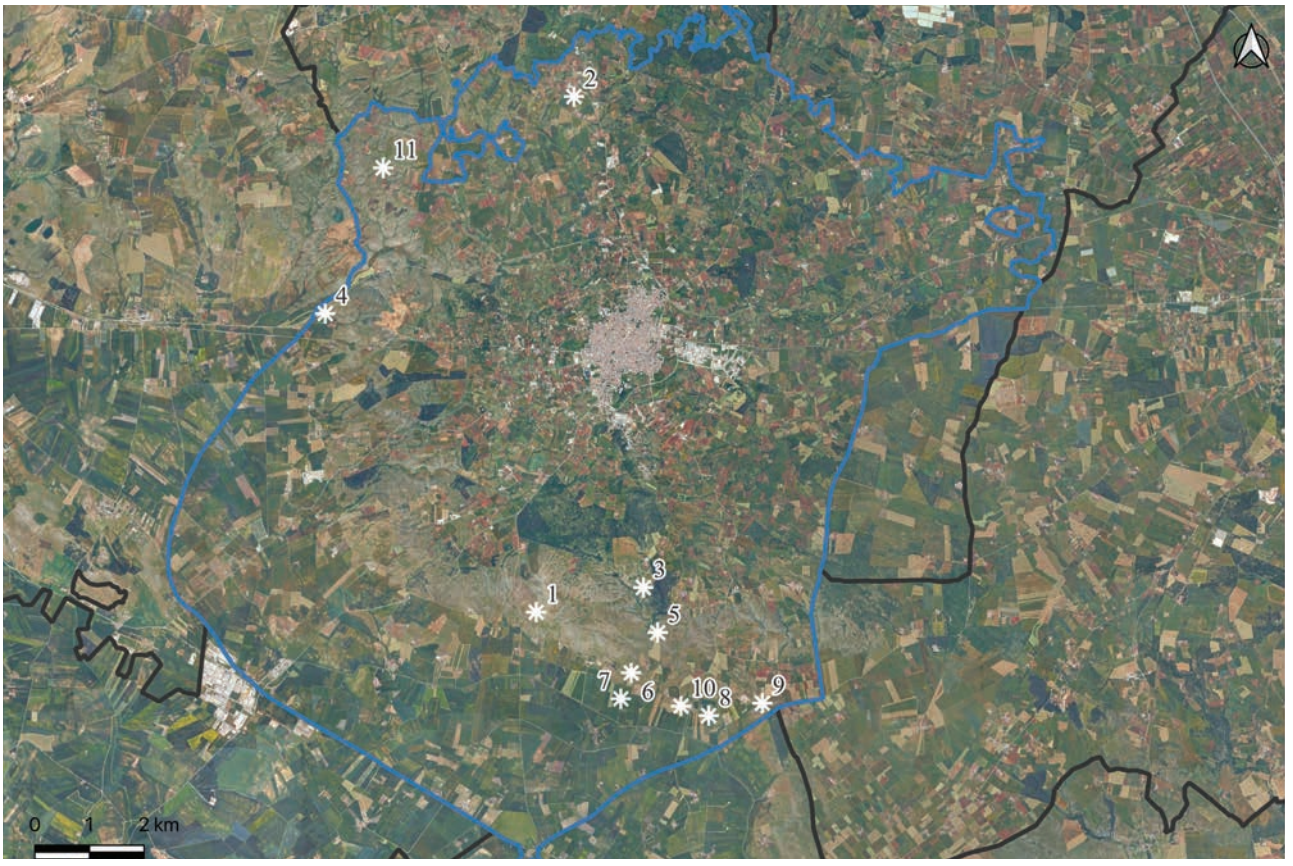

Fig. 1. Verified anthropized hypogea of Santeramo in Colle (A. Laselva, representation M. Cinelli)

Introduction: from study to enhancement
(M. Turci)

Fifty-five years have passed since the rediscovery of the cave and architectural complex of *Sant'Angelo* by don Ignazio Fraccalvieri, and 45 since its recognition as a site of considerable cultural interest by the Italian institutions.

It was only in the early 2000s that a group of scholars undertook the first systematic study of the site (Caprara et al. 2008), establishing that the cave had been continuously frequented in connection with the cult of Saint Michael the Archangel between the 5th and 15th century AD, before being converted into a *masseria* (farmstead) for the housing of livestock in the 18th century AD (Rampino 2008).

The recovery and restoration of the architectural complex were initiated by the *Comune di Santeramo in Colle* during the first decade of the 2000s (2006-2015) and completed in 2025 with the inauguration of the *Sant'Angelo* Cave Visitor Centre within the [1].

A multidisciplinary working group – including the present authors – has since been established, bringing together institutions[2], research centers[3] and Third Sector associations such as the Archeoclub di Santeramo, with three main aims: 1. to broaden knowledge of the site by recovering all hitherto known archaeological data and conducting targeted test excavations within the complex and the cave; 2. to outline a restoration plan for the wall paintings–currently in advanced decay–based on environmental and geological monitoring; 3. to develop a public access strategy for the hypogeum that ensures the conservation of the site and all its natural and anthropogenic components.

Hypogea in the territory of Santeramo in Colle
(A. Laselva)

The territory of Santeramo in Colle- whose geological formation consists mainly of Altamura limestone and, to a lesser extent, of Gravina *calcarenite*[4]-is rich in karstic cavities and anthropised hypogea. The latter,

1 https://www.grottadisantangelo.it/progetto/

2 SABAP-Bari, Santeramo in Colle Municipality, Alta Murgia National Park.

3 Politecnico di Bari, Arcod Department, (Prof. Arch. G. Martines); Università degli Studi di Bari Aldo Moro - Dipartimento di Scienze della Terra e Geoambientali (Prof. A. Garavelli).

4 The two lithological units characterising the area are as follows: Altamura Limestone: a thick succession of stratified rudist limes-

Table 1. Verified anthropised hypogea of Santeramo in Colle.

Nr.	Name	Type	Period	Bibliographic references
1	*Cocciuta* Cave	Natural karstic	Chalcolithic	Survey Report 2022 SABAP-Bari (Annese et al.)
2	*Talpullo* Cave	Natural karstic	Prehistory	-
3	Anonymous cave of *Gravinella*	Natural	Prehistory	-
4	*Jazzone* Cave	Natural	Prehistory	-
5	*Curtelupiske* Hypogeum	Artificial (*calcarenite*)	Prehistory	-
6	*Croce Cosmica* Hypogeum	Artificial (*calcarenite-* limestone)	Early medieval	Caprara 2012
7	*Cristo è Luce* Hypogeum	Artificial	Early medieval	Caprara 2010
8	Hypogeum of the Lamp	Artificial	Late Antiquity	Caprara 2010
9	*Tomba a grotticella* (rock-cut chamber tomb) in *Grottillo*	Artificial (*calcarenite*)	Pre-Roman period	Mangiatordi 2011
10	*S. Angelo alla Morsara* Church	Artificial (*calcarenite*)	Early medieval	Dell'Aquila, Fiorentino 2010
11	*Sant'Angelo in Criptis* Cave	Natural karstic	Early and Late Medieval	Caprara et al. 2008 Caprara et al. 2013

some of which have been in use since prehistory, tend to be concentrated in the so-called *Murgia Morsara*[5] (see tab. 1 and Fig. 1).

Among the anthropised natural cavities, the recent discovery of *Grotta Cocciuta* is noteworthy: a remarkable cavity accessible only through a narrow horizontal passage, whose ritual occupation dates to the Chalcolithic period[6]. Further examples include *Grotta Talpullo*, consisting of a single large chamber heavily concretion-encrusted and yielding prehistoric ceramic vessels, and the unnamed cave of the *Gravinella* which, like *Grotta Jazzone*, is currently obstructed; prehistoric ceramic sherds have been recorded on the surface at its entrance[7].

Alongside these natural cavities are rock-cut hypogea artificially hewn into *calcarenite*, attributable to Late Antiquity or the early medieval period. These include the *Ipogeo della Croce Cosmica*, a mysterious cavity bearing a large engraved cosmic cross; a small hypogeum within a quarry, from which the engraved Greek Monogram "Christ is Light" derives[8]; and the *Ipogeo della Lucerna*, situated in an area of high surface ceramic density, which unsurprisingly yielded, within a collapse debris deposit, a late antique African Red Slip ware lamp. Of particular devotional significance is the rupestrian church of *Sant'Angelo alla Morsara*, a singular example of an aniconic church with a Greek-cross plan, well concealed within a sunken area and surrounded by several minor hypogea (Dell'Aquila, Fiorentino 2010).

***Sant'Angelo in Criptis* Cave** (M. Turci)

The Sant'Angelo in Criptis Cave, located 5.5 km northwest of the centre of Santeramo and approximately 12.5 km east of Altamura, lies along the route of the ancient *tratturello* (transhumance track) nr. 93 Grumo–Santeramo, corresponding to the old road connecting the cities of Bari and Matera. The presence in the surrounding area of a considerable water supply, owing to

tones, in which the distribution of fossils is not homogeneous, interbedded with marly limestone levels indicating periods of high salinity; dolomitic levels may be found in the upper part. The age of these limestones is attributed to the Santonian (Upper Cretaceous) based on studies conducted on the rudists. Gravina calcarenite: a bioclastic limestone consisting of calcareous shell fragments and quartz sand particles cemented by a calcareous matrix. The rock has a homogeneous structure and is easily workable, to the extent that it has been widely used as a building stone (Richetti et al. 1988).

5 The sites listed in Table 1 are the result of a survey conducted as part of a research and cataloguing campaign initiated by the Archeoclub di Santeramo in Colle from 2009 onwards.

6 A Chalcolithic dagger was found inside the cave in 2015; the cave was the subject of recent archaeological investigations by the Soprintendenza di Bari in late 2022, under the direction of Caterina Annese and Ebe Princigalli, with the collaboration of Sandra Sivilli and Cora Cooperativa Archeologica s.r.l.

7 These are virtually unpublished hypogea which, like the Ipogeo di Curtelupiske, would require targeted investigations.

8 The reading is due to R. Caprara (see Caprara 2010, pp. 11–13).

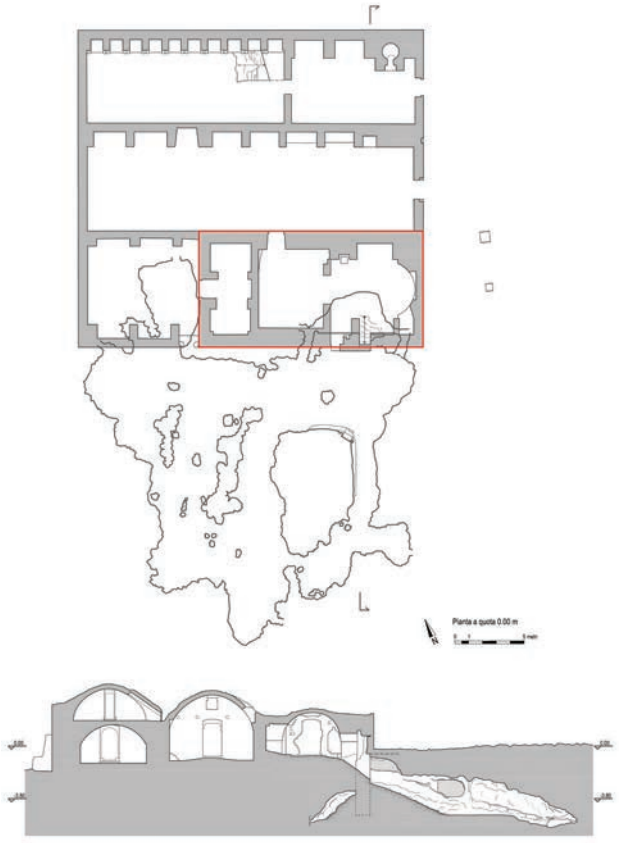

Fig. 2. Plan and Cross-Section of Sant'Angelo in Criptis Complex and Cave (G. Fiorentino)

a small lake, as indicated by the toponym itself – Sancti Angeli de Lacu travatu (Fiorentino 2008), attested in a document of 1136 – made it a crossng point of particular strategic value.

The aforementioned document constitutes the earliest attestation of the *Grotta*-complex of *Sant'Angelo*. The *Rationes Decimarum Italiae*, preserved in the Vatican Secret Archives, provides documentary evidence that in the second half of the 13th century (1274–1275), an abbot named Pietro of the monastery of *S. Angeli de Lacutrabaccu* paid tithes on his revenues to the diocese of Gravina (Rampino 2008), as did the monastery of *Santa Margherita di Ruvo*. No information survives as to which order or rules this monastery followed, though it has been proposed that an initial settlement of Byzantine monks in the cave was subsequently (Rampino 2008) followed by Benedictine monasticism.

The pictorial cycle of the cave is dated, on stylistic and palaeographic grounds, to the second half of 13th and first half of the 14th century, while the earlier paintings date from late 12th to early 13th century AD. The latter provides the *terminus ante quem* for the construction of the church that is partially incorporated into the later *masseria*. As in ancient times, the cave is accessible through an opening along the southern side of the presbyterial area of the church (Fig. 2). G. Fiorentino has reconstructed its bicellular ground plan, placing its chronology around the mid-12th century (Fiorentino 2008).

The partially uncovered masonry structures brought to light during the restoration works of the *masseria* – currently visible to visitors along the walkways of the central vaulted chamber (*lamione*) – may likely be attributed to the monastic complex known from the literary sources. We may thus observe that the architectural monumentalization of the exterior corresponded to a renovation of the cave interior, endowing the area near the entrance with three fresco cycles of considerable scenic impact.

As noted above, the cave – characterized by karstic phenomena still in progress – was dedicated, at least from the Lombard period onwards, to the cult of Saint Michael the Archangel[9]. In testimony to this cult, intimately bound to the dripping water, hundreds of graffiti and epigraphs in both Latin and Greek can be observed in it. Those signs of devotion can be seen along the walls and, above all, on the limestone concretions of the cave, attesting the presence of pilgrims over a period spanning from Late Antiquity (5th century AD?) to the 15th century AD[10].

The wall paintings (L. Orsini)

The pictorial cycle in the *Sant'Angelo in Criptis* represents important evidence for the monastic center, which served as a religious and cultural hub along the route between Bari to Matera. In fact, its geographical location encouraged visits to the sanctuary, making the site a strategic hub for trade and the circulation of cultural models and devotional practices.

The complex is dedicated to St. Michael and it's one of the devotional sites along the pilgrimage route of *San Michele Arcangelo*. Inside the cave (Fig. 3, 4), the remains of layered pictorial decoration are preserved, visible in three areas: the entrance vault, where the Apostolic Tribunal with Christ as Judge is depicted; the

9 On the importance of the cult of the Archangel during the Lombard period and the centrality of the Sanctuary of Saint Michael on Monte Gargano, see the various contributions in Carletti, Otranto 1994.

10 The most recurrent element is, as customary, represented by crosses of various forms and types. The monogrammatic cross (attested by at least 5 examples) is assignable to the second half of the 4th/5th century AD, whilst the crosses inscribed within a shield date to the Crusader period (late 11th–12th century). Among the figurative elements, the stylised depiction of a Norman-period vessel stands out. The inscriptions, in both Latin and Greek, bear formulae of devotion and acclamation, including in monogram form, as well as pilgrim names (Sabinus, the name Nicola Latinised as Colaus, Vitalis). The most recent inscription, in humanistic script and datable to the 15th century, belongs to a woman who signs herself Bella Bella (see Caprara 2008, pp. 45–81).

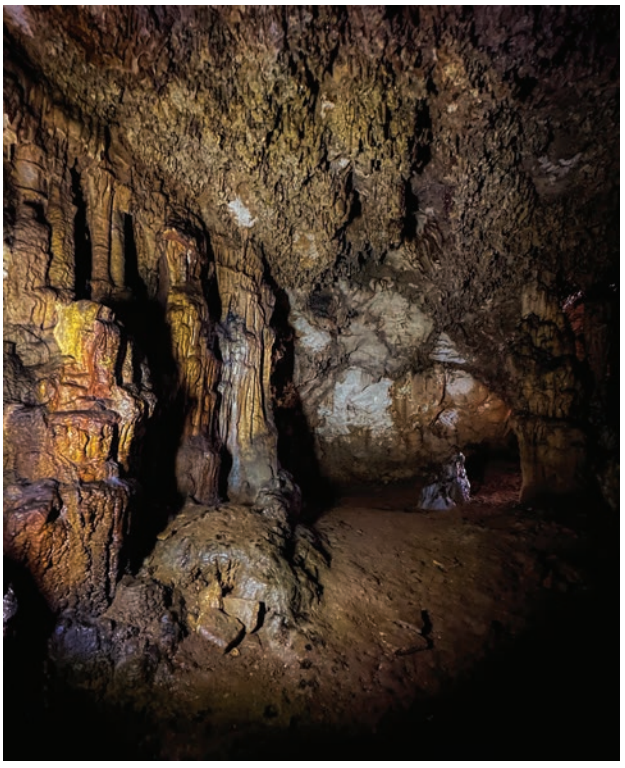

Fig. 3. View of the first corridor of the cave (photo M. Cinelli)

central niche, which contains the image of Saint Michael slaying the dragon; and the wall to the left of the tabernacle, where a sacred depiction featuring the Archangel Michael, the Virgin Mary enthroned with the Child, and Saint John the Baptist can be seen.[11.]

As will be discussed in greater detail later in this article, the painted decoration is in extremely poor condition, having been severely compromised by both natural and human factors. However, the visible portions of the fresco, particularly in the scene depicting Christ the Judge, reveal the work's artistic quality and its significance within the Bari context, making it one of the most remarkable figurative cave painting cycles in the Murgia region. Furthermore, alterations to the various layers have revealed traces of overlapping pictorial layers, a veritable palimpsest with the oldest dating from the late 12th to early 13th centuries and the most recent from the 13th to 14th centuries (Caragnano 2008), confirming the site's heavy use and decorative continuity over time.

On the vault corresponding to the cave's entrance, Christ is depicted seated on a throne beneath a canopy supported by twisted red columns, flanked by the apostles arranged symmetrically on a single bench (Fig. 5). With his left hand, the Pantocrator holds an open book inscribed with the the Gospel verse "*Ego sum lux mundi*", while the dove of the Holy Spirit appears above the canopy. The remaining inscriptions allow for the identification of some of the apostles, including Peter, Andrew, John, James, and Simon.

Fig. 4. Photographic survey of the fresco cycle at the entrance of the cave (survey by Marasco M. M., Resta G., Robles G., Specchi G., Totagiancaspro P.)

The interpretation of the scene has sparked a wide-ranging critical debate. While Fraccalvieri saw the painting as a synthesis of the Last Judgment (Fraccalvieri 1975), Caragnano instead identified it as a depiction of Pentecost, featuring the Christ Pantocrator (Caragnano 2008). More recently, Calò has proposed an integrated reading of the two iconographies, hypothesizing a fusion between the eschatological and Pentecostal themes, consistent with Eastern monastic spirituality (Calò 2016). From this perspective, the *Sant'Angelo* cycle would constitute a synoptic reduction of the Last Judgment, adapted to the specific context and based on theological interpretations related to the Syriac tradition of Saint Ephrem[12].

In the central niche, one can observe the depiction of the Archangel in the act of piercing the dragon (Fig. 6). Although heavily damaged, the painted surface preserves portions of the red cloak, the wings, and the halo, as well as fragments of the apocalyptic monster. According to Calò's interpretation, the iconography thus takes on a clear eschatological and funerary significance, elevating Michael to a supporting role within the context of the Last Judgment and as the guarantor

11 The cave's pictorial cycle has been the subject of in-depth iconographic and stylistic studies by Fraccalvieri (1975, 2010), Caragnano (2008), and, most recently, Calò (2016). Also worth noting is the recent bibliographic survey conducted by Fioretti, Garavelli, Germinario, and Pinto (2021).

12 Ibid. Based on a comparison with the frescoes in the rock-hewn church of San Leonardo in Massafra, dated to the mid-13th century by Falla Castelfranchi (1991) and Pace (1980), Calò dates the paintings in question to the second half of the 13th century, noting in their style both greater maturity and a historical connection, identifiable in the presence of the lily on the canopy, the heraldic symbol of the Angevins, who had been present in Southern Italy since 1266.

Fig. 5. Christ Pantocrator wall painting (photo M. Cinelli)

Fig. 6. The niche with the depiction of the Archangel piercing the dragon (photo by Marasco M. M., Resta G., Robles G., Specchi G., Totagiancaspro P.)

Fig. 7. Triptych depicting the Archangel, the Virgin and Child, and John the Baptist (photo M. Cinelli)

of victory over the devil and death[13].

Finally, on the left wall of the cave, there is a triptych depicting the Archangel, the Virgin and Child, and John the Baptist (Fig. 7). Although barely legible due to candle soot and flaking paint, one can make out the figure of Michael, portrayed in traditional Byzantine garb and a long purple cloak, holding a thurible in his right hand with which he is offering incense toward the Virgin Mary. To the right of the Virgin *Odigitria*, the depiction of John the Baptist links the painting's subject to the theme of the Passion and the sacrifice of Christ, further confirming the funerary significance this cave may have held within the context of the monastic institution.

The frescoes of Sant'Angelo stand as a significant testament to the high cultural standing achieved by the monastery and to the spread, within the Apulian context, of complex iconographic models, reflecting a profound assimilation of Byzantine spirituality. From this perspective, future studies, supported by scientific research and targeted conservation efforts, will contribute to a more accurate definition of the historical, artistic, and iconographic context of the pictorial cycle, fostering a broader and more nuanced critical understanding of it.

Conservation challenges of rupestrian paintings in active karstic environments
(V. Gaudio)

The Santeramo-based site is a rare example where an active karstic environment and several frescoes coexist, rendering it an extraordinary case study in the framework of Italian and Apulian caves. Originally a natural cavity later subjected to human modification, the painted support is not a uniform wall, but rather a complex system characterized by karst-related phenomena, concretions, and active groundwater flow.

Moreover, a small bat colony inhabits this delicate ecosystem and is protected by the European Habitats Directive (92/43/EEC). These mammals are very sensitive environmental markers – their presence is fundamental to the identity of this site and must be considered throughout the planning of the restoration. Carrying out a so-called "operational silence" will be fundamental during the preparation of operational procedures – this practice must take place from November to March, to prevent these animals from experiencing traumatic awakenings. Similarly, the same caution will have to be taken during late spring, namely the nursery period of the bats.

The chemicals employed – ranging from consolidants to fixatives – must not contain toxic Volatile Organic Compounds (VOC). Compatible inorganic substances should be preferred and should not disturb echolocation

13 Regarding the tabernacle, see also Bertelli 2016.

Fig. 8. Detail of dissolution of calcium carbonate on the surface of the paintings (photo M. Cinelli)

Fig. 9. Detail of multiple painting layers (photo M. Cinelli)

or animal metabolism.

Human impact is the most significant risk factor. Human presence alone modifies vapor pressure inside the cave (Lang 2024). The exhaled water vapor is warmer than the rocky walls and this creates condensation upon the painted surfaces, which triggers condensation corrosion. This phenomenon causes the dissolution of calcium carbonate in both the support and the binder of the painting, weakening the pictorial layer. Simultaneously, the rising human-emitted CO2 reacts with condensed water, forming carbonic acid (H2CO3), and causing chemical dissolution of carbonate materials (Hoyos 1998). Uncontrolled, this surface acidification transforms the cave into an aggressive environment for paintings, accelerating decohesion and loss of adhesion (Fig. 8).

The restoration record of this site appears to have been already characterized by such occurrences. The presence of multiple painting layers – where recent layers overlap a more ancient one (Fig. 9) – shows how the microclimate of the hypogeum has been stressing the materials since ancient history. (Fioretti 2021). Modern restoration techniques should comply with the practice of "minimal intervention" favoring reintegration mortars based on natural aerial lime and local aggregates, characterized by high porosity and vapor permeability, to prevent the onset of mechanical stress between the layers (Giandomenico 2023).

Currently the most significant forms of deterioration affecting the paintings' surfaces are fractures, loss of adhesion between layers, erosion, and biological colonization, as well as staining, concretions, and scratches.

Before any conservation intervention or opening to the public, however, an investigation phase divided into two steps is necessary.

The first phase is dedicated to establishing an environmental baseline through continuous, year-long monitoring. This stage identifies the cave's natural "zero state", free from human interference. Key parameters include geomechanical stability surveys to detect structural risks in the limestone (Garavelli 2021), and the mapping of seasonal microclimatic cycles (temperature, relative humidity, and air pressure). Furthermore, measuring radon gas accumulation is a non-negotiable safety requirement; in unventilated cavities, this radioactive gas can reach hazardous concentrations (Constantin 2021), posing a primary health risk to restorers and future visitors. Understanding these natural rhythms is vital to defining the site's thermal inertia and inherent chemical vulnerabilities.

The second phase evaluates the "anthropic load" through controlled experimental simulations. By introducing small, monitored groups into the environment, the immediate physiological impact of human presence can be quantified – specifically the "spikes" in temperature and CO2 caused by breathing and body heat. In this phase, it is essential to determine the environ-

Fig. 10. View of the second corridor of the cave (photo M. Cinelli)

Fig. 11. Detail of the active karstic phenomenon (photo M. Cinelli)

mental recovery time: the duration required for the cave to return to its equilibrium after a disturbance.

This data is fundamental to determining the site's carrying capacity. It dictates the maximum number of visitors and the necessary intervals between tours to prevent reaching the "dew point."

The effectiveness of any conservation protocol for *Sant'Angelo in Criptis* depends on preserving a dynamic and intrinsically precarious balance where historical memory and biodiversity are inextricably linked. Only an approach rooted in minimal intervention can ensure that inevitable anthropic impact does not irreversibly damage this delicate equilibrium.

A Multidisciplinary Project for heritage value of the Cave (M. Cinelli)

The hypogeum, with its distinctive characteristics, therefore, represents a unique case on the international level, and the issues of conservation and enhancement constitute an extremely important field of reflection. If not properly addressed, one may hinder the other and ultimately lead to the deterioration of the underground complex itself (Fig. 10).

Indeed, the international debate on rock-cut cultural heritage has highlighted how such contexts should be understood as complex and integrated systems encompassing historical, archaeological, anthropological, religious, architectural, artistic, landscape, and identity-related values. Their enhancement is therefore essential not only to ensure their preservation and accessibility to knowledge, but also to sustain and perpetuate the site's identity value within its territorial context. Consequently, the spaces of the *Sant'Angelo in Criptis* hypogeum necessarily require not only the application of methodological approaches grounded in restoration theory, with particular attention to planned preventive conservation, but also the protection of the natural environment (Fig. 11), sustainable management strategies, and digital communication tools.

The strategy of conservation interventions must certainly draw upon the principles established in the major international conservation charters–from the Athens Charter to the Venice Charter, as well as the more recent approaches concerning diffuse cultural heritage and the historic landscape. At the same time, however, the project methodology must be critically re-elaborated and specifically tailored to the individual case study, integrating the various theoretical approaches while employing contemporary tools and materials suitable for practical restoration operations. The enrichment process must therefore be implemented in full respect of the conservation of this unique context, in which the anthropized environment must yield to the natural space, with equal respect for the local fauna.

The Athens Charter introduced the principle of heri-

tage protection as a collective interest, emphasizing the importance of continuous maintenance and respect for the material authenticity of the monument. Subsequently, the Venice Charter consolidated the concept of integrated conservation, establishing that restoration should stop "where conjecture begins," privileging the preservation of historical stratifications and the recognizability of contemporary interventions. Those principles are particularly relevant in the case of the rock-cut complex, where the relationship between architecture, excavated cave, geological substratum, and surrounding landscape constitutes an inseparable whole.

More recent theoretical developments in contemporary conservation have further expanded the concept of protection by incorporating intangible, participatory, and environmental dimensions. Within this perspective, it becomes evident that heightening processes cannot be reduced merely to public accessibility or tourist use, but rather imply an integrated process of knowledge production, preventive conservation, sustainable management, and cultural transmission. This is precisely the process that has been implemented in recent years by the *Comune di* Santeramo in Colle to allow local communities, scholars, and visitors to experience the site while ensuring its full protection and long-term preservation. The institutional and scientific stakeholders involved in this project include the Archeoclub d'Italia, Santeramo in Colle "Don Ignazio Fraccalvieri," the Università degli Studi di Bari Aldo Moro, the *Politecnico di Bari*, and the Soprintendenza ABAP for the Metropolitan City of Bari. The involvement of highly qualified professionals specialized in the protection and study of cultural heritage has enabled the proper planning of interventions in accordance with the principles of compatibility, reversibility of adopted solutions, the use of non-invasive technologies, and respect for the microclimatic conditions of the natural cavity (Fig. 10).

In this regard, the implementation of an advanced digital survey campaign–including laser scanner surveys, photogrammetry, and three-dimensional modeling–now represents a fundamental tool for both conservation and dissemination purposes (Fig. 12). Alongside technological instruments, a central role is also played by the identification of decay phenomena, material alterations, and structural issues, as well as by the assessment of the environmental impact generated by human presence, which is essential for planning visitor access. The replacement of the access staircase to the underground chambers, whose dimensions are currently non-compliant with safety standards, no longer constitutes the primary focus of the project. Rather, it has become secondary to broader considerations regarding site accessibility and carrying capacity. Consequently, the sustainable use of the hypogeal spaces requires visitor-flow control, precise regulation of microclimatic parameters, continuous environmental monitoring as

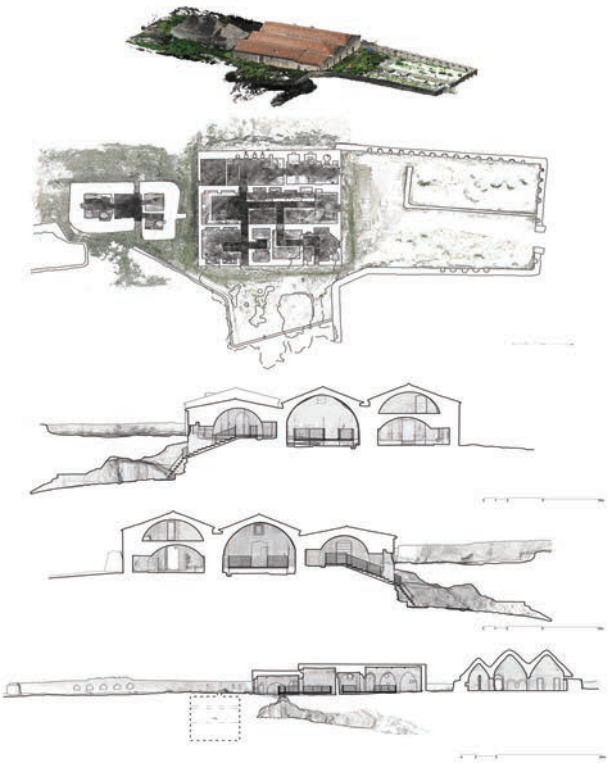

Fig. 12. Survey of the complex (survey by Marasco M. M., Resta G., Robles G., Specchi G., Totagiancaspro P.)

an integral component of the conservation strategy, and the adoption of alternative visitation systems, such as virtual tours.

A further fundamental aspect concerns the relationship between the hypogeum/cavity and its territorial context. Rock-cut heritage cannot be regarded as an isolated element but rather must be interpreted as a component of a broader cultural landscape composed of historical routes, settlement systems, local traditions, and environmental relationships (Fig. 1). Enhancement therefore acquires a territorial dimension capable of activating processes of sustainable cultural and economic development, particularly within inland areas and lesser-known contexts of the Alta Murgia National Park.

The protection of *Sant'Angelo in Criptis* Cave proves effective precisely because it is accompanied by processes of collective awareness, heritage education, and the involvement of local stakeholders. The hypogeum represents not merely an archaeological testimony, but also a place of memory and cultural identity, capable of strengthening the relationship between community and territory.

Sant'Angelo in Criptis Cave may therefore be clearly regarded both as a unique case study in terms of composition and as a commendable example of a multi-layered project in which conservation, scientific research, technological innovation, and sustainable accessibility coexist in dynamic equilibrium, deriving from an interdisciplinary and integrated approach.

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The Caves of Geghard Gorge (Armenia): from a Pagan Sanctuary to a Monastic Complex

Smbat Davtyan[1], Tigran Armenyan[2], Tigran Simonyan[3], Ruzanna Safaryan[2]

[1] Brusov State University (Republic of Armenia)
[2] Institute of Geological Sciences of Republic of Armenia
[3] National University of Architecture and Construction of Armenia
armspeleonetwork@gmail.com

Abstract

Geghard Gorge is located on the western slopes of the Gegham Mountains, within the basin of the Azat River. It stretches southwest–northeast for about 1.5km and a width of about 1km, and elevations between 1600 to 2150m a.s.l., covering about 1.5km^2. The gorge includes the valleys of the Goght River and the Karmir River, forming steep-sided gorges. Numerous temporary watercourses further dissect the slopes. Terraced cliffs, rock outcrops, and steep slopes create its distinctive landscape.
Two main geological units are exposed. The upper layer consists of andesite–basalt lava flows, up to 50m thick, originating from the Gegham Mountains. Beneath lies a several-hundred-meter-thick Pliocene volcanogenic–sedimentary sequence (Geghard Strata), composed of tuffs and tuff-breccias. The rock-cut structures of the Geghard Monastery, as well as dozens of other natural and artificial caves, are carved into this formation.
The Monastery of Geghard and the Upper Azat Valley has been inscribed on the UNESCO World Heritage List since 2000 and received "Enhanced Protection" status in 2018.
The caves of Geghard Gorge are mainly small natural cavities formed within Tertiary volcanogenic–sedimentary strata (up to 15m in length, 2–5m in width, and 3–5m in height). They originated mainly by the suffosion and erosional activity of underground waters. Some caves were later enlarged and adapted for habitation, hermitage, worship, while others were entirely artificial.
Researchers associate this caves with pagan cult practices. According to tradition, in the early 4th century, Gregory the Illuminator founded the monastery of Ayrivank on the site of a pagan sanctuary. Initially, natural caves were used for monastic purposes, explaining the name "Ayrivank" (Monastery in the Cave). From the 5th century, hermits and ascetics settled here, gradually replaced by organized monastic communities in the early 13th century. Under the patronage of the Zakarians and the Proshyans, the monastic complex of Geghardavank was constructed. From the 13th century, the monastery became known as Geghardavank due to the relic of the Holy Lance (Geghard), which pierced Christ's side and was kept there.
The monastic complex includes above-ground structures: the main church (Katoghike), the gavit, and auxiliary buildings, and rock-cut structures: two churches, a gavit, a zhamatun–tomb, chapels, hermitages, and service rooms, within enclosure. Outside of it, additional hermitages, chapels, defensive and communal structures were built, forming an integrated ritual complex.
Thus, the caves of Geghard Gorge reflect a three-stage transformation:
Pagan sanctuary (until the 4th century),
Hermitic–ascetic phase (5th–9th centuries),
Organized monastic community (10th–14th centuries).
The site has preserved its sacred status up to the present day. This evolution shows how pagan and Christian traditions succeeded one another while preserving the sacred character of the site. Geghard Gorge is a sacred landscape shaped by millennia of development, where natural and artificial caves played a key role.

Keywords: hermitage, architecture, rock-cut structures, artificial cave, cult

Geghard Gorge as a sacred territory

Among peoples with a long history, a system of landscapes is formed which differ from public and private territories and are known as sacred territories. Sacred territories, which are natural beautiful objects–mountain massifs, gorges, forests, lakes, etc.–are distinctive territories that differ from neighboring areas in landscape terms and have exceptional spiritual, religious, cultural, or historical value for the indigenous people living in that area. A natural object becomes sacred not only because of its beauty, but also due to the process of sacralization, which turns "ordinary" beauty into "special."

It is understandable that sacred territories are formed in the presence of certain factors. In order to be classified as such, they must have cult object(s), permanent water object(s), nature with physically and artistically valuable characteristics (including also a unique flora and fauna), occupy a relatively large territory, be separated from other territories by natural landscape elements (rivers, cliffs, etc.) and/or cultural-religious elements (monuments, boundary stone piles, etc.), be accessible to visitors via a road, have a self-sufficient economic system, etc.

The territory of Geghard Gorge fully satisfies the above-mentioned criteria: it occupies about 1.5 sq. km, is separated from neighboring territories by a system of high cliffs, the area is inaccessible (or hardly accessible) from all sides except the west, through which it is connected to a road by which visitors can enter the sacred territory; there are numerous caves (natural and artificial) in the gorge, some of which are objects of worship; through the gorge flows the Goght tributary of the Azat River, which is perennial; there are also springs, including those that are objects of worship; numerous are rocks of unique forms, earthen pyramids, cliffs; fauna and flora are represented in various forms, including endemic; since ancient times the Geghard monastery (Ayrivank) has had its own economy, etc.

In general, Geghard Gorge as a sacred territory was first considered in professional literature in the 1970s (Alpago-Novello 1973). The latest reference was made in the 2000s (Khachatryan et al. 2003).

It is known that Geghard Gorge is included in the UNESCO World Heritage List, and one of the criteria according to which the territory was included in the List is that, being a sacred site since pre-Christian times, Geghard Monastery remains a pilgrimage site for thousands of believers to this day.

The main sacred elements in Geghard Gorge are the caves, which have natural and artificial origin. They are located in Tertiary volcanic-sedimentary strata. Natural caves are not large formations–length up to 15 m, width 2–5 m, height 3–5 m. They were formed as a result of the suffosion and erosion work of underground waters. Underground waters brought out fine particles of rocks to the surface, as a result of which small cavities of various sizes and outlines were formed. Some of the natural caves were later partially modified by humans–expanded and improved–serving various purposes (dwelling, hermitage, cult structures).

There are also completely artificial (rock-cut) structures in Geghard Gorge. The first artificial caves were created in pagan times, and in the 4th century Gregory the Illuminator founded Ayrivank in Geghard Gorge. For the monastery, natural caves were initially used, from which the name Ayrivank originated. In the early Middle Ages, the hermit movement was widespread in Armenia and many ascetics settled in this gorge. In different parts of the gorge they constructed rock-cut dwelling-shelters (cells) and prayer places–small chapels. Later–in the 12th–13th centuries–surface (main church, gavit, economic buildings) and underground rock-cut structures (two churches, gavit, refectory-tomb, economic and auxiliary buildings) were built by the Zakarian and Proshian princes. From the 13th century the monastery was called Geghardavank due to the iron tip of the Holy Lance that pierced Christ being kept here. In the 18th century the Holy Lance was moved to Etchmiadzin and is currently preserved in the Museum of the Mother See.

Around the natural and artificial caves located in different parts of Geghard Gorge, over more than 2000 years, a sacred territory has formed, which includes elements belonging to pagan and Christian periods.

The studies of the caves

Until the 1870s, there are only brief references about the caves of Geghard Gorge; more detailed descriptions appear later. Several dozen books, articles, travel notes, and others have been published about this area, the most important of which are presented below.

V. Mankuni is the first author who provides extensive information not only about the surface structures of Geghard Monastery but also about the underground spaces. Presenting the history of the main 4 rock-cut structures, he also described in detail their dimensions, artistic decoration, inscriptions. He also provided data on several small rock-cut churches, chapels, defensive, economic and auxiliary structures, and the inscriptions placed in them (Mankuni 1871).

S. Mkhitaryan, after describing the gavit and main church of Geghard Monastery, presents with artistic richness all rock-cut churches, chapels, tombs located inside and outside the walled area, also, altars, tables, arches, pilasters, directions of windows, ceilings, entrances, rock-cut crosses, khachkars, geometric ornaments, inscriptions (about carvings and donations), etc.

Data about lengths, widths, heights, sizes of entrances and windows complete the information about rock-cut structures (Mkhitaryan 1873).

Gh. Alishan in the work “Ayrarat” presents Geghard Gorge, the monastery and the caves. He describes in detail the gorge with its cliffs, rocks and earthen pyramids. He also presents the monastery area, describing the structures and walls in the courtyard, attaching a schematic plan. He mentions not only the rock-cut structures belonging to the monastery complex but also notes the presence of natural and artificial caves, cells and chapels inside and outside the walls. Numerous inscriptions are also presented, among which there are records referring to rock-cut structures. He also provides a list of the abbots of Geghard Monastery for the period 1177–1881 (Alishan 1890).

Russian historian and archaeologist Vladimir Sysoev (1872–1933) traveled in Armenia, visited Geghard in 1907–1908 and described in detail the history, architecture, rock-cut structures and inscriptions. His 1916 publication includes plans, measurements, sections, and photographs (Sysoev 1916).

In October 1932, an expedition of the Institute of History of Culture of the Armenian SSR carried out test excavations west of the present entrance and discovered an unknown rock-cut structure. A new expedition excavated part of it, but the work remained unfinished, and the fate of this large hall (5 m height, 9 m width, 15 m length) remains unknown, as it collapsed in 1967.

In 1948, the work “Geghard” was published by the architect N. M. Tokarsky, which provides data on the rock-cut structures of Geghard. Several artificial caves are presented, including churches, gavits, and others, along with information about the princes who commissioned them and the period of their construction (Tokarsky 1948).

In 1973, a volume dedicated to the architectural complex of Geghard was published in Milan within the series “Documents of Armenian Architecture.” This work includes discussion of the geological structure of Geghard Gorge and several rock-cut complexes. In this collaborative work by Italian and Armenian authors, the rock-cut structures, their architecture, and artistic decoration are presented in detail (Alpago-Novello 1973).

In the 1980s, Armenian speleologists conducted studies of the caves of Geghard Gorge. E. Sargsyan and M. Sargsyan described about 10 artificial caves and cave complexes located in the gorge, presenting schematic plans of some of them (Sargsyan et al. 1981).

In 1985–1986, investigations in Geghard Gorge were carried out by the speleological unit of the Armenian Geographical Society. The team studied about 30 caves of both artificial and natural origin.

In recent years (2000–2025), studies have been conducted by our group. New caves have been discovered, which are presented in this research.

The Artificial caves of Geghard Gorge as elements of a sacred territory

In Geghard Gorge there are about 40 artificial cave complexes (Fig. 1, 2), which include one or more rooms (halls). Some of them were carved in the pagan period, however the main part are structures of the Christian period. In Geghard Gorge the following stages of cave construction are distinguished:

a) Pagan period

b) Christian period

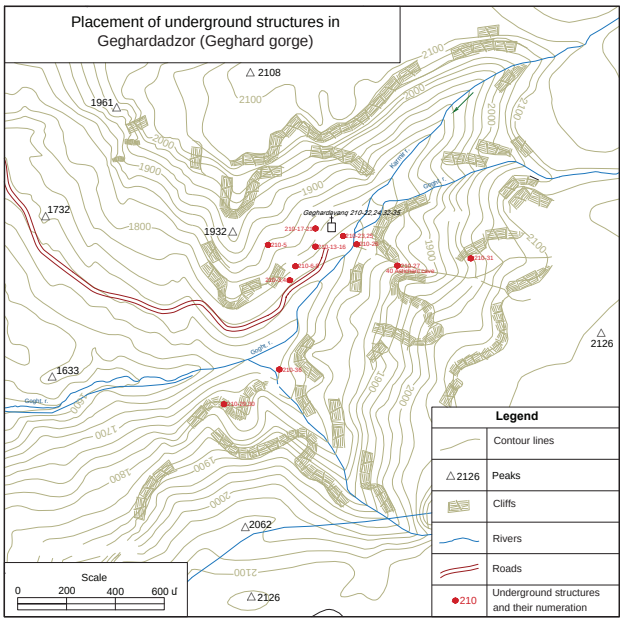

Fig. 1. Schematic map of Gegard Gorge (map Davtyan S., Simonyan T., Armenyan T.)

Fig. 2. Photo of Geghard Gorge (photo Ayvazyan V.)

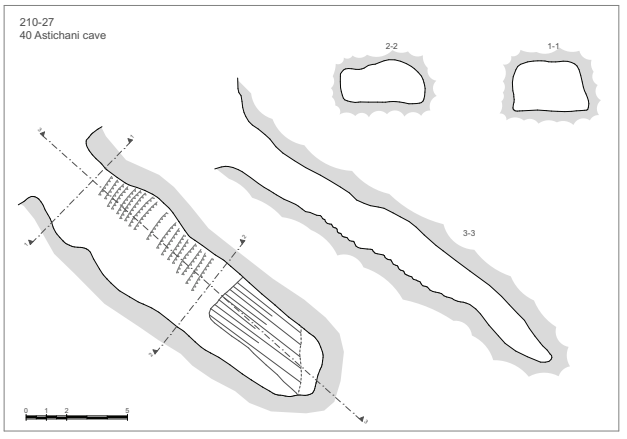

Fig. 3. Plan of 40 Astichani cave (40 Step cave) (plan Davtyan S.)

Fig. 4. Photo of 40 Astichani cave (40 Step cave) (photo Simonyan T.)

The pagan period includes the time from ancient times up to Christianity. Before the adoption of Christianity, Mithraism was widely spread in the countries of the Near East. In Armenia, the cult of Mihr had been widespread starting from the 6th century BC. Mihr was the God of Light and the Sun. The main temple of Mihr in Armenia was located in the settlement of Bagarrij in the district of Derjan of Upper Armenia. In Garni there is a pagan temple dedicated to Mihr, and in Geghard Gorge there is preserved a tunnel (Fig. 3, 4) which was one of the places of worship of Mihr. The cult of Mihr gradually disappeared from the 4th century, when Christianity was recognized as the official religion.

b) The Christian period begins in 301 AD. However, its establishment in Armenia took place with fluctuations. In the initial stage, the hermit-ascetic movement was widespread, which was later replaced by an organized monastic movement.

Hermits (ascetics) are religious people who renounced secular life and lived an ascetic life, residing in remote and hardly accessible places far from settlements (such places were called hermitages). Hermit life was characteristic of all religions. In Christianity it originated in Egypt in the 2nd–3rd centuries. In the 4th century it spread to the countries of the Near East, including Armenia. Hermitism in Armenia had a widespread nature. Starting from the 4th century, it existed until the late Middle Ages–the 17th century. After the 17th century, when all hermitages disappeared, all the dwellings of hermits became ordinary residences, and the cult structures (rock-cut or surface) became accessible to everyone.

The same processes took place in Geghard Gorge. In the early Middle Ages, Gregory the Illuminator founded the monastery of Ayrivank here, where Nerses the Great (353–373) and Sahak Partev (387–439) and others led a hermit life. In the 920s, the hermits were subjected to Arab invasions. According to historical data, Geghard Monastery had a permanent abbacy starting from 1181, that is, if before that it functioned as a monastery for small groups of hermits, then after that it became a monastic complex with cult, economic and auxiliary buildings. However, a number of references suggest that alongside the organized monastic complex, groups of hermits also functioned, and there are references about them until 1429 (Poghosyan-Khaghbakyan 2003).

The monastery (Fig. 5, 6) reached its peak in the 14th century, when it became the property of the Proshian dynasty.

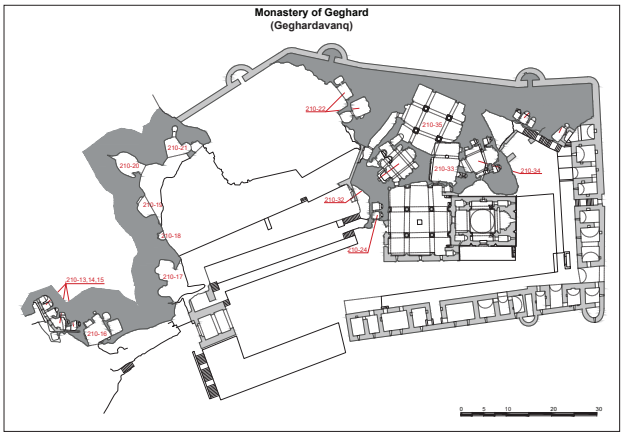

Fig. 5. Plane of Monastery of Geghard (plan Vahramian H.)

Fig. 6. Photo of Monastery of Geghard (photo Armenyan T.)

During more than 2000 years of use, dozens of artificial caves were carved in Geghard Gorge. According to their functional purpose, they are divided into the following groups: residential, cult, memorial, communal, defensive, which in turn are subdivided into separate types (Table 1).

Thus, in Geghard Gorge, which is a sacred territory, pagan and Christian sanctuaries are distinguished. As a patron, for the pagan sanctuary, the royal family (the Arshakuni) acted, which also built the Garni temple (1st century).

During the Christian period, in the first–hermit stage (4th–11th centuries), the patrons and builders were the hermits-ascetics; therefore all structures are small in size and have simple decoration.

During the monastic period (12th–14th centuries), princely houses (Zakarians and Proshians) acted as patrons, and the rock-cut structures (as well as surface buildings) built by them are large and richly decorated.

Table 1. The artificial caves of Geghard Gorge (table Davtyan S.)

Cadastral number	Name	Functional purpose	Type	Period of construction	Note
210-27	40 Astichani cave (40 Steps cave)	Dedicated to the cult of Mihr tunnel-cave	Tunnel-cave	1st century AD	
210-23	Chapel of Grigor Lusavorich (Gregory the Illuminator)	cult	chapel	4th century	3 adjacent single-nave halls
210-32	First rock-cut church (Avazan (Basin))	cult	church	1230–1250s	cross-domed structure
210-33	Second rock-cut church	cult	church	1283	cross-domed structure
210-33	Gavit of the second rock-cut church	memorial	gavit-tomb	1283	
210-34	Surb Astvatsatsin (Holy Mother of God) church	cult	church	13th century	cross-domed structure
210-35	Gavit (zhamatun-tomb) of Papak and Ruzukan	memorial	refectory-tomb	1288	central composition with 4 columns
210-13	Semi rock-cut church of Surb Astvatsatsin (the Holy Mother of God)	cult	church	1164	rectangular single-nave hall
210-14	Unnamed	cult	chapel		three single-nave halls
210-24	Unnamed (near the monastery gavit)	cult	chapel	Early Middle Ages	two single-nave halls
210-5	Mkhitar Ayrivantsi	residential	hermitage-dwelling	1291	
210-4	Jgnavori (Hermit's) cave	residential	hermitage-dwelling	Early Middle Ages	
210-7	Cave with window	residential	hermitage-dwelling	Early Middle Ages	
210-8	Hermitage	residential	hermitage-dwelling	Early Middle Ages	
210-9	Hermitage	residential	hermitage-dwelling	Early Middle Ages	
210-31	Chito's houses	residential	hermitage-dwelling	Early Middle Ages	
210-29	Zoranoc (Barracks)	residential	summer residence	Middle Ages	
210-30	Unnamed chapels	cult	chapel	Middle Ages	
210-36	Newly discovered chapel	cult	chapel	Middle Ages	single-nave hall based on a natural cavity
210-37	Collapsed refectory(1967)	communal	refectory	Middle Ages	15m × 9m ×5 m

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New Materials for the Study of the Gareji Monasteries (Georgia)

Ketevan Digmelashvili
National Agency for Cultural Heritage Preservation of Georgia
ketisha80@gmail.com
Nikoloz Zhgenti
K. Kekelidze National Centre of Manuscripts of Georgia
nikozhgenti@gmail.com

Abstract
This article examines the Satorge cave complex in the Gareji Mravalmta region and its importance for understanding the relationship between medieval monastic centers and surrounding settlements in eastern Georgia. Previous scholarship generally viewed the Gareji monasteries as isolated religious communities, focusing mainly on cave architecture and monastic life. However, discoveries at the "Kvabebi" complex and, more recently, at Satorge challenge this interpretation by demonstrating close connections between monastic institutions and nearby inhabited settlements. The Satorge complex, located near the Georgian–Azerbaijani border on the right bank of the Iori River, includes a large domed rock-cut church, smaller monastic and hermitage structures, and a large adjoining settlement. Architectural and stylistic evidence dates the churches to the 9th–10th centuries. Georgian inscriptions preserved in the complex provide important chronological and historical information. Painted and incised inscriptions mention clergy, local nobles, and King Kvirike III of Kakheti-Hereti, whose donation inscription suggests that Satorge functioned as an influential ecclesiastical seigneury with economic and territorial authority.
The article also analyzes graffiti associated with Golden Horde symbolism discovered within the complex. Together with historical written sources concerning Berke Khan's invasion of eastern Georgia in 1265, these findings indicate that Satorge likely suffered destruction during Mongol incursions.
Archaeological evidence from the settlement - including ceramics, glass, metalworking remains, jewelry, and industrial waste - demonstrates the existence of local craft production, metallurgy, and an organized economic system between the 9th and 13th centuries. The settlement's typological similarities to the "Kvabebi" complex strengthen the hypothesis that certain Gareji monastic centers functioned not as isolated monasteries but as integrated ecclesiastical-economic centers surrounded by dependent settlements, agricultural lands, and craft industries.
The study concludes that the discovery of the Satorge complex significantly reshapes the historical understanding of the Gareji Mravalmta monasteries and highlights the importance of further archaeological investigation of settlements associated with the region's rock-cut monastic complexes.

Keywords: Gareji, Monastery, Settlement, Satorge, Kvabebi

The monasteries of the Gareji Mravalmta (multi-mountain) have long remained at the center of scholarly attention. With rare exceptions, source-critical, art-historical, paleographic, and archaeological studies devoted to the Gareji Mravalmta area have primarily focused on the architecture of the cave complexes themselves and on monastic life. Consequently, considering the present climatic and environmental conditions, the prevailing assumption has been that the monasteries of Gareji emerged and continued to exist in relative isolation, far removed from settlements.

In this regard, an exception appeared to be the 9th–11th century settlement and cemetery investigated during various years near the "Kvabebi" complex of Gareji. The evidence obtained there demonstrated that the "Kvabebi" complex represents a monument typologically distinct from other centers within the Gareji monastic union, thereby raising new questions concerning the relationship between the cave complex and the adjacent settlement. In particular, the issue arose whether Kvabebi constituted a monastery accompanied by a settlement, or rather a secular settlement – a "rock village" – associated with surrounding habitation sites (Tvalchrelidze and Skhirtladze 2010, 104–105). In this respect, the Satorge complex has provided particularly significant new evidence.

The Satorge complex is situated near the Georgian–Azerbaijani border, on the right bank of the Iori River, near Mount Kajiri. The complex includes a large domed rock-cut church, an adjoining settlement, and hermitages or small monastic centers located 1.5–3 km from the main church: a decorated domed rock-cut church, a hall church with monastic and cells domestic use, and the remains of an almost entirely collapsed monastery. The large domed church and the settlement were first discovered by researchers in 1965, while the remaining churches were identified during the years 2020–2022 (Zhgenti 2025) (Fig. 1).

On stylistic grounds, the churches of the complex are

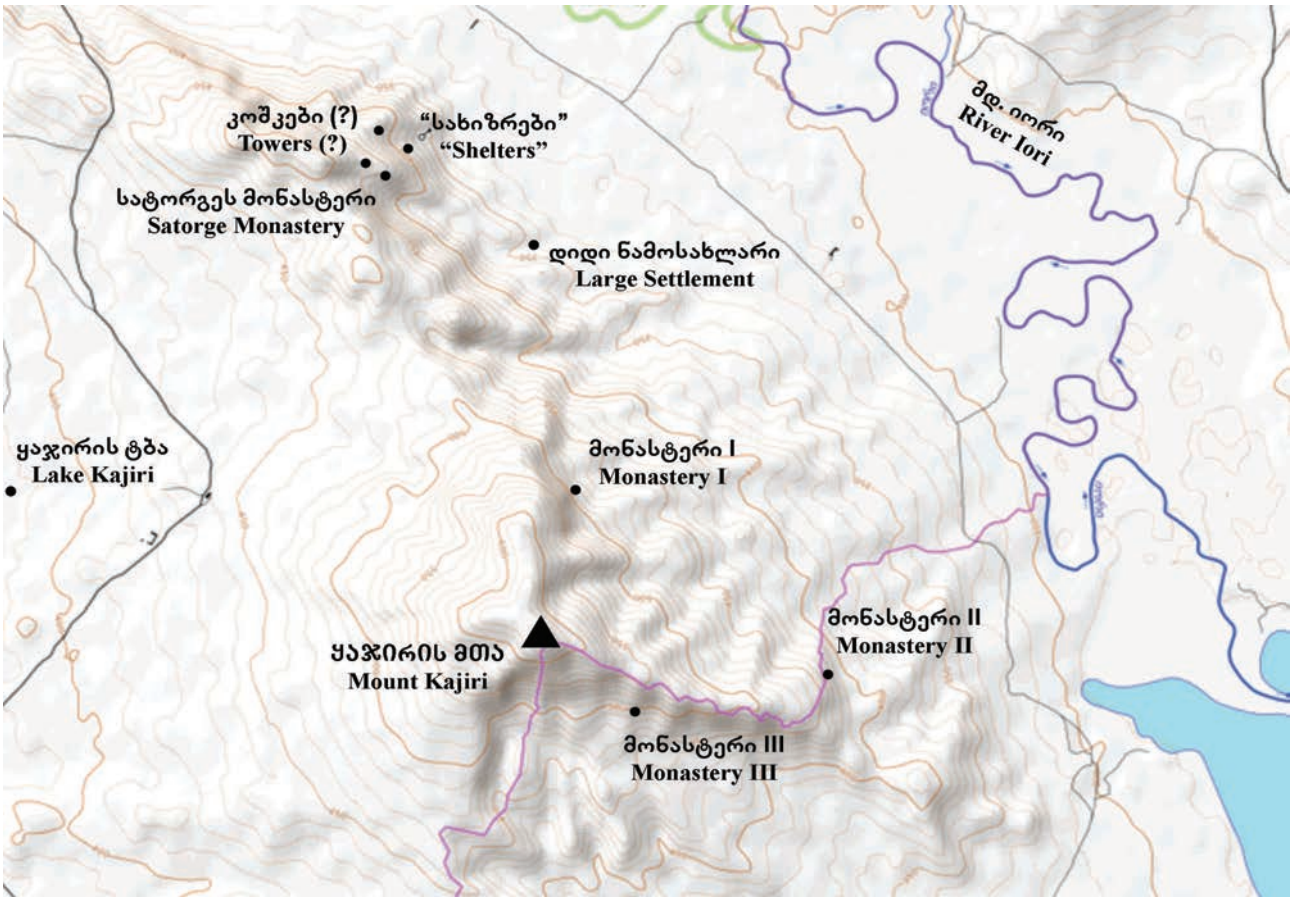

Fig. 1. Geographical sites and Monuments of Cultural Heritage in the Research Area

dated to the 9th–10th centuries. Of particular importance for determining the chronological framework of the complex are the Georgian inscriptions preserved in the large domed church and the graffiti images preserved in the church with monastic cells.

Some of the inscriptions preserved in the large domed church were fresco inscriptions painted in black pigment within the sanctuary, while others were incised graffiti. The painted inscriptions were executed using the same pigment and technique and, on paleographic grounds, are dated to the 9th–10th centuries. They are supplicatory in character, invoking mercy for certain individuals named Nishai, Gabriel, and Ivane. Since these inscriptions were painted with brush and pigment on the sanctuary wall of the church, it may be assumed that the persons mentioned were members of the clergy serving the church (Fig. 2).

Among the incised inscriptions, especially significant are two inscriptions located in the southern chapel of the church and another carved into a church window, all of which date to the 11th century. One of them is a commemorative supplication for Gurgen and his sons (?), who were presumably Kakhetian nobles; another mentions Kvirike and a dean; while the third constitutes a juridical act of donation, according to which King Kvirike granted to Tobaiod the bank of the Iori River, or certain property situated in the Iori valley. The Kvirike mentioned in these two inscriptions must be Kvirike III the Great, King of Kakheti-Hereti (1010/1014–1039), who is known from other sources as a patron and benefactor of churches.

Unfortunately, the inscription is fragmentary, and the full reconstruction of the text is impossible. It cannot be excluded that Tobaiod may even represent the earlier name of this monastery and that the inscription records the renewal of the donation of the settlement located near the Satorge church.

The inscription referring to King Kvirike's donation is also important because it presents the Satorge church as a powerful ecclesiastical seigneury. Most likely, in exchange for this donation, King Kvirike also established an *Eukterion* - a commemorative liturgy within the same church (Zhgenti 2025, 37, 45–54, 109, 116–125) (Fig. 3).

Particularly noteworthy are the graffiti incised on the plaster of the church with monastic cells. Among them, special attention should be paid to a large number of engraved symbols associated with the iconography of the Golden Horde (Zhgenti 2025, 68–69, 137–138). Such symbols appeared on Golden Horde coinage and on European maritime maps as markers of the territory of the Golden Horde (Мартынюк 2008, 79–83; Юрченко

Fig. 2. Satorge church (view from western wall) (photo Zhgenti N.)

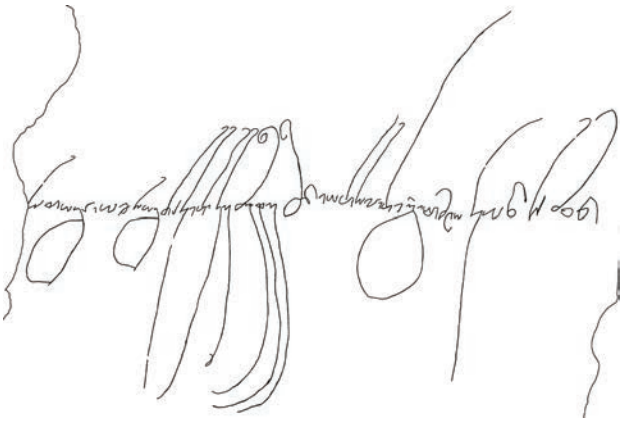

Fig. 3. Satorge church inscription of donation by King Kvirike (palaeographic copy)

2008, 50–60; Савоста 2013). Georgian written sources record that in 1265 Berke Khan of the Golden Horde invaded eastern Georgia. As a result of this campaign, numerous cities and settlements were devastated and destroyed, including Rustavi, Khornabuji, Khunani, and others (The Georgian Chronicles 1959, 254). At the same time, part of the David Gareji monastic complexes was destroyed as well. Apparently, Satorge was among them. The settlement associated with Satorge provides corresponding evidence.

The settlement extended in terraces across nearly 30 hectares on the northern slope of the ridge. The upper terrace contains the large domed church, as well as a watchtower and a large water reservoir. Throughout the territory of the settlement, one encounters ceramic vessels, bronze objects, glassware, jewelry, and other artifacts. Among these are numerous defective products, as well as glass and iron slag, indicating that the inhabitants produced ceramics and glass locally and that metallurgy was also developed there. The material recovered from the settlement is securely dated to the 9th–13th centuries, indicating that the settlement and the rock-cut churches of Satorge existed contemporaneously.

Typologically and materially, the Satorge settlement is analogous to the settlement associated with the "Kvabebi" complex, likewise situated near a cave complex belonging to the Gareji monastic system.

Its discovery and similarity to Kvabebi have strengthened the hypothesis advanced concerning the "Kvabebi" complex. Specifically, in the case of Gareji "Kvabebi," we are dealing with a type of ecclesiastical seigneury in which compact settlements, together with their industrial and craft centers and agricultural lands, were organized around a religious center (Tvalchrelidze and Skhirtladze 2010, 104–105). We believe that the settlement of Satorge likewise represents the same type of ecclesiastical seigneury associated with a connected habitation site. This is indicated, on the one hand, by the extent and location of the settlement near the bank of the Iori River, which provided access to fertile floodplain lands, and, on the other hand, by the principal church carved directly into the edge of the settlement, which, according to King Kvirike's inscription, functioned as the main church of the ecclesiastical seigneury.

Thus, the discovery of the Satorge cave complex and its associated settlement opens a new historical chapter in defining the character and context of the rock-cut complexes of the Gareji Mravalmta region. We believe that further investigation of possible settlements surrounding these complexes will yield even more precise conclusions.

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Caves in the Armenian Belief System: The Case of St. Gregory the Illuminator's Cave in Sarnaghbyur

Hasmik Galstyan
Institute of Archaeology and Ethnography, Yerevan, Armenia
Shirak Center for Armenological Studies, Gyumri, Armenia
hasmikgalstyan1979@gmail.com

Roman Hovsepyan
Institute of Archaeology and Ethnography, Yerevan, Armenia
roman.hovsepyan@yahoo.com

Abstract

In the cultural landscape of the Armenian Highlands, stone and rock serve not merely as elements of the geographical environment but as central symbols of the national worldview and belief system. As the most mysterious features of the natural mountain relief, caves have been perceived since ancient times as sacred spaces where the boundaries between the earthly and the otherworldly intersect.
The purpose of this study is to examine the cultic role of caves in Armenian beliefs, focusing on the cave-shrine of St. Gregory the Illuminator in the village of Sarnaghbyur, Shirak Province. This monument is an exceptional example where ancient pagan strata, Christian hagiography, and traditions of folk medicine intertwine. The historical transformation of the cave–from a natural cavern to an architecturally modified sanctuary–allows for an analysis of the resilience of faith even under the conditions of Soviet atheistic policy.
The cult of caves is almost invariably accompanied by the cult of water. In the case of Sarnaghbyur, we observe that the water flowing from or collecting within the cave is endowed with miraculous properties. Semiotically, this is explained through the symbolism of the womb: the cave represents the womb of Mother Earth, and the water is the life-giving fluid possessing procreative and healing powers. Notably, the faith in the water at the Sarnaghbyur cave has practical applications, such as the treatment of skin diseases, which attests to the integration of ethnomedicine and religious faith.
During the Christian era, the "Christianization" of natural caves occurred through the asceticism of saints. The legends associated with St. Gregory the Illuminator (his ascetic life and the miraculous bringing forth of water through prayer) theoretically fall under the category of "the creation of a sacred landscape." Through his presence and prayer, the Saint "cleanses" the cave of any potential evil forces previously inhabiting it, transforming it into an accessible and safe pilgrimage site for humans.
The folk tales–woven around the Sarnaghbyur cave can be divided into three primary layers reflecting the stages of development of the Armenian belief system. The first is the motif of the Saint's asceticism and the "sanctification" of the area. The version suggesting that Gregory the Illuminator spent the final days of his life here views the cave as a center of spiritual power. From a scholarly perspective, this represents the "appropriation of place" through the saint. The cave ceases to be a mere geological formation and becomes a "fortified" space where prayer has materialized, imparting healing properties to both the stone and the water.
The second and third versions (requesting water to quench thirst or pleading for water "the size of a tear") resonate with the biblical figure of Moses, who struck the rock to bring forth water.
Sarnaghbyur has preserved classical forms of pilgrimage that unite ancient and Christian customs. The Vardavar celebrations, recorded in modern times as well, represent the most essential link to the pre-Christian period. As a festival of water worship, Vardavar regains its original meaning within the cave: the veneration of sacred water springing from the depths of the earth. The example of St. Gregory the Illuminator's cave in Sarnaghbyur proves that in the Armenian belief system, a cave is not merely a geographical location but a cultural text. It encapsulates the Armenian person's connection to the land, the water, and the spiritual ancestor (the Illuminator).

Keywords: Sacred Landscape; Cave Cult; Spring; Folk Christianity; *Vardavar*

Introduction

Within the cultural landscape of the Armenian Highlands, natural formations – mountains, cliffs, springs, and caves – function not only as environmental features but as symbolic components of cosmological and religious thought, perceived as sacred loci mediating between human and supernatural worlds.

Caves occupy a particularly significant position in this symbolic order. In mythological consciousness, the cave represents an enclosed, liminal space poised between light and darkness, life and death, the earthly and the chthonic. As such, it is commonly associated with the underworld, initiation, transformation, and communication with supernatural forces (Toporov 1988, 311–312). Armenian folk belief also reflects this dual valuation: caves may serve as dwelling places of dangerous supernatural beings – dragons (*vishaps*) (Mkrtchyan 1963, 78–86), spirits and demons (Lalayean 1903, 210), or vampires (Haxthausen 1854, 191–192) – while others are regarded as sacred sites connected with saints, healing, and pilgrimage. During the Christian era, many natural caves underwent reinterpretation through association with saints and ascetic practice.

This article examines the sacred and cultic functions of caves in Armenian belief traditions through the example of the cave-shrine of St. Gregory the Illuminator, located near the village of Sarnaghbyur (*"Cold Spring"* in Armenian) in Shirak Province (Fig. 1). The site represents an exceptional convergence of pre-Christian nature worship, Christian sacred tradition, folk medicine, and pilgrimage ritual. Situated at approximately 1,925 meters above sea level, the cave was partially modified in 1954, when a wall was erected at its entrance and the spring redirected through pipes to supply nearby settlements. Despite these interventions and the anti-religious policies of the Soviet period, the cave has retained its sacred status and continues to function as an active pilgrimage destination.

Sacralization of the Cave

The Christian sacralization of natural caves (or maybe Christianization of non-Christian cave-shrine?) can be interpreted as a process of constructing a *"sacred landscape."* Through the saint's attributed presence, prayer and ascetic practice, a geological formation becomes integrated into Christian sacred geography, acquiring spiritual charge and miraculous potency. In comparative mythology, caves are interpreted as liminal spaces associated with transition, rebirth, and revelation, simultaneously evoking the womb, the grave, and the underworld (Eliade 1972, 47; Baghdasaryan et al. 2005, 292–293).

According to oral traditions recorded during fieldwork (2023), St. Gregory the Illuminator sought refuge in the Sarnaghbyur cave while fleeing persecution. Tormented by thirst, he prayed to God, whereupon water miraculously emerged from the rock. An alternative version holds that the saint spent his final days in this

Fig. 1. The Sarnaghbyur cave-sanctuary in the Shirak Province, Armenia (30.09.2023, photo by Galstyan H.)

Fig. 2. A moment of ritual healing through water pouring at the Sarnaghbyur cave-sanctuary (25.06.2023, photo by Hovsepyan R.)

cave. These narratives illustrate a process of symbolic *"appropriation of place"*: the cave acquires sacred legitimacy through its association with Gregory the Illuminator, a figure of foundational importance to Armenian Christian identity. The cave-spring complex thus operates as a unified system of fertility, healing, and spiritual renewal, drawing on the deep-seated symbolic identification of caves with the womb of Mother Earth and of spring water with life-giving, regenerative power (Cirlot 2001, 40).

Healing Functions and Folk Medicine

In local belief, the cave-shrine possesses distinct healing efficacy. The spring water is held to cure various ailments, particularly skin diseases. Pilgrims customarily visit three or seven times – numbers that carry sacred significance in Armenian ritual culture, denoting completeness and spiritual perfection. The site also functions as a fertility shrine: childless women or couples visit seeking divine assistance in conceiving children, a belief directly grounded in the cave's womb symbolism – entering the cave and drinking or being poured by its spring water (Fig. 2) symbolically enacts entry into the generative space of the earth.

The water is employed in several healing modes: drinking, bodily washing, topical application to diseased areas, and, according to field records, calming restless infants. Oral narratives collected from local inhabitants further document miraculous protection ascribed to the site, including accounts of pregnant women surviving dangerous falls and individuals escaping injury from falling rocks near the cave. Such narratives serve as collective testimonies that validate the site's sacred efficacy and sustain pilgrimage traditions across generations.

Pilgrimage and Ritual Practices

The cave of St. Gregory the Illuminator attracts pilgrims from across Armenia. Ritual practices at the site combine pre-Christian elements of nature worship with Christian devotional customs: prayer, candle-lighting, drinking of sacred water, washing, and the carrying of water home for further use.

The principal annual celebration associated with the shrine is *Vardavar*, the Armenian water festival, which preserves some of the clearest traces of pre-Christian water veneration in the Armenian ritual calendar. At Sarnaghbyur, the festival takes on a particularly archaic meaning, centered on the worship of sacred water emerging from the depths of the earth.

The resilience of these practices is notable given Soviet-era suppression. Local oral tradition records that in the 1920s–30s, attempts were made to destroy the cave in order to discourage religious devotion; these efforts allegedly failed after rockfalls endangered those conducting them – an outcome interpreted locally as evidence of the cave's supernatural protection. The architectural modifications of 1954, which incorporated the spring into the village water supply, similarly did not diminish its sacred character. Technological integration and sacred perception coexisted without apparent contradiction.

Conclusion

The cave-shrine of St. Gregory the Illuminator in Sarnaghbyur exemplifies the multilayered character of cave sanctuaries in the Armenian belief system, where pre-Christian cosmology, Christian hagiography, folk medicine, and pilgrimage tradition converge. Three principal factors shape the site's sacred character: the natural environment, the body of legend associated with the saint, and the continuity of community ritual practice.

Central to the site's significance is the sacred spring, understood as a source of healing, fertility, purification, and divine grace. The cave's identification as a *"child-giving sanctuary"* reflects the persistence of womb symbolism within a Christianized framework. The Sarnaghbyur case further demonstrates the remarkable durability of sacred landscapes under conditions of institutional suppression: preserved through oral tradition, miracle narrative, and uninterrupted pilgrimage, the site has remained a living religious space.

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Architectural Characteristics and Spatial Organization of the Medieval Rock-Cut Cave Monastery of Krepcha (Bulgaria)

Miroslav Georgiev

Regional Historical Museum – Targovishte (Bulgaria)
miro764@abv.bg

Abstract
The Krepcha Cave Monastery, located near the village of Krepcha, Targovishte District, is a remarkable monument of medieval rock-cut architecture dating back to the First Bulgarian Kingdom (10th century). The cloister was carved into a limestone massif and is organized stepped across three natural levels (terraces). The architectural complex includes a monastic church, a tomb-church (crypt), and monastic cells. The middle terrace, which is accessible to visitors today, housed the rock-cut church. Its layout reveals all the classical elements of Christian cave architecture: a well-defined altar section with an apse, arched niches, and t races of an iconostasis.
An exceptionally interesting architectural feature is the presence of clearly defined rock-cut sockets (joist holes). These provide evidence that, in the past, the rock cloister featured a massive external wooden construction–likely a covered gallery supported by wooden beams. These structures connected the individual rooms and protected the temple and the cells from harsh climatic conditions. Within this impressive complex, Cyrillic, Old Hebrew, and runic inscriptions, as well as drawings, are incised onto the walls of the ossuary, the rock church, and around some of the cells.
Two of the Cyrillic inscriptions are of extraordinary scientific interest. They contain information regarding the death of the monastery's founder–Father Antony. He was likely the progenitor of the rock-cut cloister. One of the preserved graffiti represents the oldest dated Cyrillic inscription in the world. It records the death of the monk Antony in AD 921, establishing the cleric as one of the founders of hermitism in the Bulgarian lands. This article presents unpublished data from the author's own research. The theme of the monastery's architecture has not been examined extensively, as previous studies have focused primarily on the inscriptions on its walls.

Keywords: Cave Monastery; First Bulgarian Kingdom; rock-cut architecture; cave church

Introduction

The site is located 1.9 km southwest of the center of Krepcha (Targovishte region), near the last houses of the village, in the locality of Pod Peshterite. It is a two-story rock monastery complex (Fig. 1). It is hewn into an isolated, protruding rock massif 100 m long and 25 m high, formed in the upper part of the bank of one of the tributaries of the Cherni Lom River.

The rock monastery was discovered for science by K. Shkorpil (Shkorpil 1914, 102–104). In the early 1970s, it was explored by K. Popkonstantinov, who discovered and later published numerous epigraphic materials from its premises (Konstantinov 1977, 19–28; Popkonstantinov and Kronsteiner 1994, 41–59). One of the inscriptions is the earliest dated Cyrillic inscription in the world, from 921. It mentions the death of a monk named Anton, who was probably the founder of the monastery.

The first floor of the rock cloister is an arc-shaped terrace with a flat floor (Fig. 2). Its length is 61 m, and its width varies from 1 m to 4 m. Its central part is oriented south-southeast. On the facade wall of this first floor, there are five natural rock niches that contain minimal traces of artificial carving. The premises were roughly adapted for habitation and likely functioned as monastic cells or utility rooms.

Niche No. 1 has a trapezoidal shape and measures: 4.20 m in width, 1.70 m in depth, and 2.20 m in height. The floor of the room consists of two stepped, long limestone slabs, which continue into the next three niches. The upper slab probably served as a bed or bench, as its surface is smoothed. At the southern end of the niche's ceiling, near the outer edge, a row of five medium-sized sockets for vertical wooden beams are carved.

Niche No. 2 is located 6 m east of niche No. 1. It has an irregular semi-oval shape and measures: 4.70 m in width, 2 m in depth, and 2.45 m in height. Similar to niche No. 1, its floor is composed of the same two stepped rock slabs. The ceiling of the niche bears traces of artificial shaping and scorching. A roughly leveled section measuring 1.45 x 1.10 m is shaped in its central part. Along the southern periphery of the ceiling and at the western end of the niche, a series of sock-

Fig. 1. The medieval rock monastery near the village of Krepcha – general view

ets are carved, which served to secure thin vertical and horizontal beams. It is likely that the front of the room was closed off with a wooden partition structure, and in front of it, there was a light awning with a horizontal roof.

Niche No. 3 is located 2.60 m east of niche No. 2. It has an irregular trapezoidal shape and measures: 3.80 m in width, 1.70 m in depth, and 2 m in height. The floor of the room consists of three stepped limestone slabs. In the middle part of the eastern short wall, a composition of three longitudinal cone-shaped sockets is carved, arranged in a fan shape along the curve of the rock, as well as an almost vertical, narrow, wedge-shaped groove. The purpose of these carvings on the eastern wall of the room is unclear. They probably served to attach some kind of wooden structure related to the room‘s function.

Niche No. 4 is located 2.40 m northeast of niche No. 3. It has an irregular triangular shape and measures: 7 m in width, 3.70 m in depth, and 2 m in height. Similar to the first two rooms, its floor is composed of two stepped rock slabs with smoothed surfaces. Numerous sockets are hollowed out on the ceiling of the niche and on the facade above it, which served to secure vertical beams and structural ribs for a light single-pitched roof that covered part of the terrace. A natural rock platform up to 4 m wide and 7 m long is formed in front of the room.

Niche No. 5 is located 10 m northeast of niche No. 4. The terrace leading to it abruptly narrows in the northern direction. The room is formed at the lower part of a vertical rock crevice that reaches the top of the massif. The entrance to the niche measures 3.90 m in width and 3.15 m in height. The room has an irregular wedge-like shape, its depth is 6.20 m, and towards the interior, it narrows and its height decreases to 1 m. The floor is stepped at the entrance, with a slight upward incline, becoming flat in the interior. Its surface is smoothed, indicating intensive human presence. The walls are rough and uneven, with traces of intense scorching.

A part of the first terrace most likely had a wooden parapet erected on its southern periphery, which encompassed the space in front of niches No. 1, 2, and 3. A wooden staircase led from the first to the second floor; its structure was attached perpendicularly to the western part of the monastery‘s facade.

The second floor of the complex is conventionally divided into two sections–western and eastern–separated by a transverse rock fold in the massif. In each of them, there is one hewn room: the rock church and the church-ossuary (crypt), respectively (Fig. 3).

The second terrace in the western section rises to a height of 5.30 m from the level of the first. It is 23 m long and up to 2.50 m wide. The most extensive and massive artificial modification on the site‘s territory was carried out in this section of the floor. Besides the rock church, numerous sockets and grooves were carved for the construction of a complex wooden structure, which was a wooden platform covered with a single-pitched roof, projecting in front of the terrace‘s facade. It served primarily as a walkway and an approach to the church. Probably at some stage of its existence, it was also reconstructed for residential functions. At its eastern

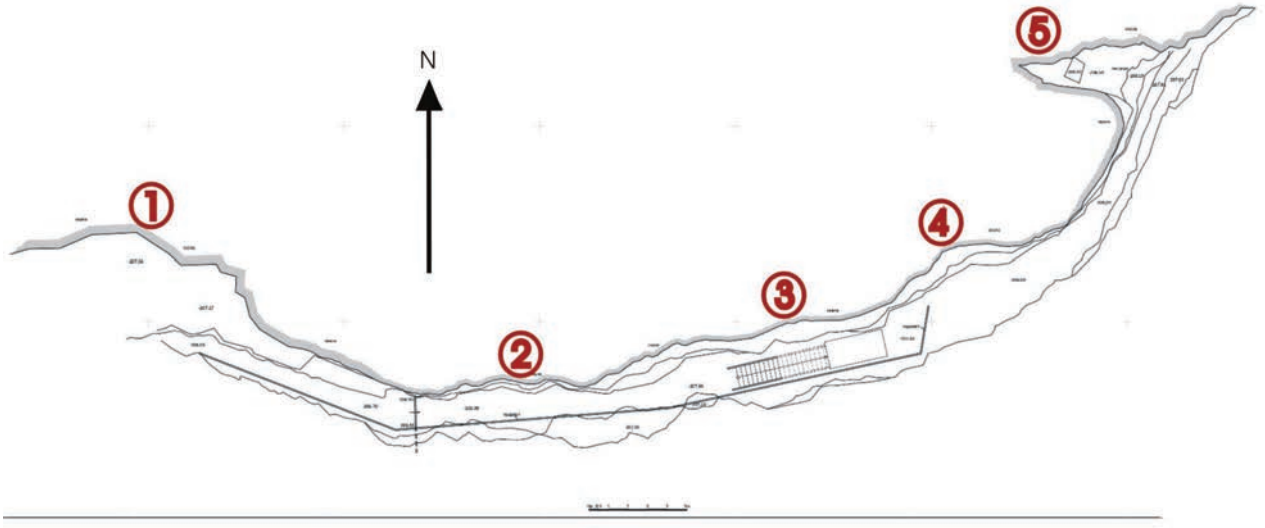

Fig. 2. Plan of the first terrace – horizontal section. The locations of the habitable niches are marked with Nos. 1 – 5 (by NIINKN - Sofia)

end, there was a rectangular wooden-board room, most likely a cell. The architectural reconstruction of the platform is complex and uncertain due to the destruction in some parts of the rock and the variety of sockets carved during different construction periods.

The rock church of the monastery is located in the eastern part of the western section of the second terrace. Its entrance faces south and is flanked by two windows. It measures 1.21 m in width and 1.83 m in height. The temple was very carefully hewn into the volume of a natural cave and has a shape close to a square. The walls are very well leveled, and a large chisel was predominantly used for their processing. The room measures: up to 6.62 m in width, up to 6.76 m in length, and up to 1.95 m in height.

At the southern end of the eastern wall, a large, roughly carved quadrangular niche functioned as an altar apse. It is located at a height of 0.77 m from the floor, is 1.40 m wide, 0.30 m deep, and 1.12 m high. In the middle of the bottom surface of the niche, a round socket with a diameter of 0.12 m and a depth of 0.09 m is carved, which most likely served as a reliquary chamber. In the wall, below the lower edge of the niche, two symmetrical trapezoidal sockets are hollowed out, serving to attach a wooden altar table to the wall. In the northern half of the eastern wall, another quadrangular niche is carved. It is located 0.48 m from the floor and is 1.41 m wide, 0.24 m deep, and 1 m high.

K. Shkorpil assumes that an east-west oriented wooden wall divided the room into two parts–a front one and a wider rear one (Shkorpil 1914, 104). According to him, the narrower southern part was a narthex, and the wider one was the actual church. R. Kostova thoroughly analyzes the architectural and liturgical features of the room and identifies it as a church primarily because of the two quadrangular niches on the eastern wall (Kostova 2005, 291–292). She believes that the intensive relations between the monks and the laity led to the arrangement of the rock church as a two-nave structure with two altars.

There was evidently an altar screen in the eastern part of the room. Traces of its attachment are visible on the northern and southern walls.

The multitude of small quadrangular and round sockets, carved seemingly chaotically on the upper half of all walls, have an unclear function. Their highest concentration is on the northern and western walls. The quadrangular sockets measure: 0.02-0.03 m in width, 0.04-0.07 m in depth, and 0.02-0.03 m in height. The round ones have a diameter of 0.03-0.05 m and a depth of 0.06 m, respectively. It can be assumed that in a later period, the interior of the church was altered, with its walls paneled with boards nailed into wooden dowels placed in the sockets. The hypothesis that wooden pegs were driven into the holes to serve as coat hooks, or that wooden boards were placed on them for shelves, cannot be excluded.

The church-ossuary is located 8 m northeast of the rock church, in the eastern section of the currently inaccessible second floor of the complex, at a height of 5.40 m from the level of the first floor. It is hewn into the volume of a natural cave. Its entrance opening faces east-southeast, has an irregular elliptical shape, and measures 4 m in width and from 1.10 to 2.95 m in height. As is evident from the shaped sockets and grooves, in its right (northern) part there was a low wooden door measuring 1.10 x 1.50 m. East of the entrance, along the southern facade wall of the rock terrace, a large, elongated, and shallow rectangular niche was roughly carved, serving as a kind of south-open corridor–an anteroom to the crypt. Most likely, when the monastery was functioning, access from the first floor to the crypt

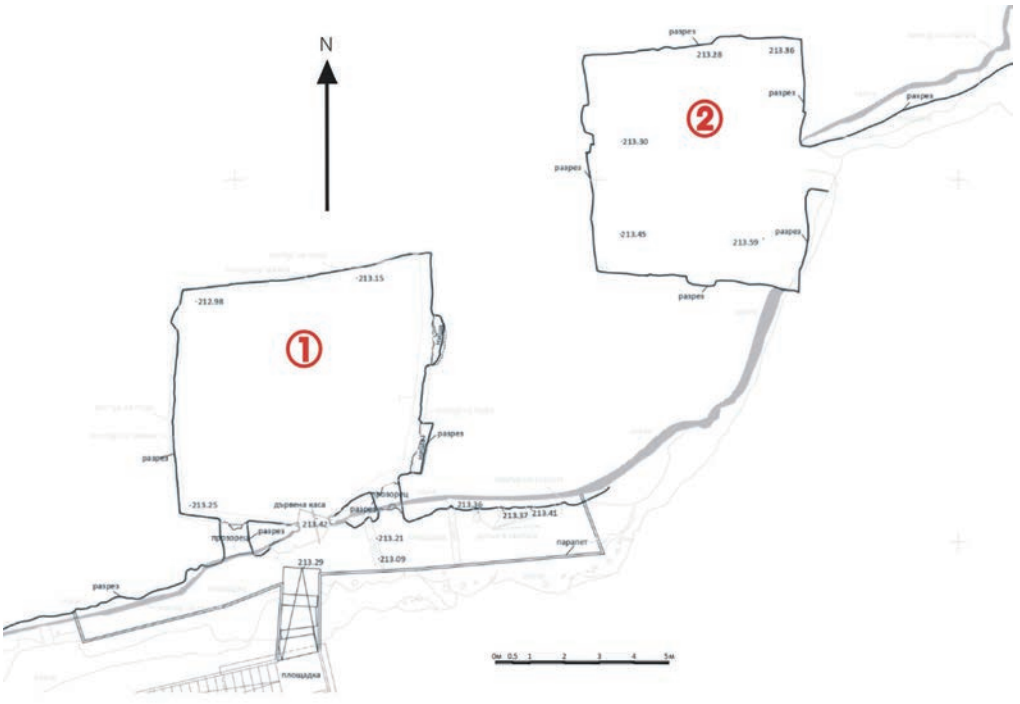

Fig. 3. Plan of the second floor of the monastery with the two rooms – the rock church (1) and the church-ossuary (2) – horizontal section. (by NIINKN - Sofia)

was provided by a wooden structure combining a ladder with a wooden floor, which were anchored in the hewn volume of the niche.

The church-ossuary has an almost square shape, resembling the outlines of the rock church from the western section of the second terrace. The room measures: from 5.70 to 5.90 m in width, 6.50 m in length, and 1.78 m in height. With the exception of the eastern wall, the other walls are roughly hewn with a large chisel and slant outward at the bottom. In three of the walls–the northern, western, and southern–at a height of 0.40 m to 0.70 m, one shallow niche with a rectangular to elliptical shape is hollowed out in each. They measure: from 0.80 to 0.90 m in width, 0.11 to 0.22 m in depth, and 0.25 to 0.40 m in height. In the upper part of all walls, compositions of small round and square sockets can be seen, identical to those in the rock church.

The floor of the church-tomb is very precisely leveled, especially in the entrance area and the northeast corner. In it, by the eastern end of the northern wall, a burial chamber is carved. It is oriented west-east and measures: 1.88 m in length, 0.46 m in width at the western end, 0.32 m in width at the eastern end, and 0.25 m in depth. Today, there are no traces of grooves for a cover lid, but K. Shkorpil mentions a recessed frame 0.09 – 0.15 m wide that served this function (Shkorpil 1914, 103).

Across the middle of the floor and ceiling, from the entrance to the western wall, runs a transverse natural crack. Within its outlines on the floor, two other graves are carved in a chain, oriented west-east. They are severely collapsed and filled with soil deposits and rock debris. Around the fissure, a large, shallow rectangular depression with a precisely polished surface is shaped. It starts from the room‘s entrance but is obliterated toward the eastern wall. Its width is 2.40 – 2.50 m, and its depth decreases from 0.10 m at the southern end to 0.02 m at the northern end. The depression, as K. Shkorpil also notes (Shkorpil 1914, 102–103), served for laying a wooden board cover over the crevice.

The ceiling is well leveled, but due to the crack, it is divided into two halves with slightly differing levels. In the southwest corner, a large round socket is carved, 0.16 m in diameter and 0.08 m deep, whose function is likely related to the nearby vertical grooves hollowed out on the western and southern walls. The surface of the ceiling bears traces of intense scorching, especially around the entrance.

In a Cyrillic inscription from the early 10th century, carved to the right of the crypt entrance, a monk named Mihal stated that the grave of the „*holy*“ father Antoni is located here and inscribed a curse-warning not to turn this church into a granary (barn) (Konstantinov 1977, 19–22; Popkonstantinov and Kronsteiner 1994, 46–47). Based on the architectural analysis of the room and the data from the graffito, R. Kostova concludes that the cave initially functioned as a granary. Later it was rebuilt into a monastic cell, and subsequently into a tomb chapel. This last transformation provoked a conflict with the local people, as evident from monk Mihal‘s warning (Kostova 2009, 207). For the initial

function of the cave as a cell, the author finds arguments in the carvings of some interior elements (Kostova 2005, 293). She believes that the vertical grooves in the southwest corner served to secure transverse wooden partitions, and the wall niches–for placing oil lamps. Added to the evidence of the room‘s functioning as a cell are the covering of the floor fissure with a wooden platform and the data of a window south of the entrance. R. Kostova supposes that the only inhabitant of the cell was father Antoni himself. After his death, it was turned into a tomb, and later the other two graves were also shaped (Kostova 2005, 294). Father Antoni was probably buried in the individual burial chamber next to the northern wall, a hypothesis supported by the carved crosses east and west of it. Although the northeastern part of the church-ossuary lacks specific liturgical furnishings, such as an altar niche, the space in front of the eastern wall most likely symbolized the Holy Sepulchre and served as a sacred place (altar) for the cult of the deceased „*holy*“ father Antoni.

The monastery was probably destroyed during the Pecheneg invasions in the first half of the 11th century, or much later, in the course of the Ottoman conquest of the region at the end of the 14th century.

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Interpretation of Ornamental Motifs on the Stone Cross Pillar of John the Baptist from David Gareji (Georgia)

Nino Goderdzishvili

Georgian National Museum, Tbilisi, Georgia
Department at Institute of History and Ethnology
nino.goderdzishvili@tafu.edu.ge
+ 995 (558) 900 293

Abstract
This article studies the ornamental repertoire and relief program of the stone cross pillar from the John the Baptist Monastery in David Gareji (late 6th–early 7th centuries). Although researchers have studied its relief program from various perspectives, specific motifs within the pillar's ornamental repertoire lack direct analogies in both local Early Christian and Sasanian art. This article demonstrates the creative transformation of these Sasanian iconographic and decorative elements within the pillar's ornamental system.
The main scientific novelty of this work lies in a fresh interpretation of the stag's figure and the rider's garments, which differs from existing studies. The article argues that the pearled medallion on the animal's body and the rider's decorative harness transcend hitherto accepted purely astral or local archaeological frameworks, directly linking them to the Sasanian imperial repertoire and transcultural symbols propagated along the Silk Road.
As a result of this research, the reliefs of the John the Baptist stone pillar emerge not as a mechanical copy of foreign forms, but as a unique artistic system where an individual plastic language is forged through the synthesis of Sasanian motifs with local traditions. This work offers a new analysis and evaluation of the master's creative approaches, expanding our understanding of the interrelation between the Georgian and Near Eastern art worlds in the Early Middle Ages and shedding light on the complex processes of artistic integration underway in the region.

Keywords: Stone Crosses, Medieval Art, Ornaments, Grapevines, Rosette

Introduction

The stone cross (6th–7th centuries) from the John the Baptist Monastery in David Gareji represents one of the most significant examples of early Christian Georgian sculpture, notable for both its monumental structure and its artistic and stylistic quality. Unique in the history of Georgian relief sculpture, this monument's main side preserves the earliest iconographic composition depicting the hunting of St. Eustace Placida. Beyond its profound historical and aesthetic value, the stele warrants special scholarly attention due to its highly symbolic ornamental repertoire.

The decorative scheme of the stele represents a unique visual synthesis of local pre-Christian traditions, Christian iconography, and Sasanian art. This ornamental system transcends mere decoration; it is imbued with profound theological and symbolic meaning. While the monument has been the subject of numerous studies, its specific decorative elements continue to raise questions and invite divergent interpretations. Although some motifs show superficial similarities to other reliefs of the period, a rigorous analysis reveals specific stylistic traits that necessitate a comprehensive investigation.

The present study aims to examine the influence of Sasanian art motifs on the sculptural decor of the Stone Cross Pillar and to demonstrate how these symbols were creatively transformed through their synthesis with Georgian pre-Christian plastic traditions and Christian iconography. Grounded in this objective, the research hypothesis addresses the following question: how were Sasanian symbolic motifs reflected in the reliefs of the John the Baptist Stone Cross Pillar at David Gareji, and what semantic reinterpretations did they undergo within the context of early Georgian Christian art?

Research Methodology

To achieve the research objectives, a complex art-historical methodology has been employed. Alongside a critical review of existing scholarly literature, the primary tools for investigating the relief program of the monument include formal stylistic analysis, iconographic-comparative analysis, and a systematic-structural approach. This methodology facilitates the synthesis of the multi-layered semantics of the decorative motifs with the monument's overarching theological and conceptual framework.

The structure of this study follows the distribution of the decoration across the vertical registers and distinct faces of the stele. Empirical data was gathered through direct on-site observation, supplemented by detailed photographic documentation and graphic sketches. Furthermore, the decorative elements were typologically classified, allowing for the identification of their underlying compositional principles. This study aims not only at a morphological description of the ornaments but also at a comprehensive analysis of their symbolic language, compositional structure, and their functional relationship with the architectonics of the monument.

Literature Review

The John the Baptist Monastery stele from David Gareji has been examined in scholarly literature through various analytical lenses. The fragment, integrated into the entrance of the church, was first described by Giorgi Chubinashvili (Chubinashvili 1948). Based on paleographic and stylistic features, he dated the relief to the 6th–7th centuries, positing that the monastery belonged to the earliest complex at Gareji. The stele is also notable for the six-line Asomtavruli inscription located beneath the relief. According to Kitty Machabeli (Machabeli 1988), the text contains the abbreviated name of the patron, while the Corpus of Georgian Inscriptions (Shoshiashvili 1980) records the monument as a commemorative stele for *„მოსახსენებელი მართუეცისა“* and dates it paleographically to the 7th century. Later, Niko Chubinashvili emphasized the Sasanian and Byzantine artistic influences evident in the monument during his broader study of early medieval steles (Chubinashvili 2008).

Giorgi Javakhishvili (Javakhishvili 1998) focused specifically on the iconographic program of the hunting scene, crowned by the bust of Christ, as a primary source for early Christian art. Kitty Machabeli (Machabeli 2008) further analyzed the stele's position within the broader context of Georgian stone crosses from multiple perspectives. The ornamental elements of the monument were partially addressed by Tamar Dadiani (Dadiani et al. 2017), who examined the morphological connection between the stag depicted in the hunting scene and pre-Christian openwork buckles. This iconographic scheme and its semantic particularities were also a subject of investigation in Nino Goderdzishvili's doctoral thesis (Goderdzishvili 2020).

The existing bibliography demonstrates that the John the Baptist stele has been primarily discussed through the prisms of iconography, epigraphy, and chronology. The present study shifts the focus toward a formal and semantic analysis of specific ornamental motifs, aiming to present the stele's decor as a unified visual system–a synthesis of Sasanian, Byzantine, and indigenous pre-Christian elements.

The Main Composition of the Stele: The Hunting Vision of Saint Eustace

The stele's composition is distributed across three faces: the primary plane depicts the hunt of St. Eustace, while the lateral sides are adorned with vegetal and geometric ornaments. The hunting scene, set within a frame created by a toroid molding, is divided into two vertical registers (Fig. 1). The upper register features an antlered stag, with the bust of Christ, crowned by a cross-inscribed nimbus, positioned between its antlers. The stag's head is turned backward, and a circular element is set upon its body. In the lower register, the rider is depicted drawing a bow toward the stag. The anatomical proportions are stylized–the hypertrophied figure of the rider appears disproportionately large relative to the horse, yet the horse's harness is rendered with meticulous detail. The rider's lamellar armor is conveyed through a grid of horizontal and vertical lines, with a quiver strapped to his waist. According to Nino Chopikashvili, such armor appears in Georgian reliefs from the 7th century (Chopikashvili 1964), while Kitty

Fig. 1. Fragment of the stone pillar, John the Baptist Monastery. End of the 6th – beginning of the 7th century (photo Mirian Kiladze)

Fig. 2. Engraved plaques for a belt buckle, Orlat, Uzbekistan; 2nd–4th century CE (photo courtesy of the Institute of Art Studies, Academy of Sciences of Uzbekistan)

Fig. 3. Lateral face of the stone pillar, John the Baptist Monastery, featuring grapevine, scroll, and rosette ornamentation (photo Mirian Kiladze)

Machabeli suggests it represents an attempt to imitate contemporary secular attire (Machabeli 1988). I propose that the linear-geometric structure of Saint Eustace's equipment directly resonates with Sogdian and late Sasanian models, with the closest parallels found on the 1st-century BCE Orlat plaques (Gruber et al. 2012) (Fig. 2).

The vertical structure of the relief carries significant theological weight: the upper register signifies the celestial realm, while the lower represents the earthly. This concept is underscored by the curved shape of the bow, aimed toward the stag. This detail fundamentally alters the narrative: the weapon is rendered powerless before the sacred animal, and the arc of the bow suggests the triumph of the hunted stag–a symbol of Christ. Thus, the focus shifts from the act of hunting to theophany and the salvation of the soul. In a broader context, the narrative originates from the Oriental tradition of the *"Royal Hunt,"* which, upon Georgian soil, became associated with the miracle that occurred during the hunt of King Mirian and the subsequent Christianization of the country. The iconographic scheme of St. Eustace effectively synthesizes the era's core tenets: conversion, the manifestation of the Lord, and the glory of Christ (Goderdzishvili 2020).

Semiotics and Concepts of Grapevine, Scroll, and Rosette Ornamentation, and the Rhombus Pattern.

The lateral faces of the John the Baptist stele are entirely covered in ornamentation: one face is dedicated to a relief grapevine motif with eight-petaled rosette, (Fig. 3). while the other features an interwoven the Rhombus Pattern. The stele's architectonics are defined by the ornamental border of its primary face–a toroid molding intersected by bands–a typology common to early Christian Georgian steles. Furthermore, the monument's narrow edges are adorned with a concentric arc ornament. This decorative model serves as a robust marker of early Christian Georgian art, confirmed both on steles (e.g., Bolnisi, Khandisi, Kataula, Dmanisi) and in monumental architecture (e.g., Tetritskaro reliefs, Ateni Sioni), testifying to the unity and canonicity of the decorative system of this period (Machabeli 1988). The composition of the vine and the geometric decor displays close stylistic affinity to the Khandisi stele (6th century) (Fig. 4), leading Kitty Machabeli to suggest that both steles originated from the same workshop (Machabeli 1988).

The face adorned with vegetal ornamentation offers an original interpretation of the vine, spiral volutes, and rosette motifs common in Christian iconography. Rising from the base, a double vine stalk merges vertically into an undulating, scrolling shoot, upon which grape clusters, leaves, and spiral volutes are rhythmically dis-

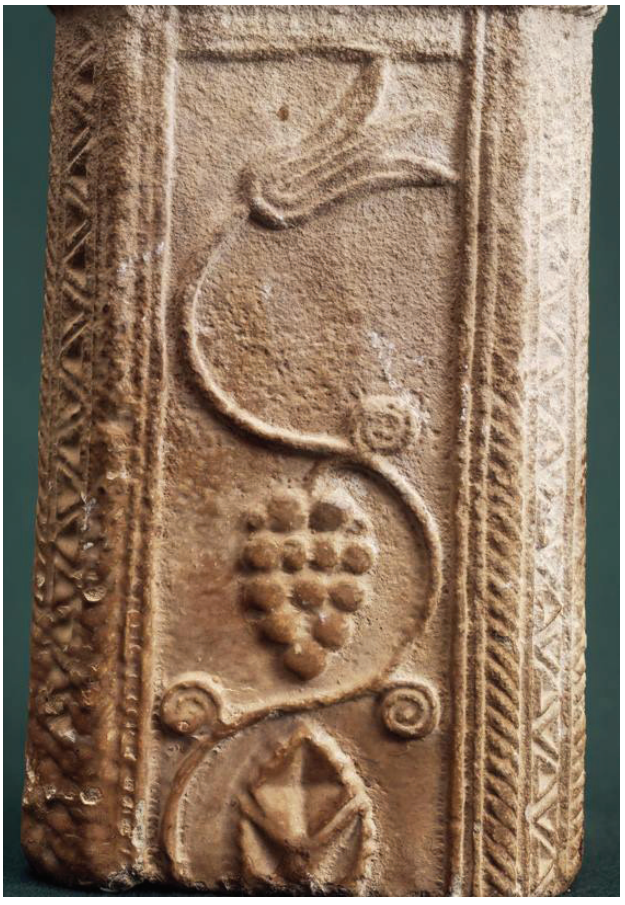

Fig. 4. Fragment of a stone pillar with vine ornament, Khandisi (photo courtesy, sakdrisiblog.wordpress.com)

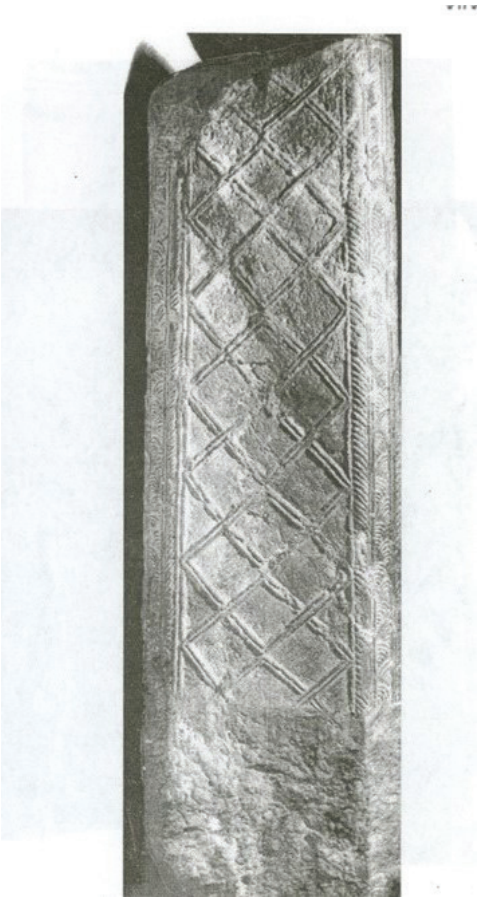

Fig. 5. Fragment of a stone pillar with geometric rhombus pattern, John the Baptist Monastery, end of the 6th century (source: private collection / author's archive)

tributed. Parallel to the rosette, two grape clusters are symmetrically depicted alongside a rhomboid leaf, its incised lines forming the image of a cross. The pearled border surrounding the leaf – a decorative element also found on the body of the stag on the same stele–echoes the pearled medallions of Sasanian Iran. According to Asmat Okropiridze, this, along with the clusters, serves as an allusion to sacrifice and fruitfulness, while the eight-pointed rosette serves as the composition's culmination–a symbol of eternity and the *"Eighth Day"* (Okropiridze 2008).

Despite the visual connection, there is a fundamental iconographic difference between the Khandisi and John the Baptist steles: the ornament on the Khandisi stele terminates in a drooping lily, while on the John the Baptist monument, it is replaced by an eight-pointed rosette, directing the composition's ideological vector toward infinity and divine light. The stylized cruciform leaf placed within the vine shoots proclaims the idea of the cross as a Cosmic Tree, extending from the earthly realm toward the heavens. The multi-petaled rosette motif became widespread in Christian art from the 5th century onwards, though it was particularly popular in Sasanian reliefs and textiles (Machabeli 2007). In many instances, this ancient astral symbol was used as an equivalent to or a substitute for the equilateral cross. Simultaneously, the symbolism of the vine ornament is based on the Eucharistic concept and the words of Christ (*"I am the vine, and you are the branches"*). Beginning with the capitals of Bolnisi Sioni, the image of the vine in Georgian art has been a mystical expression of the mystery of Communion, and can be viewed as a monumental symbol of the Conversion of Kartli (Okropiridze 2008; Machabeli 2018).

The geometric Rhombus Pattern (Fig. 5) on the second lateral face closely resonates with the repertoire of Sasanian architectural decor, further emphasizing the influence of Iranian art on early Christian Georgian plastic arts. Similar carpet-like decorative principles are employed in the stag-hunting relief of the main grotto at Taq-e Bostan and in 6th-century architectural fragments from Iran (Fig. 6). However, the continuous diamond mesh on the John the Baptist stele is unique among Georgian stone crosses for its seamless, continuous execution. In Sasanian decorative art, the infinitely repeating lattice of rhombuses represented a visual manifestation of victory over chaos and supreme cosmic order, where every micro-element is assigned a predetermined place (Herrmann 1977; Kröger 1982). Transposed onto the John the Baptist stele, this Sasani-

Fig. 6. Rombhous patern fragments from Taq-e Bostan and Isfahan, 6th century (after Ghirshman 1962)

Fig. 7. Deer with a pearled roundel, fragment of a stone pillar, John the Baptist Monastery, end of the 6th – beginning of the 7th century (photo Mirian Kiladze)

an geometric model acquires an entirely new symbolic meaning on Christian soil, linked to the unshakeability of God's will, the divine order of the universe, and the idea of the Church as an indivisible body. While in Iranian art this structure expressed the earthly power established by the Shah, on this monument, this cosmic symbol takes on a soteriological and eschatological semantic, pointing to the constancy predetermined by the Creator. This geometric symmetry, which unifies the microcosm and macrocosm, later became a primary principle of Islamic ornamental art (Baer 1998).

Deer with a Pearled Roundel: Semiotics and Concepts of the Astral Symbol

In early Christian hunting compositions, the image of the stage plays a central role. In Georgian art, spanning both pagan and Christian epochs, it was regarded as a sacred and auspicious animal. The Georgian consciousness associates the stag with the mythic hunt of King Parnavaz and the vision of King Mirian on Mount Tkhoti. Its branching antlers embody the *"Tree of Life,"* while their periodic shedding serves as a sign of constant renewal (Goderdzishvili 2020). In Christian tradition, the hunt for a stag is linked to the spiritual transformation of Saint Eustace and Saint Hubert, to whom Christ appeared in the form of a cross raised between a stag's antlers. According to P. Uvarova, the Christian reception of the stag cult directly echoes Psalm 41: *"As the deer panteth for the water brooks..."* (Uvarova 1908; Abramishvili 2000). M. Khidasheli cites another parallel from the life of Saint David Garejeli, where deer nourished hermits in the desert with their milk–a phenomenon first witnessed by hunters (Khidasheli 2000). Thus, the figure of the stag on the John the Baptist stele is imbued with profound sacred meaning, underscored by its plastic form, the architectonics of its antlers, and the astral sign placed upon its body (Fig. 7).

According to several scholars (K. Machabeli, T. Dadiani), the geometric elements on the stag's body derive from local pre-Christian openwork bronze buckles (Machabeli 1988; Dadiani 2020). A similar pearled medallion is depicted on the 6th-century stele from Nagvarevi, where the animal's rump is marked with astral symbols. The Nagvarevi stag, with its folded legs, directly replicates the archetype of these bronze buckles (e.g., the 3rd–4th-century buckle from Chiatura) (Fig. 8). This model returns us to the Georgian pre-Christian artistic tradition, characterized by a strictly planar-linear style (Dadiani 2020). Keti Machabeli firmly links the rosette-centered medallion on the stag's body to these ancient astral signs, attributing to it an apotropaic (protective) significance (Machabeli 1988).

Simultaneously, the circular element on the stag's chest reveals a close visual and ideological connection to the pearled medallion widespread in the Iranian world, which served as a hallmark of Sasanian decor and was traditionally associated with elite textiles (Sim 2012) (Fig. 9). According to M. Compareti, similar textile motifs are clearly observed in Sogdian monumental painting and Chinese art, with Taq-e Bostan serving as a clear example of these cultural contacts (Compare-

ti 2016). Iranian iconography frequently features the *"ribboned stag,"* which was distinguished from the herd by a royal ribbon tied around its neck, granting the animal an inviolable status. In the Sasanian era, this motif was directly linked to the concept of farr–representing divine glory, legitimate royal authority, and supernatural power (Lic 2023).

In the Christian context, as manifested on the John the Baptist stele, this Iranian imperial symbolism is fundamentally reinterpreted. The circular border of pearls becomes a sacred contour that *"seals"* and preserves divine power, indicating that this space is shielded from earthly threats. Consequently, the sculptor of the stele adopts the pearled medallion characteristic of the Sasanian repertoire, merges it with local astral-linear traditions, and transforms it into an ultimate sign of theophany (the manifestation of God). Here, the stag is no longer mere prey, but a sacred creature imbued with divine glory.

Sasanian Symbolic Motifs on the John the Baptist Stele: Christian Reinterpretation of Sasanian Symbolism

In the study of early Christian Georgian art, it is highly compelling to analyze the transcultural contacts established between Eastern Georgia (Iberia) and Sasanian Iran (224–651 CE). This empire served as a vital cultural crossroads, exerting an intensive artistic and technological influence on surrounding civilizations (Farrokh 2020). The rosette-centered medallion and the rhomboid net ornament depicted on the John the Baptist stele in David Gareji reveal a clear genetic connection to the Sasanian artistic repertoire. However, within a Christian context, these motifs acquire entirely new semantic layers, representing an original reinterpretation of Eastern iconographic forms.

Fig. 8. Belt buckle, 3rd–4th century CE, Chiatura (photo courtesy of the Georgian National Museum)

In Iranian imperial iconography–exemplified by the monumental reliefs at Taq-e Bostan–images of stags and hunting primarily symbolized earthly authority, the royal glory of the Shahanshah, and divine protection, known as farr. Decorative symbols and ribbons affixed to the bodies of animals served to emphasize the monarch's inviolable status and earthly legitimacy. On the

Fig. 9. Child's coat with ducks in pearl medallions, Uzbekistan, 8th century (photo © The Cleveland Museum of Art)

Gareji stele, however, these visual symbols fundamentally shift their function and are placed in the service of Orthodox dogma. Here, secular legitimacy is replaced by celestial revelation (theophany): the hunting scene is transformed into the mystical conversion of St. Eustace, while the stag is transfigured into a symbol of Christ's sacrifice, the salvation of the human soul, and eternal life in Eden.

Thus, the early Christian Georgian master adopts ready-made, formally sophisticated Sasanian ornamental models (the rhomboid mesh and the beaded medallion) but strips them of their original, secular content. On the Gareji stele, these forms now serve the ideas of Christian mystical contemplation and eschatological infinity. This iconographic transformation renders the John the Baptist stele a unique, highly artistic example of the synthesis between late antique and early medieval cultures.

Discussion

The iconographic analysis of the John the Baptist stele yields several fundamental scholarly findings.

First, it establishes a semantic distinction for the stag's pearled medallion. Contrary to traditional interpretations, this beaded roundel is distinct from local pre-Christian bronze traditions; instead, it reveals a genetic link to Sogdian and Iranian imperial iconography, where it served as a marker of the divine glory of farr. The sculptor creatively synthesized this foreign symbol with indigenous plastic traditions–such as antler architectonics and linear modeling–demonstrating a sophisticated transcultural fusion.

Second, the study identifies the rider's attire, previously misinterpreted as secular elite dress, as specific military equipment: Parthian cataphract armor. The linear execution of this armor aligns with the heavy military gear depicted on Parthian-era plates, confirming Iberia's close integration into the post-Parthian and early Sasanian military-aristocratic repertoire.

Furthermore, the monument's unique status is underscored by the rosette-centered medallion and the interwoven diamond mesh on the lateral faces. Lacking direct parallels in other Georgian steles (e.g., Khandisi, Nagvarevi, Kataula), these motifs indicate that the Gareji master utilized elite imperial imports–likely textiles or metalwork–circulating along the Silk Road as primary source material.

In conclusion, this study demonstrates that the John the Baptist stele is not merely a provincial artifact but a highly conceptual artistic manifesto. By organically merging Parthian military gear, Sogdian-Sasanian pearled motifs, and unique rhomboid architectonics with local artistic traditions, the sculptor established a distinct and original visual language for Christian theophany.

Conclusion

The 6th–7th-century stone stele from the John the Baptist Monastery in David Gareji is an outstanding example of early Christian Georgian plastic art, representing a masterful synthesis of indigenous pre-Christian traditions, Sasanian imperial decor, and Christian theology. Analysis reveals that the Gareji sculptor creatively transformed borrowed visual forms, repurposing Sasanian attributes of royal glory (farr) and the pearled medallion into expressions of theophany, divine protection, and the salvation of the soul. Furthermore, the rider's attire is identified for the first time as heavy Parthian cataphract armor, highlighting the monument's extensive cultural connectivity.

The master's independence and refined theological vision are further evident in the ornamentation of the lateral faces, where the grapevine motif–unlike that on the Khandisi stele–rises vertically to culminate in an eight-pointed rosette, an eschatological symbol of the eternal *"Eighth Day"* of Paradise. Executed in a planar-linear carving technique, this stele stands as a coherent, highly conceptual artistic manifesto. Against the backdrop of late antique and early medieval cultural exchanges, it demonstrates the remarkable capacity of Georgian artistic thought to organically assimilate diverse traditions and integrate them into a distinct, autonomous visual language.

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Cave Complex of the Spaso-Preobrazhensky Ust-Medveditsky Monastery (Russia)

Alexey Gunko, Sofia Kondrateva, Vitaly Stepkin, Alexander Gunko
Sofya Kondrateva kosofia@yandex.ru +79036518872
Alexey Gunko gunko.a@mail.ru +79173945494
Autonomous Non-profit Organization Cave Research and Protection Center Voronezh, Russia

Abstract

The Spaso-Preobrazhensky Ust-Medveditsky Monastery is located in Russia in the Volgograd region on the outskirts of Serafimovich city. The monastery was founded here in the 17th century on the basis of the previously existing Mezhyhiran hermitage. In 1785, the monastery was transformed into a women's monastery. The appearance of monastery caves here is connected with the activities of Arseniya (Sebryakova), who was ordained abbess in 1864.
The construction of the cave passages began in 1874, on St. Anthony of the Caves Memorial Day. It was carried out together with the construction of a large cathedral, completed in 1885. The excavation of the cave complex ended in 1888. Its structure is unusual and, with the exception of the temple, it is a combination of similar length sections of galleries and rooms of comparable volume, subordinated to a single plan. This is the only major religious complex in Russia, the semantics of the main galleries of which has survived to this day unchanged thanks to literary sources. According to Abbess Arsenia's conception, the western part of the complex represented the "Way of the Cross of the Savior (Via Crucis)". The southwestern section symbolized the "Passionate Way of the Mother of God." An underground church was supposed to be located in the eastern part of the complex, but its construction was not fully realized. The entrance to the caves was carried out from the basement of the cathedral. The existing temple is oriented to the northeast and consists of three large rooms: narthex, the middle part and the altar part. The total length of the complex is 147 m. The preserved spatial organization of the cave complex makes it a rare and valuable example of intentional symbolic modeling in Russian Orthodox underground architecture of the 19th century.

Keywords: cave monastery, sacred topography, Russia

The Spaso-Preobrazhensky Ust-Medveditsky Monastery is located in Russia in the Volgograd region on the right bank of the Don River, within the southwestern outskirts of the city of Serafimovich (formerly the Ust-Medveditskaya stanitsa of the Don Cossack Host). The main monastic buildings occupy the elevation range of 70-100 m a.s.l., situated on the northwestern slope of a massif bounded by the deep ravines of Kholodny and Gorodskoy (near the village of Zatonsky). The monastery is active and currently belongs to the Uryupinsk Diocese of the Volgograd Metropolis of the Russian Orthodox Church.

The Ust-Medveditsky male monastery was founded in the 17th century on the site of the existing Mezhigorskaya Pustyn. The hermitage was founded in 1638 "*on the right bank of the Don, near the present monastery, at the foot of a hill*" (Baluev 1900, 72). D. Pravdin, who described the history of the monastery, noted that the first hermits were drawn to the "*steep right bank of the Don, cut through by numerous deep gullies; the precipitous banks overgrown with ancient forest offered many natural caves, hidden from idle curiosity and inaccessible to ill-intentioned people*" (Pravdin 1885, 19). Drawing on 19th-century local historians, Yu.V. Poleva suggests that the first monks lived in dugouts and caves that have not survived to the present day (Poleva 2014, 174). From 1652, residents of the Medveditsky gorodok (later a stanitsa) began petitioning for the establishment of a monastery, having "*in fulfillment of their vow donated a site for it*" (Baluev 1900, 73). In 1662, Patriarch Nikon granted his blessing for the monastery's founding. In 1752, the monastery was buried under "*a hill that had been undermined and subsided*" and relocated "*half a verst upstream*" (Pravdin 1885, 49). Until 1785, the monastery was known as the Mezhigorskaya Spasova Pustyn (Orthodox Russian… 1909, 493). In 1785 it was converted into a convent, and the brethren were transferred to the Kremenskoy Monastery. In 1788 the monastery was dissolved as

supernumerary, but in 1798 it was restored "*at the insistent petition of the military leadership of the Don Cossack Host*" (Baluev 1900, 73). After the Revolution of 1917, the monastery continued to function and was finally closed only in 1928. Its grounds were used as a children's colony for homeless youth, then as a power station, and after World War II as a pioneer camp, a settlement for conditionally convicted persons, and a button factory (Kuryshova 2010). Since 1992 the monastery has been revived as a male monastery; in 2001 it was converted into a convent.

The history of the cave complex on the monastery's grounds is associated with Abbess Arsenia (Fig. 1). Anna Mikhailovna Sebryakova in secular life (1833–1905), who entered the monastery in 1850. On October 21, 2016, the Holy Synod decided to canonize Arsenia as a local saint. In 1864 she was consecrated to the rank of abbess (Igumenya Arsenia… 1994). Her decision to develop the caves within her home monastery was evidently influenced by her visit to the caves of the Kiev-Pechersk Lavra during a walking pilgrimage to Kiev in 1853. Construction of the cave passages is traditionally considered to have begun on July 10 (23), 1874, the feast day of St. Anthony of the Caves. At the same time, the consecration of the site for the Cathedral of the Kazan Icon of the Mother of God, with which the cave complex was later associated, had taken place only a month earlier – on June 10 (23). For this occasion a pit was dug into which people threw copper coins (Pravdin 1885, 113). The cathedral was designed by the St. Petersburg academic architect I.I. Gornostaev and consecrated on September 8, 1885 (Fig. 2).

According to A.A. Pavlovsky, Arsenia began digging the caves with the intention of subsequently "*taking the schema and secluding herself in them. But not one of the Don's archpastors allowed her to retire, finding her management of the monastery exemplary*" (Pavlovsky 1907). According to Arsenia's biography compiled in 1913, the abbess worked at night, ceaselessly reciting a prayer or akathist to the Passion of Christ. She was assisted in creating the caves by the mothers Nikodima, Agnia, and Viktorina. The work was not without danger: "*On one occasion a huge stone together with earth fell from above and nearly killed Mother Arsenia herself. Fortunately, the cell attendant standing behind her noticed a large crack in the vault in time and, without losing her composure, managed to push the mother aside, so that the falling stone only grazed her back slightly without causing any harm*" (Igumenya Arsenia… 1994). The entrance to the caves was located in the basement of the cathedral (Fig. 3). According to a brief description, the caves appeared as follows: "*Before the entrance is a small room where pilgrims are given candles* (evidently referring to the narthex of the undercroft church – note by authors). *In this room, above the doors leading into the caves, is a depiction of the Last Judgment; passing through a narrow corridor a few steps, one encounters another door with an icon of the Entry of the Lord into Jerusalem above it. Here begins the descent into the caves, which run into the hillside southward for a distance of 77 sazhens* (this apparently refers to the total length of the complex – note by authors). *In their layout they recall the caves of the Kiev-Pechersk Lavra: the walls and ceilings are earthen and cemented, the floor is brick, also covered with cement." The passages carried symbolic meaning – Arsenia "conceived the wish to depict in the depths of the earth the last days of the earthly life of the Jesus Christ, His sufferings and death on the Cross, and likewise to honor the sufferings of the Mother of God at the time of the Crucifixion of Her Divine Son*" (Igumenya Arsenia… 1994).

Fig. 1. Abbess Arsenia (Sebryakova). Photograph, late 19th century

The western passage was considered the main one and was named by Abbess Arsenia the "Way of the Cross of the Savior." Icons depicting the final days of the life of Jesus Christ lined the walls. This path was marked by widenings of the gallery and chambers dedicated to specific scenes. The interpretation of some of them, unfortunately, has not been recorded in the sources. Here and further, we rely on the modern monastic reconstruction of the sacred space, which is reflected in the interior features and the icons placed on the walls: the Savior's prayer in Gethsemane, the trial before the High Priest Caiaphas (modern interpretation), the Flagellation of Jesus Christ, and the trial of Jesus Christ by the Roman procurator of Judaea, Pontius Pilate (modern interpretation), and the fall of Christ under the cross. The path of Christ concluded at "Golgotha," where in a niche in the wall stood "*a Cross with the crucified Savior in full height, and the Mother of God and His beloved disciple standing before Him*" (Igumenya Arsenia… 1994). The southwestern section of the cave complex symbolized the "Passion Way of the Mother of God" – "*in memory*

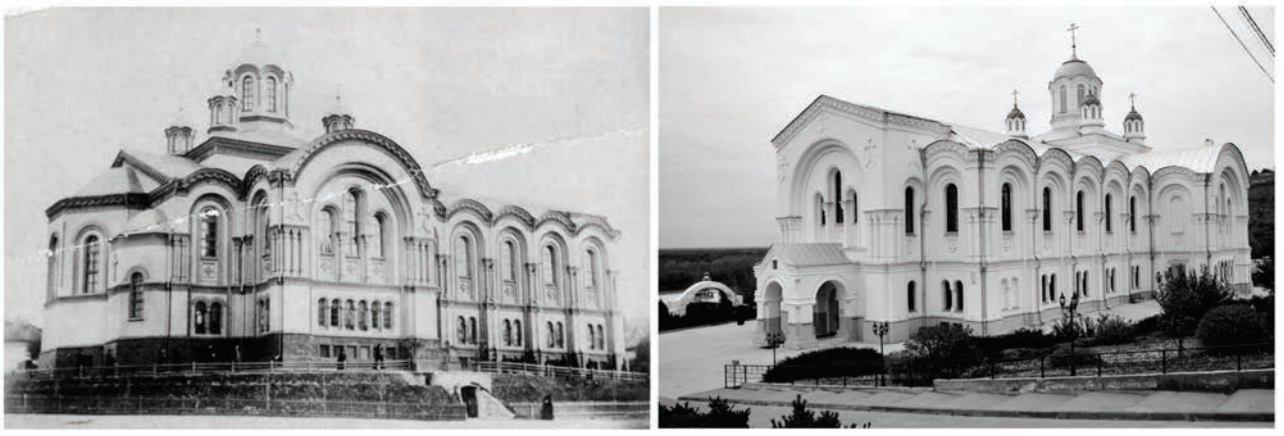

Fig. 2. Cathedral of the Kazan Icon of the Mother of God. Left – view from the north, 19th-century photograph (Pravdin 1885); right – view from the south, photograph 2016

of the suffering of the Queen of Heaven, which She experienced as She hastened to the place of execution of Her Divine Son. Opposite the place where the fall of the Savior under the Cross is depicted, stands the icon of the Mother of God known as 'Seven Arrows' or 'Simeon's Prophecy.' This place represents the moment when the Most Holy Virgin, hurrying to Her beloved Son and seeing Him fallen under the weight of the Cross, felt that a sword had pierced Her soul" (Igumenya Arsenia… 1994).

In the far part of the caves, "*Arsenia had planned to build a church and had even excavated a space for it. But she lacked the health and strength to carry out this wish, both having been finally undermined by her excessive labors*" (Igumenya Arsenia… 1994). The caves were "completed" in 1888 to mark the consecration, within the cathedral, of the lower Church of Arsenius the Great, built with funds provided by the abbess's sister, the nun Maria (Merzhanova).

In modern literature, including scholarly works, it is widely held that the cave complex was developed on the basis of pre-existing caves. V.V. Serebryanaya, for instance, suggests that the site for the cathedral was chosen precisely because of the presence of old caves, and that Arsenia was engaged in their renovation rather than excavation (Serebryanaya 2002). Yu.V. Poleva reports that "*a fairly large number of accounts have survived concerning extensive passages that existed beneath and alongside the monastery*" (Poleva 2014). In popular literature, these existing caves are often linked to an alleged multikilometer network of catacombs that supposedly extended beneath Serafimovich. There is also a story about local treasure hunters disappearing in the monastery caves, after which the entrance was blocked. (Svyatye obiteli… 2008).

After the monastery's closure, the caves fell into disrepair. With the return of the monastery to the Russian Orthodox Church, restoration of the cathedral and the caves began. By 1999 the walls had been plastered and electric lighting installed. In 2002 the complex was examined by members of the Historical and Cultural Society "SOVA" – K.E. Polev, S.A. Chumichev, and A. Chesnokov. A plan of the complex was drawn up and some information about its history and layout was later published (Polev, Poleva 2004). The motivations that led Arsenia to create the caves are examined in detail by Yu.V. Poleva (Poleva 2014).

In 2016, within the framework of the project "Atlas of Sacred Caves of the Don," the cave complex was surveyed by the authors of this article. Detailed architectural measurements were made and the current condi-

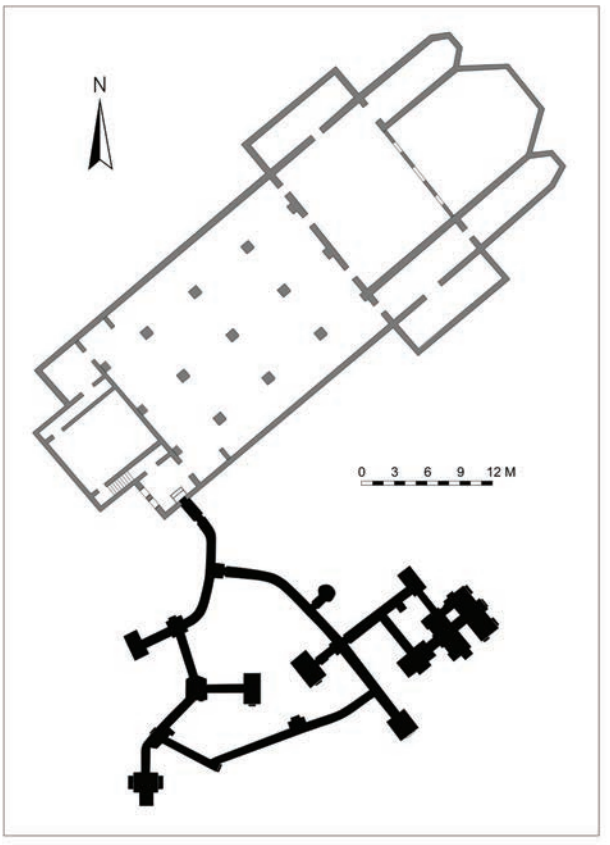

Fig. 3. General plan of the cathedral (basement level shown) and the caves

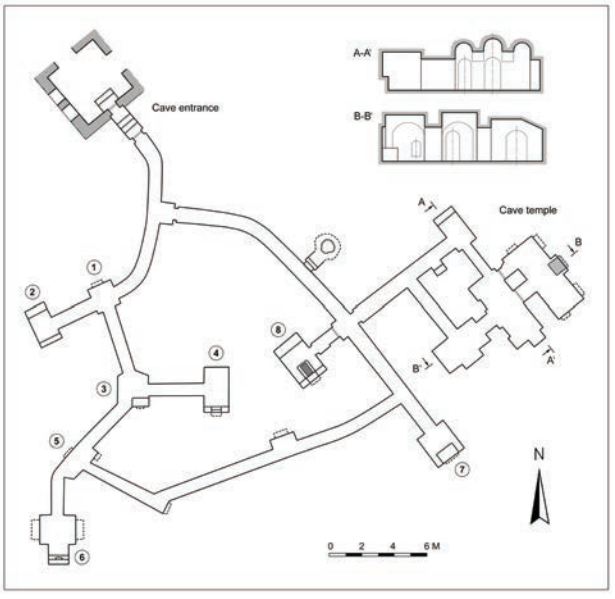

Fig. 4. Plan of the cave complex with chamber numbers (Survey: A.A. Gunko, S.K. Kondratyeva, A.P. Gunko, 2016)

tion of the site was photographically documented. The total length of the cave complex, as determined by the survey, came to 147 m (Fig. 4).

The entrance to the cave complex is located in a small semi-basement room in the southwestern part of the cathedral. It measures 3.6 × 3.8 m and serves as the narthex of the undercroft Church of Arsenius the Great (Fig. 5/1), which is entered through a doorway in the northwestern wall. In the southwestern part of the room, near the vault, there are two window openings giving onto the forecourt of the cathedral. In the floor near the southeastern wall, in front of the entrance door to the complex, there is a sump pit (Fig. 5/2). The entrance opening is 0.7 m wide. Beyond it lies the entrance section of the gallery, equipped with three steps. It extends to the southeast and ends in another opening fitted with a lockable wrought-iron grille (Fig. 5/3). From there the gallery continues to the southeast, turning south after 1.6 m. After another 2.3 m it reaches a small junction chamber. The chamber is 1.9–2.1 m high and measures 1.4 × 1.6 m. From the chamber there is a passage to the east, while the main gallery continues southward, gradually turning southwest. The gallery is 0.7–0.8 m wide and 2.1 m high, with a semicircular vault. After 5.5 m it leads to junction chamber №1. According to Arsenia's conception, this is the first chamber on the "Way of Christ", representing the Savior's prayer in the Garden of Gethsemane. It measures 1.5 × 1.4 m. In the northwestern part of the chamber, at a height of 1.2 m from the floor, there is a semicircular icon niche (Fig. 6/1). To the southwest, a 2.7-m gallery leads to rectangular chamber №2, measuring 2.4 × 1.4 m. On the "Way of Christ" it represents the trial before the High Priest Caiaphas. The chamber's vault is semicircular, reaching a height of 2.3 m at the center. Bench-like projections run along the northern and southern walls (Fig. 6/2).

To the southeast of chamber No. 1, the main gallery reaches junction chamber No. 3 after 4 m, representing the Flagellation of Jesus Christ. It is 1.9 m wide, 2.0–2.3 m long, and 2.2 m high at the center. In the southeastern corner there is a projection measuring 1.0 × 0.56 m and 0.8 m high (Fig. 6/3), above which is a semicircular icon niche 0.5 m high, 0.35 m wide, and approximately 0.05 m deep. To the east of the chamber, a 3.5-m gallery leads to rectangular chamber No. 4, measuring 2.9 × 1.5 m (elongated along the north–south axis). This chamber represents the trial of Christ by the Roman procurator of Judaea, Pontius Pilate. The vault is semicircular (cylindrical), reaching a height of 2.3 m. Along its southern wall, two identical projections stand in the corners, each 1.2 m high and 0.4 m wide. Between them are three step-like projections with

Fig. 5. 1 – Refectory of the undercroft Church of Arsenius the Great; 2 – entrance to the caves from the narthex of the Church of Arsenius the Great; 3 – approach section of the gallery ("Entry of the Lord into Jerusalem")

Fig. 6. 1 – Chamber "The Savior's Prayer in the Garden of Gethsemane"; 2 – southeastern part of the chamber "Trial before the High Priest Caiaphas"; 3 – chamber "Flagellation of Jesus Christ" with gallery section; 4 – southern part of the chamber "Trial of Jesus Christ by the Roman Procurator of Judaea, Pontius Pilate"; 5 – icon of the Mother of God "Seven Arrows"; 6 – northwestern part of the chamber "Fall of Christ under the Cross"; 7 – cross in the chamber "Golgotha"; 8 – eastern niche in the chamber "Golgotha"; 9 – Passion Icon of the Mother of God at the turn of the gallery

a combined height and width of 0.7 m, which "lead up" to a rectangular icon niche. The projections and steps evidently symbolize the raised dais and throne of the procurator Pilate (Fig. 6/4).

From chamber №3 the main gallery, 0.74–0.8 m wide, extends to the southwest. After 3.5 m it connects with junction chamber No. 5, which represents the fall of Christ under the cross and marks the beginning of the "Passion Way of the Mother of God." The chamber is irregular trapezoidal in plan, up to 2.5 m long and 1.4 m wide, with a barrelvault-like ceiling 2.1 m high at the center. Two niches are present in the chamber. In the eastern corner, at 0.77 m from the floor, is a deep semicircular icon niche 0.9 m high and 0.43 m wide, containing the icon of the Mother of God "Seven Arrows" (Fig. 6/5). On the northwestern wall, at 0.75 m from the floor, is a semicircular icon niche 0.7 m wide and 1.15 m high, containing an icon depicting Christ's fall under the cross (Fig. 6/6). In the southwestern part of the chamber, the "Way to Golgotha" begins – a short gallery 0.7 m wide that almost immediately turns south and after 2.5 m leads to chamber № 6. The main volume of this chamber is rectangular, measuring 2.2 × 1.78 m, with a semicircular (cylindrical) vault reaching 2.9 m at the center. In the western and eastern walls, at 0.45 m from the floor, are niches 1.2 m wide and high and 0.5 m deep, with barrel-like vaults. On the south, a small extension 1.2 m wide and 1.3 m long is attached to the main volume, with a height of 2.49 m at the entrance and a semicircular vault. Two steps, 0.2 m and 0.3 m wide and 0.15 m high, lead up to the rear wall. This chamber concludes the "Way of Christ," symbolizing Golgotha. A cross with the crucified Savior stands upon the steps (Fig. 6/7). The eastern niche in the chamber symbolizes the burial (laying in the tomb) and Resurrection of Christ (Fig. 6/8).

From chamber № 5 the gallery of the "Passion Way of the Mother of God" continues in a southeasterly direction, coming to a stop at a wall with an icon niche (Fig. 6/9). A semicircular niche holds the Passion Icon of the Mother of God. The gallery then changes direction to the northeast. It is 0.7–0.88 m wide with an average height of 2.1 m. After 7.5 m, a tall arcosolium-style niche with a barrel vault opens to the northwest (Fig. 7/1). It is 1.8 m high, 1.45 m wide, and 0.54 m deep; inside the niche, an icon of the Holy Trinity is placed in a bracket. The gallery makes a slight bend (Fig. 7/2) and after 7 m reaches a T-junction.

To the southeast of the junction, a short passage leads to chamber № 7, which concludes the "Way of the Mother of God" (in the current interpretation) and represents Her Dormition (Fig. 7/3). The chamber measures 2.0 × 1.9 m and is 2.7 m high, with a barrel (cylindrical) vault. To the northwest of the junction, the gallery widens to 0.9 m and after 4.5 m reaches a cruciform intersection. From there a corridor 2.3 m long leads southwest to chamber № 8 (Fig. 7/4). This is currently one of the most significant spaces in the complex, as it houses the stone of "Tears and Repentance" ("Repentance"), venerated as a sacred relic (Fig. 7/5). The chamber measures 2.9 × 1.8–1.9 m and is 2.4 m high, with a barrel (cylindrical) vault. A projection 0.6 m wide and 0.4 m high runs along the northwestern wall. Along the southeastern wall a stepped projection descends toward the center of the chamber; the heights at the corners are 1.1 m, and the central lowered section is 0.8 m wide. In front of the ledge an inclined dais 0.8 m wide and 0.6–0.7 m high has been constructed, serving as the base for the stone mentioned above. The stone bearing "imprints" of palms and knees was reportedly located in various parts of the complex at different times. According to the plan published by V.V. Serebryanaya, in the 1990s it was situated in chamber № 5. On the 2002 plan (K.E. Polev et al.) it is shown in chamber № 8.

To the northwest of the intersection, the gallery continues for 14 m, bending westward and joining the first junction chamber described above. In the right wall of the gallery, 3.5 m from the intersection, at a height of 0.8 m from the floor, there is a vaulted opening (Fig. 7/6). The opening is 0.9 m high and 0.6 m wide, and through it one can access a small chamber. Deeper inside, the height increases sharply due to a step in the floor and the vault. The walls are reinforced with brick for a distance of 0.7 m from the opening. On the left inner side, fragments of metal hinges are preserved, indicating that the chamber was once closed with a door or grille. Within the brick-lined section the chamber is 2.1 m high – sufficient to stand upright. This section is adjoined by an unlined, roughly circular section with irregular earthen walls and a vault formed by natural gravitational erosion. The floor contains a round shaft resembling a prospecting or treasure-hunting pit. Evidently, unsuccessful attempts were made here to locate the mythical lower level of the complex. The shaft is approximately 1.5 m deep.

To the northeast of the intersection lies the principal section of the underground complex – the cave church. A gallery 0.8 m wide and 2.1 m high leads to it. After 3.7 m, a branch passage opens to the southeast, leading to a room interpreted as the church's narthex. After another 1.3 m, a short branch 0.67 m long, 0.7 m wide, and 1.9 m high opens in the southeastern wall. The gallery then continues for 1.3 m into a rectangular chamber measuring 2.5 × 1.4 m, with a semicircular vault up to 2.4 m high. From this chamber a 2-m passage leads southeast, connecting it to the church.

The layout of the church clearly indicates that it was never completed. It is oriented to the northeast and consists of three main spaces: the narthex, the nave, and the sanctuary. The narthex is a rectangular chamber with a semicircular vault that descends toward the southwestern wall. It measures 3.2 × 1.9 m and is 2.6 m high.

Fig. 7. 1 – Tall arcosolium niche; 2 – gallery section; 3 – chamber № 7; 4 – chamber № 8; 5 – stone slab with "imprints"; 6 – opening into the chamber; 7 – nave of the cave church; 8 – Royal Doors; 9 – view from the nave into the narthex

In the northeastern wall there is an apsidal niche (exedra) 1.9 m high and 1.4 m wide. From the narthex, a 0.9-m-wide passage leads into the nave (Fig. 7/9). The nave is a chamber elongated along the NW–SE axis over 4.4 m (Fig. 7/7), and 1.9– 2.1 m wide. The ceiling is divided into three sections by two transverse semicircular relieving arches 2.4 m high (Fig. 4), which rest on projections 0.2 m thick and 0.6–0.7 m wide along the southeastern wall. Each section forms an independent semicircular (cylindrical) vault facing the sanctuary. The northern and southern vaults rise to 2.9 m and the central one to 3.0–3.1 m, making this the highest chamber in the complex. The northern vault corresponds to the North Door of the sanctuary, and the central one to the Royal Doors. There are no South Doors. In the southeastern wall there is a tall semicircular niche 0.55 m deep, 1.9 m high, and 0.9 m wide. As noted above, entry into the sanctuary is through the South Doors and the Royal Doors, separated by a pier measuring 1.1 × 0.8 m. The South Doors are 2 m high and 0.7 m wide; the Royal Doors are 2.1 m high and 0.9 m wide (Fig. 7/8), with semicircular vaults. The main volume of the sanctuary measures 5.0 × 2.0 m. As in the nave, the ceiling features alternating semicircular (cylindrical) vaults oriented in different directions. The maximum height, at the center, is 2.88 m. In the direction of the central vault, the northeastern part of the chamber widens to form the bishop's throne niche (Gorneye mesto), in the wall of which there is a tall icon niche with a barrel vault. The altar table, consecrated in honor of the LifeGiving Cross, is faced with dark-green tile and is set directly into the widened section, abutting the wall. In the left half of the sanctuary, 0.8 m from the widened section and at a height of 0.8 m, there is a semicircular prothesis niche 1.4 m high and 0.9 m wide. In the adjacent northwestern wall there is another niche with a barrel vault, 0.5 m wide. The niches in the right half of the sanctuary mirror the position and dimensions of those in the left half.

The structure of the surveyed cave complex is unusual and, apart from the church, consists of a combination of gallery sections of similar length and chambers of similar volume, all subordinated to a single artistic concept. This is arguably the only large sacred cave complex in Russia whose symbolic program has survived to the present day in an unchanged form, thanks to written sources. Could such a complex have been developed on the basis of pre-existing caves? Of course it could – however, the assumption that caves existed here before 1874, resting solely on local legends and not on the study of the natural morphology of the cavities, seems to us unsubstantiated. Nor does the complete absence of any genuine historical evidence of caves in the monastery prior to the construction of the cathedral support this version. Also noteworthy is the depth at which the cave entrance was placed – its entry section lies at least 2.5 m below the surface. Thus this cave, if one had no prior knowledge of it, could only have been discovered when digging a foundation pit for the cathedral. Had the excavation exposed any underground spaces, this would inevitably have become public knowledge. It is quite possible that the construction of the caves had been agreed upon in advance between the abbess and the cathedral's architect Gornostaev – one can see how well the location of the underground entrance fits the overall layout of the above-ground structure, which was designed long before construction began (Fig. 3). The coherence between the underground and the aboveground structures is further underscored by the cave church, excavated parallel to the cathedral and bearing an identical northeastern orientation. As for the widespread view that creating such a cave was arduous labor for a small group of women – this is certainly true. It was genuinely demanding work; yet, given the time period of the cave's creation (1874-1888) and the favorable properties of the surrounding soils, it was within their capacity. Arsenia's biography gives the length of the cave as 77 sazhens, meaning that approximately 5.5 sazhens (11.5 m) needed to be excavated each year. In addition to the digging itself, work was carried out to line the caves with brick and cement, most likely performed by outside craftsmen – skilled bricklayers.

Regrettably, during the restoration of the caves, the brick walls were plastered with ordinary mortar, which quickly affected their appearance. The absence of natural ventilation, the cave's proximity to the surface, and the consequent ingress of meltwater and rainwater provoke excessive ground moisture and condensation on the walls and vaults. The plaster swells and in places is crumbling, with its surface layer peeling away. Due to the high humidity, the electrical lighting has ceased to function, and its use in such conditions has become unsafe. Nevertheless, the cave complex remains a unique architectural monument and deserves close scholarly attention.

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Once More on the Function of Uplistsikhe Iwan Complexes (Georgia)

Kakha Khimshiashvili

Tbilisi State Academy of Arts
Corresponding Author: Kakha Khimshiashvili
Email: Kakha.khimshiashvili@art.edu.ge

Abstract
Uplistsikhe is a major rockcut settlement in central Georgia, situated on the northern bank of the Kura River. Carved into soft sandstone sloping toward the river, the site occupies approximately three and a half hectares. Archaeological evidence indicates continuous occupation from the Bronze Age to the late medieval period, with its greatest prosperity occurring during the late Hellenistic and late Antique periods. Although the site retained relevance in the medieval period, it had largely declined by the fourteenth century and was thereafter inhabited only intermittently.
In previous research, I argued that the distinctive rock-hewn complexes defining the architectural character of Uplistsikhe correspond to the Iwan (or Livan) architectural type that emerged in the Parthian period. On this basis, I proposed that these spaces were created in the first–second centuries CE and primarily fulfilled sacred or temple-related functions. An alternative interpretation, advanced by Dr. Guram Kipiani, identifies these complexes as funerary structures. Drawing parallels with the rock-cut tombs of Phrygia and Paphlagonia, he questions the Iwan identification and suggests an earlier date, emphasizing the carved ceilings imitating wooden beam constructions.
Reassessing both positions, the present paper proposes that the rock-cut complexes of Uplistsikhe represent a deliberate architectural synthesis. They integrate the spatial articulation and vaulted façade characteristic of the Iwan with the depth, interior organization, and ceiling treatments typical of Asia Minor rock-cut tombs. Within this hybrid framework, the vaulted opening may be interpreted as a symbolic canopy marking a sacred interior space, accommodating ritual practices that could have been directed either toward deities or toward commemorative cults of the deceased. This reinterpretation highlights Uplistsikhe as a dynamic site shaped by the interaction of regional Caucasian traditions and broader Hellenistic–Parthian cultural influences. The study thus contributes to ongoing debates concerning the function, chronology, and cross-cultural architectural vocabulary of rock-cut monuments in the ancient Near East and the Caucasus.

Keywords: Uplistsikhe, Iwan, rock-cut architecture, Hellenistic Georgia, funerary cult

Uplistsikhe is a major rockcut settlement in central Georgia, situated on the northern bank of the Kura River (Fig. 1). Carved into soft sandstone sloping toward the river, the site occupies approximately three and a half hectares. Archaeological evidence indicates continuous occupation from the Bronze Age to the late medieval period, with its greatest prosperity occurring during the late Hellenistic and late Antique periods. Although the site retained relevance in the medieval period, it had largely declined by the fourteenth century and was thereafter inhabited only intermittently.

In previous research and publications, I argued that the distinctive rock-hewn complexes defining the architectural character of Uplistsikhe correspond to the Iwan (or Livan) architectural type that emerged in the Parthian period (Khimshiashvili 1999).

The rock-hewn complexes of Uplistsikhe exhibit a consistent spatial organization and shared architectural features. Specifically, they comprise rock-cut courtyards and associated interior spaces. Opposite the principal space of the complex–where permitted by the microtopography–an entrance opens onto the courtyard.

The main space lacks a façade wall and is entirely open toward the courtyard. Its prominence and dominance are emphasized by its size and height; it is invariably the largest space within the complex. The floor level of this space is slightly elevated relative to that of the courtyard. In most cases, it is surmounted by a rock-hewn cylindrical vault.

Behind, and occasionally to the sides of this principal space, are smaller chambers with flat ceilings. These are often decorated with carved imitations of wooden beams. Adjacent to these smaller, flat-ceilinged spaces–on their sides or at the rear–are rock-cut alcoves.

Along the perimeter of the courtyards, rock-hewn benches are commonly present. The surfaces throughout these complexes are carefully smoothed and generally do not display traces of the carving tools used in their construction. In contrast, surfaces modified during later medieval periods were not finished to the same

Fig. 1. Uplistsikhe, General View (photo Khimshiashvili K.)

standard and retain visible tool marks, making subsequent interventions readily distinguishable.

The spatial organization outlined above represents a general scheme that is realized in varying forms across different complexes. For instance, the *Tsiteli* and *Sada* complexes share a single common courtyard, while in the complex with a coffered vault the courtyard assumes the shape of a circular segment due to microtopographical constraints. In the *Makvliani* complex, the courtyard lies approximately two meters below the level of the cave spaces (Fig. 2).

Despite such variations, all of these complexes are spatially dominated by open-fronted, vaulted halls–iwans–which constitute their principal architectural feature.

Thus, the spatial blueprint of the Uplistsikhe complexes closely corresponds to the canonical iwan configuration, adapted into a rock-cut architectural medium. More specifically, as in the case of iwan-centered complexes in Parthian and Sasanian architecture (and later in Islamic architectural traditions), several defining characteristics can be identified: (a) complete frontal openness toward a courtyard; (b) a clear spatial hierarchy, in which these open, vaulted spaces serve as the primary structural and visual focus of the architectural ensemble; and (c) the presence of a barrel vault (d) the presence of a courtyard.

In fact, these complexes demonstrate that the structural and engineering principles developed in the Parthian and Sasanian architectural traditions of the Near East were replicated in carved form.

On this basis, I proposed that these spaces were created in the first–second centuries CE (as Iwan genesis attributed to the Parthian period) and primarily fulfilled sacred or temple-related functions.

An alternative interpretation, advanced by Dr. Guram Kipiani, identifies these complexes as funerary structures (Kipiani 2001). Drawing parallels with the rock-cut tombs of Phrygia and Paphlagonia, he questions the Iwan identification and suggests an earlier date, emphasizing the carved ceilings imitating wooden beam constructions.

Dr. Kipiani suggests that open vaulted spaces–iwans–were later additions, introduced during the Parthian/Roman period in response to changing aesthetic preferences and emerging architectural trends. This interpretation, however, is difficult to accept, as the iwans at Uplistsikhe constitute integral and organic components of the complexes. I would therefore argue that the construction of these complexes at Uplistsikhe took place in the first and second centuries CE.

Reassessing both positions, and taking into account the relative lack of attention in my previous research to the alcoves carved into the spaces behind the iwans at Uplistsikhe (Fig. 3), I am inclined to tentatively recon-

Fig. 2. Uplistsikhe, Makvliani iwan complex (photo Khimshiashvili K.)

Fig. 3. Uplistsikhe, Gzispira iwan complex with alcove in the background (photo Khimshiashvili K.)

sider the interpretation of these complexes as funerary chambers and, accordingly, to suggest that they may be understood as hypogea featuring arcosolia.

Thus, it may be suggested that the rock-cut complexes of Uplistsikhe represent a deliberate architectural synthesis, integrating the spatial articulation and vaulted façade characteristic of the iwan with the depth, interior organization, and ceiling treatments typical of Asia Minor rock-cut tombs. Within this hybrid framework, the vaulted opening may be interpreted as a symbolic canopy marking a sacralized interior space, accommodating ritual practices that may have been directed either toward deities or toward commemorative cults of the deceased.

This reinterpretation highlights Uplistsikhe as a dynamic site shaped by the interaction of regional Caucasian traditions and broader Hellenistic–Parthian cultural influences. The present study thus contributes to ongoing debates concerning the function, chronology, and cross-cultural architectural vocabulary of rock-cut monuments in the ancient Near East and the Caucasus.

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Utilities for Rainwater Harvesting in the Laura of St. David, and Rock-Cut Furnishings In the Udabno Monastery of Davitgareji Wilderness, Georgia

Lado Mirianashvili

Independent Researcher
V. Bochorishvili str. 37B, Tbilisi 0160
lado_miriani@yahoo.com

Abstract

This article addresses the study of the rainwater harvesting infrastructure used in the Laura of St. David and provides a detailed knowledge about functioning of the entire system.
In the second part of the article, rock-cut furnishings of a refectory, martyrium and stable of Udabno Monastery are discussed.

Keywords: rock-cut monastery, water cistern, stone refectory table, rock-cut larnax, feed trough

Davitgareji Wilderness lies some sixty kilometers from Tbilisi, the capital of Georgia. While the area shows traces of settlement in the second and first millennia BC, as evidenced by archaeological finds, there was a distinct break in continuity in ancient history until a monastic community led by a monk named David Garejeli settled there in the sixth century AD. According to a hagiographic tradition, Father David was one of thirteen missionaries who came from Mesopotamia to strengthen the Christian faith in Georgia.

St. David Garejeli laid the foundations for the large-scale monastic movement in east Georgia, which ended up by establishing some twenty monasteries between the watersheds of the Iori and Mtkvari Rivers. All twenty monasteries are rock cut. The three of them – Laura of St. David, Dodorka and Natlismtsemeli Monasteries were established in the lifetime of St. David by him and his disciples.

Utilities for Rainwater Harvesting in the Laura of St. David

The role of water management within rock-cut monasteries of Davitgareji Wilderness has received little attention so far. This article examines the rainwater harvesting system in the Laura of St. David. Since we lack documentary sources related to the water supply system of local monasteries, the research is based on the study and analysis of the surviving architectonic remains.

An ancient center of the monastic movement in Georgia Davitgareji Wilderness is a semi-desert with hot and dry climate. Monasteries needed water for drinking, cooking, washing and gardening. Unfortunately, there are no natural freshwater sources throughout the area. The clay pipeline system traditionally used in Georgia for supplying medieval monasteries and palaces with water, which is well attested in Vardzia, Dmanisi, Geguti, Shiomgvime and Tiflis, did not develop in Davitgareji Wilderness. Taking the above into consideration, there was an urgent need for identifying an alternative and somehow regular water supply ensuring survival of the monastics. The monks of Davitgareji successfully solved the problem by use of the ancient rainwater harvesting techniques. The method is simple but effective. This technique was used as early as in 1,700 BC in Knosos, Crete, as well as in the Roman Empire. It is well attested both in East and West Christendoms, such as the monasteries in Palestine or a monastic settlement of Skellig Michael in Ireland.

An ancient rainwater harvesting system survived in the Laura of St. David, Davitgareji Wilderness. It is difficult to state an exact date of its construction. Most probably the rainwater harvesting system functioned there since the ninth century AD or even earlier.[1] Monks residing in the Laura of St. David still use the system. This gave me a good opportunity to understand the technical design, construction and functional aspects of rainwater harvesting system used in Middle Ages.

Monks used and still use rainwater both for personal needs and gardening. Despite the fact that they have

1 The study of characteristics of hydraulic plaster layers of rock-cut cisterns and their radiocarbon dating, which could have assisted in dating the entire rainwater harvesting system, was far beyond my scope.

Fig. 1. A sloping bedrock with grooves directing water streams into cisterns. Laura of St. David (Photo Mirianashvili L.)

Fig. 2. A zigzag groove entering the cistern. Laura of St. David (Photo Mirianashvili L.)

selected the semi-arid region with its dry climate and poor vegetation as a place of habitation on purpose, since it was the most appropriate spiritual training area for confronting demons and controlling bodily desires, for training souls and contemplation of the divine – the monks attempted to somehow modify the environment in the immediate proximity of the Laura of St. David. To implement the plan, the monks first selected an appropriate site for planting a garden – a mountain recess, a kind of geological depression shielded from direct sun and hot winds.

Before discussing medieval rainwater harvesting system functioning in the Laura of St. David, I should mention a water source which is more of a religious significance rather than being a water supply used for drinking. I mean a *"fountain of tears"*[2] dripping in one of the caves of the Laura. Believers consider that the water has miraculous powers, and call it *"St. David's water source"* or *"water source of grace"*. The latter embodies the concept of *"living water"*, symbolizing the Holy Spirit and holy water used in baptism. According to the legend, the *"fountain of tears"* was generated by God to sustain St. David and his disciple after the former prayed fervently. Since water is dripping from a cave ceiling all year long, this is not the case when the snowpack melts over the cave during the spring months and water from the surface seeps down. Most probably *"a fountain of tears"* is the condensation water.

Rainwater for everyday use was harvested from the exposed smooth, sloping bedrock overlooking the Laura (Fig. 1). Narrow grooves are cut directly into rock to direct water streams, preventing water from dispersing. The rainwater harvesting utilities in Davitgareji Wilderness have certain original peculiarities. The water channeled down the slope goes through several cleverly designed devices. The jet of water approaches the cistern by a zigzag path needed to decrease velocity of water flaw to avoid washing off the sand and gravel from the rock surface into the cistern. The zigzag groove enters into a shallow, basin-like depression near the opening of a cistern (Fig. 2). In these sedimentation basins silt and sand would settle before water entered a cistern. It was easier to remove sediments from surface basins than from the cisterns. It also may be that these depressions held a mixture of sand and gravel allowing for the purification of rainwater through natural filtration method. There was also an assumption that the depressions were filled with the mixture of sand with salt to increase rainwater salinity, which would guarantee a long-term preservation of water in cisterns (Nikolaishvili 1950, 33). There is no reason to think that the assumption is true. On the one hand, the use of salt seems to me unlikely because there was a large deficit of it in Georgia. Salt was brought from Kars, namely from the upper reaches of Araxes. Due to this, the salt cost was high, making it a precious commodity. The Georgians even have an idiom *"He went to fetch the salt"* which means that a person who travelled hundreds of kilometers to bring the salt home, did not return back, i.e. he died on the way. In addition to high cost, the basin-like depressions are found near the opening of those cisterns which held water for irrigation purposes. It is obvious that the saline water could not have been used for watering plants.

Along the grooves channeling water down the mountain slope, indentions are rock cut at equal distances from each other. They served as steps facilitating access to grooves to maintain them clean: as a result of rainwater downflow, mud, silt and sediments accumulated in the grooves over time. They were to be cleaned on a regular basis.

The rainwater running down the mountain slope was collected and stored in large cisterns carved into the

2 Jeremiah 9:1.

Fig. 3. An indoor cistern. Hermitage, Laura of St. David. The close-up of the cistern on the left (Photo Mirianashvili L.)

rock at the foot of the mountain slope. Their positioning underground guaranteed reduced evaporation and keeping water cool. At the same time, stable temperature prevented bacterial growth.

Four water cisterns were surveyed within the Laura's grounds, each with a channel feeding them. Three cisterns are located within the perimeter of the enclosure wall of the Laura, and one of them – outside of the latter. Walls of the cisterns are covered with a uniform layer of yellowish waterproof lime plaster to prevent water leakage. In the majority of cisterns, the plaster is still well-preserved. One of the four cisterns is used till now. An average size of each cistern is 60-70 cubic meters, and an average capacity – 60,000-70,000 liters.

The cisterns are of rounded shape. Their openings are quite wide to fit a man through them. Openings of the cisterns were probably covered by a lid made of wood. Nowadays, monks use to cover an opening of a cistern by wooden lid made of several wooden boards paired with rainproof canvas.

Cisterns found in the Laura of St. David can be subdivided into two types:

a) The cisterns intended for collection and storage of potable water. These are two-tier vessels positioned one below the other. Water was first channeled into an upper cistern. After heavy sediment drops settled in it, water from the upper cistern was channeled into the lower cistern in which finer particles settled. The lower cistern was used for the prolonged storage of water. Periodically, the cisterns were cleaned from accumulated waste materials and the cracks in their walls, if any, were sealed.

b) Cisterns holding the water for irrigation purposes were rock-cut at the highest point of the garden so that gravity could aid in the distribution of water. These cisterns have a drain hole at the bottom. The plug was removed when watering of plants was needed. In several cases, below the cisterns we see an overflow basin to ensure that nothing was wasted during strong downpours. The overflow system prevented flooding and redirected excess water to the garden. In one case, a water trough is rock cut below a cistern for watering animals. Its average size is 30X50X80 cm.

Calculations show that assuming an annual consumption rate of 7 m3 per person (Tsuk 2011, 28–33) and taking into consideration total population of the Laura not exceeding 50 monks (including the hermits living outside the Laura), the number of pilgrims visiting the site, requirements for watering animals and gardening, and taking into consideration existence of at least four large rock-cut cisterns capable of holding up to 350 m3 of water, the water storage capacity of the Laura of St. David satisfied all basic needs during a hot season, moreover from time to time an opportunity arose to replenish the expended water resources.

Agricultural terracing can be noted on the patch of land where the garden was built. It is important to note that the garden is rather small, therefore its main func-

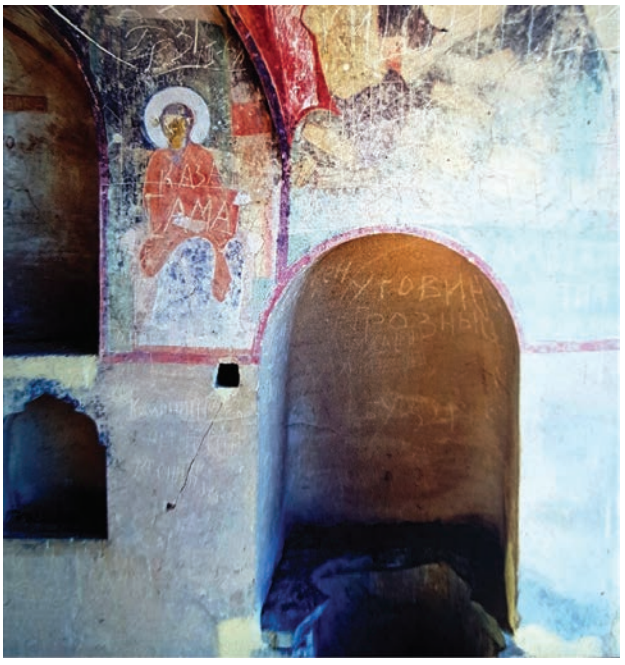

Fig. 4. An indoor cistern. Hermitage, Chichkhituri Monastery (Photo Mirianashvili L.)

Fig. 5. An indoor cistern. Refectory, Udabno Monastery (Photo Mirianashvili L.)

tion was not providing exclusively a livelihood for the monks. Traditionally, monasteries of Davitgareji Wilderness were large landowners. Their agricultural lands were located elsewhere. Those lands were cultivated by monastery serfs, who functioned as unfree laborers bound to the land. Growing crops in the garden of the Laura of St. David had a symbolic meaning as can be judged from a paragraph of *"The Regulations of the Royal Court"*, a historical document of the fourteenth century AD:

"The gifts from Gareji [to the Royal Court] are pickled capers, some reed and some small gifts – well-tied brooms…. The gifts worthy of being viewed: figs strung on a stick, "churchkhela"[3]*; … also almonds, pine cones, sumac, dried pomegranate, twelve jugs of honey, …"* (Regulations 1993, 97).

It can be concluded that the role of the gifts brought from the monasteries of Davitgareji Wilderness was to share grace of the holy place with the Royal Court. In exchange for this, the monasteries received significant donations.

Apart from large cisterns rock-cut under open sky, there are smaller ones located within caves. One of them is found in the so-called branch of St. Hillarion in the Laura of St. David. Its opening is placed within a semi-circular niche rock cut in the east wall of a residence room (Fig. 3). Another example is from a complex with an oratory in the Chichkhituri Monastery. Here the opening of a cistern is also placed within a semi-circular niche rock cut in the east wall, south of a prayer niche (Fig. 4).

One more indoor cistern is found in the refectory of Udabno Monastery.

The Furnishings of a Refectory in the Udabno Monastery

The opening of a rock-cut cistern found in the refectory is placed within a high semi-circular niche rock cut in the west wall of the main hall (Fig. 5). The cistern is of larger capacity than two other indoor cisterns found in the Laura of St. David and Chichkhituri Monastery. This is understandable taking into consideration that the refectory was the place where all monks would gather after they completed the liturgy in the church. The refectory of Udabno Monastery could accommodate some fifty monks at a time.

The rainwater was harvested on a mountain slope and clay pipes were used for channeling water into the cistern from outside. The pipes are tapered from one end to the other. Each pipe is 45 cm long with spigot and bell ends that were necessary for assembling a single pipeline. Joints in clay pipes were sealed with mortar. This method was ensuring a rigid connection of spigot and bell ends and was excluding water seepage. The clay pipeline was not equipped with intermediate inspection chambers to allow for cleaning from clogs. Monks probably had to disassemble the pipes to clean

3 Churchkhela is a kind of sweets made from walnut meats in halves placed onto thread and coated with dried grape juice boiled with flour.

Fig. 6. The rock-cut tables. Refectory, Udabno Monastery (Photo Mirianashvili L.)

them when necessary. A bucket on the end of a rope was used to remove water from the cistern.

The plan of the refectory in Udabno Monastery was a rectangle elongated along the N-S axis. Due to the collapse of a mountain slope, the south wall with part of the base also collapsed. At present, the south side of the refectory is open to the elements. The load-bearing rock-cut triple arcade supports the ceiling along its central axis. Columns of the mid-arch are painted with figures of stylites standing on columns. The arcade creates a rhythm in a large space and somehow separates an apse with an altar table from the dining hall, even though the stone tables extend from one space into another: two long N-S oriented rock-cut tables pass through the mid and eastward arches (Fig. 6). Originally, wooden boards were laid on top of the stone tables, which resemble refectory tables known from Cappadocia and Palestine, though with some difference: the tables in Udabno Monastery, as well as in Bertubani monastery, have small recessed shelves rock cut at equal distances from each other. They were used for storing earthenware. Stone tables in the refectories of Cappadocia and Palestine lack this feature. Another difference concerns existence of two long tables in the refectory of Udabno Monastery, whereas refectories in Cappadocia and Palestine always have a single long table.

In the refectory of Bertubani Monastery of Gareji Wilderness, as well as in the refectories of Cappadocia, a dining table has stone benches on both sides. Since the refectory of Udabno Monastery lacks stone benches, I can conclude that they were disassembled or the benches were made of wood.

Two arched niches are rock cut in the north wall of the refectory in line with the mid and eastward arches of the triple arcade. The westward arch of the triple arcade is in line with a large quadrangular niche on the north wall. At the far end of the stone table, which runs closer to the center, is rock cut an arch-headed niche-within-a niche in which the Superior's stone seat is arranged. Like the refectories of Davitgareji Wilderness, the refectories of Cappadocia also have a niche for the Superior's commanding position at the head of a table. The upper half of the Superior's niche in the refectory of Udabno Monastery is decorated with Deesis. The mural dates to the early eleventh century AD, with traces of the thirteenth century renovation.

Other monks occupied their seats at the long sides of a table according to their rank and seniority. This setup reinforced monastic hierarchy during communal meals.

Analogies of the refectory of Udabno Monastery, which dates to the eleventh century AD, are found not only in Cappadocia, but also in the Holy Land. A German Christian pilgrim Thietmar who visited the Holy Land in 1217–1218 and wrote an account of his travels, describes the one: "*They all have in common one large and beautiful refectory, and similarly one long table placed*

Fig. 7. A rock-cut *larnax*. Martyrium, Udabno Monastery (Photo Mirianashvili L.)

Fig. 8. A feed trough. Stable, Udabno Monastery (Photo Mirianashvili L.)

in the middle of the refectory, at which their bishop sits at the end and the others around it, two by two, eating from the bare table without a table cloth… They eat without a reading, but with discipline. They always drink water, except on a few solemn feast days when they partake of a little wine." (Pringle 2016, 124).

Refectory of the Udabno Monastery has two ancillary facilities: an arched opening eastward of the Superior's niche leads into a small cave which was used for storing provisions. A low cellar for holding wine is located to the west of the refectory. Wine was the standard drink in monasteries of Georgia and Byzantium. It was stored in a large clay vessel called *kvevri* (a kind of *pithos*) dug into the floor[4]. Cooking and food preparation took place in a kitchen separated from the refectory.

Meals in the refectory were served twice a day. Apart from that, commemorative meals for the dead were also held and prayers were read. One of the primary components of the refectory was a reader's pulpit. During meals, a monk read aloud the Bible and other sacred texts from a pulpit to provide spiritual nourishment for the souls of monastic brothers. It can be assumed that a pulpit in the refectory of Udabno Monastery was made of wood because no trace of it has survived; or taking into consideration that the pulpit stood for sure at the south end of the hall where was plenty of light for reading, the stone pulpit could have vanished together with the collapsed south end of the hall.

The refectory walls are lavishly decorated with murals. The Last Supper, which was the most popular scene in refectories, is depicted on the east wall of the hall symbolizing spiritual continuity. Hospitality of Abraham is depicted in the eastward niche of the north wall. The iconography of the scene is unique because apart from Abraham, his eldest son Ishmael is depicted in the mural (Mirianashvili 2013, 110).

In general, after the Catholicon, the refectory was the second most important architectural structure within a monastery. These two structures were traditionally located in close proximity with each other. This was due to the fact that the Catholicon and refectory were linked by a monastic ritual that started in the former and continued in the latter. There is an apse-shaped niche with the altar table in the east wall of the refectory in Udabno Monastery. The same is found in the Bertubani Monastery, also in Davitgareji Wilderness. Unfortunately, we lack historical accounts about the rite performed at the niche in the above-mentioned refectories. Based on the study of written sources, I arrived to the conclusion that the main ceremony conducted at the apse was the Elevation or Lifting of the *Panaghia*. To back up this consideration, I adduce account from the diary of John Lloyd Stephens, an American explorer, writer, and diplomat (nineteenth century AD), about his visit to the Monastery of St. Catherine on Sinai, with which Georgian monks maintained close contacts, as well as a *typikon* of Shio-Mgvime Monastery in Georgia. The pilgrim writes that he was invited to dine with monks. After dinner the monks approached the altar, which stood at one end of the refectory. *"They kneeled, prayed, and chanted and went through a long routine of ceremonies."* (Stephens 2008, 512). The consecrated bread and wine were distributed at the end of the ceremony. John Lloyd Stephens considered it a sacrament. Actually, this was the rite of the Lifting of the *Panagia*. In the surviving thirteenth century *typikon* of Shio-Mgvime Monastery we find an account about practicing this rite after *trapeza*. According to the text, the *Panaghia* was Lifted by a refectorian. Psalms 110: 4-10 and 121:1-9 were chanted during the ceremony. As this part of the *typikon* was translated from Greek into Georgian by Giorgi Mtatsmindeli (the Athonite) in 1042, I consider that the tradition of the Lifting of the *Panaghia* was introduced in Georgian monasteries after 1042 (Earlier, there existed the Jerusalem rite of lifting the consecrated bread).

Other Furnishings in the Udabno Monastery

A Trough-Shaped Rock-Cut *Larnax*

On the western edge of the Udabno Monastery there is a structure called *"Motsameta"* (Of the Martyrs) which is a combination of a rock-cut cave and a stone-built external part – a later addition. The double arches lead into a slightly trapezoidal-shaped cave with its shorter base oriented toward the cave mouth. A stone altar and prothesis are abutting upon the east wall which lacks an apse: it is flat. An east–west aligned, a trough-shaped rock-cut *larnax* (without a lid) runs along the north wall (Fig. 7). It was rock cut within the bedrock by removing a vertical rock layer above the *larnax*. A multi-figure composition of the martyrdom of monks is depicted on the north wall above the *larnax*. In 1920, members of a scientific expedition to Davitgareji Wilderness have evidenced that the *larnax* was full of human bones (Gordeev 1920, 43). Taking the above into consideration, it can be concluded that the cave was a collective martyr shrine. It is considered that the martyrium is dedicated to the Davitgareji monks who were martyred by Turk-Seljuks during their invasion in the second half of the eleventh century. The *larnax* for the remains of the martyred monks was made in a form of a winepress, *"in imitation of pressing sweet grapes in the winepress of torment"* (Anton I 1980, 206).

4 *Kvevri* for wine are buried underground to maintain a stable, cool temperature throughout the year, allowing for natural fermentation.

A Feed Trough in a Rock-Cut Stable

At a distance of some 50-60 meters from the "*Motsameta*" martyrium, there is a wide and shallow cave. The walls of the cave are left raw, without plastering. There is a feed trough rock-cut along the north wall of the cave (Fig. 8). The feed trough features holes used for fastening ropes. Since monks in monasteries of Davitgareji Wilderness followed a strict, plant-based diet, never consuming meat, we can assume that the cave with trough was not the space for livestock, but it was used for housing mules and horses, the dominant means of overland travel in ancient times. Beside the practical benefits, the stable had also a symbolic meaning: by being born in a manger, Jesus showed that he came to be a part of everyday humanity. Therefore, the manger is a major spiritual symbol that represents Christ's love for all people.

Conclusion

The study of material cultural heritage that has survived in rock-cut monasteries of Davitgareji Wilderness, fosters understanding that people in the Middle Ages were a great deal more mobile than it may be considered by the modern society. The surprisingly intense relationships between Georgia, Byzantium and the Holy Land during the Middle Ages is confirmed by implementation of the knowledge accumulated in remote monastic centers into the monasteries of Davitgareji Wilderness. It is of note that the shared knowledge was not copied blindly: specific needs and local traditions were taken into consideration. Taking the above into account, the study of Georgian monastic heritage will contribute not only to local history, but also to general knowledge of Eastern Orthodox monastic heritage and traditions.

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Burials and their Paintings in the Gareja Monastic Association
The Tomb of Saint Dodo Garejeli

Zaza Skhirtladze
Ivane Javakhishvili Tbilisi State University
Institute of Art History and Theory
Zaza.skhirtladze@tsu.ge

Abstract

This paper examines the fragments of the paintings survived in the northern arm of the burial chapel of St Dodo Garejeli in the Monastery of St Dodo, one of the principal monastic foundations of the Gareji Desert. Drawing upon hagiographical sources, nineteenth-century descriptions of the opening of the saint's tomb, early twentieth–century expedition records, and the surviving remains of the wall painting, the study reconstructs the mural programme of the funerary chapel and reassesses its iconographic meaning.

The *Life* of St Dodo Garejeli records that the saint's tomb bore his painted image "in the form of the deceased", while the surrounding walls were decorated with a representation of his soul being ascended to heaven by angels. These textual testimonies correspond closely with the surviving paintings uncovered during the cleaning of the church by the local brethren, including the painted image on the tomb and the group of monks represented on the adjacent north wall. Their stylistic analysis further reveals that the painting of the northern arm of the funerary chapel comprises several chronological phases, reflecting the complex history of the monument.

The surviving fragments formed a unified iconographic programme representing the *Dormition of St Dodo Garejeli.* This concise adaptation of the Late Byzantine iconographic type of the Dormition of monastic saints ingeniously distributes the composition between the saint's tomb and the surrounding walls, transforming the painted image itself into the focal point of the funerary image. The monument thus represents a unique reinterpretation of a well–established Christian Orthodox iconographic tradition and constitutes the only known surviving example of this subject in medieval Georgian monumental painting.

The article illuminates broader questions concerning the commemoration of saints, the decoration of monastic burial chapels, and the development of funerary iconography in the medieval Christian East.

Keywords: desert monasticism; Gareja monastic association; rock-cut burials; wall paintings; funerary portrait

Situated on the southern slope of the ridge beyond the Gveleshapi Gorge, to the north-east of the principal centre of the Gareji monastic association – the Lavra of St David – the monastery founded by St Dodo, a disciple of St David Garejeli, during the first half of the sixth century remained for centuries not only one of the principal monastic establishments of the Gareji Desert but also one of the foremost spiritual centres of medieval Georgia. Its foundation originated in the initiative of St David himself, who, as the monastic brotherhood increased in number, instructed his disciple to establish a new monastery. The obedient disciple fulfilled St David's command by founding a monastery dedicated to the Mother of God, while he himself took up residence in a small cave cell, where he pursued an ascetic life for many years. Following his death, St Dodo was buried in this cell (Monuments 1968, 418):

The entire assembly of the Fathers gathered together and carried him to the upper rock, to the cell wherein he had pursued his ascetic labours. There they transformed the cell into a church, hewn from the rock on its left side, wherein his holy relics repose. The dust from his tomb heals every infirmity of mankind. Upon the tomb was painted the holy Father in the likeness of the deceased, while upon the walls surrounding the tomb was depicted his ascent into heaven borne by angels.

The Synaxarion recension of the *Life of St Dodo Garejeli*, preserved in a single manuscript (National Centre of Manuscripts, MS A–220, dated 1726), contains a brief yet exceptionally valuable account of the painted decoration of the saint's burial chapel. This recension was most probably composed during the 1720s by Metropolitan Romanoz Eristavi (1695–1753), a hierarch who had taken monastic vows at Gareji and spent

twelve years in the Monastery of St John the Baptist in the Gareja Desert (Mirianashvili 2020, 342–359). He was therefore intimately familiar both with the history of the monastic centres of the Gareji Desert and with their condition in his own day. During the first half of the eighteenth century the monastery was still inhabited by monks, although a considerable number of its rock-cut churches, cells, and ancillary structures had already been abandoned and partially buried beneath accumulated earth. At the same time, liturgical services continued to be celebrated in several of the rock-cut churches, quite possibly including the burial church of St Dodo. Equally significant is the existence of a local oral tradition, comparable to numerous monastic traditions preserved and transmitted through successive generations of monks over the centuries.

The Monastery of the Mother of God founded by St Dodo continued throughout the centuries to rank among the most important spiritual centres of the Gareji Desert. Extending over a vast area along the southern slope of the rocky ridge, the rock-cut complex was gradually enlarged during successive phases of its history with the addition of new churches, residential sections, and economic and service structures, while many of the earliest caves underwent architectural modification. This process continued until the 1760s, when monastic life at St Dodo monastery came to a prolonged halt (Kavtaria 1965, 183). During the ensuing centuries of abandonment, the complex fell into ruin, and its churches together with other structures were gradually filled with earth. The same fate befell the saint's burial church. By the second half of the nineteenth century it was already partially buried (Sabinin 1882, 292):

The tomb of the venerable Father could still be seen within the katholikon of his monastery; but now the rains have completely filled it with sand, thus concealing from us forever this treasure of the church.

Compounding this deterioration, the southern half of the rock-cut church collapsed, rendering access to the monument exceedingly difficult.

On 16 March 1880, at the initiative of Mikhail (Gobron) Sabinin, members of the brotherhood of the Lavra of St David opened the tomb of St Dodo. The saint's relics were translated to the Church of the Transfiguration in the Lavra of St David, the principal sanctuary of the Gareji monastic association. In the rock-cut bay opposite the tomb of St David a small tomb-shrine was cutted, within which the relics of St Dodo were deposited (Skhirtladze 2001, 35–36).[1]

The opening of St Dodo's tomb is described both in a contemporary account written by Spiridon Grdzelishvili, a novice of the Lavra of St David and an eyewitness to the event (National Centre of Manuscripts, MS S–3283d), and in the account of St Dodo appended to *The Paradise of Georgia*, published by Mikhail (Gobron) Sabinin. These two descriptions, of considerable importance for the study of burial customs in the monasteries of Gareji and, more broadly, throughout the Christian East, correspond closely in their essential details (Mirianashvili 2012, 3551; Mirianashvili 2004, 110–117; Mirianashvili 2010, 109–121). Both explicitly attest that an image of the saint was painted upon his tomb (Mirianashvili 2012, 38):

"The Paradise of Georgia":

The tomb of the venerable Dodo
was uncovered, and upon it was
painted the image of the holy Father,
wrapped within a funerary
covering beneath an arched canopy.

Spiridon Grdzelishvili:

The plastered tomb of the saint
was revealed, and upon it
was painted the image
of the venerable Dodo.

During the opening of the tomb, the large stones covering part of the burial were removed. These had been plastered by three successive layers. Beneath them was a layer of earth, under which the stone slabs sealing the grave were revealed.

* * *

Both the above-cited passage from the Synaxarion *Life of St Dodo Garejeli* and the accounts describing the opening of his tomb and the transferring of his relics to the Lavra of St David preserve two pieces of evidence of exceptional importance.

First, they state that the saint was buried in his own ascetic cell, which was subsequently converted into a church.

Secondly, they record that the saint's tomb bore his painted likeness "in the form of the deceased", while the surrounding walls were decorated with a representation of his soul being ascended into heaven by angels.

Like many of the earliest cave structures of the Gareji Desert, St Dodo's burial place – originally a modest and architecturally simple cave burial chamber retaining much of its natural form – appears to have been renovated during the second half of the ninth century, in the course of the extensive process of monastic renewal undertaken in Gareji by St Hilarion the Georgian (†875). At that time it was transformed into a small cross-in-square domed church (Fig. 1).[2] Similar churches were

1 This development elicited mixed reactions within the local society. A number of strongly critical responses were published, giving rise to a sustained polemical debate.

2 Giorgi Chubinashvili dated the church to the end of the seventeenth century (Chubinashvili 1948, 101). Research conducted

Fig. 1. Burial church of St Dodo Garejeli. General view from south-west

created throughout the ninth and tenth centuries in numerous monastic centres of the Gareji Desert, including Sabereebi (Gaprindashvili 1987; Gaprindashvili 1988, 5−17;[3] Tumanishvili 2013, 39−55), the first complex of Beris Seri (Gaprindashvili 1988, 9, sch. 17−18), Didi Kvabebi (Gaprindashvili 1987, sch. on p. 30), Patara Kvabebi,[4] Berta Mt'a (Skhirtladze 2004, 115−122), Mravaltsq'aro (Kldiashvili et al., 1998, 40−41, sch. 45), Verangareja (Gaprindashvili 1987, shc. on p. 23), Kotsakhura (Gaprindashvili 1987, sch. on p. 22; Gaprindashvili 1988, 9, fig. 15−16), Satorge (Jgenti 2025), and the Monastery of St Dodo itself (Gagoshidze 2013, 64−72).

During the reconstruction the tomb of St Dodo came to occupy the northern arm of the newly executed church. Neither the original form of the saint's burial nor the character of its original decoration is known (Fig. 2). By contrast, the decoration of the sanctuary conch, namely the so-called liturgical version of the *Glory of Christ* has long been known and studied.[5]

Fig. 2. Burial church of St Dodo Garejeli. Conch composition

over the following decades, however, has demonstrated that the church was most probably created in the second half of the ninth century or at the beginning of the tenth century. The *terminus ante quem* for the execution of the church is provided by the second half of the ninth century, when the apse conch and, supposedly, the upper section of the north wall of the northern arm were decorated with mural paintings.

3 In the publication of Gaprindashvili the churches of the Sabereebi cave complex are dated to the fifth–sixth centuries.

4 Unpublished.

5 The frescoes decorating the apse conch of the sanctuary constitute one of the finest surviving monuments of the formative stage of the David Gareji school of painting. Most scholars attribute the execution of the conch composition to the ninth century (see Virsaladze 1977, 6; Volskaia 1983, 9; Sheviakova 1983: 16; Lazarev 1986, 58−59; Volskaia 1988, 138; Volskaia, Buchukuri 1990, 53−63; Skhirtladze 1991: 109; Skhirtladze 2008: 26−28).

Fig. 3. Burial church of St Dodo Garejeli.
Color drawing by Yevgeny Lansere. From: Chubinashvili 1948

The remaining evidence concerning the painted decoration of St Dodo's burial church is considerably more fragmentary, particularly with regard to the surviving paintings in the northern arm, which were still partially preserved during the first decades of the twentieth century. Nevertheless, these remains are of considerable importance for the study of the painted decoration of saints' burial chapels, both within the Gareji monastic association and in medieval Georgia more generally.

During the scientific expedition to the Gareji Desert organised in 1921 under the direction of Giorgi Chubinashvili, the artist Yevgeny Lansere produced a colour drawing depicting the burial church of St Dodo from the south-west (Fig. 3). His drawing records, in a schematic manner, the paintings preserved in the upper part of the northern arm, where fragments of two haloed frontal figures standing side by side are visible against a blue background on the eastern half of the wall. The drawing further indicates that, by that date, much of the plaster in the lower part of the arm had already been lost.

Another participant in the expedition, Dmitry Gordeev, provided a more detailed description of the surviving paintings on the north wall of the northern arm: "*On the upper register of the north wall of the church are full-length figures of warrior saints (originally numbering three). Traces can still be discerned around the halo: adjacent to the spear of the easternmost saint − St Theodore, while the central figure − St George. In the lower register, only fragments of the full-length representations of the holy Fathers remain. Nearly all of them, except for the two easternmost figures, have perished together with the plaster layer. These holy ascetics were painted by an artist distinct from the master responsible for the decoration of the conch and the warrior saints; instead, they exhibit close stylistic affinities with the painted decoration of the built-in iconostasis, which is adorned with carved stucco ornamentation executed in the Persian style*" (Gordeev 2019, 376). Apart from the identification of the figures depicted in the upper part of the wall, of particular significance is the observation that the paintings in the upper section of the north wall of the northern arm differ in execution from those preserved in the chancel conch and on the lower half of the north wall. This distinction is of particular significance, as it suggests the existence of different decorative phases within the painted programme of the church.

Comparable evidence is provided by another participant in the same expedition, Shalva Amiranashvili, who briefly described the fragments of wall painting that still survived in the northern arm of the church during the first quarter of the twentieth century. According to Amiranashvili, one fragment preserved the image of St George, although the severe deterioration of the painting rendered any determination of its date impossible. A second fragment depicted the three-quarter figure of an elderly monk turned to the left, which he attributed to the fourteenth century (Amiranashvili 1957, 31).

The surviving paintings on the north wall of the northern arm of the church were described somewhat differently by Tatiana Sheviakova. She identified the remains of what were probably two standing saints represented at full length, of which only the heads had survived. On the basis of facial type, she identified one of the figures as St George, while the other appeared to have represented an elderly monk. Judging from the palette and the manner of execution, Sheviakova considered these frescoes contemporary with the decoration of the sanctuary conch. She further observed that the eastern and western walls of the northern arm had remained unpainted (Sheviakova 1983, 16).

None of these descriptions, however, mentions the tomb of St Dodo Garejeli and its painting. It would appear that by the beginning of the twentieth century the tomb itself had already been buried beneath accumulated earth, whereas the paintings immediately above it, on the lower part of the north wall of the northern arm, remained exposed.

During the subsequent decades, flood deposits gradually filled the interior of the church almost to the level of the sanctuary conch. The remaining plaster on the up-

Nevertheless, alternative chronological assessments have also been advanced, assigning the monument to the late Middle Ages (Chubinashvili 1948, 101; Gordeev 2019, 375−377) or to the seventh century (Amiranashvili 1957, 31−33; Ihm 1992, 43).

Fig. 4. Painting on the tomb of St Dodo Garejeli and the fragments of the murals on the northern wall of the north arm of the church. General View

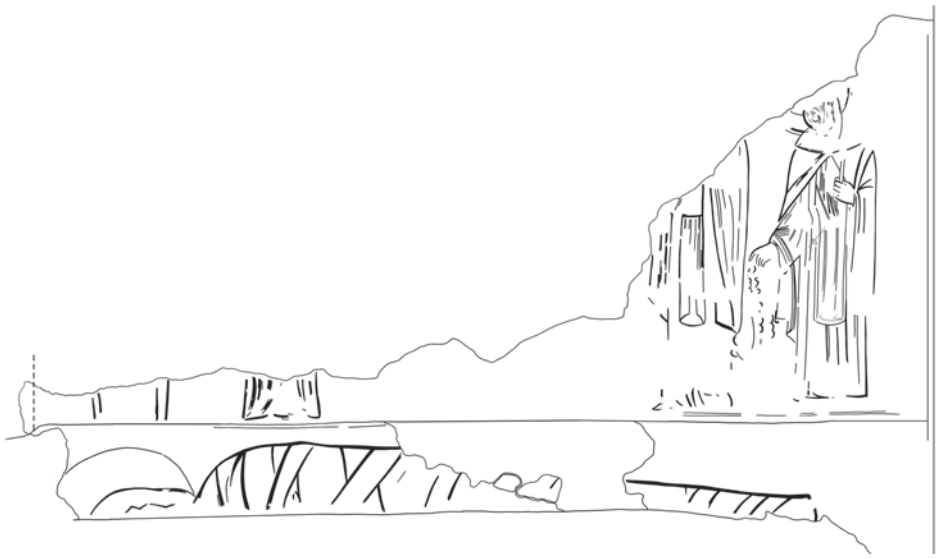

Fig. 5. Painting on the tomb of St Dodo Garejeli and the fragments of the murals on the northern wall of the north arm of the church. Scheme

per part of the walls was completely lost, together with the paintings it once bore.

At the beginning of the 2000s, monastic life was re-established at the Monastery of St Dodo. At the same time, the newly established brotherhood undertook the clearance of the cave structures that had become filled with earth. The burial church of St Dodo was likewise cleaned,[6] and a new grave slab was subsequently placed over the saint's tomb. Following the removal of the accumulated earth from the interior, the tomb and its painted decoration, to-

6 Several years before the cleaning campaign, the location of the tomb of St Dodo became the subject of the study (Jojua 2000, 36–44; Jojua 2001, 75).

Fig. 6. Burial church of St Dodo Garejeli. Fragments of the scene on the northern wall of the north arm

gether with the surviving fragment of wall painting on the north wall of the northern arm, were photographed, and measured drawings of the frescoes on both the tomb and the adjacent wall were executed.[7]

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The tomb of St Dodo is situated within the northern arm of the church upon a low platform raised one step above the floor level. At a certain stage in the history of the monastery, the upper surface of the tomb was plastered and painted with the lying frontal figure of the saint. During the opening of the tomb in 1880, the upper surface of the burial structure – more precisely, the plastered and painted layer covering its southern (left) half – was removed along its entire length. As a result, the southern half of the painted image of the saint was irretrievably destroyed.

The surviving right half depicts the deceased holy Father lying supine against a dark yellow background, his pale yellow halo framing the head and his hands crossed upon his chest. His monastic cowl and mantle are rendered in greenish–grey tones, while the contours of the garments are defined by a broad dark green outline. The folds of the drapery are articulated by oblique diagonal strokes of the same colour, imparting to the figure an appearance reminiscent of a funerary shroud. The perimeter of the tomb is enclosed by a double border composed of alternating reddish and white bands.

The lower register of the north wall of the northern arm, extending the full length of the saint's tomb and corresponding to the length of his recumbent figure, was occupied by a group of monks set against a blue background. These standing figures, relatively small in scale (approximately one metre in height), are represented with bowed heads, all facing towards the centre of the composition, that is, towards the body of the deceased saint (Fig. 4 and 5).

The easternmost figure is comparatively well preserved. This yellow-haloed hieromonk holds a censer in his right hand, depicted in the act of incensation; both the hand and three rows of the brown suspension chains remain visible. His raised left hand, held before the breast, evidently once carried a candle, although its upper portion has not survived. He is vested in a dark reddish-brown tunic, the folds of which are modelled with dark brown highlights. Over it he wears a greenish-ochre monastic mantle fastened across the chest. The cowl and epitrachelion are blue, the latter embellished with white linear highlights indicating the folds and terminating in white knotted tassels. The partially preserved face, inclined towards the centre of the composition, is executed in ochre over a yellowish underpaint, with pale green shadows defining the modelling. The surviving features preserve the general outline of a short, wavy grey beard (Fig. 6).

Immediately to his left stands another hieromonk, similarly attired. Only the lower half of his body has survived, while both hands are concealed beneath the folds of the mantle.

After a short distance, two additional figures of monks were depicted standing side by side in the western half of the north wall. Of these figures, only the lower hems of their monastic robes have been preserved.

The surviving fragments further reveal incised preparatory lines beneath the painted contours, demonstrating that the preliminary design of the composition was transferred onto the fresh plaster by means of incision.

Owing to the extensive deterioration of the plaster and the painted layer, any attempt to reconstruct the image that once occupied the upper central zone of the composition must necessarily remain conjectural. Nevertheless, the Synaxarion *Life* of the saint explicitly records that the tomb bore the image of the holy father "in the likeness of the deceased", while "upon the walls surraunding the tomb was depicted his ascent into

7 The photographs of the surviving fragments of the wall paintings preserved in the northern arm of the church and in the vicinity of St Dodo's tomb were taken by Giorgi Gagoshidze and Neli Chakvetadze in 2015. The graphic tracings of the paintings were executed in the same year by Neli Chakvetadze.

heaven borne by angels". Such a representation would naturally have occupied the uppermost part of the composition, providing both its formal culmination and its iconographic fulfilment. At the same time, it should be borne in mind that the row of warrior saints extended directly above this area, with their feet positioned immediately over the presumed scene.

The eastern wall of the northern arm is simply coated with a dark crimson colour. At its centre there appears to be the lower arm of a white cross. Equally, however, this may represent nothing more than an accidental area of pigment loss whose outline happens to resemble the lower arm of a cross.

Yevgeny Lansere's colour drawing does not record the paintings on the lower part of the north arm of the church, although it does indicate the upper edge of the surviving plaster. This omission suggests that by the 1920s this section had already been concealed beneath accumulated earth, thereby protecting it from further deterioration.

Even a cursory examination of the surviving paintings on St Dodo's tomb and the lower part of the north wall reveals substantial differences from the decoration of the chancel conch. Moreover, the painted image of the deceased saint upon the tomb is stylistically distinct from the figures represented on the adjacent wall. The execution of the tomb painting exhibits characteristics typical of sixteenth- and seventeenth-century mural painting, whereas the treatment of forms, linear modelling, and chromatic range evident in the figures on the north wall points to a date in the late fourteenth or early fifteenth century.

The stratigraphy of the painted decoration in the northern arm of the church, together with the relationship between its successive decorative phases, requires separate and detailed research. Nevertheless, one conclusion may already be advanced with some confidence. Considered as a whole, the painted image upon saint's tomb and the group of monks depicted along the lower part of the north wall most probably constituted a unified iconographic programme illustrating the ***Dormition of Saint Dodo Garejeli***.

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The practice of depicting a saint upon his or her burial place is attested in Georgia, as elsewhere throughout the Christian world, from the Early Middle Ages onwards, as demonstrated by both surviving monuments and written sources. In the principal church of the Monastery of St Nino at Bodbe, the image adorning the tomb of the Enlightener of Georgia, St. Nino (†ca.340) was most probably repainted during the sixteenth or seventeenth century. Nevertheless, the possibility cannot be excluded that the tomb of the Apostolic female saint had been embellished with her image from a much earlier period (Skhirtladze 2001, 24–25).

By contrast, explicit written testimony survives concerning the burial of St King Vakhtang Gorgasali (†502) in the Cathedral of Svetitskhoveli, where the existence of his painted image upon the tomb is specifically recorded (Juansher 1955, 204).

A comparable tradition is reflected in the written account of the Monastery of Iviron on Mount Athos, which states that the burial place of Sts Ioane (†1005) and Eptvime (†1028) the Hagiorites was adorned with an icon depicting the two saints (Giorgi Mtsire 1967, 201–202). This testimony appears to preserve a practice rooted in the broader Christian funerary tradition.

Further evidence may be adduced from the original burial chapel of St Queen Tamar (†1210), presumably located in the south-eastern chapel of the katholikon of the Gelati Monastery. Her memorial portrait is likely to have survived there, executed at the end of the thirteenth century in connection with the burial of King David VI Narin and the subsequent repainting of the chapel's interior (Skhirtladze 2011a, 223–255; Skhirtladze 2011b, 505–523).

Following the transferring of the relics of St Ioane Zedazneli, the leader of the Syrian Fathers who arrived in Kartli (East Georgia) at the beginning of the sixth century, to Mount Zedazeni and their deposition within a specially constructed stone reliquary in the funerary chapel, the tomb appears to have been surmounted by a sculpted stone slab bearing a relief composition. This depicts the Ascension of Christ, beneath which St Ioane is represented together with his local disciples and, most probably, the donor of the monument. Particularly significant in the present context is the interpretation of this relief as possessing a liturgical dimension, representing the commemorative service celebrated for the repose of the saint's soul (Volskaia 1979, 91–106; Iamanidze 2010, 105; Khundadze 2016–2017, 10–11; Dadiani, Kvachatadze, Khundadze 2017, 258).[8]

At Gareji, the tradition of placing the image of the deceased upon the tomb likewise appears to have originated in connection with the burial of the founder of the monastic community. Fragments of mural painting discovered on the eastern side of St David's tomb indicate that it was once decorated with painting. In this context, it is reasonable to suppose that the decoration originally included the image of the saint (Skhirtladze 2001, 22).

Of particular importance is a notice preserved in the treatise of Archimandrite Tarasi (Aleksi Meskhishvili). He records that, during the renovation of the burial sanctuary of St David, the Church of the Transfiguration

8 Aneli Volskaya dated the slab to the seventh century (Volskaya 1979, 91–106). More recently, however, the relief has been recognised as exhibiting close stylistic and compositional affinities with monuments of the sixth and seventh centuries (Dadiani, Khundadze, and Kvachatadze 2017, 258).

in 1811, *a carefully plastered wall, upon which were painted the images of St David and the Venerable Dodo, depicted embracing one another with joyful countenances as if celebrating their recent meeting. The subject of the representation was made explicit by the inscription above it, which read: "The Image of St David Returning from Jerusalem"* (Archimandrite Tarasi 1864, 42). The painting was dismantled immediately after its discovery.[9] Nevertheless, the subject does not preclude the possibility that it originally formed part of a more extensive pictorial programme decorating the vaulted funerary recess. Such an arrangement would find a close parallel in the burial chapel of St Nino at Bodbe, where the walls of the burial chapel were adorned with scenes from the saint's life (Janjalia 1990, 145–157).

A further parallel may be recognised in the Bertubani Monastery, where the image of the buried monk appears to have been incorporated into the upper register of an iconographically exceptional composition painted, most probably, during the tenth century above the stone tomb-shrine set against the north wall of the rock-cut martyrium (Skhirtladze 2006, 66–67, Fig. 6).

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The Dormition of eminent representatives of monasticism, and particularly of the Desert Fathers, remained one of the most enduring subjects of Christian art for many centuries. The iconographic scheme of this composition, grounded in both hagiographic literature and the liturgical traditions associated with the burial of holy monks, evolved gradually over an extended period. It is now generally accepted that its ultimate prototype was the iconography of the Dormition of the Virgin.

Representations of the dormition of holy ascetics are attested from the Middle Byzantine period – for example, in the concise versions preserved in the miniatures of the Menologion of Basil II – although the iconographic type appears to have assumed its fully developed form only during the Late Byzantine period. The approximately forty examples currently known from icons, monumental painting, and written sources (Achemastou-Potamianou 1991, 44–46) demonstrate that, by the fourteenth and fifteenth centuries, the scene had evolved into a complex, multi-figured composition. At its centre lies the deceased saint upon a bier, surrounded by disciples, fellow ascetics, and members of the clergy. This arrangement should be understood not merely as a visual expression of the veneration accorded to the saint but also as an affirmation of the spiritual unity of the monastic community (Achemastou-Potamianou 1991, 46).

At the same time, the composition exists in several iconographic versions, ranging from highly concise renderings to elaborate narrative cycles incorporating numerous episodes and a large number of figures. These subsidiary scenes generally relate to the saint's earthly life and activity.[10] One episode, however, recurs with particular frequency: the funeral service itself. This is typically represented by a hieromonk standing either at the head or at the feet of the deceased, swinging a censer while holding a lighted candle in his other hand. A deacon standing behind him likewise participates in the rite, while another monk, positioned at some distance, serves as a cantor. Among compositions of this type, the Dormition of St Ephrem the Syrian is by far the most widespread. Comparable scenes also depict the deaths of other eminent monastic saints, including St Arsenius the Great, St Euthymios the Great, St Sabas the Sanctified, St Onouphrios the Hermit, St Athanasios the Athonite, and several others. This iconographic tradition continued uninterrupted until the eighteenth century (Achemastou-Potamianou 1991, 47).

The composition preserved in the burial church of St Dodo Garejeli represents a concise adaptation of this iconographic programme. Given the modest dimensions of the church, a more extensive arrangement would scarcely have been feasible. Nevertheless, the decorative programme reveals an ingenious reinterpretation of the established scheme. Whereas in icons and frescoes depicting the Dormition of monastic saints all components of the composition are normally contained within a single pictorial field, in St Dodo's funerary church they are distributed between the saint's tomb and the adjacent wall. The painted image of the saint upon his tomb, executed in accordance with a long–established funerary tradition, thus became the focal point of the composition,

9 "The complete renovation of the church undertaken at that time necessitated the demolition of the wall, together with its painting, in order to realign the chancel screen. Once the wall had been dismantled, another wall was revealed behind it. Set within this wall was a small niche, plastered with gypsum, containing a small cavity in which was preserved the precious stone brought from Jerusalem by St David" (Archimandrite Tarasi 1864, 43).

10 For example, in the *Dormition of St Ephrem the Syrian*, the icon of the Virgin Hodegetria occupies the centre of the composition. This iconographic feature is generally interpreted as reflecting St Ephrem's profound devotion to the Mother of God while simultaneously alluding to his extensive hymnographic legacy dedicated to the Virgin (Achemastou-Potamianou 1991, 51).

Fig. 7. The tomb of St. Dodo. View from south

while the accompanying funeral rite was represented on the north wall of the church's northern arm. Through this spatial arrangement, the composition extends beyond the confines of a single pictorial surface into the architectural space itself, thereby transforming those who approach the tomb of St Dodo to venerate the saint into symbolic participants in the funeral service.

Despite these observations, a number of important questions concerning the painted decoration of St Dodo's burial church remain unresolved. The relationship between the successive decorative phases requires further clarification, as does the reconstruction of the upper part of the funerary composition. These and other problems await further investigation and will be addressed in future research.

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Today the tomb of St Dodo Garejeli is covered by a newly carved stone slab (Fig. 7). Only a small portion of the saint's painted image remains visible in the narrow space between the slab and the north wall of the church. Exposed to the open air, the surviving paintings – both those upon the tomb and those preserved on the lower part of the northern wall – are undergoing continuous deterioration as a result of environmental factors. Unless appropriate conservation measures are implemented without delay, these unique and historically significant paintings are likely to disappear irretrievably within the foreseeable future.

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Artificial Cavities Within the Kura River: *From Turkey to Georgia*

Ali Yamaç
OBRUK Cave Research Group, Istanbul, Turkey
ayamac@gmail.com

Abstract
The Kura River, known as the Mtkvari in Georgian, traverses approximately 190 km within Turkey before flowing through Georgia and Azerbaijan and ultimately discharging into the Caspian Sea. As the most significant watercourse in the region, it acts as the primary catchment for surface waters within its basin. This river, extending a total of 1,515 kilometers, is characterized by numerous rock-cut churches, monasteries, and settlements carved into the valley walls in both Turkish and Georgian territories. While extensive scholarship has focused on the rock-cut structures within the Georgian segment–highlighted by the designation of Vardzia as a UNESCO World Heritage Site–systematic research regarding the Turkish segment of the Kura River has only commenced in recent years. Although less abundant than their counterparts in the Georgian segment, a significant number of rock-cut structures have recently been identified and documented in the Turkish section. This presentation explains the findings from our four-year investigation of the rock-cut settlements along the Kura River. Our fieldwork utilized a combination of archaeological surveys and digital mapping techniques to categorize these previously overlooked sites, creating a detailed inventory of the region's cultural heritage. The investigation revealed a diverse array of rock-cut typologies, ranging from simple monastic cells to complex, multi-chambered habitation units interconnected by tunnels and internal staircases. Preliminary analysis suggests a strong architectural and chronological continuity with the better-known sites in Georgia, indicating a unified cultural landscape that historically transcended modern political borders. Furthermore, this study addresses critical gaps in the understanding of medieval habitation patterns in northeastern Anatolia, offering new insights into the socio-religious dynamics of the region. By documenting these vulnerable heritage sites, we aim to provide a comprehensive baseline that lays the groundwork for future conservation efforts and comparative cross-border analysis.

Keywords: Kura River, Ardahan, rock-cut structures, Harosman Caves

Geology

The Kura River, the region's largest fluvial system (1,515 km total length; 190 km within Turkey), collects surface waters from the basin before draining into the Caspian Sea. Originating south of the Göle district, the river traces a semicircle through Ardahan, eventually flowing northward near Kaşlıkaya Village. The riverbed morphology is characterized by deep canyons with wall heights ranging from 150 to 300 meters. These geological features, along with plateaus at elevations of 1,750–1,850 meters, are the result of continuous tectonic uplift driven by NE-SW and NW-SE trending faults in a region of relatively young volcanism (approx. 3.8–2.6 Ma).

The lithology of the study area is dominated by Pliocene volcanic rocks, divided into two distinct formations:

- **Kura Volcanics (Upper Miocene-Lower Pliocene, 3.8–3.6 Ma):** This unit represents the oldest identifiable rock formation in the region. Extending from Altaş Village to the Georgian border, it consists of basal agglomerates followed by alternating calc-alkaline volcaniclastics, tuff, and andesite flows. These formations create distinct sequences within the canyon walls, occasionally exceeding 300 meters in thickness.
- **Öncül Volcanics (Pliocene, 3.6–2.6 Ma):** Representing the final phase of volcanism, these basaltic andesites conformably overlie the Kura Volcanics. Varying in thickness between 60 and 80 meters, these lavas erupted from structural fractures and constitute the plateau morphology observed on both banks of the river (Innocenti et al. 1982; Aktimur et al. 1991; Duru & Keskin 2014).

Historical Background

While prehistoric habitation in the region is hypothesized, it remains unproven due to a lack of systematic archaeological excavation. Similarly, although Urartian inscriptions have been located in Hanak and Çıldır, de-

finitive evidence of the Urartian Kingdom's control over the Ardahan plain is insufficient. Historical data becomes more robust regarding the Late Antique Period.

From the 4th century BC, Georgian culture was predominant in the region. The area (Tao-Klarjeti) was under Roman rule until the 4th century AD, followed by a period of Persian occupation. King Vakhtang liberated the region in the late 6th century AD and established a bishopric in Erusheti.

Arab dominance extended into Transcaucasia in the mid-7th century, leading to significant architectural destruction. By the late 8th century, Georgian King Ashot I established his capital in Ardanuch (Artvin). He allied with the Byzantine Empire, receiving the high-ranking title Kouropalates (Guardian of the Palace), but was ultimately killed by Arab forces in 826/830 AD.

The 10th century witnessed the political unification of the Georgian and Abkhazian kingdoms under Bagrat III (1008–1014). However, relations with Byzantium deteriorated under his successor, Giorgi I. In 1021 AD, Byzantine Emperor Basileios invaded the region, plundering Ardahan (Artaani). The subsequent weakening of both the Georgian and Armenian kingdoms by Byzantine aggression created a power vacuum that facilitated the later Turkish conquest. The majority of surviving medieval archaeological assets in Ardahan date to this 10th–12th century interval (Bayram 2014; Patacı 2015).

Rock-cut Structures of the Region

The earliest mention of rock-cut dwellings in the region is found in the *Anabasis* written by Xenophon in the 4th century BC. The Ten Thousand were a force of mercenary units, mainly Greeks, employed by Cyrus the Younger to attempt to wrest the throne of the Persian Empire from his brother, Artaxerxes II. Their march to the Battle of Cunaxa and back to Greece (401–399 BC) was recorded by Xenophon in his work *Anabasis*. In Book 4, Chapter 5 of this work, the exact location is not specified, it is written:

"Their houses were undergound, the entrance like the mouth of a well, but spacious below; there were passages dug into them for the cattle, but the people descended by ladders. In the houses were goats, sheep, cows, and fowls, with their young; all the cattle were kept on fodder within the walls" (Brownson 1922).

Although some researchers claim the region referred to is Cappadocia (Giovannini 1971), this section of the book is the Ten Thousand's return route and passes much further east, near Lake Thospitis (today's Lake Van) and the Euphrates springs. Therefore, the region in question could be Ani near Kars or the rock-cut dwellings near the Kura River.

Rock-cut structures in the region begin to appear in volcanic rocks in the Kura River basin, approximately 30 km west of Ardahan. From there, these structures increase in density eastward, exhibiting an incredible diversity after crossing the Turkish border. The rock-cut structures of the Georgian side of the Kura River–Vardzia, Vanis Kvabebi, Gelsunda Caves–possess an architectural richness. All these structures along the Kura River extend up to Gori.

The fortified citadels carved out of the rock are found mainly in the Kartlia region, a morphologically very varied area, in which the mountain complexes shrink into a narrow valley crossed by the Kura River. To the west of Tbilisi, in the Gori area, in a rocky massif above the Kura, the Uplis-Cihe complex was excavated at the turn of the Crisian era, which had maximum development between the 9th and 11th centuries and was destroyed in the 13th century by the Mongols. The remains show caves for housing and others, larger, for collective function, whose ornamental elements, carved in the rock, repeat those of traditional wooden structures, including beams and coffered ceilings.

The most spectacular example of a Georgian rock-cut settlement is that of Vardzia. Also dominating the course of the Kura River was initially conceived as a fortified city and later adapted as a convent. The work was commissioned by King Giorgi III (1156-84) to prevent attacks by Arab neighbors. The death prevented the king from completing it. His daughter Tamar (1184-1213) enlarged many of the 550 rock-cut rooms already excavated (Nicoletti 1980; Bakhtadze 2019).

Despite the richness of rock-cut structures on the Georgia side of the Kura River, the Turkey side is not as productive. Our research in the Kura River basin, which we began as the OBRUK Cave Research Group in 2020, continued for four years. During this time, the entire basin and its surrounding area, from east of Ardahan to the Georgia border, were surveyed. Although more than 40 caves were identified in the region during preliminary research, surface studies revealed that most of them were natural. Only 11 caves were artificial or has human intervention to natural caves.

These are:

Village	Cave
Kotanlı	Şadırın
Akkiraz	Pedris
Akkiraz	Rock-cut settlements
Akkiraz	Gaçiyan
Övündü	Beyaz
Övündü	Kızıl
Övündü	Rock-cut settlements
Övündü	Rock-cut church
Ortakent	Harosman caves
Taşdeğirmen	Keçi
Akçıl	Şiko Cave

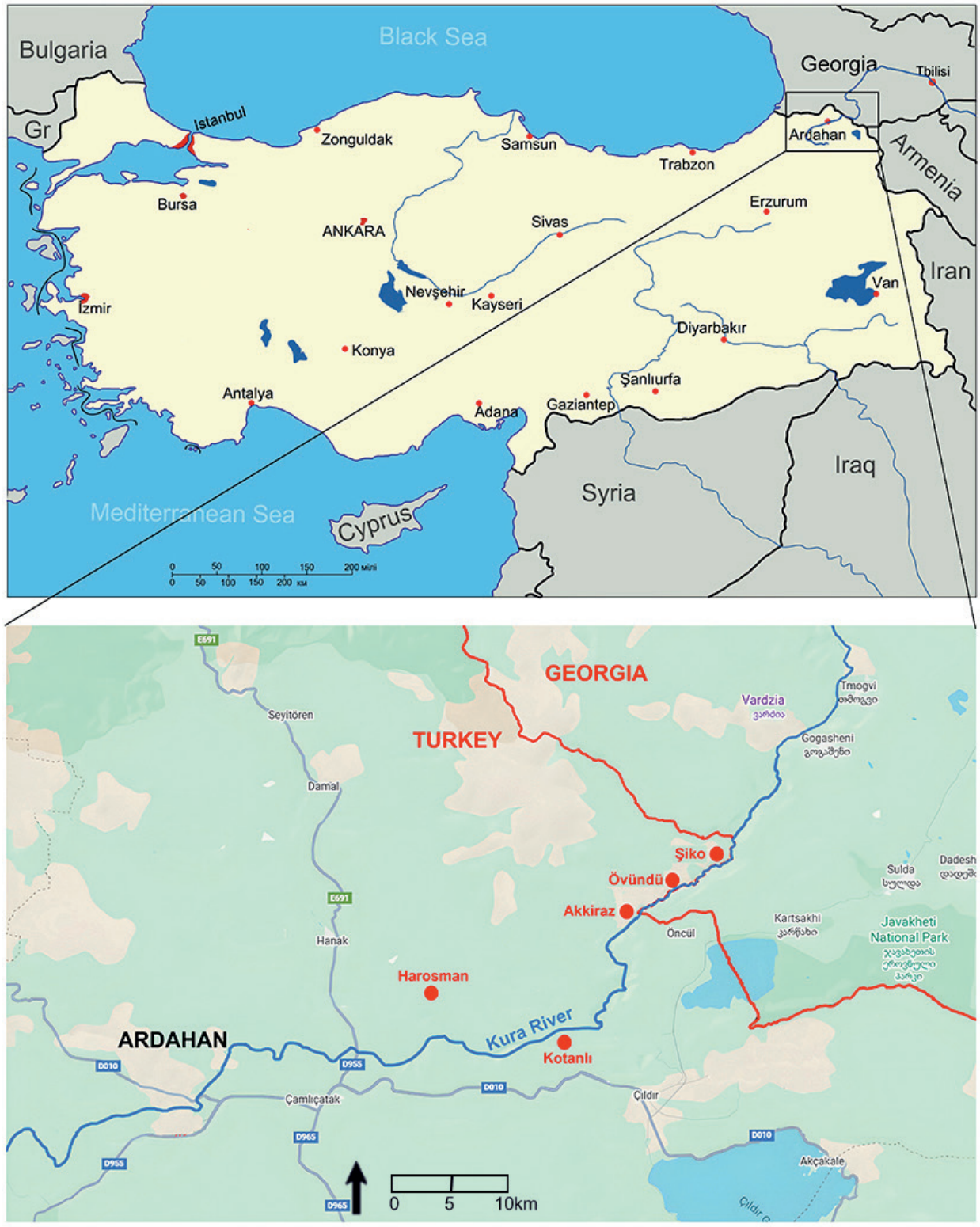

Fig. 1. Location map showing the Ardahan Province and the caves explored (after Google Maps - elaboration A. Yamaç)

Fig. 2. Harosman Caves from the southwest (photo A. O. Turan).

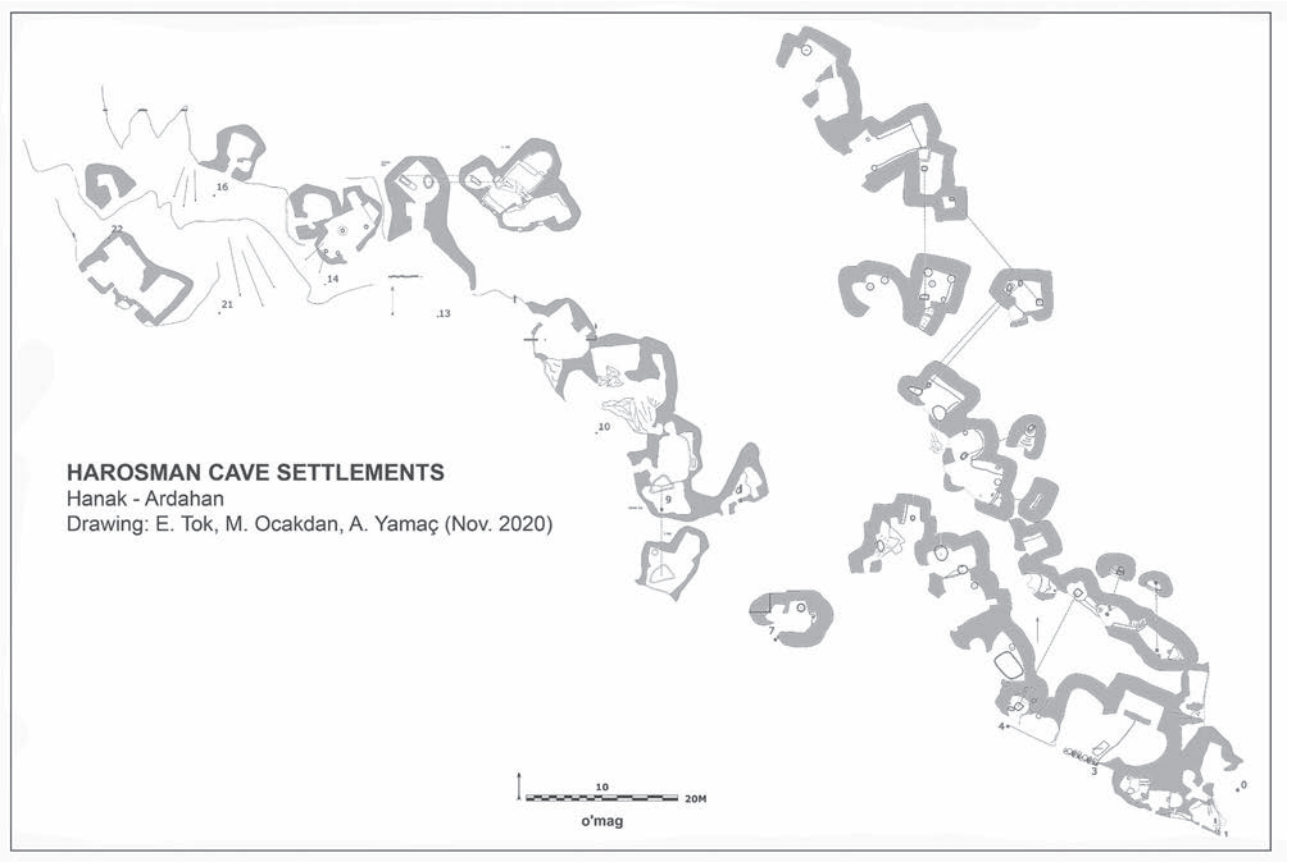

Fig. 3. Plan of Harosman Caves (drawn E. Tok, M. Ocakdan, A. Yamaç)

These 11 caves were documented, surveyed and mapped. Seven of the studied caves are small, isolated dwellings, only four are multi-story rock-cut settlements. These are; Harosman Caves which is the largest rock-cut settlement in the Kura River basin within Turkey, Şiko, Övündü and Akkiraz settlements (Fig. 1).

Harosman Caves

Harosman Caves are in the Kura River basin within the borders of Hanak District. The pyroclastic rock commonly observed in the south of Hanak and around the Harosman Caves is ignimbrite. This is a rock type that is much more difficult to excavate than the soft tuff found in Cappadocia. The rock on which these caves are located is approximately 236 meters long, 25 meters high (Fig. 2).

There are a total of 66 caves. Interior spaces of the caves grow towards the middle parts of the range from the southeast direction, and become smaller sized cave settlements towards the northwest. It can be thought that the caves in the southeast direction were mostly used for worship, and the cave settlements in the northwest side were arranged in smaller spaces, so they might have been used for shelter and/or residence (Fig. 3). One of the most important parts of the caves complex is the place arranged as a rock church. The

Fig. 4. Apsis of the main church of Harosman Caves (photo A. Yamaç)

part of this cave, which we think is the only entrance gate, has been partially destroyed due to natural reasons. Although traces of a thick layer of white plaster were found on the surfaces of some walls of the cave, it was not possible to get an idea whether the other walls were plastered due to the thick oily soot and soot layer on the other walls of the building. The naos is in the west and the apse is in the east (Fig. 4). To the south of the apse, there are sections belonging to pastohorion. It is understood from the grooves opened in the form of channels on the floor, side-upper walls and ceiling that these parts of the rock church were closed and separated from the naos part by piers/plates. Except for the apse part, culverts were opened along the northern wall of the cave. There is also a marytyrion part in this rock church. One or more burial chambers carved into the rock structure under the ground were destroyed.

The spatial arrangement of another cave within the cave complex is particularly noteworthy. The entrance to this cave is through a carefully opened doorway. The cave has two rooms; The first room is the section where the entrance is located, and there is an altar in the middle of the opposite wall, a niche on the side wall and a window opening on the river side in a small area in the form of an apse, which is reached by two steps on the east side. The second room is accessed through a rectangular shaped door. The sacrificial/votive/offering pits and some of the associated channels opened on the floor of this place were opened especially from the facade of the cave facing the river.

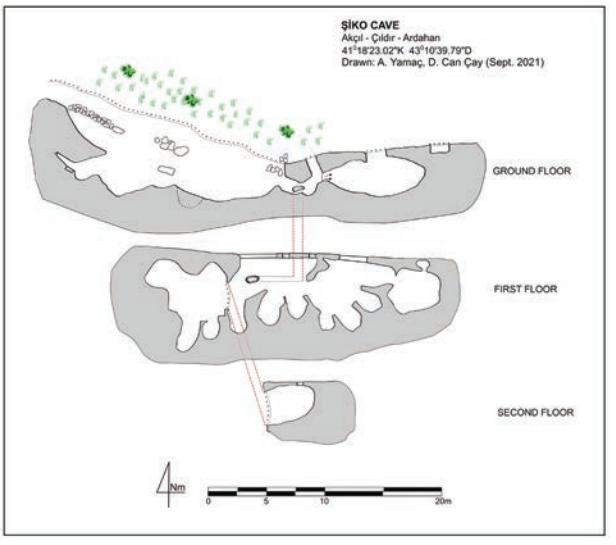

Fig. 5. Plan of Şiko Cave (drawn A. Yamaç, D. Can Çay)

The second floor of these caves, carved into the rocks, is reached by tunnel passages opened through another cave, which first continues vertically and then horizontally. While some of the caves carved into the rock mass consist of a single space, it has been determined that most of them have 2-3 rooms.

The transitions between the spaces are provided through doors and stairs opened properly into the rock. Channel-shaped cavities and stepped formations on the sills of some cave entrances are traces of mechanisms used in door closing. There are culverts or lighting holes in the northern part of the caves and on the facades facing the river, and almost all of them have shafts. Seating benches, small and large niches on the walls and hollows used as shelves can be seen in almost all of the spaces built into the rock (Arda 2023).

Şiko Cave

Şiko Cave is located three kilometers east of Akçıl Village as the crow flies, in the valley floor. In this area, the Kura River flows through a valley approximately 300 meters deep from the plateau and forming a border between Georgia and Turkey. The villages are situated on the plateau, lined up along a northeast-southwest axis. Şiko is carved into a single ignimbrit rock block as a three-storey structure.

Upon entering, there is a large space with its entire facade open to the Kura River. From this space, a shaft leads up to the upper floor through the middle of the gallery that connects to the single, large room on the east.

The absence of steps and handholds in this 4-meter-high shaft leading from the ground floor to the first floor suggests a possible defensive structure, but the large

Fig. 6. Şiko Cave (photo A. Yamaç)

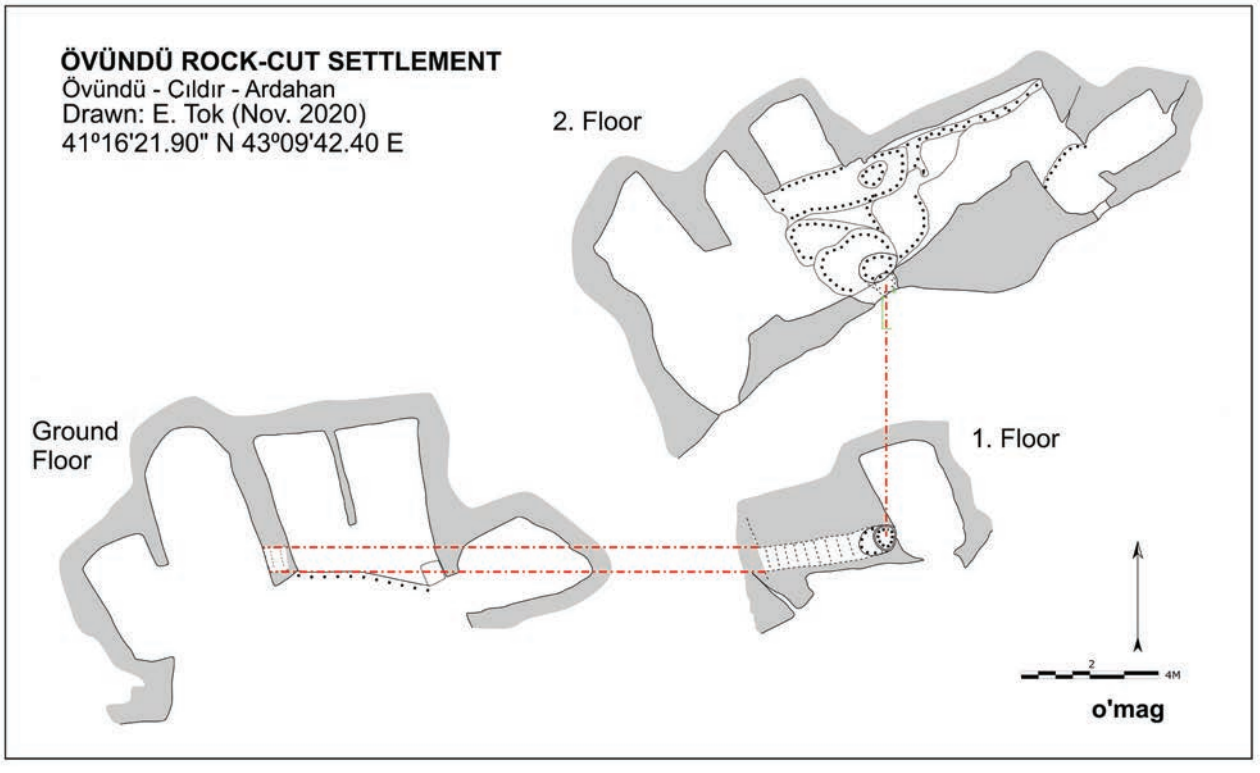

Fig. 7. Plan of Övündü Rock-cut Settlement (drawn E. Tok)

windows on the upper two floors invalidate this idea. The upper floor has a total of 12 rooms that can be divided into four sections. From the western section, one gradually reaches a single room measuring 3x5.5m with a window. All the rooms of the structure are carved amorphously with rough workmanship.

The Kura River valley in this region is extremely fertile for agriculture. As can be seen below in Övündü Village, there are orchards as well as farmlands in the valley. Accessing the valley floor from the top of the plateau, although not a very long distance, is strenuous. Therefore, the fact that Şiko Cave, despite being three-storeys, has such amorphous and carelessly constructed workmanship suggests that it may have been excavated as a temporary dwelling for villagers working in these orchards and fields. The fact that it is three-storey can be explained by the absence of any other rock formation suitable for excavation in the vicinity (Figs. 5-6).

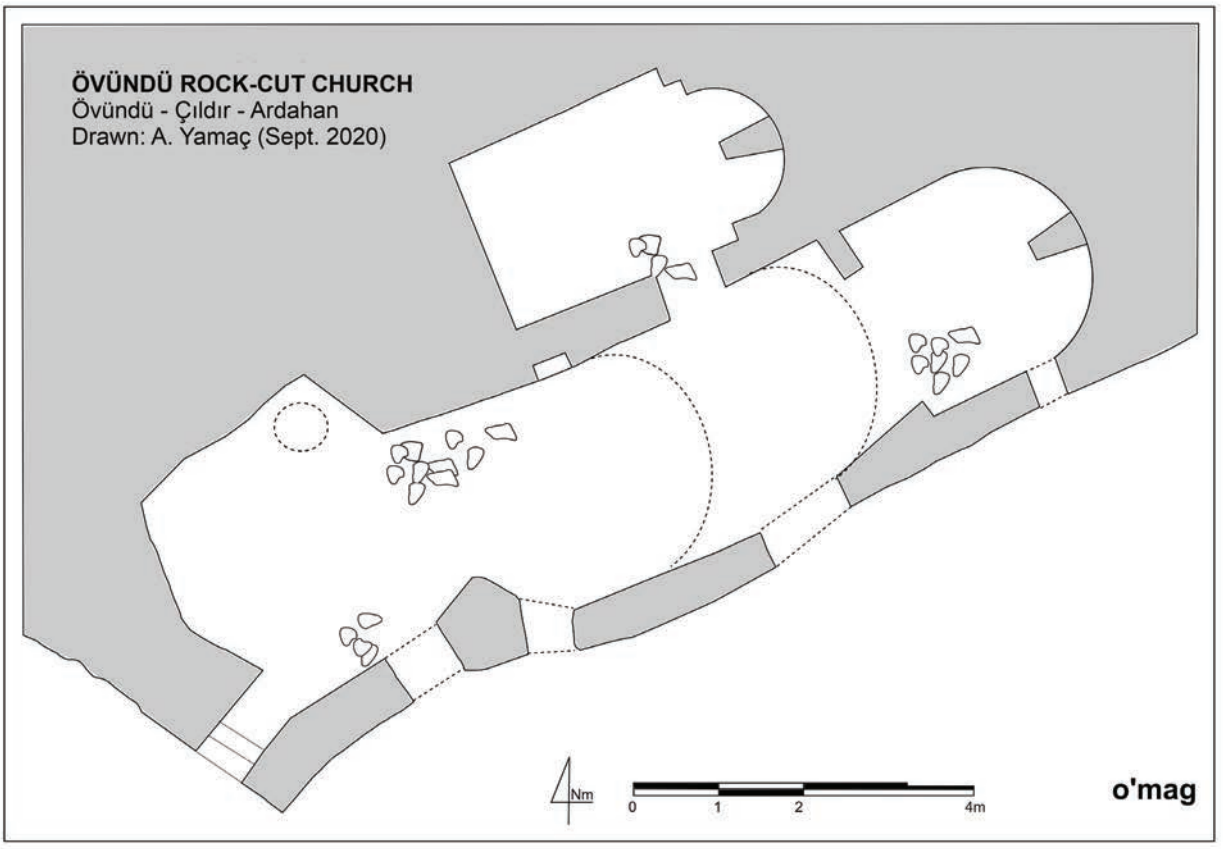

Fig. 8. Plan of Övündü Rock-cut Church (drawn A. Yamaç)

Övündü Rock-cut Settlement and Church

Övündü Village is located seven kilometers south of Akçıl Village and, like the other village, is situated on top of the plateau. The rock-cut structures being explored here are also located in the valley floor and on the banks of the Kura River.

The three-story rock-cut settlement located here is smaller than Şiko Cave. The ground floor contains five rooms with their fronts entirely open to the valley. The entrance to the central double room is stepped. These rooms, devoid of any architectural elements or ornamentation, must have been used as barns or storage. A staircase carved into the bedrock leads to a single room on the upper level. This room, and indeed the entire structure – much like Şiko Cave described above – may have served as a temporary dwelling. The staircase leading from the ground floor to this room then leads to an upper floor (2nd floor) via a shaft. This upper floor contains a large central space and five different rooms. The function of the stepped platforms in the central space is unclear (Fig. 7).

Located 200 meters south of this rock-cut settlement is a rock-cut church. This church, with a double nave and double apse, has suffered significant erosion and extensive damage from illegal diggers. The main structure is approximately 11.5 meters long and 3.5 meters wide. Although its connection to the church is now completely lost, the large space after the stepped entrance carved into the bedrock to the west must have been the narthex. The eastern wall of the structure has four windows overlooking the valley. The first is in the narthex, two in the nave, and the last in the apse. The presence of a window in the apse is unusual, suggesting that the structure had a later use different from its original purpose, and that this window was added at that time. The templon walls of the apse are quite damaged (Figs. 8-9).

A passage north of this main *nave* leads to another, smaller church. Both churches have horse-shoe *apses*, barrel-vaulted ceilings, and altars carved into the bedrock in each *apse*.

While extensive studies have been conducted on a nearby masonry complex, it is interesting that the rock-cut structures were initially examined by our team. The Vashlobi Monastery structures are situated 300 meters south of the previously mentioned rock-cut formations. From Vashlobi Monastery, a church to the north and a chapel to the south, built adjacent to each other, a two-story section to the west of the church, and a two-story corridor providing access to this section from the chapel have survived to the present day. Remnants of walls adjacent to the north facade of the church in-

Fig. 9. Övündü Rock-cut Church (photo S. Bahadır)

dicate the existence of other spaces. No records have been found regarding the construction date of the structures. It is known that the use of regularly cut stone became widespread in the region from the second half of the 10th century onwards. Therefore, it is possible to place the construction of the chapel, built with regularly cut stones, after this date, in the 11th-12th centuries. Considering both the building materials and the fact that it was constructed before the chapel, it can be assumed that the church was built in the first half of the 10th century, with the two-story space and aisle added shortly afterward (Takaishvili 1909; Bayram 2014).

Rock-cut Settlements of Akkiraz and Kotanlı villages

Kura River flows within Turkey up to 1 km east of Akkiraz Village, at which point it forms the Turkey-Georgia border. Located at the zero point of the border, next to the bridge crossing the river, there are three distinct, small artificial cavities in the rocky outcrop. These caves, which are not of much architectural significance, were probably excavated as barns and temporary dwellings. Similarly, the Pedris and Gaçiyan caves, also near Akkiraz Village, are small structures with simple workmanship, although they are artificial. There are numerous caves and rock caverns in the valley near Ogeçe, Kotanlı Village. However, most of these are natural formations, with no evidence of human intervention. Only a natural cave called Şadırın Cave has sections artificially carved.

Conclusion

Along a line of approximately 100 km stretching from Turkey to Georgia, countless artificial cavities are carved into the rocks on the slopes of the Kura River. Although the rock formation is the same, the diversity and architectural quality in the Georgian part of these cavities, compared to the limited number and simple workmanship in the Turkish part, can be attributed to a single reason: While artificial cavities in Georgia, as seen in the Vardzia example, are built with state or church support as part of a monumental project, the vast majority of those in Turkey were likely built by local communities for simple needs such as barn, storage or dwelling.

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Rock Cut Monastery From the 10th Century in "Voden-Iri Hisar" State Hunting Area, Razgrad District, NE Bulgaria

Alexey Zhalov

Bulgarian Caving Society, Sofia, Bulgaria
azhalov@gmail.com

Abstract

The complex has two horizons, conditionally called I - Lower and II - Upper. The lower one includes two caves appeared in front of the facade of the vertical rock ridge located next to each other on 2 levels with a small difference in elevation. They are conditionally called "Small" and "Large". The upper horizon II of the complex includes the actual rock monastery or the easier to identify structures – the carefully shaped rock – cut structures. They are: the Church and the Cell. The Church is located in the east of the entrance of the Large Cave at 220 m above sea level. It is partially processed natural cave with an area of about 36 m^2. It is an approximately pentagonal room with a carefully hewn floor, walls and ceiling with a height of 1.50-1.60 m. It is oriented along the cardinal directions, with the nave being wider /maximum about 4.20 m/ than long /about 2.90-3.00 m/. Approximately in the middle of the eastern wall, the entrance to the apse is carefully shaped, with a rectangular shape. The apse, oriented to the East with a slight deviation to the south, is raised by one step about 0.15-0.25 m. It is carefully hewn /more carefully than the nave/ with a markedly elliptical shape with a width of 2.15 m, a depth of 1.62 m and a height of about 1.40-1.50 m. About 1.5 m from the northwest corner is the entrance, which is triangular and is located at a height of 3.90 m above the base of the rock ridge. It has a northeast exposure. The dimensions of the opening are: width at the base 1.61 m, with a max. height of about 2.00 m. At the base we register a carefully cut threshold about 0.30 m high. About 1.5 m from the northwest corner is the entrance with at approximately triangular in shape, wide at the base about 1.50-1.70 m and high about 2.05-2.20 m. A threshold about 0.30 m high has been carefully cut. On both sides of the entrance, there are raised beds for anchoring a wooden door frame, respectively about 0.10 m wide - the right one and 0.16 m wide on the left and about 0.05 m deep. The left one is stored at a height of 1.17 m below the ceiling and the right one at 0.80 m. The eastern wall of the nave /wider than long/ is doubly beveled, which gives it an approximately pentagonal shape, with the southeastern and northeastern ones being about 1.50-1.55 m long. The Cell is located east of the church in the same rocky ridge at about 5.20 m above the surrounding terrain, respectively above the easternmost of the three caves, with which it is connected from the northeastern corner by a natural inclined opening, about 0.50–0.60 m wide and high. The cell is a relatively carefully hewn rectangular room, oriented along the cardinal directions, with a length /north-south/ of 3.75 m, a width /west-east/ of about 2.85-2.95 m and a height of 1.64 m. There are made parallels with several rock churches from 10th century in the rock monastery close to Murfatlar Town in Romania. Analysing the plans of the church and apse, the monastery is dated to the 10th century and was abandoned, together with the nearby fortress of Zavet around the beginning of the 11th century.

Keywords: rock cut, church, monasticism, Bulgaria, mediaeval

History of Discovery and Exploration

In 2021, Nikolay Kolev learned that in the area of the "Voden-Iri Hisar" State Hunting Enterprise, there were several caves. Later не visited them personally and reported the find to the project coordinator for the exploration of caves in the area of the "Sborianovo and Surroundings" Historical and Archaeological Reserve. The study of the sites was included in the program of the upcoming 2022 expedition of the Bulgarian Speleological Society. This expedition took place from April 7 to 10, 2022. At that time, the sites were located and mapped by Alexey Zhalov, Stoycho Stoychev, and Nikolay Kolev. The researchers then hypothesized that one of the sites, which would later be named "The Church," due to the presence of an altar niche, was a rock-hewn church! To verify this hypothesis, specialists from the Regional Historical Museums were invited to the next expedition, held from July 21 to 24, 2022, led by Prof. Dr. Georgi Atanasov from Historical Museum of Silistra, Georgi Dzanev from Historical Museum of Razgrad, Evgeni Georgiev from Ruse Historical Museum, Teodora Vasileva, and Maria Nikolaeva from the Historical Museum in Isperih. The expert group conducted a thorough inspection of the rock-cave complex, with Prof. Atanasov expressing strong support for our hypothesis that the artificial structures represent a cell and a rock-hewn church, which, together with the caves, form a monastic dwelling-monastery that existed from the 10th century onwards. The ceramic fragments found in the caves were identified as prehistoric (Eneolithic) and from antiquity. The dwelling, later named "Pervoletka Rock-Cave Complex," is located at 220 m a.s.l. The complex is situated 300 m south of a flat Neolithic mound,

upon which the Aliya Hussein Baba (Mazhar Pasha) Tekke was later built (Yavashev 1930; Marinov, 1942).

Description

The complex has two horizons, conventionally named I - Lower and II - Upper. The Lower includes two natural caves that appear as rock overhangs in front of the facade of the vertical rock face. It includes two caves located next to each other on 2 levels with a small elevation difference, conventionally named „*Malka*“ (Small) and „*Golyama*“ (Large) (Fig. 1).

I-1. The Small Cave is located in the north-western part of the rock face. Its entrance is triangular and faces east. It is 1.60 m wide at its base and has the same maximum height. It is a single gallery 7.63 m long. Its average width is 2 m, and the height varies between 1.60 m at the entrance, 3.40 m in the middle, and 2.20 m at the end. About 1.5 m after the entrance, there is an opening in the ceiling of the gallery that opens to the surface, through which soil falls into the cave, forming a small cone. The height to the surface is 2.85 m. The floor is covered with soil and small angular pebbles. The cave is level, semi-lit, dry, and devoid of formations.

I-2. The Large Cave is immediately next to the Small one. It has two entrances – a small (north-western) triangular one measuring 1 x 1 m, and a large one, also triangular, facing NE with dimensions: width at the base 1.70 m and height 3.15 m. In the entrance area of the large entrance space, at a height of about 2 meters above the base (floor), symmetrically on the left and right walls, there are shallow carvings, likely „steps“ for beams that once partitioned the entrance. Both entrances lead into a semi-circular, bright, and level hall with a diameter of about 4.60 m and a height of 1.80 m. Two galleries lead out from the hall; the longer and more easily passable one develops in a southerly direction and is a logical continuation of the gallery coming from the larger entrance. It is 5 meters long, with a width and varying height from 1 meter at the beginning to about 2 m at the end, from where it lowers and narrows. A narrow gallery exits from the east wall of the hall, becoming impassable after 4 meters. Deposits are observed in its walls. The cave floor is covered with dry soil, dust, and angular stones. Fragments of pottery, visibly from different periods – mainly Eneolithic (4800 – 4000 BC) – were found on the deposits.

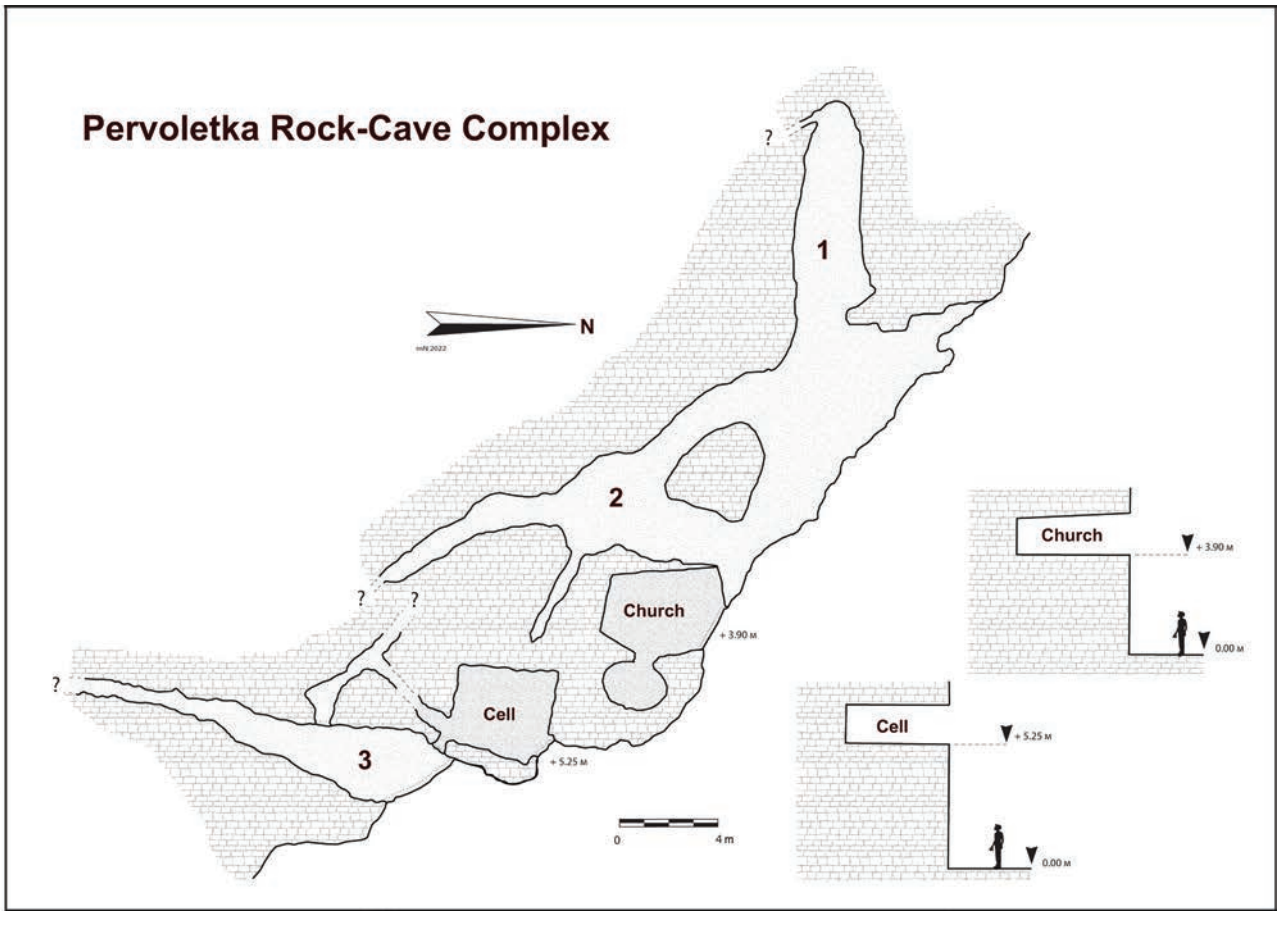

Fig. 1. Plan of the “Pervoletka Rock-Cave Complex”(after A.Zhalov)

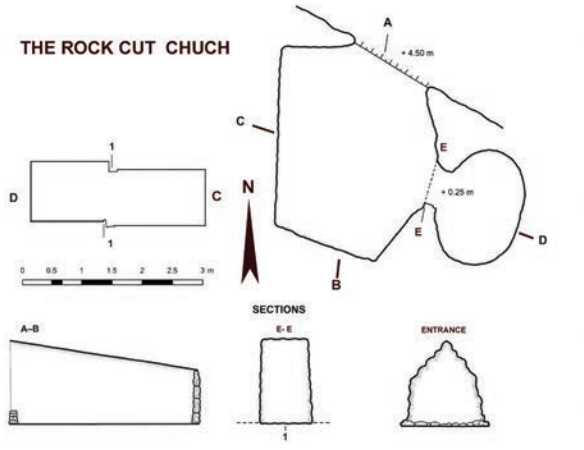

Fig. 2. Plan of the rock cut church (after A.Zhalov&N.Kolev)

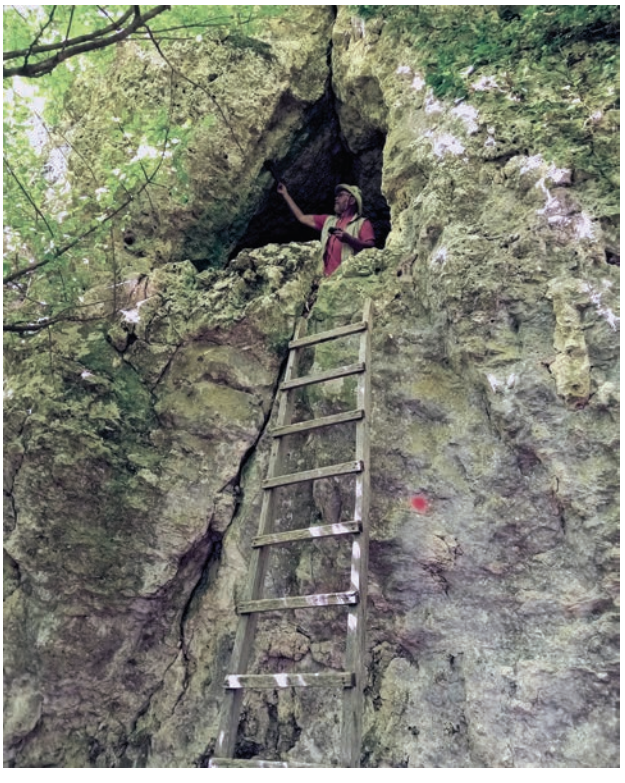

Fig. 3. The entrance of the church is reachable by stair (Photo A.Zhalov)

I-3. „Kiliyata“ (The Cell) Cave

Length: 22.80 m Elevation difference: +2.20 m It is located 20 m east of the large cave of the „Pervoletka“ complex. The entrance is triangular, height 3.10 m, width 2.52 m, facing N-NE. The main gallery develops in a southerly direction. From the entrance up to the 7th meter inside, the gallery gradually narrows and lowers to 0.50 m. It is followed by a narrow section of about 2 m, after which the gallery sharply changes its height (about 4 m), maintaining a width of approximately 0.6 m. The floor of the entire section is covered with soil and small angular stones. There is a strong airflow from inside out, with one of the presumed (unconfirmed) reasons being that the fissure along which the southernmost part of the gallery was formed emerges at the surface. It is possible that, through excavation, the gallery could continue further inward. In the west wall, which is the right side when entering, there are two branches. The first of them is of particular interest. Practically, it is accessible through an elliptical opening located at +2.50 m relative to the cave floor. Through the opening, measuring 1.1 m in height and 0.6 m in maximum width, one reaches a rectangular room artificially worked into the rock, which has been identified as a monastic cell and, together with „The Church,“ forms the Upper II horizon of the complex. Oriented by cardinal directions, with a length (north-south) of 3.75 m, width (west-east) of about 2.85-2.95 m, and height of 1.64 m. The entrance, with an approximately triangular shape, is in the north wall near the northeast corner of the room and has a width of about 1.00 m and a height of 1.45 m. The ideal area of the cell is 10.84 m², and its volume is 19.08 m³. In the northern part of the room, there is a natural opening (window) with a height of 1.92 m and a width of 0.80 m, which has been secondarily modified. In fact, this opening serves as a second, but inaccessible, entrance to the room, which is revealed at a height of 5.25 m relative to the base of the rock face where the cave is located. At a height of 1.4 m above the floor of the „cell,“ on both sides of the „window,“ there are clearly distinguishable, carved grooves in the rock, rectangular in shape and 0.15 m deep. On the deposits of the main gallery, immediately before the described narrow section of the cave, pottery fragments were found. The Upper Horizon II of the „Pervoletka“ complex includes the actual rock monastic dwelling or the more easily identifiable structures – the carefully shaped rock-worked 1. Church and 2. Cell, which was described above.

II-1. The Church

It is located 6 m east of the entrance to the Large Cave of the „Pervoletka“ complex, situated at 220 m a.s.l. and represents a modified natural cave with an area of about 36 m² (Fig. 2 & 3). It is an approximately pentagonal room with a carefully carved floor, walls, and ceiling with a height of 1.50–1.60 m. It is oriented by cardinal directions, with the nave being wider than it is long. Approximately in the middle of the east wall, the entrance to the apse is carefully shaped, rectangular, about 0.85-0.90 m wide and 1.50 m high, with the wall between them being about 0.40 m thick. The apse, oriented east with a slight southward deviation, is raised by a step of about 0.15-0.25 m. It is carefully carved with a distinctly elliptical shape, 2.15 m wide, 1.62 m deep and about 1.40-1.50 m high (Fig. 4). About 1.5 m from the northwest corner is the entrance, which is triangular and is at a height of 3.90 m above the base of the rock face. It faces northeast, and a small platform is

formed in front of it, which was likely reached by a ladder mounted in the rock. The dimensions of the opening are: width at the base 1.61 m, with a maximum height of about 2.00 m. At the base, we register a carefully carved threshold, about 0.30 m high. About 1.5 m from the northwest corner is the entrance, approximately triangular in shape, about 1.50-1.70 m wide at the base and about 2.05-2.20 m high. A carefully carved threshold, about 0.30 m high, is present. On both sides of the entrance, beds for anchoring a wooden door frame are formed; measuring approximately 0.10 m (right) and 0.16 m (left) wide and about 0.05 m deep, respectively. The left one is preserved at a height of 1.17 m below the ceiling, and the right one at 0.80 m. At the top, they have rectangular widening's, about 0.28 x 0.20 m and 0.07 and 0.17 m deep, respectively. 0.06 m from the vertical bed on the right side is another, very interesting L-shaped bed, 0.25 m high, 0.10 m wide, and 0.07 m deep, with the upper part being narrower, about 0.07 m. Parallel to the left side of the door, a small round hole is formed. We assume this was a „locking" wooden mechanism, consisting of a wooden beam about 1.10 m long and with a cross-section (or diameter) of about 0.07 m, which descended along the L-shaped bed and was secured in the round hole on the opposite side. The east wall of the nave (wider than it is long) is double-sloped, resulting in an approximately pentagonal shape, with the southeast and northeast sides being about 1.50-1.55 m long. On the right side of the entrance, between the nave and the apse, a cross with triangular branching ends is incised, but it is possible it was made in recent decades over old contours. Prof. Dr. of Historical Sciences Georgi Atanasov, analyzing the plan of the church and apse, dates the dwelling to the 10th century (Atanasov et al., 2023; Atanasov 2023). It was likely abandoned, along with the nearby fortress near Zavet and the settlements in „Sborianovo," around the beginning of the 11th century. The monastery complex serves as a connecting link between the rock monasteries in Dobrudzha along the Suha River and the Kanagiol/Dristra River from the 10th century, and those along the Lom Rivers in the Ruse region.

Fig. 4. Apse (altar) of the church (Photo A.Zhalov)

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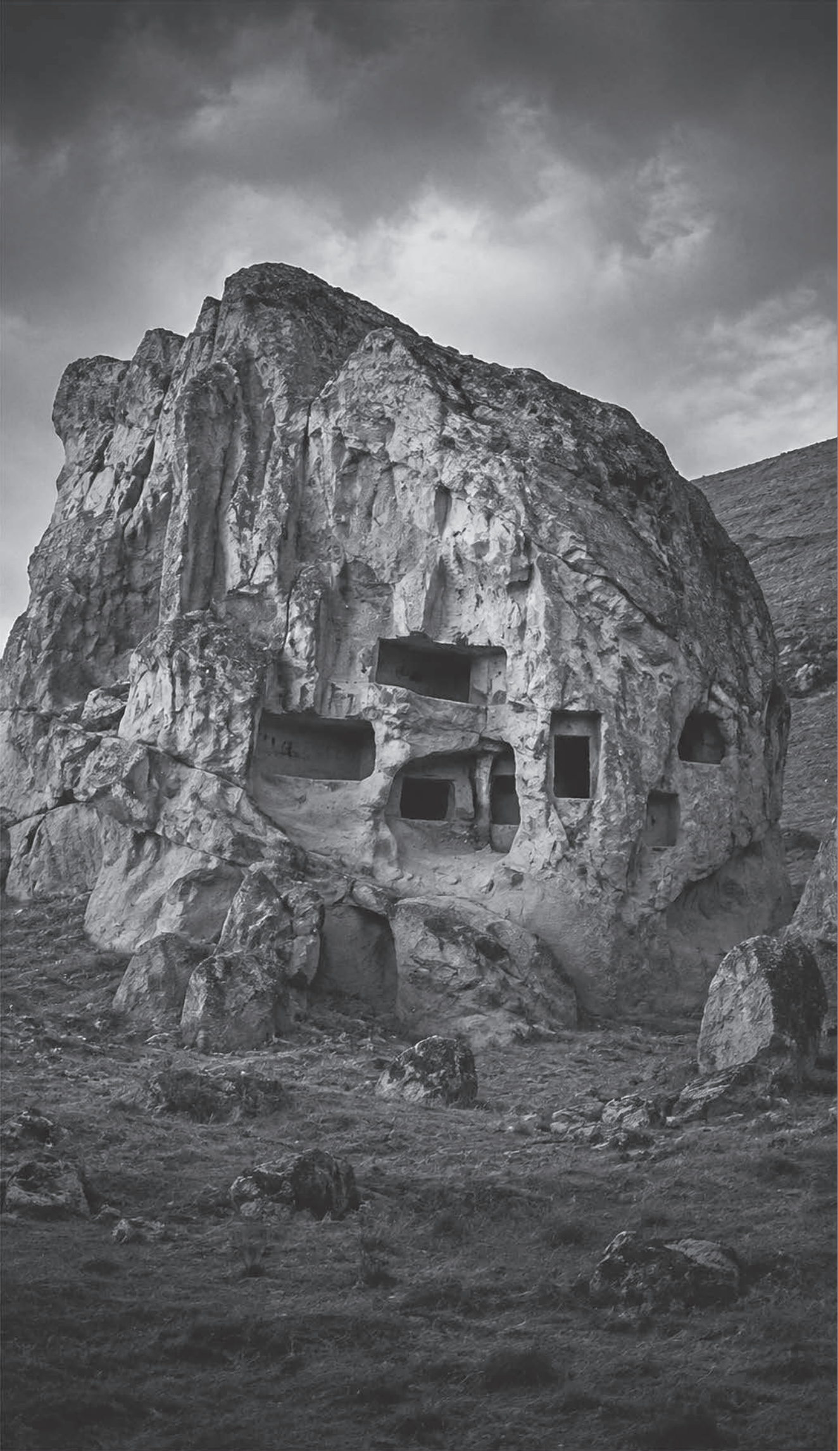

ARCHAEOLOGICAL RESEARCH OF THE ARTIFICIAL CAVITIES

HYPOGEA
TBILISI•2026

Rock-Cut Funerary Complexes of Armenia: Problems of Definition, Chronology and Function

Ani Adigyozalyan,[1] **Artur Petrosyan,**[1] **Hayk Haydosyan,**[1] **Soseh Aghaian,**[1] **Boris Gasparyan,**[1] **Dmitri Arakelyan,**[2] **Roberto Dan**[3]

1 Institute of Archaeology and Ethnography, National Academy of Sciences, Republic of Armenia
2 Institute of Geological Sciences, National Academy of Sciences, Republic of Armenia
3 ISMEO – The International Association for Mediterranean and Oriental Studies, Italy

Abstract
Rock-cut architecture represents one of the most persistent and characteristic components of the cultural landscape of the Armenian Highlands. In the territory of present-day Armenia, the earliest evidence for anthropogenic modification of rock surfaces dates back to the initial phases of the Pre-Pottery Neolithic, while during the Chalcolithic, the Bronze Age and the Iron Age these practices became part of increasingly complex landscape systems, often connected with settlements, cultic areas, petroglyph fields, ritual installations and funerary spaces. During the Urartian period, in particular, rock-cut structures acquired more elaborate architectural forms, including chambers, tombs, wine presses, platforms and ceremonial installations connected, in some cases, with the cult of the dead. However, the long duration of the rock-cut phenomenon and the frequent reuse of these structures in Classical, Medieval and modern times make any attribution based exclusively on morphology extremely problematic. This paper therefore proposes to treat the so-called "rock-cut tombs" of Armenia not as a fixed typological category, but as an analytical problem to be assessed case by case through a set of criteria: access systems, closure devices, internal organization, stratigraphic context, associated material culture and relationship with the surrounding landscape. Within this framework, Yelpin represents a borderline case, since its architectural affinities with Urartian installations call for functional caution, while Agarak shows the decisive role of archaeological context in identifying funerary use.

Keywords: Armenia, Armenian Highlands, rock-cut architecture, rock-cut tombs, Urartu, Yelpin, Agarak, cult of the dead

1. Introduction

Rock-cut architecture is one of the most distinctive and long-lasting forms of monumental intervention in the Armenian Highlands.[1] The predominantly mountainous character of the region, the availability of workable rock formations and the long continuity of settlement, cultic and funerary practices favoured, over several millennia, the creation of a wide range of structures carved into or directly associated with the bedrock: chambers, tombs, niches, platforms, canals, cisterns, wine presses, altars, cultic spaces and, in the Medieval period, churches and chapels. This long duration, however, is precisely what makes the interpretation of these monuments so complex. Not every rock-cut structure is a tomb; not every chamber carved into the bedrock is Urartian; and not every formal analogy can be transformed into chronological evidence. The history of research on rock-cut architecture in the Armenian Highlands has often been conditioned by a tendency to attribute many structures to the Urartian period, especially when they display regular plans, carefully cut entrances or niches. Yet recent investigations have shown that this approach is no longer sufficient. The rock-cut phenomenon is both broader and more complex: it precedes Urartu, continues after Urartu and is repeatedly reactivated in later historical periods (Dan et al. 2022a: 73–80, 92-93; Dan et al. 2022b: 316–317, 325-327). In the territory of Armenia, rock-cut activity is already attested in the initial stages of the Pre-Pottery Neolithic, with anthropogenic modifications of natural tuff cliffs in contexts associated with settlements and trapping installations. During the Chalcolithic and the Bronze Age, such interventions appear to have become part of wider sacralized landscapes, in which settlements, cultic areas, open-air temples, petroglyph fields and other monumental features formed complex ritual systems. During the Iron Age, and especially in the Urartian period, rock-cut architecture developed more complex architectural solutions, including funerary chambers, wine presses and installations associated with ceremonial practices related to the cult of the dead. Classical and Medieval communities later continued to use, transform and reinterpret these spaces, creating new tombs, sanctuaries, churches and chapels and modifying the rock-cut heritage inherited from the past. The aim of this paper is therefore not to present a simple catalogue of Armenian "rock-cut tombs", but to discuss the validity and limits of this

1 All photographs are by R. Dan unless otherwise indicated.

category. The analysis must begin by distinguishing between rock-cut structure, chamber, cultic installation, commemorative space, primary tomb and secondary reuse. Only the integration of morphology, technique, topography, stratigraphy and associated material culture allows a funerary function to be proposed with sufficient reliability.

2. Landscape, Geology and the Selection of Place

The rock-cut structures of Armenia were mostly carved into relatively soft volcanic and volcano-sedimentary formations, especially tuff and tuff-breccia, while basalt, because of its greater hardness, was used much more rarely. Complexes carved into sedimentary formations such as limestone, travertine and flowstone are also known. This choice certainly reflects practical and technical considerations, but it cannot be reduced to the mere workability of the stone. In many cases, the location of the structures suggests a deliberate selection of places with specific visual, symbolic or ritual qualities: isolated cliffs, secondary gorges, natural terraces, rocky spurs, spring zones and water sources emerging directly from the rock. The recurrent relationship between rock-cut chambers and natural water sources is particularly significant. In several cases, these structures were established near springs, sometimes in contexts where water emerges from the same rock mass into which the chamber was carved. Such associations point to a broader cultic dimension, perhaps connected with water worship, regeneration, purification, communication with chthonic powers or the symbolic passage between the world of the living and that of the dead. A chamber located near a spring was not necessarily a tomb in the strict sense. It could have functioned as a place of offering, commemoration, ancestral cult or ritual transition. This point is crucial for the interpretation of Armenian rock-cut monuments. The presence of a chamber, a forecourt, a niche or a platform is not enough to define a structure as funerary. In mountainous landscapes, and especially in areas where the bedrock itself became the support of ritual action, cultic and funerary meanings could overlap. A single structure may have been used for deposition, ritual visitation, libation, offering or later Christian devotion at different moments in its biography. The category of “funerary” must therefore be treated as a hypothesis to be tested, not as an assumption.

3. The Problem of Chronology

One of the greatest difficulties in studying Armenian rock-cut architecture is chronology. In the absence of inscriptions, grave goods, human remains or controlled stratigraphic deposits, the technique of rock-cutting alone does not currently allow secure dating. Rock-cut chambers often remained accessible for centuries or millennia, undergoing pastoral reuse, liturgical transformation, looting, Medieval adaptation and modern modification. Even when archaeological materials are found inside or near them, these finds may document only one phase of occupation or reuse, not necessarily the moment of construction. This problem affects the entire Armenian Highlands. In earlier scholarship, rock-cut works were often attributed almost automatically to the Urartian period, especially when they included chambers, recessed entrances, niches or carefully regularized surfaces. Recent research has shown that this procedure is methodologically fragile. Some of these structures may be Medieval or post-Urartian; others may be earlier and later reused; still others may belong to the Iron Age but not necessarily to a funerary sphere. Only a few categories of monuments can be securely attributed to Urartu: those bearing cuneiform inscriptions, those with unmistakable Urartian decorative features, or those with highly diagnostic architectural traits such as extremely careful finishing, orthogonal planning, multiple entrance recesses, symmetrical niches for urns, funerary beds, columbaria or installations compatible with the coexistence of inhumation and cremation (Çevik 2000; Sevin 2012, 91–96; Dan et al. 2022a, 83-86). The north-western Iranian evidence confirms the same methodological difficulty. At

Fig. 1. Aerial view of the rock-cut chamber of Kal Kharabe (photo courtesy of B. Khanmohammadi)

Fig. 2. View of the interior of the central chamber of Kal Kharabe (photo courtesy of B. Khanmohammadi)

Kal Kharabe, near Orumiyeh, the Urartian attribution rests on a convergence of elements: a carefully planned chamber, axial organization, high-quality workmanship, well-shaped niches and an entrance with multiple recesses (Figs. 1-2). Where such diagnostic features are absent, chronological attribution becomes far less secure (Dan et al. 2019, 68–71, 78–79). The same principle must be applied to Armenia. Formal resemblance can guide interpretation, but it cannot replace archaeological context. This has important implications. When a rock-cut chamber is located in a site occupied during the Urartian period, it may be tempting to consider the structure Urartian. Yet the presence of Urartian occupation at a site does not automatically date every carved feature to that period. Conversely, the presence of Medieval materials inside a chamber does not necessarily prove that the structure was originally Medieval. The decisive issue is whether the finds are stratigraphically connected to the original cutting, to a phase of use, or only to a later reuse. This distinction is often difficult, but it is essential.

4. Criteria for Identifying Funerary Function

The identification of a rock-cut structure as funerary must be based on a minimum set of criteria. The most significant are: the access system, including steps, *dromoi* or corridors; closure devices, such as rabbets, door sockets or cuttings for blocking slabs; the internal organization of the space; the presence of niches, benches, platforms, beds, basins or containers; the relationship with human remains, urns, *pithoi* or grave goods; the association with a cemetery or other funerary structures; and the presence of diagnostic material in primary deposition. Among these indicators, access and closure systems are especially important. A carefully arranged entrance, a dromos or a sequence of recesses may suggest a controlled transition from outside to inside, from public space to restricted space, and perhaps from the world of the living to that of the dead. However, even this criterion is not decisive by itself, since cultic installations and storage spaces may also have required controlled access. Likewise, niches may have held urns, offerings, lamps, icons or other objects at different times. The interpretation must therefore depend on the convergence of several indicators, not on a single architectural trait.

The Urartian royal tombs of Ṭušpa/Van provide the most important comparative corpus for Iron Age funerary rock-cut architecture in the Armenian Highlands (Fig. 3). The monuments of the Van cliff, including the mausoleum of Argišti I (Figs. 4-5), the İç Kale tomb, the Neft Kuyu tomb, the Ostkammer/Doğu Odaları tomb (Figs. 6-7) and the so-called Cremation Tomb, display complex access systems, monumental facades,

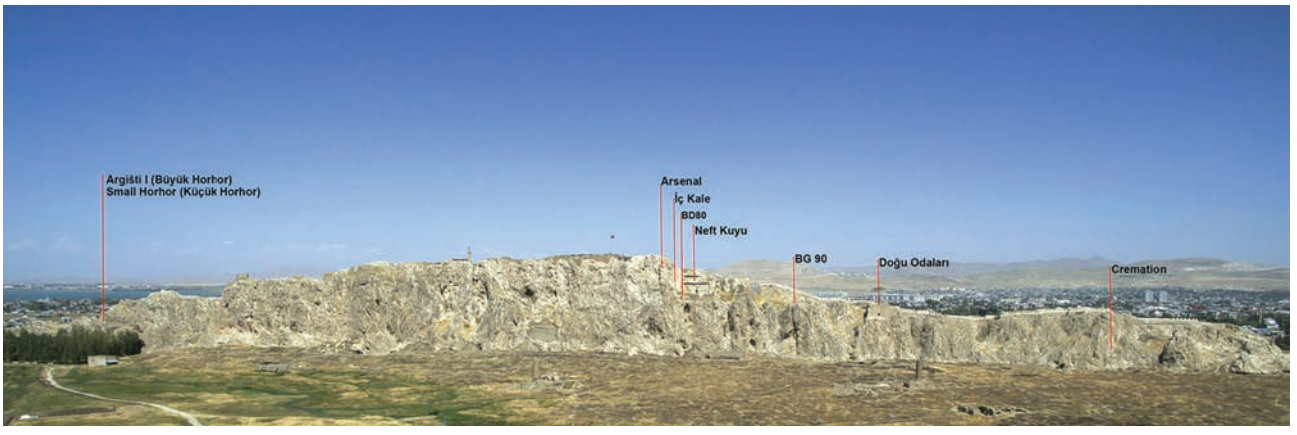

Fig. 3. Panoramic view of the Van Rock with the location of the rock-cut chambers (after Konyar and Genç 2025: fig. 9.1)

Fig. 4. Plan of the mausoleum of Argišti I (redrawn by R. Dan after Konyar and Genç 2025: fig. 9.6)

Fig. 5. Interior view of the main chamber of the mausoleum of Argišti

main halls, secondary chambers, niches, funerary beds, sockets and carefully planned internal arrangements (Sevin 2012; Konyar and Genç 2025). These examples provide a fundamental reference point for the study of Armenian rock-cut chambers. Yet they also demonstrate the danger of using Ṭušpa as a rigid template. Urartian rock-cut architecture was not exclusively funerary. At Ṭušpa and in the Van region, rock-cut niches, platforms, cultic installations, hydraulic structures, ceremonial spaces and symbolic signs coexist with tombs. In other words, a rock-cut monument may be Urartian without being funerary (Kuvanç 2025; Dan 2025). The T-shaped niches provide a particularly instructive example. They appear to belong to a symbolic and architectural repertoire concentrated mainly in the eastern and northern Lake Van area, while no examples of this specific type are currently known in modern Armenia, north-western Iran or the lands east of Lake Van (Dan 2025, 10-11).

5. Yelpin: A Borderline Case

The rock-cut complex of Yelpin-1, in the Vayots Dzor region, is one of the most important cases for methodological discussion (Figs. 8-9). The chamber is characterized by an entrance with multiple recesses and by architectural features that find parallels in Urartian rock-cut architecture. This evidence has helped challenge an older interpretive tendency, according to which single-roomed rock-cut chambers in eastern Anatolia

Fig. 6. Plan of the Ostkammer at the Van Rock (redrawn by R. Dan after Konyar and Genç 2025: fig. 9.55)

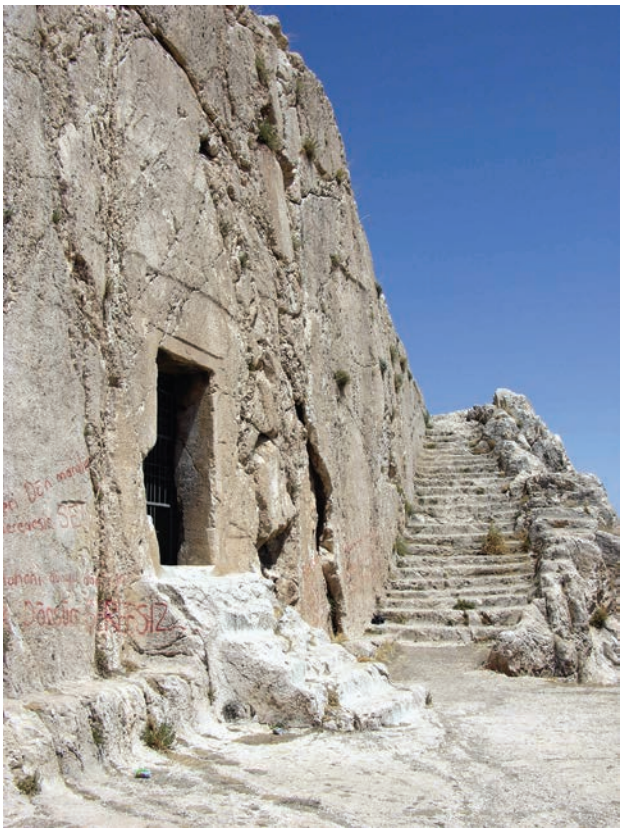

Fig. 7. Exterior view of the Ostkammer

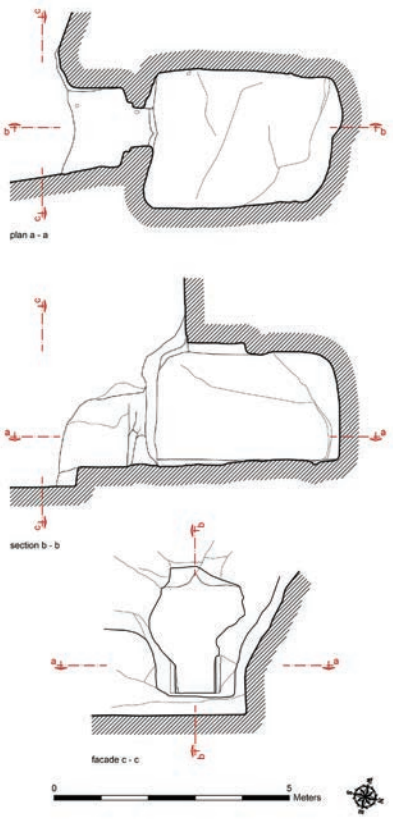

Fig. 8. Plan of the rock-cut chamber of Yelpin (drawing by S. Aghaian)

were generally considered post-Urartian, Hellenistic or Roman. Yelpin shows that even a single-roomed chamber can display features compatible with an Urartian or Urartianizing horizon (Dan et al. 2018, 60–62, figs. 5-10; Kroll 2019; Dan et al. 2022a, 84–85, footnote 6). The function of the structure, however, remains problematic. Some architectural elements may suggest a funerary interpretation, but there is no decisive evidence allowing the chamber to be defined securely as a tomb. Stephan Kroll has proposed that the Yelpin chamber should be interpreted as a cultic structure rather than a funerary one (Kroll 2019, 323), and the Medieval materials recovered during the 2017 cleaning of the chamber document a later phase of reuse rather than the original function of the monument (Dan et al. 2022b: 320). The Yelpin case is therefore a borderline example in the strictest sense. Its architecture may be placed within an Urartian or Urartianizing technical and conceptual horizon, but its funerary function cannot be assumed automatically. The complex has an external arrangement that may be described as a forecourt or platform, and the entrance system includes rabbetted features that recall Urartian architectural solutions. Nevertheless, these traits may equally belong to a cultic installation, a commemorative monument or a structure connected with ritual actions performed outside the chamber. This ambiguity is not a weakness of the interpretation but

Fig. 9. View of the entrance to the rock-cut chamber of Yelpin. Note the remains of the multiple frames at the bottom

one of the most important results of the analysis. Yelpin shows that the relationship between rock-cut architecture, cult of the dead and burial was not linear. A structure could be connected with commemorative or ritual practices without containing burials; it could have been cultic in origin and later reused; or it could have had a funerary role that was transformed in subsequent periods. The Yelpin complex therefore requires the separation of three analytical levels: chronology, original function and history of reuse. This distinction is essential for the whole corpus of Armenian rock-cut structures. The more recent discussions of Armenian rock-cut architecture strengthen this point. The Armenian evidence now shows that rock-cut monuments cannot be interpreted through a simple binary opposition between Urartian tombs and Medieval chapels. Between these two poles lies a broad category of ambiguous or multifunctional structures, some of which may have been connected with ritual actions, water cults, commemorative practices or non-depositional forms of the cult of the dead. Yelpin is the clearest example of this interpretive field.

6. Agarak: The Decisive Role of Archaeological Context

Agarak offers a different and complementary case. The site is famous for its extensive rock-cut complex and for its long occupation history, especially during the Bronze Age. Avetisyan emphasized that before the excavations at Agarak no such extensive complex of “artificial landscape” had been recorded in the Armenian

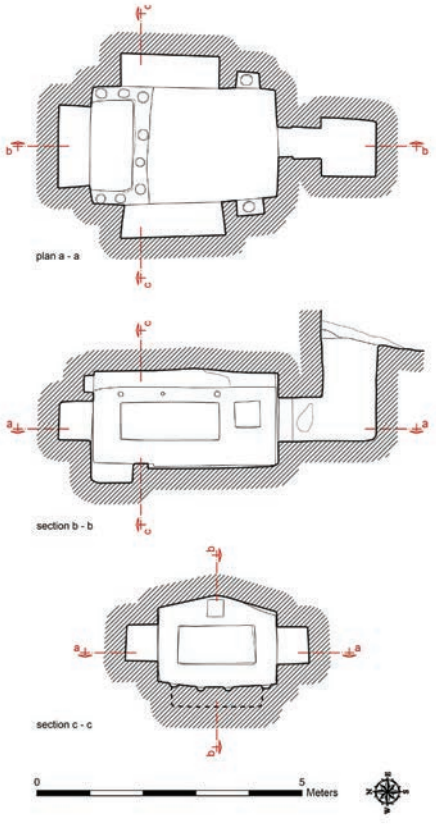

Fig. 10. Plan of the rock-cut chamber of Agarak (drawing by S. Aghaian)

Highlands (Avetisyan 2008, 43). The site, however, also produced Urartian-period evidence, including funerary remains, among them the well-known pithos burial (Yengibaryan 2011, 152–155). The rock-cut chamber of Agarak (Figs. 10-12) has been interpreted as a mausoleum on the basis of both architectural and contextual data (Kalantaryan 2005, 154–160; Dan et al. 2022b, 322–323, figs. 13-16). Its importance lies not merely in its form, but in the possibility of placing it within a broader archaeological sequence. Unlike Yelpin, where the interpretation remains suspended between cultic use and possible funerary function, Agarak demonstrates the decisive role of archaeological context. Materials, stratigraphy, funerary evidence and the long-term organization of the site allow the function of the monument to be discussed on firmer grounds. Agarak is also important because it shows how Iron Age communities could reactivate pre-existing monumental landscapes. The site was not created ex novo in the Urartian period. Its Bronze Age dimension is fundamental, and this long memory may have contributed to its later ritual and funerary significance. The Urartian or post-Urartian use of a pre-existing rock-cut landscape should not be seen as a contradiction. On the contrary, it confirms that rock-cut places often functioned as long-lived spaces of memory, repeatedly reinterpreted by different communities. This point has broader consequences for the study of funerary landscapes. A place already marked by ancient rock-cut works may have acquired a special status precisely because of its antiquity. Later communities could have reused it not only for practical reasons, but also because it was perceived as ancestral, powerful or ritually charged. In this sense, Agarak is not only a possible funerary monument, but also a key example of the long biography of rock-cut landscapes in Armenia.

7. Discussion: Tombs, Cultic Installations and the Cult of the Dead

The available evidence suggests that Armenian rock-cut complexes should be understood as a long-term phenomenon rather than as a homogeneous class of monuments. Some structures are probably funerary; others are cultic; others were transformed into chapels, shelters, pastoral spaces or places of Medieval devotion. In

Fig. 11. View of the Agarak chamber with the niches

Fig. 12. View of the Agarak chamber with the access doorway and the access shaft

many cases, the original function cannot be recovered without new stratigraphic investigation. The distinction between “tomb”, “sanctuary” and “place of the cult of the dead” is particularly delicate. In ancient societies, and especially in rock-cut contexts, burial was not always clearly separated from offering, commemoration, libation or ancestral cult. A chamber could be conceived as a space for the dead, but also as a place to be visited by the living. A platform could serve for deposition, but also for ritual performance. A spring could form part of a symbolic system linked to passage, purification or regeneration. For this reason, the term “funerary” should be used in two different senses: a narrow sense, referring to the presence of human remains or burial installations, and a broader ritual sense, referring to spaces connected with death, memory and the cult of the dead. This distinction helps avoid two opposite errors. The first is to define every rock-cut chamber as a tomb. The second is to deny any funerary dimension whenever human remains are absent. In many ancient contexts, the dead could be commemorated, invoked or ritually approached in places where no burial was present. Therefore, the absence of bones does not necessarily exclude a funerary or mortuary dimension, but it does prevent a secure identification of the structure as a tomb in the strict archaeological sense. The Armenian evidence must also be placed within the wider framework of the Armenian Highlands. The great royal tombs of Ṭušpa represent one end of the spectrum: highly formalized, monumental, elite and clearly embedded in the royal ideology of the Urartian capital. The more modest or ambiguous Armenian chambers occupy a different position. They do not necessarily imitate the royal tombs of Van, nor should they be interpreted as provincial versions of them. Rather, they belong to a wider world of rock-cut practices in which local traditions, Urartian influence, landscape memory and later reuse intersect.

8. Conclusions

The study of the rock-cut funerary complexes of Armenia requires a cautious, contextual and interdisciplinary approach. Morphology alone is insufficient for determining chronology and function. Chambers carved into the rock must be analysed through an integrated system of criteria: access, closure, plan, internal organization, cutting technique, topographic relationships, lithology, presence of water, stratigraphy and associated material culture. Yelpin and Agarak illustrate two different interpretive poles. Yelpin is a borderline case: it displays affinities with Urartian architecture, but it does not allow a secure funerary identification. Agarak, by contrast, shows the decisive importance of archaeological context in building a more reliable interpretation. Between these two cases lies a broad spectrum of monuments that must be re-examined through architectural survey, geological analysis, three-dimensional documentation, stratigraphic excavation and systematic study of finds. The category of “rock-cut tomb” should therefore be retained, but critically redefined. It cannot designate every chamber carved into the bedrock. It should be applied only where architectural, contextual and material indicators converge. Such an approach allows the role of Armenia in the long history of rock-cut architecture in the Armenian Highlands to be properly appreciated, while avoiding unsupported chronological and functional attributions. Armenia should no longer be considered marginal in relation to the major rock-cut complexes of Van or north-western Iran. Recent research has revealed a much richer and more complex picture, in which Armenian monuments participate fully in the architectural, cultic and funerary history of the Armenian Highlands. The main issue is not the absence of the phenomenon, but the need for systematic investigation and for a methodology capable of distinguishing original use, later reuse and modern interpretation.

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Cave Monasticism in Southern Georgia: Archaeological Insights from Kazreti Ortvala Cave

David Berikashvili

University of Georgia, Tbilisi
Department of Archaeology
E-mail: davidberikashvili8@gmail.com

Abstract

The archaeological complex of Kazreti Ortvala Cave is located in the historic region of Kvemo Kartli in southern Georgia. Although the site was first identified in 1957, systematic archaeological excavations were conducted only recently, between 2018 and 2025.
Research carried out within the cave complex and on the adjacent terrace has revealed multiple cultural phases dating to both prehistoric and historical periods. The earliest evidence belongs to the Stone Age and Early Agricultural (Neolithic) cultures, while later occupation phases correspond to different stages of the Bronze Age. However, the most clearly represented and archaeologically visible period at the site is the Middle Ages.
During the Early Middle Ages, a small monastic complex functioned within Kazreti Ortvala Cave. Stratigraphic evidence indicates that the complex was destroyed by a strong earthquake at the end of the 11th century, which also caused significant structural damage to the caves. By the 12th century, the monastery had been renovated and monastic life resumed. At this time, a small wine cellar (marani) and additional agricultural or storage facilities were also in use.
The final destruction of the restored monastic complex is associated with the Mongol and Tamerlane invasions of Georgia in the 13th-14th centuries. This presentation discusses the archaeological investigation of the Early and High Medieval monastic complex, supported by associated archaeological, palaeographic, and epigraphic materials.

Keywords: Cave Monasticism, Early Christian Churches, Rock-Cut Architecture, Kazreti Ortvala Cave

Introduction

The Kazreti Ortwala Cave is situated in the southern part of Georgia, within the historical region of Kvemo Kartli, in the valley of the Mashavera River. The site lies in a canyon-like gorge formed through the incision of volcanic andesite-basalts and tuffs. This geomorphological formation widens from south to north and develops into three natural terraces positioned at varying elevations[1] (Fig. 1).

The terraces are largely horizontal, exhibiting only a slight inclination toward the river, which would have facilitated their use for habitation and subsistence-related activities. Among them, the second (middle) terrace occupies a particularly favorable position, rising approximately 35–40 m above the river level. It is on this terrace that the cave is located, with a southwest-facing entrance that provided optimal natural lighting and relatively dry conditions[2].

Fig. 1. Map showing the location of Ortvala Cave in the Kvemo Kartli region, southern Georgia

Such environmental advantages likely played a decisive role in attracting human groups to the site from an early period. Indeed, archaeological evidence suggests

1 For the geological formations of Kvemo Kartli and the Mashavera River valley, see: Parfenov, Lebedev et al. 2023.

2 Given that several other so-called "Double Eye Caves" (Ortvala Mgvime) are attested in Georgia–including those of Godogani, Didi Rgani, and Tsutskhvati–the cave investigated in the present study has been designated as the Kazreti Ortwala Cave, and it will be referred to by this name throughout the article.

Fig. 2. Ortvala Cave in the Mashavera River valley (2019). (Photo Berikashvili D.)

that the cave was occupied from the early stages of the Stone Age and remained in use, either continuously or intermittently, until the end of the Middle Ages (Fig. 2).

Although intact stratigraphic deposits from the earliest phase of occupation have not been preserved *in situ*, the recovered assemblage nonetheless attests to a Lower Paleolithic presence. This is primarily indicated by obsidian artifacts which, based on technological and typological analysis, have been attributed to the Mousterian culture and identified as Levallois flakes[3].

Given the well-documented distribution of Mousterian sites in this part of Georgia, the presence of such materials at Kazreti Ortvala is entirely consistent with broader regional patterns (Grigolia & Tatishvili 1960; Grigolia 1963; Kalandadze 1970; Berzenishvili 1991). The absence of preserved stratified layers is most plausibly explained by intensive later activity, particularly associated with prolonged monastic occupation, which likely resulted in the disturbance and eventual loss of earlier deposits.

Subsequent occupation phases are represented by artifacts dated to the 6th–5th millennia BCE and associated with the early agricultural (Neolithic) culture of Kvemo Kartli. These include coarse ceramic fragments in straw-colored and light brown tones, comparable to materials from regional settlement mounds (Hansen et al. 2013; Chikovani et al. 2015). The assemblage also comprises tools made from animal bone and antler, as well as obsidian bladelets and flakes, all of which find close parallels in contemporaneous sites of the same cultural horizon.

Evidence for continued use of the site during later prehistory is provided by ceramic materials characteristic of both the Early and Late Bronze Age. Notable among these are sherds comparable to those associated with the Kura-Araxes culture, alongside fragments bearing blackish-gray surfaces decorated with vertically burnished lines–features typical of Late Bronze–Early Iron Age assemblages in eastern Georgia. These finds indicate that the cave remained occupied and was not abandoned during the Bronze Age.

The most intensive phase of activity at the site, however, dates to the Middle Ages. This period is represented by substantial cultural deposits, architectural remains, and a diverse material assemblage. Excavations have revealed that a small hall-type church functioned within the northern cave of the complex as early as the 5th–6th centuries CE. Constructed using mixed stone masonry and ornamented internally with green and red tuff, this structure reflects an established monastic presence. Archaeological evidence further suggests that the church was destroyed by a major earthquake affecting eastern Georgia at the end of the 11th century, after which it was restored and the monastic complex resumed its function.

The principal findings outlined above, together with the results of recent excavations, are examined in detail in the following sections of this study. These are accompanied by an analysis of the architectural and paleographic materials recovered from the site, with the aim of situating them within a broader historical and cultural framework.

Site description

As noted above, the Ortvala Cave is situated approximately 35-40 m above the Mashavera River and its both caves (“eyes’’) is naturally enclosed on both sides by basaltic rock formations. The northern cave is comparatively more spacious and well illuminated, with an entrance approximately 10 m wide, 5.0–5.5 m high, and extending approximately 14 m in depth; such a configuration promotes effective air circulation and a relatively dry interior environment. In contrast, the southern cave, measuring approximately 11 m in width and 4.5 m in height at the entrance, assumes the form of a long corridor that penetrates deeply into the rock mass, rendering its whole extent indeterminable without specialized speleological equipment. It may be identified as a lava tube (pyroduct) formed through complex geomorphological processes associated with the outflow of molten lava beneath a solidified surface crust[4] (Fig. 3).

The cave’s vault and walls are intensively fractured, allowing for the active seepage of groundwater. Pro-

3 Materials dating to the Mousterian culture were first identified at the Kazreti Ortwala Cave in 1957, when the archaeologist Guram Grigolia conducted archaeological surveys in the valley of the Mashavera River. The discovery of this complex is associated with this distinguished scholar, as is the opening of the first archaeological season in 2018. Since 2019 to the present, excavations at Kazreti Ortvala have been directed by the author of this article.

4 For pyroducts and lava tubes, see Kempe (2009).

Fig. 3. Pyroduct (Lava tube) in the Southern Cave of Ortvala (2023). (Photo Berikashvili D.)

longed exposure to moisture has significantly smoothed these surfaces, giving them an appearance reminiscent of karstic caves formed within calcareous formations. The terrace located directly in front of the cave likely developed as a result of sustained water activities and sediment accumulation; it extends over approximately 230–250 m² and slopes subsequently toward the river. A path descending from this terrace provides access to the river floodplain and appears to have been in consistent use during the Early Middle Ages, when a church and a small monastic complex operated within the cave.

Over the course of its existence the cave has undergone substantial morphological changes. Among the most significant was likely the powerful earthquake that struck Georgia in 1088, as recorded in *Kartlis Tskhovreba* (1955, 323). This event appears to have led to the abandonment of the Early Medieval monastic complex at Ortvala Cave and to the collapse of the nearby hall church[5] (Fig. 4).

Results

A small church was discovered in 2019 within the northern cave of the Ortvala complex (Berikashvili 2024). The structure represents a modest yet architecturally and culturally significant example of early medieval ecclesiastical construction adapted to a cave environment. Its western, northern, and southern walls were built of medium-sized basalt stones, carefully arranged to create a stable enclosure within the natural rock setting. In contrast, the eastern part of the church–including the apse–was integrated directly into the cave's rear rock face. The apse, characterized by a slightly horseshoe-shaped plan, was elevated by one step above the floor level of the central space, thereby emphasizing its liturgical importance within the interior arrangement.

The flooring materials further underscore the deliberate aesthetic and functional design of the church. The apse floor was plastered with a distinctive redish mortar composed of lime mixed with finely ground red tuff, suggesting both technical knowledge and an intention to enhance the visual quality of the sacred space. The central area of the church was paved entirely with red tuff slabs, which not only provided durability but also contributed to a cohesive and visually refined interior.

Fig. 4. Rockfall from the cave ceiling following the earthquake of 1088 (2023). (Photo Berikashvili D.)

5 The 1088 earthquake and its extensive destructive impact have also been confirmed by modern geophysical studies (see Varazanashvili et al. 2011)

Fig. 5. Western view of the church in the northern cave of Ortvala (2023). (Photo Berikashvili D.)

The same material was used for the threshold of the entrance, where a carved socket indicates the placement of a wooden doorpost. These architectural features collectively demonstrate a thoughtful integration of local materials and construction techniques within a religious context (Fig. 5).

At the time of excavation, the interior of the church was completely covered by accumulated cave deposits and archaeological layers containing material from the developed and late medieval periods. However, the underlying floor level, along with associated architectural and paleographic evidence, points to an earlier phase of construction dating to the early medieval period. Among the most significant discoveries within the apse were fragments of a profiled column made of green tuff. These remains likely formed part of the altar structure, indicating the presence of a more elaborate liturgical furnishing than might be expected in such a small cave church. Additional architectural elements crafted from the same green tuff were found both within the church interior and on the terrace in front of the cave, suggesting the former existence of a more extensive architectural ensemble.

Particularly noteworthy is the discovery of a squared block of greyish-bluish tuff (60 × 60 × 60 cm), identified as the pedestal of a stele, located near the church entrance on its southern side. The block features a centrally carved rectangular socket (30 × 30 × 15 cm) on its upper surface, presumably intended to hold the vertical element of the stele. While three sides of the block are plain, the fourth is decorated with an equal-armed cross inscribed within a circle–commonly referred to as the "Bolnisi cross"–accompanied by a two- to three-line inscription in the *Asomtavruli* script[6]. This iconographic and epigraphic combination closely parallels examples from Bolnisi Sioni Cathedral, a key monument of early medieval Georgia dated to the 5th century (Chubinashvili 1940; Khoshtaria 2023). The stylistic and paleographic features of the inscription, including the archaic forms of the letters and the technique of execution in high relief, strongly support a similar chronological attribution.

The contextual evidence surrounding the stele base further enriches the interpretation of the site. Directly in front of the base, excavations revealed a artificially arranged altar constructed of flat stone slabs, upon which were placed the bones and horns of various wild animals, including boar and deer. This assemblage is particularly significant, as it appears to reflect the persistence of pre-Christian ritual practices into the early Christian period. Specifically, it echoes a tradition attested as early as the Bronze Age, whereby selected parts of hunted animals were offered at sacred sites. The coexistence of Christian symbols and such ritual deposits suggests a degree of continuity and adaptation in local religious practices during the transitional period of Christianization (Fig. 6).

Further excavations conducted outside the church, especially in the vicinity of the stele base, yielded additional architectural and paleographic materials that have substantially clarified the history and chronological development of the complex. Among these finds are fragments adorned with relief vegetal motifs and bearing high-relief inscriptions in the *Asomtavruli* script[7].

6 The upper portion of the right arm of the raised relief, equal-armed cross, which broadens at its extremities, bears a three-line Asomtavruli inscription arranged in a single line within a rectangular frame. Due to the advanced state of preservation, the text is largely illegible. Nevertheless, it was possible to discern the last two characters of the upper line: „e" (Ⴓ) and „a" (Ⴑ). In the latter part of the second line, some poorly preserved letters are still visible, notably „l" (Ⴖ) and „a" (Ⴑ). while below these, albeit faintly, „o" (Ⴝ) and possibly „n" ?(Ⴗ) can be read.
A similarly damaged Asomtavruli inscription, set within a small rectangular frame (15 × 15 cm), was located at the extremity of the left arm of the cross. In the upper line of this inscription, traces of „a" (Ⴑ) and „n" (Ⴗ) , as well as „e" (Ⴓ) and „v" (Ⴕ), are discernible, with additional, analogous traces preserved in the lower, third line.
Although the complete content of the inscription cannot be reconstructed, the style of the cross relief and the archaic forms of the letters allow its execution to be securely dated to the 5th–6th centuries CE.

7 Although the inscription (Fig. 7.1, 3) is incomplete, the good state of preservation and pronounced relief of the individual Asomtavruli characters allowed for relatively easy reading. It can be transcribed as: „ ... Ⴘ Ⴓ Ⴒ Ⴓ Ⴕ Ⴗ Ⴓ ... Ⴓ Ⴙ Ⴓ Ⴖ Ⴑ ..." - „ .... მ ე ფ ე ვ ნ ი ... ი დ ი ს ა ...". It is likely that the initial and final characters of each line are missing; the complete text may have read - „ შეფევნი(თა) (წმ)იდისა(ითა)". („ ... by the intercession of the saint ...").
A second inscription (Fig. 7.6) preserves the following elements: in the upper line, „ …Ⴒ Ⴑ …" ("… t a …"), and in the lower line, „ ...Ⴕ Ⴑ Ⴗ... " ("… v a n …").

Fig. 6. Stone pedestal of a stele featuring an Asomtavruli inscription and a relief cross (3, 4), 5th–6th centuries CE. (2020). (Photo Berikashvili D.)

The stylistic features of the ornamentation, combined with the archaic character of the letter forms and the technique of carving, allow these elements to be confidently dated to the 5th–6th centuries. It is highly probable that these fragments originally formed part of a monumental stele or related architectural feature situated near the church entrance. Their fragmented condition suggests that they were destroyed during a later phase of structural collapse (Fig. 7).

The evidence for such destruction is closely linked to a broader regional phenomenon: the devastating earthquake of 1088. This event, which affected not only Kvemo Kartli but much of southern Georgia, is well documented in both historical sources and modern geophysical studies. Notably, seismic activity of varying intensity appears to have continued for an extended period, possibly up to a year, exacerbating the damage to already weakened structures. At Ortvala Cave, this catastrophic event is clearly reflected in the stratigraphic record. Layers corresponding to this period contain substantial quantities of large rock fragments that had detached from the cave ceiling and fallen into the interior spaces. Beneath these collapse layers were preserved earlier materials, including the architectural and epigraphic elements described above, effectively sealing them within a destruction horizon.

Despite this significant disruption, the monastic complex did not remain abandoned for long. Archaeological evidence indicates that it was revived relatively soon after the earthquake, marking a second major phase in its development. During this period, the church itself was restored, and new functional installations were introduced in its immediate vicinity. Most notably, a small wine cellar (*marani*) was established in front of the entrance to the southern cave. This addition reflects the economic and liturgical importance of viticulture within monastic life.

The dating of this renewed phase is supported by the material culture associated with the wine cellar. At the level of its tamped clay floor, excavators identified a distinct cultural layer containing fragments of polychrome glazed ceramics and various metal implements characteristic of the 12th–13th centuries. The typological analysis of these finds provides a secure chronological framework for the period of renewed occupation and activity.

The organization of the wine cellar itself offers valuable insights into monastic practices. Excavations revealed that four *qvevri*–large ceramic vessels traditionally used for wine production and storage–were installed within natural depressions in the bedrock. Each vessel was externally coated with a layer of clay approximately 8–10

Fig. 7. Fragments of relief ornamentation with floral motifs and Asomtavruli inscriptions, 5th–6th centuries CE. (Photoes Berikashvili D.)

cm thick, ensuring stability and insulation. The *qvevri* were sealed with flat lids featuring central perforations, a detail that suggests their use not only for storage but also for fermentation processes. Additional evidence, including the presence of stones, supports this interpretation.

The spatial arrangement of the cellar further reflects a well-organized production system. On its northern side, the *marani* was enclosed by a wall constructed of basalt stones. Beyond this wall, a arteficially prepared space was identified, intended for the installation of a wine press. Comparative evidence from other monastic sites indicates that both fixed stone presses and movable wooden presses were commonly used. In the case of Ortvala Cave, it is plausible that a wooden press was employed, with the extracted grape juice being transferred through clay pipes into the *qvevri* positioned on the opposite side of the wall (Fig. 8). This arrangement demonstrates an efficient integration of production and storage facilities within the confined cave environment.

In summary, the archaeological investigations at Ortvala Cave have revealed two principal phases in the history of the monastic complex. The first phase, dating to the 5th–6th centuries, corresponds to its establishment and initial development, characterized by the construction of the cave church and associated liturgical features. The second phase, dated to the 12th–13th centuries, reflects the restoration and renewed use of the site following the destructive earthquake of 1088. The evidence for both continuity and transformation across these phases highlights the resilience of monastic communities and their ability to adapt to changing environment.

The eventual decline and abandonment of the monastery, however, remain less clearly understood. This process must be considered within a broader historical and socio-political context, taking into account regional developments that may have affected monastic life in southern Georgia. A more detailed exploration of these factors is necessary in order to fully understand the final stages of the complex's history, and this issue will be addressed in the following section.

Discussion

The Ortvala Cave monastic complex in Kazreti represents a significant example of early medieval monasticism in Georgia, and its interpretation gains depth when considered within the broader context of rock-cut architecture and ascetic practice in the region. Over the past decades, substantial research has been conducted on Georgian rock-cut monuments and early Christian monasticism (Chubinashvili 1948; Kekelidze 1956; Javakhishvili 1984; Gaprindashvili 1987; Bakhtadze 1988; Gaprindashvili 1988; Kipiani 2000; Bakhtadze 2001; Bakhtadze 2002; Bakhtadze 2003; Bakhtadze 2007), resulting in a systematic clarification of both the chronology and periodization of such sites, as well as their genesis and interactions with prominent early Christian centers in Syria, Palestine, Egypt, Cappadocia, and elsewhere (Posnov 1964; Hirschfeld 1992; Bakhtadze 2007, 81–138). Within this broader framework, the Ortvala complex should be assessed in relation to comparable data and general regional trends, allowing for a nuanced understanding of its chronological, architectural, and functional significance.

Recent studies indicate that Christian ascetic communities emerged in Georgia as early as the fifth and sixth centuries (Khoshtaria 2000; Bakhtadze 2001). These early formations predate, by nearly two centuries, the activities of Grigol Khandzteli and his disciples, whose efforts in the eighth and ninth centuries were instrumental in establishing a fully organized monastic system in Georgia (Kekelidze 1951; Javakhishvili 1984). Among the earliest monuments that exemplify these formative phases are the monastic complexes of Shio-Mgvime (Chubinashvili 1970), Zedazeni (Chubinashvili 1971), Breti (Sanikidze 1974), Kondamani (Chubinashvili 1959), and the Katskhi Pillar Monastery (Tsintsadze 1979; Berikashvili 2010; Gagoshidze 2015), all of which are securely dated to the 5th and 6th centuries. The Ortvala complex appears to belong to this group, a conclusion strongly supported by the architectural, archaeological, and paleographic evidence uncovered during excavations.

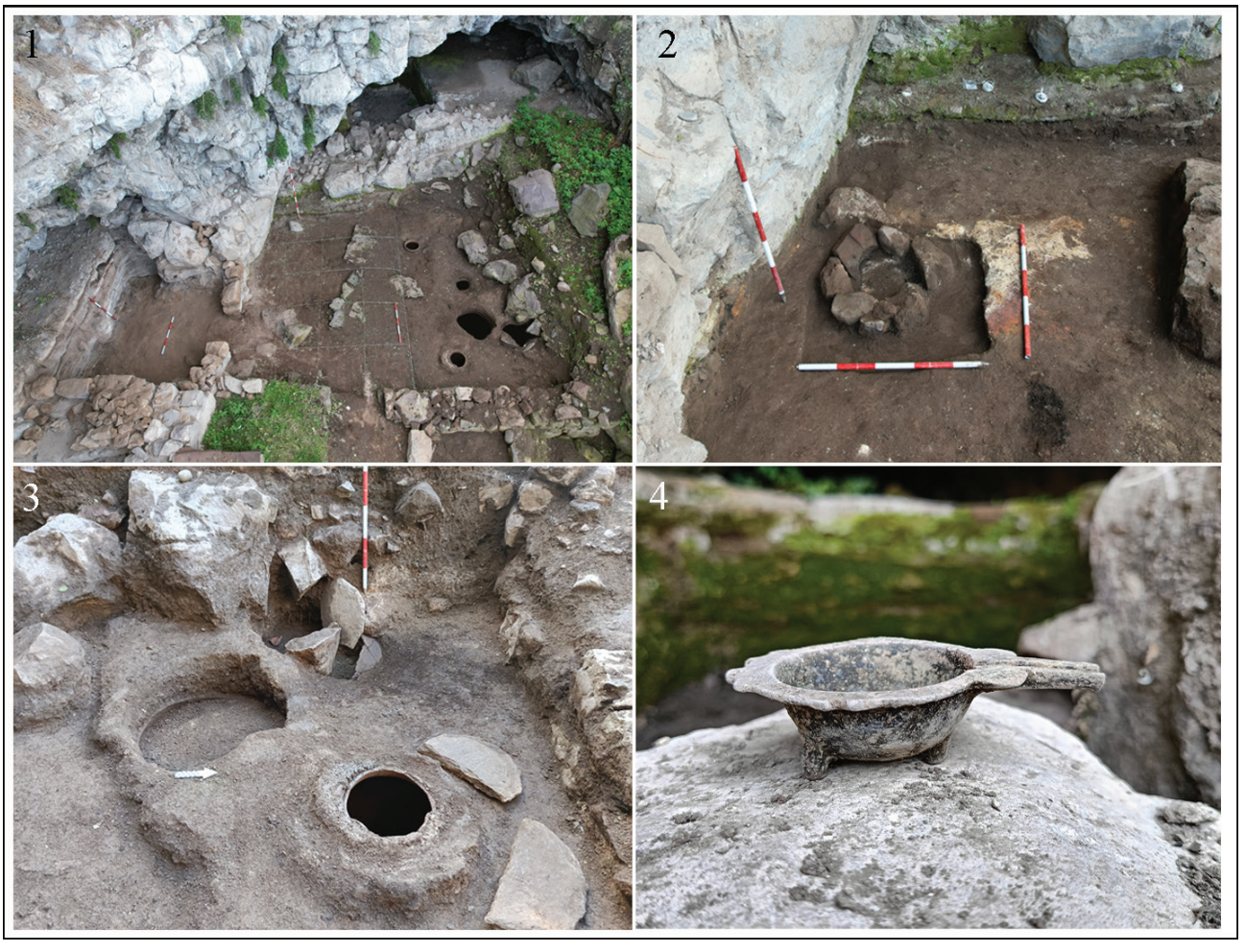

Fig. 8. Wine cellar (marani) and storage area of the Ortvala Cave Monastery (1); hearth within the cellar (2); remains of a qvevri (3); bronze oil lamp discovered in the cellar (4), 12th–13th centuries. (Photoes Berikashvili D.)

However, some variation is observable among these early sites in terms of architectural and structural characteristics. At certain locations, natural caves were merely adapted or modestly expanded to meet the minimum requirements of monastic life, whereas in other cases, small hall-type churches and various stone-and-mud-built economic or storage structures were constructed either within the cave interiors or immediately adjacent to them[8]. In this point, Ortvala aligns more closely with the latter category of monuments. Its architectural layout and construction techniques reveal strong affinities with the monastic complexes of the Kechuti Gorge and the Muguti complex.

The similarities between Ortvala and Kechuti are evident both in the overall planning of the complexes and in the architectural features of the churches themselves. The church at Kechuti, built on a terrace immediately in front of a natural cave, displays early medieval constructional traits, including a hall with a rectangular east end terminating in a slightly horseshoe-shaped apse, as well as walls dressed with carefully worked stone both internally and externally (Chubinashvili et al. 1948; Bakhtadze 2007). Similarly, at Ortvala, the hall-type church incorporates a rectangular plan with a slightly horseshoe-shaped apse, a finely dressed stone interior, and an elaborately paved floor. The principal distinction between the two lies in their settings: at Ortvala, the church is integrated directly into the cave interior, taking advantage of the natural rock environment, whereas the Kechuti church stands on the terrace in front of the cave. Furthermore, Ortvala has yielded a more diverse array of architectural and paleographic material that allows for precise dating, while Kechuti lacks datable inscriptions or other chronological markers. Despite these differences, both monuments clearly belong to the early medieval period and correspond to the initial phases of ascetic monastic activity in Georgia.

Ortvala also demonstrates significant affinities with the Muguti monastery, located in Kvemo Kartli near the village of Dageti (Bakhtadze 1988). This complex, like Ortvala, is situated within a natural rock formation that was subsequently expanded to accommodate monastic func-

8 A noteworthy observation on this issues was presented by the art historian and architect Givi Gaprindashvili, who argued that within early Christianity in Georgia, two distinct forms of monastic practice existed. The first emphasized ascetic life, seclusion, and "desert dwelling," whereas the second corresponded to organized monasticism, involving the establishment of a monastic complex or lavra and communal activity within it (Gaprindashvili 1987).

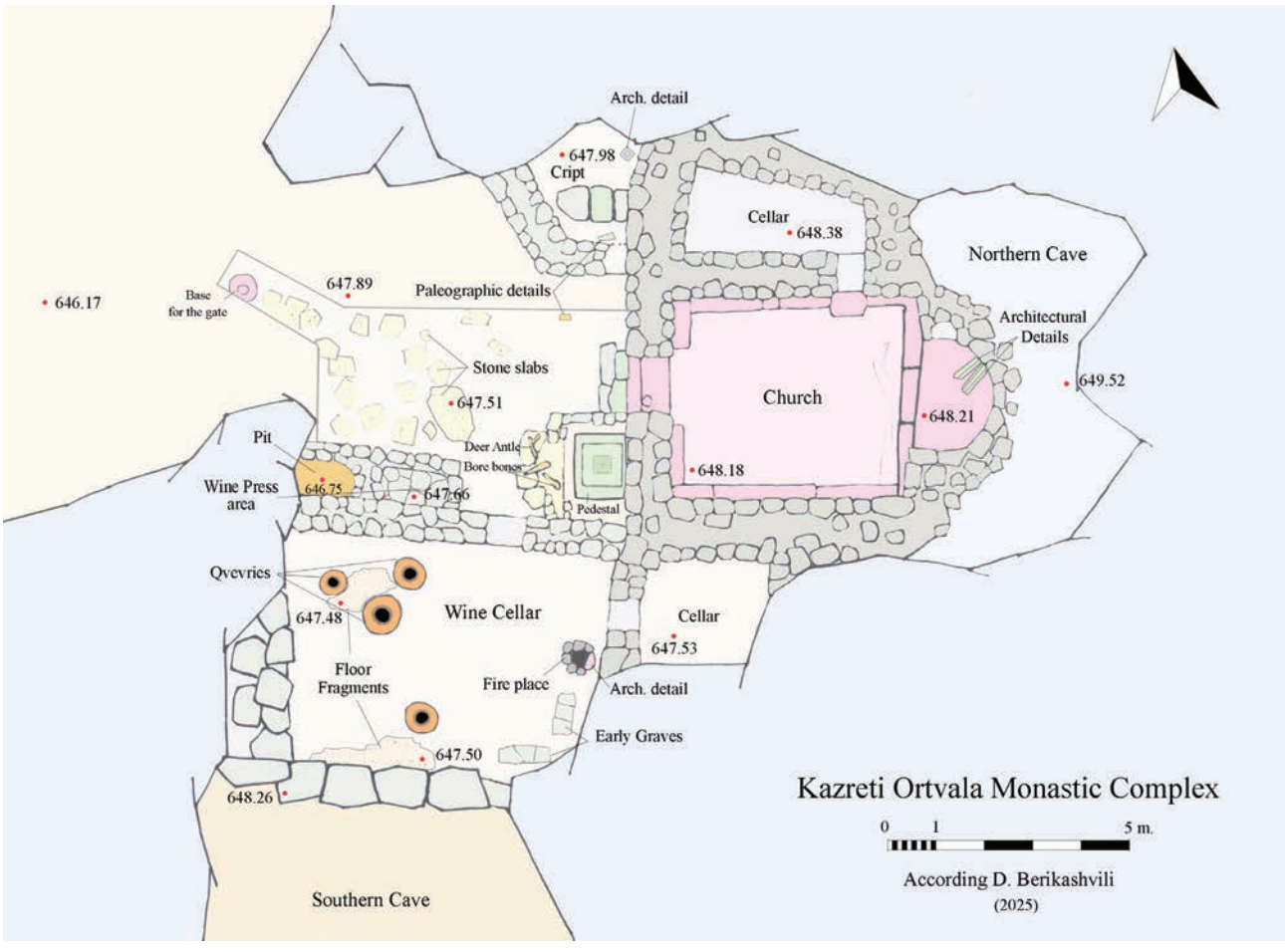

Fig. 9. Site plan indicating the main features of the Ortvala Cave Monastic Complex (2025). (According to Berikashvili D.)

tions. Its main structure is a hall-type church constructed of stone and mud (Bakhtadze 2007, Tab. 146–147), and it represents one of the most important examples of 12th and 13th century rock-cut architecture, established on the site of earlier settlements or facilities. During its period of activity, the Muguti complex included various economic and service spaces in proximity to the church, such as ovens, *qvevri*, storage areas, and refectories (Bakhtadze 2007, Tab. 154.1–2). In this respect, Ortvala exhibits a clear parallel: during later medieval restoration and renovation work conducted in its hall-type spaces, economic and service areas–including a refectory, storage facilities, and a wine cellar (*marani*)–were constructed (Berikashvili 2024, Tab. XXII) (Fig. 9).

Observations of these similar sites, together with analysis of the associated material and data, underscore a discernible pattern in early medieval cave monasteries and "cave desert" settlements in Georgia. They highlight a consistent approach to adapting natural rock formations for religious and monastic use, as well as the integration of hall-type churches and associated economic facilities to support ascetic communities. In addition, Ortvala's excavated architectural, archaeological, and paleographic remains provide important evidence for the chronological development, construction techniques, and liturgical organization of early Georgian monasticism. Taken together, the Ortvala complex not only confirms broader regional trends but also offers a unique case study in the adaptation of natural cave environments for ecclesiastical and monastic purposes, illustrating both continuity and variation in early Christian ascetic practices.

In conclusion, the Ortvala Cave complex represents a vital link in the network of early medieval Georgian monasticism. Its similarities with the Kechuti Gorge and Muguti complexes, in terms of layout, architectural design, and functional organization, situate it firmly within the early phases of monastic development in the region, dating to the 5th and 6th centuries. At the same time, Ortvala's distinctive integration into the cave interior, combined with the diverse range of recovered material, highlights both the ingenuity and adaptability of early Georgian ascetic communities. The study of Ortvala, therefore, not only enriches our understanding of local monastic traditions but also provides insights into broader patterns of Christian monasticism in the South Caucasus during the medieval period, offering a foundation for further comparative research and synthesis of early monastic landscapes in Georgia and neighboring regions.

These observations and comparisons provide a solid foundation for drawing broader conclusions about the devel-

opment, organization, and significance of early medieval monasticism in Georgia, which will be addressed in the following section

Conclusion

The results of the archaeological investigations at the Ortvala Cave in Kazreti, together with previous research conducted over past decades, clearly attest to the active monastic life that must have taken place within natural caves and rock-cut complexes from the early medieval period onward. Moreover, these monastic complexes were often established upon earlier cave dwellings or rock shelters containing material remains from even more ancient periods, which are frequently encountered during archaeological investigation.

Particularly intense monastic activity is observable in rock-cut complexes beginning in the 5th and 6th centuries, likely associated with the arrival of Assyrian christian ascetic monks from the neighboring eastern regions and the introduction of their hermitic, desert-oriented mode of life, known as *meudabnoeba*. It was during this period that foundational monastic complexes were established, including those of Gareja, Zedazeni, Shio-Mgvime, Kondamani, and other monasteries situated in the eastern part of the country. Most of these sites were subsequently renewed and restored during the high medieval period, which generally corresponds to a broader era of cultural flourishing and architectural development in Georgia. The monastic complex of Vardzia, in particular, belongs to this same epoch and represents the culmination and apex of rock-cut monastic architecture in the country.

However, this period of monastic flourishing was soon disrupted. Prolonged and devastating incursions–first by the Mongols, and later by Tamerlan and other invading forces–virtually destroyed not only the cultural and economic foundations of the country but also the well-established monastic networks within rock-cut sanctuaries. The centuries-old spiritual traditions that had been cultivated in these cave monasteries were largely interrupted and, in the later medieval period, persisted only in fragmentary form or as exceptional survivals.

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Finally, we wish to pay profound tribute to the archaeologist Professor Guram Grigolia, whose name is inseparably linked to the discovery of Ortvala Cave in 1957 and who generously offered his guidance as project and expedition leader in 2018. The discoveries made within the Ortvala Cave monastic complex are dedicated to his memory.

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Details of the Natlismtsemeli Monastery in Gareji Based on the Study of a Single Burial (Georgia)

Eliso Kvavadze
Georgian National Museum
e.kvavadze001@gmail.com
Liana Bitadze
Ivane Javakhishvili Tbilisi State University
liana.bitadze@tsu.ge
Ketevan Digmelashvili
National Agency for Cultural Heritage Preservation of Georgia
ketisha80@gmail.com

Abstract
The report is devoted to the interpretation of data obtained from the 2018 excavations in the rock-cut church of the Natlismtsemeli rock-cut Monastery (Gareji) in the context of the history of the monastery itself.
Archaeological, anthropological, and palynological studies of the burial, as well as comparison of these data with historical sources, showed that the grave was carved in front of the altar at an early stage of monastic life. A clergyman who had the right to give blessings was buried there. He was a 51 year old man who died in winter after a long illness. Later, another man aged 55–65 was buried above him. He died suddenly in summer during a trepanation of the skull caused by a head wound. This person was also probably a clergyman, since a bead from a prayer rope was found with him.
Historical sources indicate that the Natlismtsemeli Monastery, whose foundation is attributed to Lucian, a disciple of David Garejeli, in the 6th century, was abandoned in the 14th – first half of the 17th centuries. It can be assumed that the second burial took place before the devastation of the Gareji area by the Golden Horde in the 13th century. In the late Middle Ages, the grave pit was filled with plaster debris and sand and then re covered.
Palynological studies showed that during the first burial the climate on the monastery's territory was more humid than at the time of the second burial. At the same time, during the life of the second deceased, the monastery had its own economy, which included both grain fields and livestock farming.
Considering the fact that in the monasteries of Gareji only a few cases of burials in churches in front of the altar have been confirmed to date, and all of them belonged either to founders or abbots, it can be assumed that in the case of the Natlismtsemeli Monastery, abbots of the church or particularly distinguished clergymen were buried in this grave.

Keywords: Natlismtsemeli Monastery; Gareji; archaeological excavation; burial; palynology

The Natlismcemeli Monastery of Davit Gareji is located on the Iori Plateau, 10 km west of the Davit Gareji's Lavra. The Natlismcemeli Monastery was founded by Davit Garejeli's disciple, Lucian, in the 6th century, by Davit's command. The major construction phase of the complex dates to the 9th–12th centuries. Written sources and archaeological excavations on the monastery grounds indicate that during the 14th–first half of the 17th centuries, the Natlismcemeli Monastery was not functioning. In 1672, the monastery was restored. The late 17th and 18th centuries mark the period of its flourishing. Later, the monastery gradually declined, and by the beginning of the 20th century monastic life had ceased (Bulia et al. 2010, 9–22; Tvalchrelidze 1988, 12–21).

In 2018, members of the monastery partially cleared a church-oratory in the western part of the complex, where a burial was discovered in the northern crypt. The crypt has a semicircular apse. The walls were plastered, and the floor was covered with lime mortar. In the northwestern part of the oratory, a tomb was arranged, above which three niches were cut into the vault for hanging lamps.

The tomb was carved into the rocky layer beneath the oratory floor and bordered by a ledge supporting the roof. It was sealed with four partially worked sandstone slabs. The tomb was filled with debris of plaster and rock chips. Within this fill was found a small fragment of a red-clay lamp covered with azure glaze, typical of 11th–13th century glazed lamps (Mitsishvili 1969, 57). The fill indicated that it entered the tomb after the burials, before the tomb was closed with stone slabs.

The tomb was originally intended for one deceased, but later a second was interred. Both were buried supine, with heads to the west. The first deceased had the right arm bent at the elbow, resting on the shoulder, and the left arm on the abdomen. The second deceased had both hands placed at the pelvis. No objects were found with the first burial, while in the clavicles of the second burial was discovered a pendant - part of a rosary - con-

sisting of a barrel-shaped organic bead mounted on a bronze wire.

In Georgia, the tradition of arranging burials in front of the altar in the northern part of the church is attested from the early Middle Ages. Founder's tombs are arranged in this way at the Davit Gareji Lavra, Dodorka, Alaverdi, Zedazeni, Tsilkani, Khirsa, Martkopi, Breti and Samtavisi. Likewise, martyr's tombs were placed along the northern wall in the early Middle Ages at the monasteries of Gareji's Tsamebuli and Bertubani (Skhirtladze 2006, 16–19; Skhirtladze 2001, 50–55; Jojua 2000, 36–44). The same arrangement was revealed in 2011–2012 at a church-oratory discovered in Dodorka Monastery (Makharadze et al. 2013, 83–84). It seems that in the case of the Natlismcemeli Monastery we are also dealing with the continuation of this tradition, and in terms of attribution the tomb must be connected with important figures of the monastery. The burial posture of the first deceased - right arm bent at the elbow and placed on the shoulder - suggests that he was a distinguished cleric in monastic life. According to N. Bakhtadze, the right hand raised to the shoulder is the posture of blessing. Accordingly, burials in this position belonged to clerics of a rank authorized to bestow blessings (Bakhtadze et al. 2020, 123–124). Cases of burial with the "blessing" right hand are attested in the basilicas of Dolochopi and Vashlobi, and in a specially arranged stone crypt at Ulumbo Monastery.

The form of the Baptist tomb is characteristic of rock-cut burials in the Gareji complex (for example, the tomb of Davit Garejeli, the necropolis of the "Kvabebi" settlement, dated by material to the 10th–11th centuries (Mchedlishvili 1977, 157–170); the original tomb of Dodo Garejeli (sshvili 2012, 35–51)). Thus, such rock-cut funerary chambers appear to have been widespread in the Gareji monastic complexes during the 6th–11th centuries. The tomb of the Baptist Monastery's oratory should likewise be considered as belonging to this period.

When did the debris of plaster and rock enter the tomb? The fragment of a glazed lamp from the High Middle Ages found in the tomb indicates that this layer cannot be earlier than the 12th–13th centuries. It is known that during Easter of 1265, the campaign of Berke Khan of the Golden Horde devastated Rustavi, Khunani, and Khornabuji. Berke himself encamped in the Gareji mountains, as a result of which the villages and economy around the Gareji monasteries were permanently destroyed. The absence of 14th–16th century cultural layers in the excavations of the Natlismcemeli Monastery may be the consequence of this campaign. On the other hand, if we take into account the devastating earthquake of 1283, which lasted for a whole week, it is plausible that the tremors caused the collapse of plaster and rock layers from the walls. But how did the debris settle not on the tomb's roof but directly on the deceased? The only logical assumption is that the debris deposited on the tomb during the destruction was later thrown inside, filling the tomb during subsequent repair or embellishment (perhaps similar to cases attested in Dodo Garejeli's tomb and the crypt of Ulumbo Monastery). In this regard, it is noteworthy that King Alexander II of Kakheti is reported to have restored martyr's tombs in the abandoned monasteries of the Udabno and Tsamebuli (Skhirtladze and Tvalchrelidze 2001, 50–55). It is reasonable to assume that a similar case occurred with this tomb of the Natlismcemeli Monastery, when by 1672, through the efforts of King Archil, monastic life was revived here.

Archaeological data are supplemented and clarified by anthropological and palynological studies of the individuals buried in the tomb. Anthropological research shows that both individuals interred in the tomb were male. The first deceased was 51 years old, while the second was between 55–65 years old.

The two individuals differ significantly in cranial form. The first had a dolichocranial skull, while the second had a brachycranial skull. Based on the preserved skull of the first deceased, his morphological appearance differed from the anthropological type common among the population of Georgia in the early Middle Ages. He was characterized by a reduction in facial profiling at both levels (upper and middle facial angles). As for the brachycranial skull of the second deceased, this type becomes dominant in the population during the late Middle Ages.

The long bones of the deceased allow us to assess their physical development and activity (Bitadze et al. 2014). Both individuals were of tall stature: the first measured 178.7 cm, the second 177.2 cm. The first was taller and broad-shouldered. Both had body weights significantly lower than expected: 63.3 kg (first) and 63.0 kg (second). The ratio of height to weight suggests that both were of muscular build. According to the proportions of shoulder width and leg length relative to body length, both exhibited dolichomorphic proportions.

The spectrum of pathologies and probable causes of death must have differed. The first deceased showed cribra orbitalia (porosity in the eye sockets), a marker of anemia or acute infections. He suffered from osteoarthritis, had signs of osteoporosis in the lumbar and thoracic vertebrae, and possibly brucellosis, with bony growths on several vertebrae (including two cervical vertebrae).

The second deceased suffered from osteoarthritis, rheumatoid arthritis, osteoporosis, and brucellosis. On the skull there is a small osteoma–a benign bone tumor–and hyperostosis in the occipital area. He had sustained several injuries: on the fibula there is a bony callus indicating a healed fracture; on the parietal bone there is evidence of a healed wound caused by a blow from a blunt object; near the right temple there is a small square-shaped hole, very similar to the beginning of a

Fig. 1. The tomb of Natlismcemeli monastery

Fig. 2. The skeleton of the first dead

Fig. 3. The skeleton of the second dead

trepanation procedure. Since no signs of infection are visible, the operation may have been halted due to the patient's death. In the right temporal area there is also a wound, probably caused by an arrow, which must have been the cause of death. These data suggest that he may have participated in battles.

Eight samples from the tomb were examined palynologically. For palynological analysis, samples were taken from beneath the skull, on the chest, between the pelvic bones, and above the coccyx. Organic residues beneath the skull are always rich, since human hair accumulates dust from plants and objects encountered in daily life. Examination of organic residues in the abdominal and coccygeal areas is particularly important for identifying the diet of the individual in his final days.

The study of this material showed that both deceased lived under similar conditions. Their dwelling was damp, as indicated by the large quantity of mold spores (Mucoraceae). This is natural, since rock-cut cells are always characterized by coolness and humidity.

Both deceased mainly consumed porridge made from cereals and other plant-based foods. They also boiled stews of ash-tree leaves and nettles.

At the same time, differences are also observed in the palynological spectrum of these two deceased individuals. In the abdominal and coccygeal areas of the first deceased, in addition to food plant pollen, pollen of medicinal plants was found: linden (*Tilia*), plantain (*Plantago*), valerian (*Valeriana*), yarrow (*Achillea*), cocklebur (*Xanthium*), nettle (*Urtica*), and ephedra (*Ephedra*). It is also noteworthy that his hair contained little plant pollen, which indicates that for quite some time before death he no longer went outdoors. The presence of medicinal plant pollen grains in the abdominal area suggests that the deceased suffered from numerous illnesses. For example, plantain and yarrow are used in folk medicine mainly for gastrointestinal and liver diseases, while nettle is a remedy for rheumatism (Rivega et al. 2012). Linden is known as a treatment for fevers and as an antipyretic.

It is interesting that during the lifetimes of both deceased, the monastery must have had a fairly large economy. They cultivated cereals and practiced animal husbandry. This is indicated by the phytoliths of wheat husks and wheat pollen grains found in the clothing of the second deceased (apparently he was threshing wheat), as well as by spores of dung fungi (*Sordaria* and other coprophilous fungi) found in the clothing of both deceased.

The large amount of plant pollen found in the hair of the second deceased indicates that until death he led an active life and moved about frequently. He had been in riparian forests where alder (*Alnus*) grows. His hair spectrum also contained abundant pollen grains of hazelnut (*Corylus*), pine (*Pinus*), walnut (*Juglans*), and ephedra (*Ephedra*).

The analysis of the taxonomic list of plants revealed by palynological study shows that the first deceased must have lived under different climatic conditions. Spores of forest ferns and willow pollen found on his clothing indicate that at that time the climate in the Gareji desert must have been humid subtropical. Only in the hair of the first deceased was pollen of the common grapevine (*Vitis vinifera*) discovered. It is plausible that this moist climate made possible the cultivation of vineyards in Davit Gareji. Similar results were obtained from the palynological study of material from the Dodorka monastic complex. It should also be noted that a cooler and more humid climate spread across almost all of Eurasia in the 5th–7th centuries, with the peak of cooling occurring in the 6th century (Bradley 2003, 404–405).

During the lifetime of the second deceased, climatic conditions were not as cool as in the time of the first, but precipitation was considerably greater than today. This fact, in addition to the vegetation cover, is confirmed by the presence of helminthic disease revealed through palynology. In the abdominal area of the second deceased, an egg of the parasitic worm *Trichuris* was found, which severely damages the gastrointestinal tract. Helminthic diseases generally do not spread in arid and dry climates, since the eggs of parasitic worms die in the soil.

The study also showed that the death of the second deceased must have been sudden, occurring during the cold season of the year, while the first deceased died after a prolonged illness in the warm season. This is indicated by the fact that numerous remains of ticks and other insects were found on his clothing, whereas they are almost absent on the clothing of the second deceased.

Both deceased were clerics, since their living conditions were identical. The results fully correspond with the anthropological data, as both suffered from rheumatism caused by the dampness of the rock.

Thus, the interdisciplinary study of the tomb excavated in the crypt of the Natlismcemeli Monastery provides certain information about the tomb itself and the monastery:

Considering the fact that, to date, only a few cases of burials in front of the altar have been confirmed in the Gareji monasteries, and all of them belonged either to the monastery's founder or to its abbot, it is reasonable to assume that in the case of the Natlismcemeli Monastery, the tomb likewise contained abbots or particularly distinguished clerics; 2. The tomb must have been constructed in the early Middle Ages and reused until the 12th–13th centuries; 3. Based on the arrow wound to the head and the sudden death of the second deceased, it is likely that he perished during an enemy attack on the monastery; 4. During the lifetimes of both clerics, the monastery must have maintained its own economy, which included both cereal fields and livestock.

Fig. 4. The bones of the skeleton of the first dead

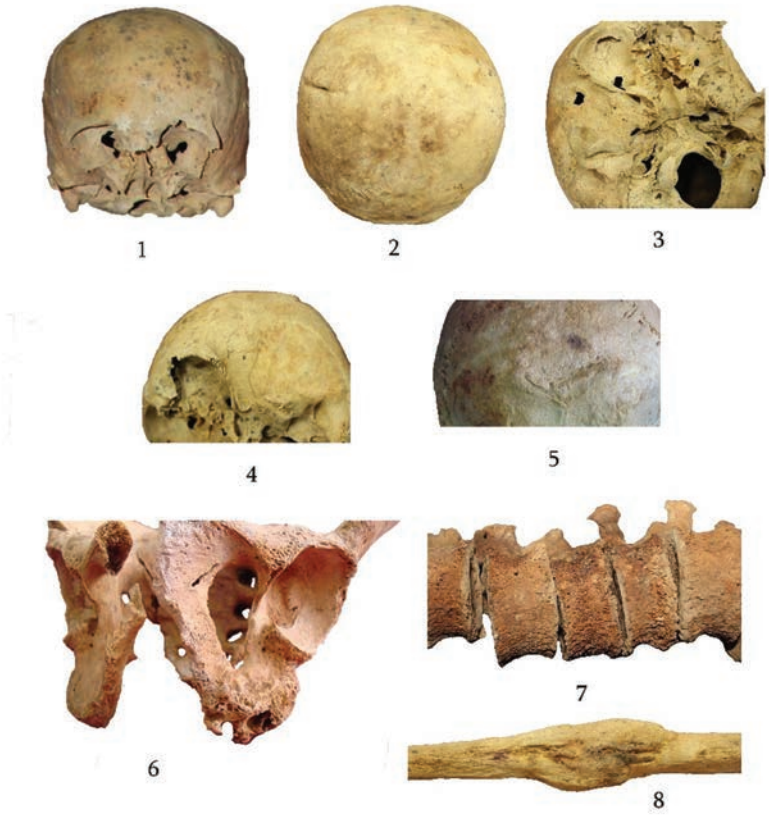

Fig. 5. The bones of the skeleton of the second dead

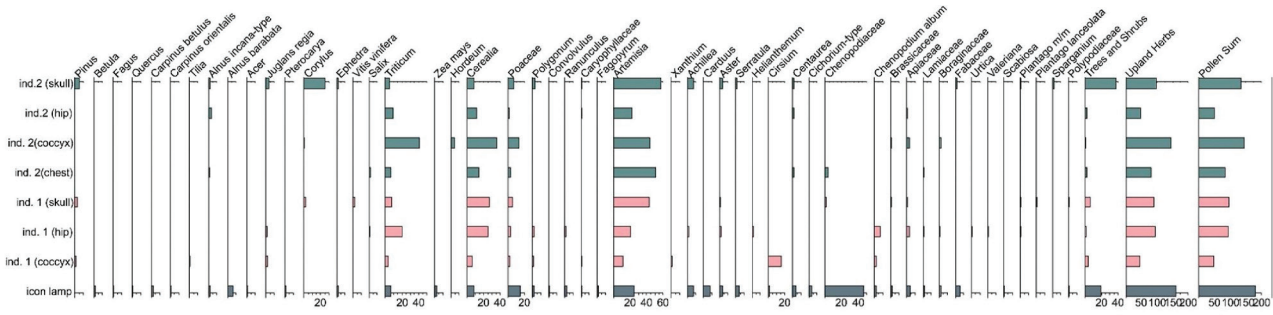

Fig. 6. Natlismcemeli Monastery, Grave 1, Palynological diagram of organic remains

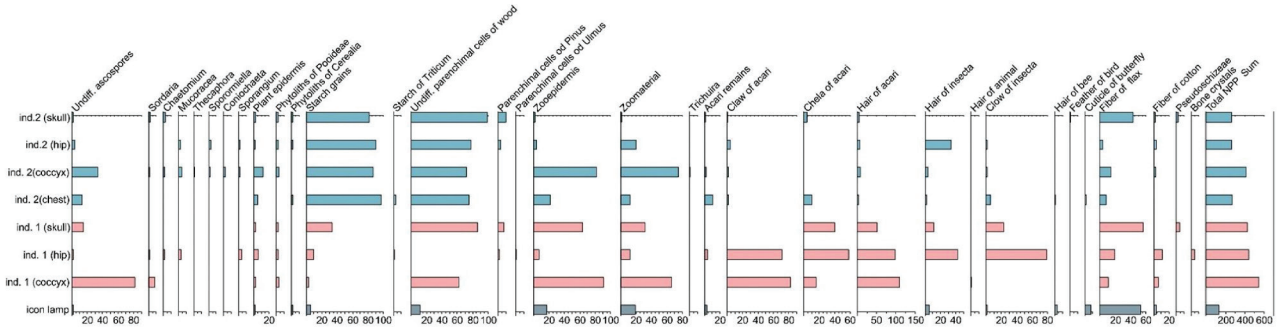

Fig. 7. Natlismcemeli Monastery, Grave 1, Non Pollen Palynomorphs diagram of organic remains

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Newly Discovered Medieval Rock-Cut Complex of Ohanavan (Armenia)

Dianna Mirijanyan[2], Arman Nalbandyan[1,2], Mher Khechoyan[1]

[1] Scientific Research Center of Historical and Cultural Heritage, Yerevan, Armenia
[2] Institute of Archaeology and Ethnography, NAS RA, Yerevan, Armenia

Abstract:
Discovered in 2024 in Armenia's Kasagh gorge, the Ohanavan rock-cut complex offers unique insights into early Christian memorial architecture. Carved into tuff, the site includes spiritual and economic structures that stand out among known early medieval martyriums.
The east-west oriented crypt features rare basket-weave wall decorations and a decorated northern entrance. Excavations revealed two graves containing the partial remains of two men and a child, suggesting the site served as a repository for holy relics. Notable finds include a floral-carved rock altar and 41 clay oil lamps. This newly revealed complex provides significant new data on early medieval spiritual and production practices.

Keywords: Armenia, Ohanavan, funeral archaeology, medieval, rock-cut, altar, oil lamps, anthropology

Introduction

The medieval rock-cut complex of Ohanavan is situated within the administrative boundaries of Ohanavan village in the Aragatsotn province of the Republic of Armenia. Specifically, the site is located in the Serkevili Dzor area of the Kasagh River gorge. The entire complex is monolithic, carved directly into a tuff rock massif. In February 2024, it was revealed that a local resident had conducted unauthorized earthworks over several years in the left-bank section of the gorge, leading to the discovery of the complex. Prior to formal excavation, this archaeological site sustained significant damage due to mechanical interference. The area was further obstructed by large-scale rockfalls, necessitating substantial time and labor for clearance during the initial stages of investigation.

Current archaeological research indicates that the complex comprises an early medieval rock-cut tomb, a spiritual (ecclesiastical) building, and various structures of economic and production utility. Based on functional analysis, these structures are categorized into two primary types: spiritual-memorial and economic-production (Fig. 1).

The Tradition of Rock-Cut Burials in Armenia

The tradition of rock-cut tombs in the Armenian Highlands peaked during the Urartian period, when the elite were interred in such structures across the empire and its capital, Van (Melkonyan 1995: 11-19; Piliposyan, Khachatryan 1995: 81-83; Kalantaryan 2005: 154-160; Petrosyan, Bobokhyan 2014: 84-86; Kroll 2019: 317-323). In Christian doctrine, the "rock" symbolizes the Church's foundation (Matthew 16:18), a metaphor that influenced Armenian architecture and was used to describe spiritual pillars like Stepanos Syunetsi (Stephannos Orbelyan 1986: 148.). Caves also served as ascetic refuges for hermits and are frequently linked to saints, particularly Mesrop Mashtots.

Another remarkable early medieval structure is the early Christian rockcut complex of Vankasar, created as a result of the processing of karst formations. The rock-cut complex consists of a well- processed road (120 m), open halls, stairs, a church, and five sarcophagi. There are cross sculptures, and Greek and Armenian inscriptions on the different parts of the walls of the complex (Petrosyan, Kirakosyan 2016: 165169).

Rock-cut churches and tombs, which make a part of rock-cut settlements, are also known in Armenia. The best example of such a settlement is the capital of the Bagratid period, Ani. Members of the Ani archaeological expedition wrote about the study of hundreds of rock

Fig. 1. Rock-cut complex of Ohanavan (photo Alexanyan T.)

Fig. 2. The entrance of rock-cut crypt (photo Alexanyan T.)

complexes of the city, which was summarized by Nikolai Marr's student David Kipshidze (Kipshidze 1972). It is important to emphasize the fact that one group of rock-cut churches in Ani is directly related to the burial structures. Among them, a special place is occupied by the burial vault of the wealthy family of Tigran Honents, consisting of several halls and about four dozen graves (Kipshidze 1972: 46-48). At the same time, rock-cut churches find their parallels in Cilicia and Cappadocia (Braeva, Klyuev 2022: 16-19; Kalas 2009: 81-88). The architect V. Harutyunyan very accurately described the rock-cut architecture of Ani as a creative laboratory (Harutyunyan 1992: 289).

The best example of a tomb structure dating back to the High Middle Ages is the crypt of the Proshyan princes in Geghard, cut from a single piece of rock (1288). In terms of its plan and volume-spatial composition, it belongs to the type of fourcolumned chapels (Hovsepyan 1928: 103).

In the upper reaches of the Pambak River, on the left side of the gorge, in the territory of Geghasar village in Spitak district, a rock-cut settlement dating back to the 12th-14th centuries was also discovered. Ritual (small church and double-hall crypt, with rock-cut 12 graves), as well as public, production and residential structures were also revealed here (Kalantaryan, Sargsyan 1980: 21- 26).

Another example is the 'Cave of Davrizhetsi', located in the right-bank cliff of Ukhtuakunk (Khosrov Reserve) in the upper reaches of the Azat River, which is called so because it is mentioned in the works of the historian Arakel Davrizhetsi. There are also rooms of spiritual and economic significance carved into the rock massif. They have not been studied yet, but, according to the historian, the arched entrances, which have rock-cut pillars on both sides, deserve attention, as is the case with the crypt of Ohanavan (Shahinyan 203, 36f).

Excavations of the Rock-Cut Crypt

The most significant spiritual-memorial structure within the complex is the rock-cut crypt. It is oriented on an east-west axis, with internal dimensions of 295 × 135 cm. The entrance is located on the northern side (height: 150 cm; width: 70 cm), decorated with a pair of semi-cylindrical pilasters featuring distinct capitals and bases. The entrance terminates in an arched decoration with a carved window above it. A niche-like space is situated between the rectangular frame and the arched upper section (Fig. 2). The crypt entrance is stepped, with three steps of varying heights leading down to the grave: 25 cm, 20 cm, and 10 cm, respectively.

The crypt ceiling is dome-shaped. The southern wall shows traces of wedge-tooling and contains apertures for oil lamps. According to the discoverer, five lamps were recovered from the interior. The western wall features a decorative "basket-weave" treatment. The eastern wall, to the left of the entrance, bears a carved cross and a lamp hole. Eight additional crosses of varying sizes are carved to the left of the entrance. Adjacent to these is a cubic pedestal for a tetrahedral stele (50 × 50 × 39 cm), featuring carvings of two Evangelists holding Gospels (Fig. 3). Architectural parallels for such steles at crypt entrances are found at the Botanical Garden highway site and the royal tomb of Aghtsk.

Prior to formal excavation, the crypt interior had been opened. Subsequent systematic work focused on two rock-cut graves on the western side.

One grave featured a gabled tombstone (burial pit: 150 × 50 × 70 cm; tombstone: 110 × 50 × 17 cm. The burial chamber includes a head depression at a higher elevation than the pit floor. At the foot of the grave, a processed tuff stone (50 × 50 × 10 cm) was found. The head depression and the foot-stone were both positioned at a depth of 50 cm.

The second burial was covered by a flat tombstone (pit: 165 × 40 × 85 cm; tombstone: 105 × 49 × 20 cm. Structural analysis suggests that the hardness of the rock in the first grave presented difficulties during carving, which is why the head depression was not as deeply recessed as in the second burial.

The presence of incomplete skeletons suggests that these chambers served as repositories for collected relics.

Fig. 3. Stele with two evangelists (photo Alexanyan T.)

The altar and Spiritual Structure

Adjacent to the crypt entrance, a rock-cut niche containing an altar was identified (Fig. 4). It is adorned with floral ornaments and an equilateral cross on the stipes, characteristic of early Christian iconography (Petrosyan 2008, 27-36). Evidence suggests lamps were placed both on the altar and within flanking niches, with a preserved nail in the left wall indicating a suspended lamp. The altar surfaces are finished with limestone plaster and flanked by decorative carvings.

The spiritual structure (chapel) is located north of the tomb and altar. It is accessed from the south via a rock-cut corridor (width: 70 cm; excavated length: 3.5 m). Much of the corridor's upper section was destroyed by machinery, obscuring its original dimensions. Unlike the monolithic tomb, the southern wall of this structure consists of stone masonry. The hall measures 270 cm in length and 157 cm in width, featuring an eastern altar-niche. Finds from this area include a window opening, approximately twelve coins (likely ecclesiastical donations), and a bell. Excavations also recovered ceramic and glass fragments and a pearl earring. Removal of the 65–75 cm thick roof sediment revealed a basalt stone wall containing an inset tuff stone with an Armenian inscription.

Economic and Household Structures

To the southeast of the chapel roof, a rock-cut winepress was uncovered, featuring a central residue depression (diameter: 75 cm; depth: 24 cm). Approximately 20 meters north lies another rock-cut structure intended for production activities. During clearance of debris, a hearth (diameter: 35 cm; depth: 50 cm) was discovered at the entrance, covered by a 60 × 52 cm slab leveled with basalt stones. Ceramic fragments were found within the hearth, alongside a north-oriented ventilation hole in the floor.

Fig. 4. Rock-cut Altar (photo Alexanyan T.)

Artifactual Findings (The Assemblage)

Excavations yielded a diverse assemblage of ceramics, glass vessel fragments, and metal objects. A notable find is the gold earring with pearl decoration from the chapel; the only known parallel in Armenia for this style was found at Garni and is dated to the post-Mongol period (Petrosyan 1988: 97f).

The most significant category of finds consists of oil lamps. Although collected out of primary context by the site owner, their reported locations include the tomb (5), the altar (1), and various other areas. The lamps are classified into four typological groups:

1. **Four-spouted lamps (7 specimens):** Variable dimensions and bases (flat or emphasized). Includes a bowl-shaped subtype and a heavy, perforated specimen (h.166/7) likely used as a hanging chandelier.
2. **Single-spouted lamps (30 specimens):** High-quality clay in brown shades. Sooting patterns vary from the spout tip to the entire body, suggesting varying levels of use.
3. **Bowl-shaped lamps with stems (3 specimens):**

This group includes lid handles repurposed as lamps, evidenced by internal sooting.

4. **Teapot-shaped lamps:** Includes one handmade, sooted example and a polished vessel similar to those found at the Tsitsernavank monastery, potentially used as an incense cup. One specimen (no. 166/2) contained resin residue, confirming its use as an incense burner.

Conclusions

Preliminary study of the Ohanavan rock-cut complex leads to the following conclusions:

The crypt serves as the primary focal point of the complex.

The Ohanavan crypt is architecturally distinct from other known early medieval tomb structures (e.g., Aghtsk, St. Mesrop Mashtots, Talin).

The integrated spiritual and economic structures suggest the complex was designed to sustain the memory of those interred.

The absence of complete skeletons indicates the burial of relics rather than primary interments.

Based on architectural and compositional features, the crypt and chapel are dated to the early Middle Ages (5th–6th centuries).

The economic structures are more challenging to date precisely, as associated artifacts extend to the 13th century.

Archaeological and architectural analysis strongly suggests that the Ohanavan complex served as the burial site for prominent spiritual figures who played a significant role in the history of the Armenian Church.

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The Cremation Urn Discovered in the Samshvilde Cave No.2 and its Similarities in Anatolia (Georgia)

Mikheil Shalvashvili

Ilia State University, Tbilisi, Georgia
michael.shalvashvili@gmail.com

Abstract

The Late Prehistoric use of artificial cave complexes in the South Caucasus remains an underexplored subject. Though there are hundreds of such caves only in the Khrami and Mashavera river basins of Georgia, research about them has been limited due to a mid-20th-century assumption that all of them were medieval hiding shelters. This assumption remained largely unchallenged, influencing excavation methodologies and restricting the exploration of these monuments to medieval cultural layers, thus leaving potential older strata undiscovered.

During excavations in one of these caves at Samshvilde, ceramic sherds were recovered alongside a cremation urn buried beneath compacted gravel. A preliminary assessment suggested a Late Bronze Age date for the urn, which opens interesting parallels with funerary practices from the Anatolian region. The paper will discuss available data and potential for new investigations of this interesting topic.

Keywords: Samshvilde Cave No.2, Sherd-Lid Cremation Urns, Osmankayasi necropolis, Hittite burial codex

Introduction

In the 1980s, during an expedition organized by the Janashia State Museum of Georgia, a group of archaeologists led by Professor Nodar Bakhtadze studied dozens of cave complexes located in the valleys of the Khrami River and its tributaries: Mashavera, Chivchavi, Zurtakerti, and other smaller gorges.

The abundance of the studied caves and their scale clearly indicated that the initial intention of the excavators was not to conceal them. Moreover, the cave complexes have their living spaces terraced on the easily accessible part of the rock. So that access to each of these terraces was easily possible. That is, these caves represented everyday use, multi-purpose premises (Bakhtadze 1991)

Despite the fact that the expedition was mainly of an exploratory nature, some discoveries were made that are of great importance not only for the study of Georgia's rock monuments. Traces from the Middle Ages and to the all periods of the Bronze Age were revealed. However, due to the situation prevailing in the country at that time, further detailed study of the mentioned cave complexes of Lower Kartli did not take place.

It was during this reconnaissance expedition that, in 1987, during the excavation of one of the Cave No. 2, in the Khrami gorge near the Samshvilde settlement, Professor Nodar Bakhtadze discovered a cremation urn in which cremation remains were confirmed (Bakhtadze 1991). The existence of a cremation ritual in Georgia in general is a confirmed fact on many archaeological sites of the Bronze Age. But the facts of the use of a cremation urn for burial are only two. This does not exclude the possibility that similar ceramics with a different purpose may have been found earlier or later elsewhere. But since no cremation remains were confirmed in them, they were considered by researchers to be household ceramic vessels.

Description of excavation site – Samshvilde Cave No. 2

The Cave No. 2. of the cave complex at Samshvilde, where the mentioned urn was found, is an interesting monument in itself. It represents a notable example of rock-cut complexes in the Kharami Valley of Lower Kartli. Not to mention other caves in the same complex or valley, this particular cave clearly shows traces of wooden beams used during the cutting of the rock. This indicates a well-known technique where wooden beams were inserted into natural or manually created grooves in the rock, and by subsequently wetting them, parts of the rock would collapse. Based on the preserved traces of thermal processing on the cave walls, it can also be inferred that a technique of heating the rock with fire and then blasting it with cold water was used here.

Today the left side of the initial cave entrance is collapsed. According to the preserved traces of the collapsed wall, the entrance's width should have been about 1.5 meters. The interior space can be conditionally characterized by two different volumes. The main, front part is relatively round in shape, with a diameter of 4.2 meters. The walls of this part of the cave gradually narrow in height, forming a domed ceiling approx-

imately 2 meters high in the center (Fig. 1).

In the back wall of the main part of the cave, opposite the entrance, there is a relatively small niche. This niche is 1.5 meters wide and slightly more in height. The shapes of the niche echo the forms of the cave entrance, leading us to believe that a short tunnel was first excavated in the rock, followed by the widening and raising of the tunnel's central part, after which the cave took on its known shape. From a temporal perspective, the excavation of the tunnel and its transformation into a cave must have occurred simultaneously but in this exact sequence. This is because the shape of the niche matches that of the cave entrance. If the niche had been added after the main part of the cave was cut out, it would likely have had a different shape and direction. Additionally, the floors of the niche and the cave are at the same level, but the cave ceiling is higher, while the niche is lower, further confirming that first was excavated a tunnel, with a shared floor level, and only later was its middle part widened and raised.

During the initial inspection of the cave, the floor was covered with sediment up to 70 centimeters thick. Subsequently, this space was not actively used by humans, even in the Middle Ages. Its low height, approximately 1.3 meters, did not allow for this. This means that the

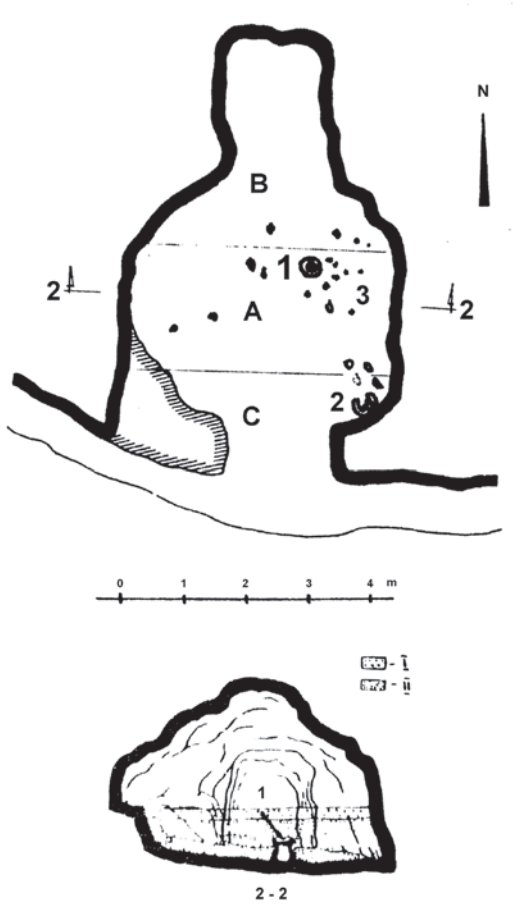

Fig. 1. Samshvilde Cave No.2. Plan. (graphic Bakhtadze N.)

filling of the cave with sediment to one-third must have occurred shortly after its excavation. In later periods, no attempts were made to clear it. As a result, contemporary archaeological material from the excavation has been preserved. Specifically, at a depth of 50-70 centimeters from the starting level of excavations, various fragments of ceramic vessels were found *in situ* on the carefully compacted floor. These are primarily fragments of black and yellowish-brown pottery with various purposes. The fragments are richly decorated with different amorphous, wavy, soliform, relief, net-like, or ribbed ornamentation. Based on the characteristics of this pottery and a preliminary examination of the material, it has been determined that it dates to the Late Bronze Age.

In line with the ceramics, the remnants of a hearth found to the right of the cave entrance were dated to the same time. Based on similar fragments of hearths found at other sites in Georgia, it can be inferred that this hearth must have had a diameter of approximately 50 cm.

The most significant, and the only undamaged material, is the cremation urn found *in situ*, located in the main round part of the cave, in the inner right quarter, close to the center, buried under the compacted floor, apparently in a specially made pit for it. The urn was completely buried in this pit, standing vertically and with its lid resting on top. The lid is a sizable irregular sherd that does not represent a lid originally made for the urn (Fig. 2).

As an archaeological discovery, these two artifacts, the cremation urn and the sherd of the lid, are inseparable details.

Main archaeological finding at the site – Cremation urn and it's sherd lid

The urn represents a 17.5 cm high, wide-mouthed, handleless pot. The bottom of the pot is close to a circle, an irregular oval shape, with an average diameter of 12.5 cm. The pot walls widen elliptically and reach their maximum width of 16 cm at a height of 9 cm on the waist. At 13.5 cm from the bottom, the pot shoulders are pronounced, with a diameter of 15 cm. From there, the walls sharply transition into the neck. The outer diameter of the neck at 15 cm high is 13.5 cm, and the inner diameter is 12 cm. 3.5 cm above the neck, the pot lip develops, forming a smooth, flared rim with a width of 14.5 cm at the very top of the pot. The thickness of the clay varies from 8 mm to 9 mm (Fig. 3).

It should be noted that all the mentioned dimensions are approximate, as the pot is clearly handmade without the use of a potter's wheel. Therefore, its forms more or less vary from different angles. The fact that the pot was handmade is another way to date it.

Externally, the cremation urn is plain, without ornamen-

Fig. 2. Samshvilde Cave No.2. Cremation urn in situ (photo Bakhtadze N.)

tation. It clearly shows the horizontal mechanical-looking discontinuous lines of different sizes, thicknesses and lengths left during the making process. The material is yellowish-gray in color. The walls show uneven firing traces.

After our detailed examination of the urn, several previously unnoticed details were revealed. Specifically, in one place on the rim of the urn, there are three 6-8 mm long and 2 mm wide, elongated leaf-shaped diagonal indentations, 2 mm apart from each other (Fig. 4). Exactly below these indentations, at the shoulder height, the surface of the urn is slightly depressed. It is clear that the depression of the pot wall is related to the indentations. It is very likely that when making the indentations, the potter accidentally touched the pot wall with his hand. The depression is so inconspicuous that the potter did not try to correct it. This deformation is still barely noticeable at first glance.

Fig. 3. Samshvilde Cave No. 2. Cremation urn (photo Shalvashvili M.)

Upon examination, obsidian fragments were found embedded in the pot's clay. The fragments are more or less evenly distributed, indicating that the obsidian fragments were intentionally included during the clay kneading process. Which is common practice for that period.

The urn's contents contained a solidified gray burned mass. In 2002 study conducted by Dr. Konrad Zehnder, a geologist at the Swiss Federal Institute of Technology, confirmed that the solidified gray mass represented a mixture of human cremation residues, tiny bone fragments, and wood ash (Bakhtadze 2007).

As already mentioned, a sherd of a different vessel covered the urn, which was not made for it. The sherd is trapezoidal in shape, with a maximum length of 17.5 cm and a maximum width of 14 cm. One of its corners is right-angled. Diagonally opposite this angle, the sherd is rounded and does not form an angle. Of the remaining corners, one is sharp and the other is blunt. The average thickness of the clay is 1.5 cm. Examination of the sherd reveals its reddish-angobed surface with a large black spot, which is a sign of uneven firing. The angobed surface easily peels off and leaves a red pigment on the touch. The sherd also retains a horizontal ornament in the form of parallel lines (Fig. 5).

Similar type of burials in Anatolia - Osmankayasi

Despite of the other ceramic fragments found around the urn in the same cave, detailed studying of which could help us for more precise dating, we preferred pay special attention to burial similarities found outside of Georgia.

One of such a place is the Osmankayasi necropolis. It is located on the ritual road leading from Hattusa to Yazilikaya, about 800 meters from the city wall of Hat-

Fig. 4. Indentations on rim. (photo Shalvashvili M.)

Fig. 5. Sherd lid. (photo Shalvashvili M.)

tusa. Sometimes the Osmankayasi necropolis is mentioned together with the Yazilikaya sanctuaries as part of a single complex. In reality, however, Osmankayasi represents a separate archaeological monument. Thus, Yazilikaya itself is rock carved archaeological site. According to archaeologists excavated this site in 1960's, within a rocky plateau of 72 sq. m. there once stood a large necropolis carved into the rock, which later collapsed (Fig. 6). At present, the space in the middle of the rocky plateau, measuring 10.25 × 5 m, does not correspond to the original natural level. The Osmankayasi necropolis was a communal burial space. In total, 91 burials were discovered and excavated here: 52 well-preserved cremation vessels, 17 fragmented cremation vessels, and 22 pit graves. (Axelsson 2017)

It is noteworthy that this rock-cut tomb was actively used at least from the 19th to the 14th centuries BCE. The dating is based on ceramic material found in the tomb. Meanwhile, the construction of the Yazilikaya sanctuaries began only in the 15th century BCE, with the main part built in the mid-13th century BCE. This means that Yazilikaya and Osmankayasi did not function simultaneously; rather, one replaced the other (Axelsson 2017).

It is known that during the Middle and Late Bronze Age, the rulers of Hattusa came from Kanesh. They fully adopted and assimilated the local Hattian customs and religious beliefs. Therefore, in the 19th century BCE – that is, at the time of the arrival of the Kanesh rulers in Hattusa – the existence of the tomb may well be connected to an older burial tradition already present in the area.

Cremation vessels found in Osmankayasi are not uniform. They differ both in volume and in form. In total, 48 different types of vessels were identified. As lids for the urns, fragments of other vessels were used, as well as other full vessels themselves, specially made covers for the burial vessels, or stones. All of them were placed in a vertical position against the wall of the cave. Some had stones or other supporting objects arranged around the base for reinforcement.

The degree of cremation also varies. In most urns, fully burned ash was preserved. In some, human bones were also found. In certain urns, based on the number of bones, it is determined that the ashes of two or more individuals were stored together.

According to Dr. Kurt Bittel, one of the archaeologists leading the excavations, it is most believable that, from time to time in the tomb old urns were broken, or the contents of several urns were combined, in order to free up space and allow further use of the chamber (Axelsson 2017).

Osmankayasi tomb-necropolis was not intended as a burial place for a single person, but rather the cave space was repeatedly used for several dozen deceased individuals. As already mentioned, the necropolis was dated according to the ceramics found within it. This raises the question: if, as according to Dr. Bittel, old ceramic material was destroyed, is it possible that the tomb existed earlier, but the ceramics of the corresponding older period were lost over time? Therefore, it is impossible to determine exactly when this space was first used for burials.

Hittite burial codex as possible description of ritual

The main information about the Hittite burial custom and ritual is provided by the Hittite cuneiform codex of Boğazköy. These were first deciphered, translated into German, and published in 1958 by Professor H. Otten (Otten 1958). Since then, the Hittite codex have been translated into other languages and published as well. Over time, with deeper study of Hittite culture, the texts have been refined and edited.

Of course, the information contained in these texts is invaluable and, in fact, can be said to represent testimony received directly from the source – a rare and unique occurrence in the archaeological and historical field.

The text mainly serves as a kind of manual for performing the ritual. It appears that in the Hittite ritual the spiritual aspect was more important than the physical, unlike Egyptian rituals where the body of the deceased itself played a major role.

It should also be noted that the ritual described in the Hittite codex concerns the king, queen, and members of the royal family. The text says nothing about the death of an ordinary person. It is clear, however, that the rituals must have been more or less similar.

Fig. 6. Osmankayasi necropolis. (photo www.kulturportali.gov.tr)

According to the text, the funeral ritual lasted for thirteen days and nights. It was accompanied by incantations and sacrifices. The vessels used each day were not reused; instead, they were broken and replaced with new ones the following day. From the seventh day onward, the ritual was conducted around a statue representing the deceased. According to codex, by this point, the burial of the cremated remnants of the deceased had already taken place (Otten 1958).

Therefore, for us – in drawing parallels with cremation urns from Samshvilde or other Early Bronze Age contexts – only the first six days are of interest.

The cremation itself was completed on the second day. Afterward, the women participating in the ritual collected the bones of the deceased with shovels, wrapped them in a linen shroud following certain procedures, and until the end of the ritual arranged them on a couch in the case of a man, or on a small backless chair in the case of a woman. It seems that the remains, wrapped tightly in the linen shroud, were gathered into a single bundle, since it was possible to place them on the couch or chair.

Additional ritual acts were performed with the collected remains, after which they were transferred to the, as it is mentioned in the codex - *"stone house,"* most likely a rock-cut tomb or cave. In general, the use of artificial caves or natural grottoes as burial chambers, whenever such possibilities existed, as we know was a widespread practice throughout human history in various cultures around the world.

As for what form the burial took inside the *"stone house,"* the Hittite codex no longer provide this information, since the descriptions of the rituals for the fifth and sixth days have not been preserved.

Therefore, in the final analysis, whether the remains were placed in urns or simply left resting on the couch or chair inside the tomb remains unclear. However, it is highly probable that the first option – placement of the remains in urns – was the case, as it is confirmed at Osmankayasi or other tombs excavated on the territory of the Old Hittite Kingdom dating to the same period.

Cremation urns used at Osmankayasi and similarities with Samshvilde cremation urn

Concerning vessels itself used in these rituals, as it was noticed during Osmankayasi excavation, 48 out of 69 cremation urns were totally different types and they show no difference from vessels used in everyday life. This means that there were no special vessels dedicated to the burial processing, but household ceramics without any special meanings or symbols. Any daily purpose pottery could be used for burial. Which lead us to conclusion that three elongated leaf-shaped diagonal indentations found on the rim of Samshvilde cremation

urn, were just decorative element, which had no ritual meaning.

On the other hand, sherd lids, used to cover cremation urns had ritual importance and religious meaning. As we already mentioned, according to Hittite burial codex, vessels used during ritual, were broken at the end of each day and replaced with new ones the following day. Of course we cannot be sure, but it is most believable that sherd of the last vessel used just prior to burial of the cremation urn, was used as a lid after it has been broken. Probably as a symbol of sharing ritual drink or food with deceased.

Conclusion

At the end we should mention that only one third of Samshvilde Cave No. 2 is excavated at the time. Further excavation could give us more evidences for proving or disallowing our vision of the mentioned burial. Similarities to the cremation urns from Osmankayasi and therefore to the Hittite burial rituals are obvious. Religious cult which did not paid attention to the vessels itself used for burials, had Sherd-lid as must for the ritual. Exactly to this detail should be paid attention during future excavations and research.

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Filling the Gaps on the Cliff: Constructive Strategies in the Vertical Chachapoya Necropolises of Diablo Wasi and La Petaca (Amazonas, Peru)

Toyne, J.M.*, University of Central Florida, 4000 Central Florida Blvd, Howard Phillips Hall rm309, Orlando, Florida, USA, 32816-1361, j.marla.toyne@ucf.edu, +01 407 408 0549
Ribera-Torró, Esteve, Panograma Labs, Spain–Peru
Anzellini, Armando, Lehigh University, Bethlehem, USA
Pans, Miquel, Department of Physical and Sports Education, Universitat de València, Valencia, Spain
Ribera-Torró, Josep A., Panograma Labs, Spain–Peru
*Corresponding author

Abstract
Chachapoya cliffside necropolises are recognized for their visibility and dramatic placement, yet the practical construction of these vertical mortuary spaces remains poorly studied because access is hazardous, contexts are often disturbed, and architecture is embedded in complex rock morphologies. Drawing on results from recent archaeological documentation campaigns, this paper examines two key sites–Diablo Wasi and La Petaca–to clarify how pre-existing cavities, ledges, and fissures were transformed into architecturally elaborated funerary spaces and how movement and activity were organized across extremely narrow cliff terraces.
The archaeological-architectural record points to recurring constructive strategies expressed through two principal configurations: enclosed chambers created by sealing pre-existing cavities with masonry façades incorporating narrow exterior openings and attached mausoleums defined by two or three built walls that complete a structure with the cliff face as the rear surface. The first configuration appears especially visible at Diablo Wasi and the second at La Petaca, although preservation biases require caution in assessing their relative frequency. Across both forms, a consistent operational sequence can be observed: (1) selection of concave or undercut sectors offering natural shelter from rainfall; (2) preparation and leveling of substrates through stone-and-mortar bases and platforms built over fissures, voids, and irregular ledges; and (3) enclosure and architectural consolidation of burial spaces, producing protected yet ventilated micro-interiors favorable to organic preservation.
Beyond chamber formation, both sites preserve solutions for circulation and access in mid-air contexts, including elevated platforms supported by timber elements anchored into horizontal geological cracks and combined with transverse members and slabbed surfaces. Such arrangements imply deliberate planning for funerary deposition, maintenance, and controlled access in vertical terrain rather than opportunistic occupation of rock shelters.
Methodologically, the study applies an archaeology-of-architecture approach integrated with high-resolution 3D documentation tailored to vertical environments. Digital models are used to map architectural units, analyze intra-site spatial relationships (clusters, pathways, sector organization), and quantify chamber and platform volumes, providing a replicable basis to discuss capacity, depositional dynamics, and spatial constraints. By linking constructive strategies to rock morphology, micro-shelter conditions, landscape exposure, and site-wide circulation, the paper reframes Diablo Wasi and La Petaca as engineered cliff architectures situated at the interface between natural cavities and built funerary spaces in the Andean landscape.

Keywords: Chachapoya; vertical necropolises; mortuary architecture and tombs; archaeology of architecture; 3D documentation; volumetric analysis

Introduction

The Chachapoyas region in the northern highlands of Peru is home to one of the archaeological traditions that remains, in spite of advances in the number of investigations, generally poorly understood and understudied (Church and Guengerich 2017) (Fig. 1). With a cultural fluorescence during the Late Intermediate Period (A.D. 900-1470) the region was also conquered by the Inka (A.D. 1470-1535) before the arrival of the Spanish in the 16th century. The overall mountainous topography is daunting but this group, labeled as "warriors of the cloud", overcame this verticality to build settlements on ridge tops and mortuary complexes that are architectural and creative achievements.

The rock-cut necropolises of the Chachapoya culture constitute one of the most singular archaeological heritages of the Andes. Poised on vertical limestone cliff faces tens to hundreds of meters above the valley floor, their tombs defy both gravity and time, and have fas-

cinated travelers and researchers since the nineteenth century. Despite this extreme visibility[1], the specific mechanisms of their construction have received limited analytical attention: dangerous access conditions, contexts frequently disturbed by looting, and their integration into complex rock morphologies have all hindered systematic study (Toyne et al. 2018).

The diversity of Chachapoya mortuary traditions is well documented: it ranges from individual sarcophagi and burial pits to collective deposits in mausoleums, mortuary chambers, and natural caves, as well as interments beneath house floors and within walls (Kauffmann Doig and Ligabue 2003; Ruiz Estrada 2009). This variation may be chronological or that it may reflect distinct social identities or ethnic groups within the Chachapoya sphere of influence, although few have sought to understand it. At the intra-site scale, similar variation is evident in constructive styles and in the degree of elaboration of the structures (Toyne and Anzellini 2017).

This article addresses two key sites in the Tambillo Valley: La Petaca and Diablo Wasi, both situated 2 kms apart on limestone cliffs along the eastern margin of the San Miguel river gorge (south of the modern municipality of Leymebamba, department of Amazonas, Peru). La Petaca, with more than 12,000 m² of exposed rock surface and an occupation spanning more than six centuries, is the largest mortuary site documented to date within this cultural tradition (Epstein and Toyne 2016).

Diablo Wasi–the devil's house in Quechua–is a necropolis articulated across six sectors of contiguous cliff faces, smaller in overall extent but notable for its high concentration and variety of funerary structures. Both sites feature collective, artificially constructed funerary structures, yet show marked differences in the constructive systems employed.

Through an approach informed by the archaeology of architecture, integrated with high-resolution digital documentation in vertical environments (Ribera-Torró et al. 2026; Toyne et al. 2018), this paper examines how pre-existing cavities, ledges, and fissures were transformed into architecturally elaborate funerary spaces, and how movement and activity were organized across

1 The tombs were originally made highly conspicuous through painted plaster façades and perimetral rock paintings. Today, however, many blend into the limestone cliff face due to the loss of these chromatic red and white layers, making them difficult to identify at a distance.

Fig. 1. Map of the Chachapoya territory with the main archaeological sites (graphic modified Ribera-Torró E., basemap from Nat Geo. From Ribera-Torró et al, 2026)

extremely narrow and vertical terrain. The ultimate goal is to present Diablo Wasi and La Petaca as planned cliff-face architectures situated at the interface between natural cavity and constructed funerary space within the Andean landscape.

The sites and their geology

The sites

Diablo Wasi and La Petaca are located a few kilometers apart, both on the eastern margin of the San Miguel gorge. No evidence of domestic or productive spaces have been documented at either site: both are exclusively mortuary in character. On the opposite side of the ravine, ancient agricultural terraces and the residential sites of Tambillo and Bóveda are identifiable, located just over one kilometer from La Petaca and Diablo Wasi respectively. This configuration suggests a functional and symbolic relationship between the spaces of the living and those of the dead within the landscape, potentially extending to other residential nuclei in the area such as La Joya, also a few kms away on the plateau above the cliffs.

La Petaca is the largest rock-cut necropolis documented in the department of Amazonas (Muscutt 1998). The site is articulated into four sectors (north, central, upper, and south), separated by zones of vegetation covering slopes that are unpassable without vertical progression rope techniques (Fig. 2). The south sector, the most extensive and representative, concentrates a minimum of 96 documented archaeological structures.

Diablo Wasi is organized into six sectors of contiguous cliff faces separated by gullies, with cliff surface areas ranging from 100 to 5,000 m² and concentrations of

Fig. 2. South sector of La Petaca as rendered in Chacha XR. Yellow markers indicate documented archaeological structures. (photo and graphics Panograma Labs)

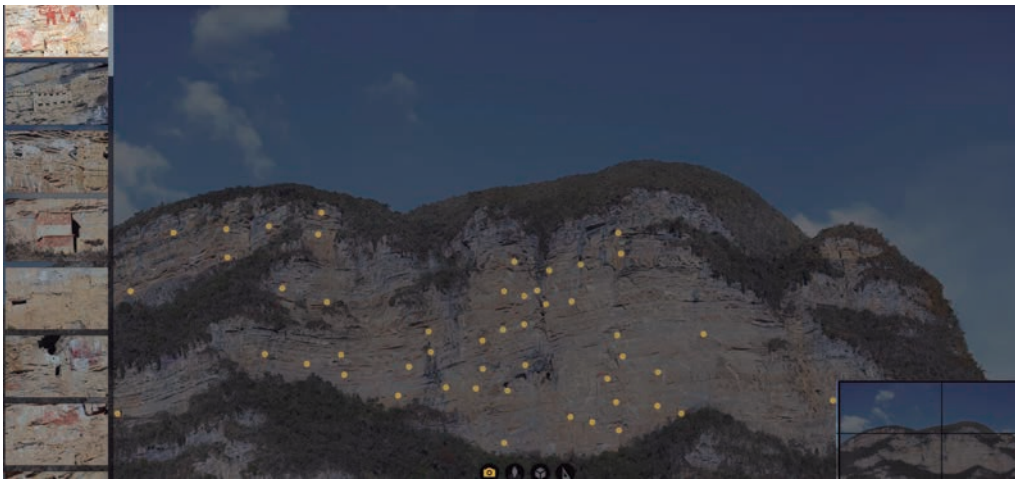

Fig. 3. Aerial view of the San Miguel gorge and Diablo Wasi cliff sectors (1–4), captured from the Chacha XR interactive application. (photo and graphics Panograma Labs)

between 2 and 40 archaeological structures per sector (Fig. 3). Sectors 1 and 4 concentrate the majority of funerary contexts at the site, in a notably good state of architectural preservation. Large caverns at the base of the cliff or large overhanging shelters on the cliff wall have been documented in virtually all sectors.

Geology as a constructive determinant

The cliff faces at both sites are composed of tabular wackestone-textured limestones of the Condorsinga Formation (Lower Jurassic, Sinemurian–Toarcian), arranged in strata between 0.1 and 2.0 m thick, interbedded with thin siltstone and clay layers. This formation produces a karstic relief characterized by spectacular cliff faces, dolines, and caves (Sánchez I. and Jacay H. 2020).

Differences in the mineralogical and mechanical properties of these strata–hardness, compaction, resistance to fragmentation, and carbonate dissolution–have generated two complementary morphological features that structure the entire funerary space: ledges and cavities.

Ledges result from the alternation between projecting strata (overhangs or counter-slopes) and recessed strata that form naturally rain-sheltered horizontal platforms, ranging from surfaces of several square meters to ledges of only a few centimeters–all exploited constructively.

Cavities encompass a broad spectrum: large caverns (>10 m²) situated frequently at the base of the cliff; large-opening constructed chambers suspended on the cliff ledges; medium-sized cavities (1–10 m²) used as sepulchral chambers–especially at Diablo Wasi; and small niches (<1 m²) that usually contained very young individuals (infants and children). Due to natural and human disturbance while many contained primary deposits of human remains, others appear to have functioned as ossuaries or for secondary placement.

The predominance of ledges at La Petaca versus the predominance of cavities at Diablo Wasi constitutes the primary determinant of the constructive differences between the two sites. The friable nature of certain strata made it possible to obtain building materials *in situ*: a probable quarrying area has been documented at La Petaca–with associated stone percussors and blocks extracted from the first ledge of the south sector–where stones were obtained by controlled fracture of the limestone (Toyne and Anzellini 2017). However, the very fragility of the overhangs that create the ledges compromises the long-term durability of the structures, as these tend to collapse by gravity as erosion progresses or tectonic activity. The remains preserved today represent a small fraction of what once existed, especially at La Petaca.

Fig. 4. Mortuary chambers DW-S1-EF01 (left) and DW-S1-EF06 (right), Diablo Wasi Sector 1. EF01 displays a low-relief zigzag frieze on the façade and discontinuous squares on the foundation base; EF06 presents two rows of discontinuous squares on the base (photo Ribera-Torró E.)

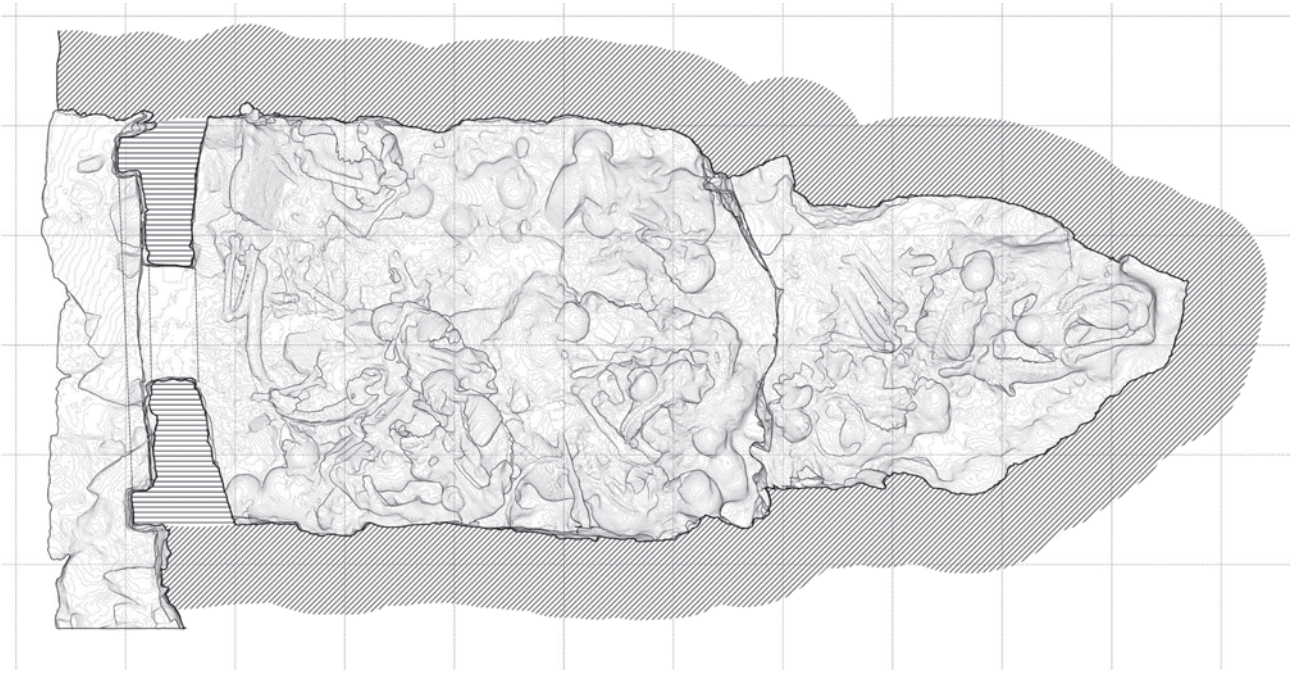

Fig. 5. Plan view of mortuary chamber DW-S1-EF17 (Diablo Wasi, Sector 1) derived from photogrammetric 3D documentation. Diagonal hatching indicates surrounding rock mass; horizontal hatching indicates masonry walls (graphic Ribera-Torró E.)

Chromatic indicators of the cliff face

Systematic observation of the cliff surfaces reveals a chromatic pattern directly related to the morphologies described, which allows identification of microenvironments even at a distance. Dark gray or black is the dominant coloration on vertical surfaces exposed to rain, where lithobiont biofilms of cyanobacteria and lichens generate a dark patina of predominantly biogenic origin (Gaylarde and Baptista-Neto 2021). Green appears in zones colonized by rupicolous vegetation or phototrophic algal biofilms; the same cyanobacterial community that appears black when dry may revert to green upon rehydration, so gray and green may represent alternating states of the same biofilm. Beige or pale ochre is the color of bare limestone without biological colonization, characteristically present on ledges and shelters, and constitutes the most reliable visual indicator of protected zones suitable for the construction and preservation of remains. Finally, white is observed on the underside of overhangs and results from bird guano deposited by nesting birds above the structures–with taphonomic effects documented at La Petaca (Toyne and Anzellini 2017)–and from calcium carbonate efflorescences produced by the evaporation of percolating water.

Methodology

From 2012 onward, the first campaigns of archaeological documentation at La Petaca and Diablo Wasi were conducted using vertical progression techniques (rappelling and ascending) and speleo-archaeology to physically access and document the structures, combining photography, manual measurements, and drawings (Toyne et al. 2018). Radiocarbon dates suggest early construction of some tombs 900 A.D. and long term use based on remains through to 1500 A.D. Subsequent campaigns incorporated digital methodologies: photogrammetry (Structure from Motion, SfM), 360° spherical panoramas, gigapixel imagery, and high-resolution three-dimensional modeling, both of exterior and interior spaces. The digitization and heritage virtualization procedure is described in detail in Ribera-Torró et al. (2026).

In the present paper, we apply an archaeology of architecture approach to the digital models obtained, complemented by systematic direct observation during fieldwork campaigns. This approach has allowed us to: (a) map architectural units and their intra-site spatial relationships; (b) identify and classify constructive strategies in relation to rock morphology, micro-shelter conditions, and exposure to the landscape; and (c) establish a descriptive and typological basis for comparing both sites. Systematic quantitative volumetric and spatial analyses are ongoing and will be the subject of future publications.

Results: constructive systems

The architectural record at La Petaca and Diablo Wasi documents recurrent constructive strategies that reflect a consistent operational sequence: (1) selection of concave cliff sectors or overhangs that provide natural protection from rain; (2) preparation and leveling of substrates through stone and mortar bases and platforms constructed over fissures, voids, and irregular ledges; and (3) architectural closure and consolidation of the sepulchral spaces, producing protected yet ventilated

micro-interiors favorable to organic preservation (Fig. 4). Structures are organized into two functional categories: mortuary and structural.

A) Mortuary function

Two main types of constructed funerary spaces on the cliff faces are distinguished here. Excluded from this section are both unmodified natural spaces (large caves and open niches) and beehive-type tombs[2].

The mausoleum is a structure with a generally quadrangular floor plan, with two or three masonry walls abutting the rock face, which serves as the rear wall. Most are raised on a basal or foundation level that regularizes the irregularity of the supporting ledge or platform. Documented dimensions at La Petaca vary considerably, but a well-preserved example (LP-SC-EF01) illustrates characteristic proportions: 2 × 1.2 m base and more than 2 m in height, with two constructive stories separated by a projecting corbelled course. The walls, composed of generally rectangular-format worked stone tiers bonded with clay mortar, display notable technical consistency: 71% of the structures evaluated at La Petaca exhibit well-coursed masonry (Toyne and Anzellini 2017)[3].

Mausoleums constitute the dominant typology at La Petaca, where narrow ledges (~50-80 cm) provides directly usable construction surfaces, although at least nine structures of this type have been documented at Diablo Wasi. Many feature one or two constructive stories and variable decorative elaboration: application of plaster to exterior walls; painting in broad horizontal red and white bands; cornice edging; and perimetral C- or inverted U-shaped painting directly on the cliff face above, which visually frame the structure and of which only the chromatic patina often remains once the tomb has collapsed–becoming an indirect indicator of now-vanished structures.

The mortuary chamber[4] exploits a pre-existing natural cavity and constructs only its closing façade, which incorporates a reduced-dimension access opening (Fig. 5). It requires neither an artificial roof nor complete lateral walls, as the rock cavity substitutes for them. This type predominates at Diablo Wasi, where the cliff morphology–rich in medium-sized cavities–makes it particularly suitable, but at least three examples have been documented at La Petaca. In the most elaborate cases, the façade incorporates lateral pilasters and a projecting visor that produces a recessed effect relative to the cliff face plane. Low-relief decoration is documented at both sites, though with distinct repertoires. At La Petaca, mausoleums feature friezes of discontinuous squares in horizontal rows, characteristically concentrated on the foundation bases. At Diablo Wasi the repertoire is more varied: mausoleum façades display inverted T-, T-, and fret friezes composed of L-motifs in the first row and inverted L-motifs in the second, with discontinuous squares on the foundation bases; mortuary chamber façades bear friezes with T-, zig-zag, and stepped motifs, also combined with discontinuous squares. In some cases, structures at both sites are found in spatial association with anthropomorphic and zoomorphic red paintings executed directly on the rock (Toyne and Anzellini 2017).

Both types share building materials and constructive techniques–limestone extracted *in situ* by controlled fracture, clay mortar, plaster, and mineral-based paint–and the same function: to accommodate collective and sequential depositions that imply recurrent revisitation of the funerary space. The principal distinction is formal: mortuary chambers feature a single constructed façade, while mausoleums have two or three (Fig. 6).

B) Structural function

Beyond natural ledges as the primary support, constructive elements are documented that were designed to create or extend horizontal surfaces and to enable movement and access on a vertical rock face. Three subcategories are distinguished:

Foundation bases. Constructed by filling cracks and voids over natural ledges, these elements fill and level fissures and concavities, creating the first structural level upon which the funerary structure proper is raised. They may be built below or above cantilevered platforms, and some feature low-relief decoration (friezes of discontinuous squares in one or multiple rows).

Putlogs (or anchor stakes). Wooden timbers were inserted perpendicularly into the rock face and projecting horizontally outward, exploiting the soft siltstone and clay layers interbedded between the limestone strata.

Cantilevered platforms. Over two or more putlogs, transverse timbers and large stone slabs were laid to form aerial surfaces that could extend pre-existing micro-ledges or create entirely new surfaces on the vertical cliff (Fig. 7). Where a platform has collapsed, the isolated putlogs frequently constitute the only surviving evidence of aerial circulation systems that must

2 Low-walled circular structures that enclose a set of bodies directly, of which often only the footprint of the walls survives (Toyne & Anzellini, 2017).

3 The rectangular access opening rarely exceeds 50 cm in width by 60 cm in height. Wall thickness ranges between 35 and 40 cm. No relationship is observed between the level of elaboration of the surface finish and the quality of the underlying wall construction: some of the best-built structures at La Petaca show no evidence of plaster, and vice versa (Toyne & Anzellini, 2017).

4 Others may use the term “burial chamber”; however, these are not burials but rather deposits of human remains.

Fig. 6. Photogrammetric 3D models of the two principal constructive types: (a) mausoleum LP-SC-EF02 (La Petaca), with discontinuous-square frieze on the foundation base and red and white painted bands on plastered walls; (b) mortuary chamber DW-S1-EF01 (Diablo Wasi), with lateral pilasters, projecting visor, zigzag frieze, and polychrome finish (graphic Ribera-Torró E.)

have articulated entire sectors of the cliff face. They appear in several functional configurations: as access platforms attached frontally to the opening of a mausoleum or mortuary chamber; as lateral platforms attached to the flank of a structure, potentially related to circulatory, temporary body exposure, or ceremonial functions; and as platforms with no evident association with any preserved funerary structure[5].

Taken together, both sites evidence an intensive and systematic exploitation of all geologically suitable space for funerary use, with solutions adapted to each microenvironment and to the physical constraints of access and material transport in vertical environments (Epstein and Toyne 2016; Toyne and Anzellini 2017).

Discussion

Geology and constructive strategy

The most evident typological difference between the two sites–the predominance of mausoleums at La Petaca and of mortuary chambers at Diablo Wasi–is explained, at least in part, by the dominant morphology of the respective cliff face. Where the rock offered a platform, an enclosure was built on three walls; where it offered a cavity, a façade was constructed to close it. In both cases the underlying logic is identical: to maximize the exploitation of natural geometry in order to minimize constructive effort in an environment of extremely difficult access.

A deterministic reading must, however, be avoided. The documentation of at least nine mausoleums at Diablo Wasi (Fig. 8) and at least three mortuary chambers at La Petaca demonstrates that the constructive repertoire was shared and applied flexibly. Other factors–chronology, group identity, or differences in the social organization of the communities that frequented each site–may have contributed to the observed differences, but their resolution requires a corpus of radiocarbon dates and comparative bioarchaeological analyses beyond the scope of the present study.

Criteria for location selection

The selection of each specific position on the cliff face for tomb construction responds to environmental, structural, and symbolic criteria.

Environmental. Rain protection is the primary determinant: all documented structures are located beneath overhangs or within cavities. Related to rain protection, adequate ventilation–favored by the reduced size of the access opening–and the thermal stability of limestone cavities create conditions favorable to the preservation of soft tissues and organic materials documented in some contexts. This supports arguments for intentional natural mummification of bodies.

Structural. The integration of the structure into the bed-

5 The platform associated with DWS1-EF06 illustrates the complexity of some of these assemblages: built in two apparent phases, it incorporates a projecting course of flat slabs on its northern half and a double row of square niches on its southern half, with wooden stakes both perpendicular and parallel to the wall that consolidated and extended the surface.

Fig. 7. Diablo Wasi Sector 1: mortuary chamber DW-S1-EF06 (left) and cantilevered platform DW-S1-EF07 (right). EF06 preserves only the putlogs of a now-collapsed frontal access platform. EF07 illustrates the constructive strategy for extending micro-ledges: putlogs anchored into siltstone interbeds support transverse members and stone slabs to form an aerial cantilevered surface (photo Ribera-Torró E.)

Fig. 8. Mausoleum DW-S4-EF03 (Diablo Wasi, Sector 4): two masonry walls enclosing a natural cavity, with foundation base, corbelled course, access opening, and T-motif low-relief frieze. A projecting putlog marks the former position of a cantilevered access platform (photo Ribera-Torró E.)

Fig. 9. South sector of La Petaca showing the coexistence of multiple constructive types: mausoleums on broad ledges and on micro-ledges requiring aerial infrastructure, a mortuary chamber, anthropomorphic rock paintings, and structural remains–putlogs and perimetral C-shaped chromatic traces–as indirect indicators of collapsed funerary structures (photo Ribera-Torró E.)

rock increases seismic resistance and enhances long-term durability. The considerable investment in foundation bases and cantilevered platforms in environments of difficult access is explained by the fact that tombs were not built for single use, but as collective spaces intended to receive successive members of a group across generations.

Symbolic. The high visibility of the structures from the valley floor–accentuated by perimetral painting on the rock and by plaster-coated façades in red and white–transformed the tombs into permanent markers of the landscape (Fig. 9). The presence of the dead was literally visible to the living from the fields and paths of the valley, in a configuration consistent with the Andean practice of ancestor veneration and with the conception of the deceased as active extensions of the community of the living (Crandall 2012; Epstein and Toyne 2016). The anthropomorphic and zoomorphic paintings adjacent to some structures reinforce the symbolic character of the funerary space (Toyne and Anzellini 2017; von Hagen 2002).

Necropolis growth and spatial pressure

The prolonged use of both sites over more than six centuries implies a cumulative process of necropolis growth that would inevitably have generated progressive saturation of the most favorable spaces. Geologically optimal positions–broad ledges, large-opening shelters, appropriately sized cavities with relatively direct access–would have been occupied first. As the necropolis grew, builders would have been compelled to resort to increasingly less favorable positions: narrow ledges, overhanging shelters on a vertical cliff face with no horizontal access, cavities of minimal dimensions, or completely vertical surfaces with no natural supporting morphology. The construction of cantilevered platforms in the absence of any ledge can be interpreted precisely as the technical response to this pressure: the artificial creation of the support that the geology no longer provided spontaneously. The title of the chapter by Epstein & Toyne (2016), *When Space Is Limited*, directly anticipates this dynamic. In this way, the location of structures in apparently impossible positions would not necessarily be the result of symbolic choice, but rather the testimony of a necropolis that had exhausted its low-resistance available space and had been compelled to colonize the margins of what was technically achievable.

The paradox of revisitation

One of the most striking aspects of the record is the paradox between the extreme difficulty of access to the cliff faces and the recurrent revisitation implied by the collective and sequential deposition model. The cantilevered platforms and isolated putlogs preserved at both sites are the direct material testimonies: they constitute an aerial access infrastructure–walkways, ladders, ropes–that must have articulated entire sectors of the cliff face and have not survived in its entirety. Volumetric analysis of the mortuary chambers, planned for subsequent phases of research, will allow approximation of the depositional capacity of each one.

Conclusions

The comparative study of the constructive strategies at Diablo Wasi and La Petaca allows four main conclusions to be drawn.

First, the geological morphology of the cliff faces–the predominance of ledges at La Petaca and of cavities at Diablo Wasi–is the primary determinant of the typological differences observed. Mausoleums and mortuary chambers represent two constructive responses to the same objective: to create a collective, protected, and durable funerary space by exploiting the natural geometry of the cliff face and minimizing constructive effort in an environment of difficult access. Neither typology is exclusive to a single site.

Second, the analysis of cantilevered platforms and foundation bases reveals that Chachapoya funerary engineering extended well beyond the construction of the sepulchral chamber itself. The putlogs and preserved platforms are partial testimonies to a planned access infrastructure designed for deposition, maintenance, and recurrent revisitation in vertical terrain.

Third, the progressive spatial saturation of the necropolises over more than six centuries of use constitutes a key explanatory factor for the location of structures in apparently implausible positions. The artificial creation of cantilevered platforms where the geology no longer provided natural support represents the technical response to a necropolis that had exhausted its low-resistance available space and was compelled to colonize the margins of what was technically achievable.

Fourth, the symbolic dimension of vertical funerary architecture is inseparable from its technical dimension. The high visibility of the tombs and their integration into the valley landscape transformed the necropolises into permanent markers of ancestral presence in the territory of the living. La Petaca and Diablo Wasi must be read as planned cliff architectures that articulate nature, technique, and symbol in a coherent and original response.

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Rock Structures of Chivchavi: Based on Archaeological Survey Data (Kvemo Kartli, Georgia)

Shota Tvaladze

University of Georgia
shota.ug.tvaladze@gmail.com

Levan Kvakhadze

International Center of Archaeology, University of Georgia
levan.kvaxadze@gmail.com

Abstract

Kvemo Kartli is distinguished by its diverse cave structures. A notable example is the still insufficiently studied Chivchava River Valley. This article presents data from recent archaeological surveys of the cave complex on the left cliff of the Chivchava River, north of the Samshvilde archaeological site.
Within the framework of the research, reconnaissance and documentation of sub-complexes I, II, and III was carried out. The tangible cultural heritage discovered as a result of the reconnaissance indicates that the cave sub-complexes of Chivchava Valley were in active use during the High Middle Ages. The discovered ceramic material is represented primarily in both glazed and unglazed forms and was used for domestic purposes, pointing to everyday activities, while the additional material (a coin) provides an opportunity to determine the chronological framework of the sub-complexes.

Keywords: cave complexes, medieval archaeology, ceramic analysis, reconnaissance survey, High Middle Ages

Introduction

Kvemo Kartli region, with its deep valleys and canyons, represents a significant archaeological landscape. In this regard, the territory adjacent to the Samshvilde archaeological site is particularly noteworthy, where monuments from various periods are represented in a complex manner (see Fig. 1). Among the most interesting subjects for interdisciplinary research are the cave complexes located in the Ktsia/Khrami and Chivchava river valleys, which to this day remain insufficiently studied - a fact that creates a significant gap in the reconstruction of the region's medieval historical and cultural picture.

The caves located on the left cliff of Chivchava valley are of special interest in this context. Chivchava cave complex is composed of three independent yet interconnected sub-complexes (I, II, and III) which are connected to one another by a narrow footpath. (Fig. 2) Their spatial arrangement, rocky environment, and architectural characteristics suggest that these sites may represent a more multifunctional complex than merely residential spaces.

The main research problem lies in the fact that the function, chronology, and relationship of these complexes to the urban centre of Samshvilde remain unstudied to this day, both due to the scarcity of written sources and the difficult terrain and the limited amount of archaeological material. Particularly pressing is the question of whether these spaces constituted a permanent living environment encompassing religious, agricultural, and defensive functions, or whether they were used for temporary purposes.

Methodology

The research is based on archaeological reconnaissance conducted in sub-complexes I, II, and III of the cave sites located on the left cliff of the Chivchava Valley. The work included field observation, documentation of architectural elements, and collection of surface material. The reconnaissance employed methods of visual observation and location recording commonly used at sites where stratigraphic excavations have not yet been undertaken (Renfrew & Bahn 2016). The recovered material was analyzed through typological and technological methods, allowing chronological and cultural interpretation (Rice 1987; Orton et al. 1993; Bakhtadze 2013). Architectural analysis focused on spatial organization, wall structures, entrances, storage areas, and the relationship between natural and constructed elements within the cave environment (Bakhtadze 2007).

Fig. 1. Physical map of the region and Location of the Chivchavi Cave Complex (photo Kvakhadze L.)

Research History of the Site

Historical references to the cave complex of Chivchava River, located to the north of the royal district of Samshvilde settlement ruins, are scarce and fragmentary in Georgian written sources. The only account is provided by Vakhushti Batonishvili, according to whom the gorges/valleys of Ktsia and Chivchava rivers are full of caves of various sizes: "...The Ktsia Gorge here is 200 mkhari [fathoms] or more in height, and 560 mkhari in width; and the Chivchiva Gorge is 200 mkhari deep. Here, above the Chivchiva, there is a white cliff, and from it fall crystals, hewn into angular shapes, pointed on both ends... Furthermore, within these gorges, there are many caves, carved into the high cliffs as places of refuge (sakhizari); some are now inaccessible to men, and within them are many bees, from which honey flows down." – (Qaukhchishvili 1973, 323). The spatial proximity between Samshvilde settlement ruins and Chivchava cave complexes gives rise to a hypothesis regarding their functional connection. Moreover, the northern gate of Samshvilde settlement (Berikashvili et al. 2026) leads precisely into Chivchava valley and falls directly beneath these caves, which creates a movement corridor connecting them to the settlement ruins.

Fig. 2. The Chivchavi River Valley and the Chivchavi Cave Subcomplexes (I–II–III). (Photo Tvaladze Sh.)

Interest in the caves of the Ktsia/Khrami and Chivchava rivers grew significantly as far back as the last century. The first reconnaissance works and in-depth research in the vicinity of the monument were carried out by archaeologist Nodar Bakhtadze, who subsequently published a scientific work on the rock-cut architectural monuments existing in Georgia. The author notes that the Khrami river valley, including the surroundings of Samshvilde settlement ruins and Pirghebuli Monastery, is particularly rich in monuments of this kind, with up to twenty grand cave complexes located along its canyon (Bakhtadze 1991; Bakhtadze 2007, 15).

In 2015, the reconnaissance group of Samshvilde Archaeological Expedition of the University of Georgia carried out reconnaissance works encompassing the caves developed on the plateau and its cliffs located 150-160 metres above river level, to the north of Samshvilde Cape on the left bank of Chivchava River (Berikashvili 2017, 8-40). The above group visited only sub-complex III, which is situated at the easternmost point.

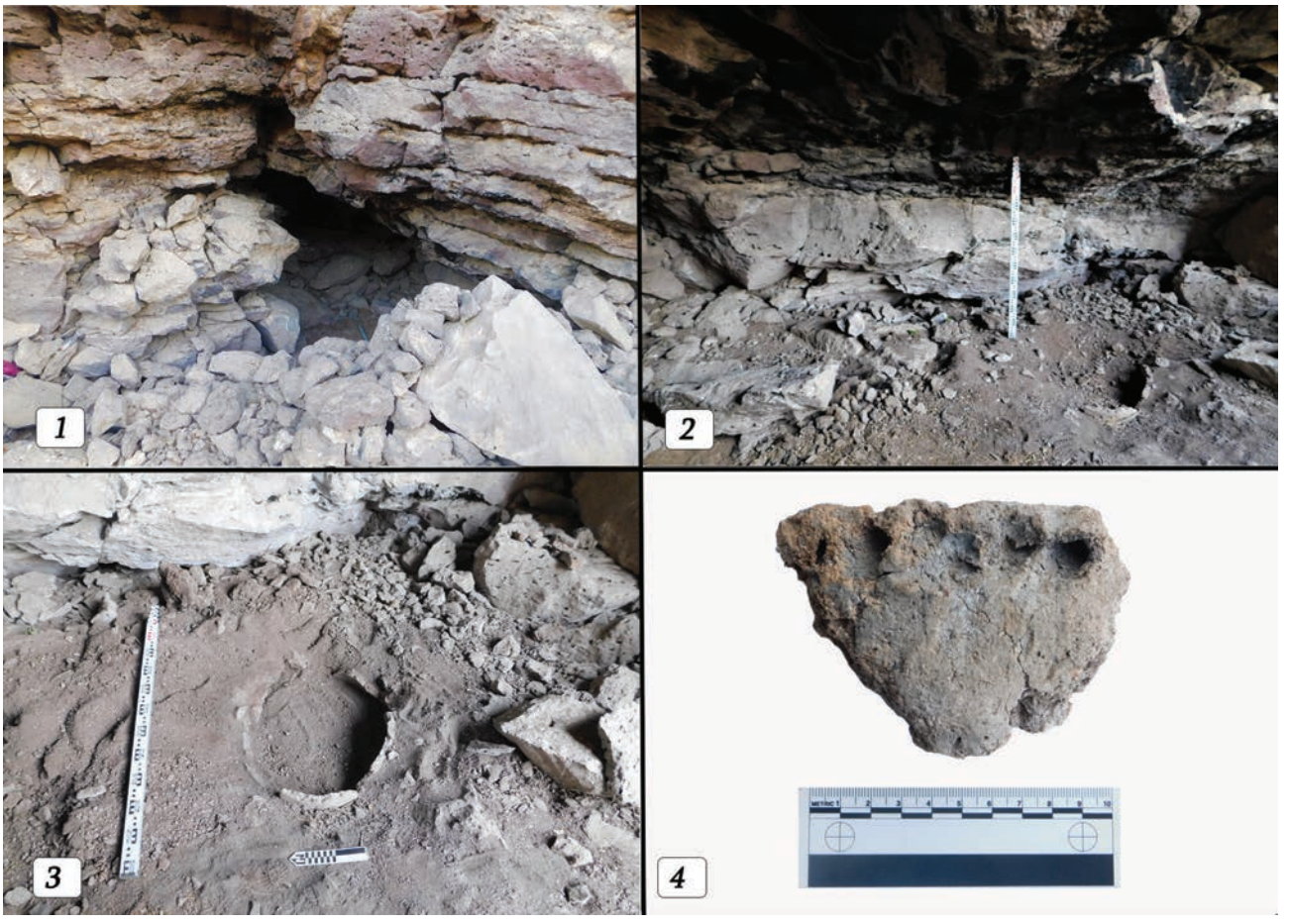

Fig. 3. 1) Collapsed entrance and accumulated stone debris 2) Interior space of the cave and the "floor" level 3) Fragments of a qvevri or storage jar embedded in the "floor" 4) Rim fragment of a qvevri or storage jar. (Photo Kvakhadze L., Tvaladze Sh.)

During 2020-2023, the reconnaissance group of Samshvilde Archaeological Expedition of the University of Georgia (Shota Tvaladze, Levan Kvakhadze, Nikoloz Memanishvili, Zura Tkhelidze) conducted reconnaissance in the cave sub-complexes I and II. This reconnaissance revealed previously unknown secular and ecclesiastical structures and archaeological artefacts (Tvaladze 2024, 91–112).

Results – Architecture and Ceramics

Cave No. 1

Cave No. 1 is located approximately 200 m to the east of the third sub-complex. A pile of basalt stones was concentrated near the entrance, partially blocking it. The cave's dimensions are: length 6–6.5 m, width 3.80 m, height 2.20 m. The walls and ceiling are uneven, and the ceiling is entirely smoke-blackened (Fig. 3).

In the south-eastern part of the cave, a *qvevri* (a traditional clay vessel; diameter 0.63 m) was found embedded in a pit, though its rim has not survived. Fragments of domestic ceramics (flat bread pan, bowl) were also found on the surface, indicating that the space was used for domestic or household purposes (Fig. 3).

The stone debris near the entrance may be associated with either natural collapse or human modification of the space. Similar processes are characteristic of cave dwellings (Binford 1983).

The data obtained suggest that the interior space of the cave was functionally differentiated; however, this interpretation requires further clarification based on archaeological excavations (Kent 1990; Renfrew & Bahn 2016).

Particularly noteworthy is a coin discovered near the entrance, which is patinated and bears traces of an inscription (Fig. 4).

Sub-complex I

The sub-complex is located to the west of the second sub-complex and is represented by a single large cave incorporating several rooms (Tab. 1).

The southern part of the cave is blocked by large basalt boulders that form a wall; the gaps between the boulders are filled with smaller stones (Fig. 5, Sub-complex I). This structure sits beneath the cave's overhang and likely served a defensive function.

The cave has a single entrance, located in the south-eastern corner, which is structurally reminiscent of a gateway. At a short distance from the entrance, a semicircular wall begins, partially delimiting the interior space (Tab. 1).

There are several rooms within the interior, differing from one another in size and location (see Tab. 1). The material recovered during the reconnaissance is represented by fragments of domestic ceramics, indicating active use of the space. Particularly noteworthy is a coin discovered near the entrance, which is patinated and bears traces of an inscription (Tab. 1).

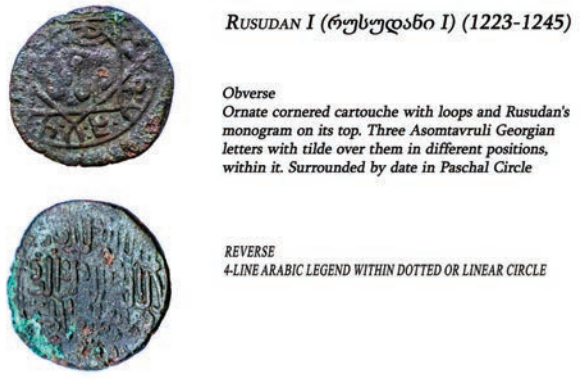

Fig. 4. Copper coin of Rusudan I. The obverse bears Georgian monogrammatic symbols, while the reverse contains an Arabic legend. (Photo Kvakhadze L.)

Tab 1 – Subcomplex I: Structural and Architectural Description (Graphic Kvakhadze L.)

Element	**Dimensions**	**Wall Type / Masonry**
Cave Complex (general)	L–18.50 m; W–17.00 m; H–6.70 m	Natural rock
Front Defensive Wall	–	Massive basalt boulders
Entrance	–	Two stone blocks with upper covering (gateway type)
Semicircular Wall	L–6.30 m; H–3.30 m; W–1.20 m	Dry masonry (basalt)
Storage Room No. 1	L–5.20 m; W–2.60 m	Dry masonry
Storage Room No. 2	L–6.00 m; W–3.50 m	Natural
Storage Room No. 3	L–5.50 m; W–2.00 m	Natural

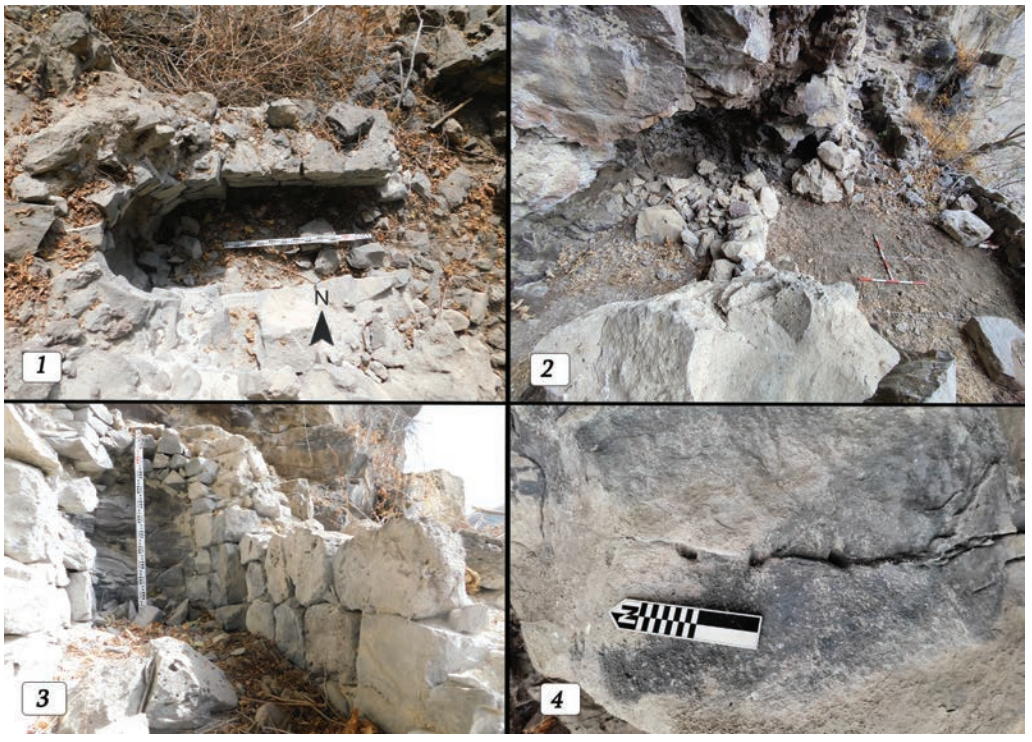

Fig. 5. 1) View of the apsidal structure from the south 2) View of the apsidal structure from the north 3) Interior of the apsidal structure 4) Wall of the apsidal structure attached to the cave (Photo Tvaladze Sh, Kvakhadze L.)

Sub-complex II

Chivchava sub-complex II represents a natural-to-semi-modified space situated within a rocky massif, located on a slope and distinguished by a complex morphological structure.

The sub-complex is set within a broad rock niche formed as a result of erosional processes. The surface of the niche is uneven, characterized by deep recesses and small natural cavities, indicating intensive weathering of the rock and the effects of atmospheric exposure. The upper section of the cliff forms an overhanging massif that partially shelters the space below from precipitation.

In the central part of the sub-complex, relatively small openings and caves are observed, some of which have been partially enlarged by human intervention. Their entrances are irregular in form and are covered by partially collapsed rock. Debris from rock fall is widespread across the surrounding area, indicating the dynamic condition of the cliff face and periodic episodes of collapse.

The micro-terrain is steeply inclined, making movement through the space difficult. In the lower section, small platforms and natural steps were found, which may have been used for movement and the organization of functional zones. Vegetation is sparse, consisting primarily of shrub cover and dry grasses.

Overall, sub-complex II is characterized as a complex, multi-functional rock-cut space in which natural forms and what appears to be minimal human intervention together constitute a unified architectural system (Tab. 2).

In the eastern part of the sub-complex, adjacent to the first cave, an apsidal structure has been identified, built of dressed basalt stones and abutting a larger cave; lime mortar was used as the binding material (Fig. 5; Tab. 2). The layout form and proportions of the structure suggest that it likely represented a small vaulted space. The horseshoe shape of the apse points to its archaic character and may be associated with building traditions characteristic of the Early Middle Ages. From a functional standpoint, the architectural characteristics more strongly support its interpretation as a small chapel rather than a funerary structure. Without excavation, it is difficult to determine the floor level and precise parameters; however, based on the available evidence, its interpretation as a small chapel appears the more probable.

On the second tier, a wall fragment was recorded (length 2.50 m; height 1.00 m), constructed using dry-stone masonry technique, and may be associated with spatial arrangement and ancillary functions (Tab. 2).

In the caves located in the western part of the complex, domestic ceramic material was identified, including glazed vessels, indicating the residential use of the space (Tab. 2). A long dry-stone wall (approximately 11.00 m in length) identified within the same complex served as a connecting element between the individual rooms (Tab. 2).

In summary, sub-complex II exhibits the co-existence of residential and religious spaces, pointing to its multi-functional use.

Tab 2 – Complex II: Structural and Architectural Description (Graphic Kvakhadze L.)

Location / Level	Architectural Description	Dimensions	Construction	Archaeological Material	Interpretation
East, Level I	Partially built-up entrance; apsidal structure to the south	L-2.60 m W-1.00 m H-1.40 m	Worked basalt, mortar; wall thickness 0.75 m	Ceramics (surface finds)	Probable cult structure (chapel)
Level II	Wall fragment	L-2.50 m H-1.00 m	Dry-stone masonry	Not recorded	Auxiliary space
West, Level II	Natural cave	-	-	Domestic ceramics; glazed bowl (with bird depiction)	Residential function
West, Level I	Partially filled cave; central wall	Wall: L-11.00 m H-2.20 m W-0.80 m	Dry-stone masonry	-	Space divider / passage

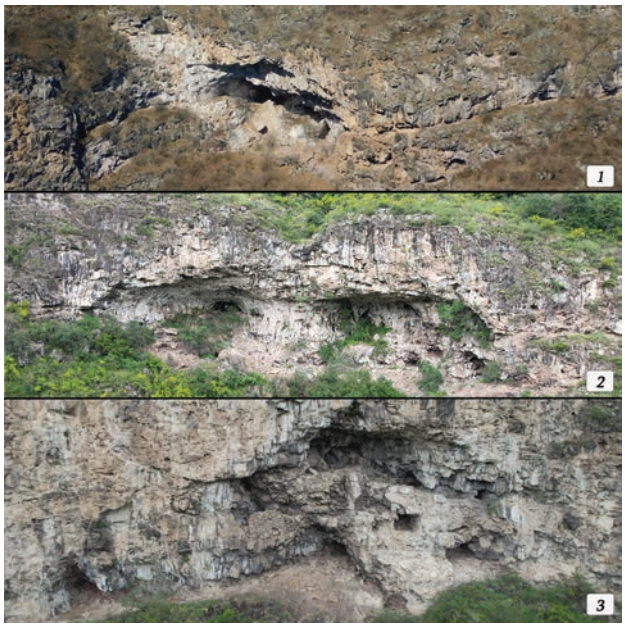

Fig. 6. 1) Sub-Complex I, 2) Sub-Complex II. 3) Sub-Complex III. view from the north, (photo Berikashvili D.)

Sub-complex III

Sub-complex III comprises approximately 20 small caves arranged across four tiers, which were adapted for residential and economic purposes during various periods (Fig. 6).

Although some of these caves are currently inaccessible due to rock erosion, surveys conducted in the reachable spaces have revealed significant archaeological material, primarily medieval ceramics and obsidian fragments washed out onto the surface.

The entrances to several "chambers" have been artificially modified and protected by masonry walls, indicating an organized use of space, specifically for economic activities.

Thus, the complex represents a multi-functional archaeological site that was utilized over a long period and requires further research.

Analysis of Archaeological Material

As a result of reconnaissance work carried out between 2020-2023, significant archaeological material was identified in all three subcomplexes of the cave system located on the left bank of the Chivchava River. Although this material was obtained through surface surveys and lacks a stratigraphic context, its analysis, preliminary dating, and comparison with parallel finds provide a vital foundation for a more complete reconstruction of the site's overall history.

Based on chronological, functional, and technological characteristics, the presented material includes artifacts typical of various stages of the High Middle Ages (Fig. 7; Tab. 3).

The ceramic assemblage includes various types of vessels, such as pots, bowls, plates, and jugs. Fragments of thin-walled, single-handled small pitchers (chinchila), fired to a straw or light brown colour, were identified; based on typological features, these are tentatively dated to the 11th-12th centuries (Ramishvili 1970, Tab. XXVIII).

A fragment of a polychrome glazed bowl likely belongs to a slightly later period. It is executed on white engobe with green and brown pigments, covered with a transparent glaze, and decorated with underglaze engraving; the ornamentation features the depiction of a bird.

Tab.3 – Architectural Elements in the Complexes (Graphic kvakhadze L.)

Element	Sub-Complex No. 1	Sub-Complex No. 2	Interpretation
Apse	✖	✔	Cultic
Dry-stone masonry	✔	✔	Residential / Defensive
Gateway	✔	✖	Control
Inner chambers	Partial	Distinct	Functional zoning

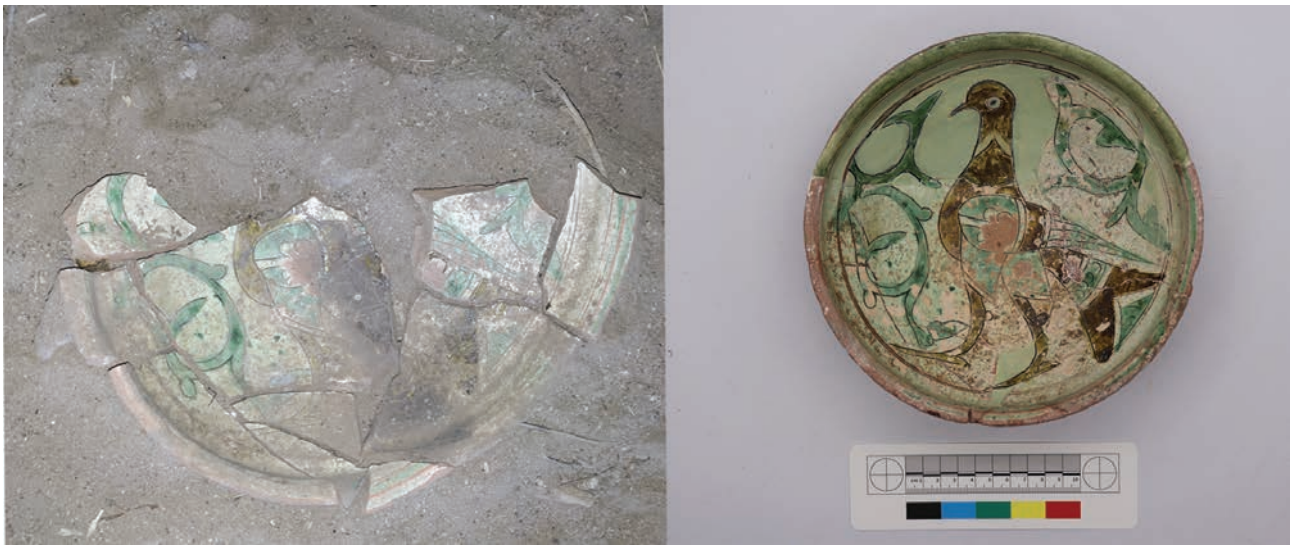

Fig. 7. Glass bowl discovered in archaeological context (left) and after restoration (right), decorated with vegetal motifs and a bird figure. (photo Tvaladze Sh.)

Discussion

The study of the rock-cut complexes in the Chivchavi Valley has shown that these monuments were not merely temporary shelters. Their architecture, spatial organization, and archaeological material indicate that the complexes represented a multifunctional system. Residential, economic, defensive, and religious spaces are identified within the same environment (Bakhtadze 1991; Bakhtadze 2007; Berikashvili 2017; Tvaladze 2024; Berikashvili et al. 2026).

The location of the complexes is directly connected to the ancient settlement of Samshvilde. The road descending from the northern gate of the citadel leads toward the Chivchavi Valley and the cave complexes. Such positioning was probably not accidental. Rock-cut monuments of Kvemo Kartli are frequently associated with important settlement and defensive centres (Qaukhchishvili 1973; Muskhelishvili 1977; Muskhelishvili 1980; Bakhtadze 1991; Bakhtadze 2007).

Cave Villages and Residential Spaces

A significant part of the Chivchavi complexes points to residential and economic functions. In Subcomplex I, the gate-like entrance, dry-stone walls, internal rooms, and connecting spaces form an organized settlement system. The discovered ceramic material – including qvevri fragments, bowls, pans, and other domestic pottery – confirms that everyday life took place here (Japaridze 1982; Rice 1987; Orton et al. 1993).

We share the view of Nodar Bakhtadze that an important part of the rock-cut monuments of Kvemo Kartli represented multifunctional “rock villages” rather than isolated monastic spaces (Bakhtadze 1991; Bakhtadze 2002; Bakhtadze 2007). Similar multifunctional rock-cut systems are also known in Cappadocia and the Near East, where residential, economic, and religious spaces were integrated within the same complexes (Giovannoni 1971; Rodley 1985; Kostof 1989). The architectural elements and archaeological material identified in the Chivchavi complexes do not contradict this interpretation and in several cases further support it.

Similar rock-cut settlements are known from other regions of Georgia, including Uplistsikhe, Vardzia, David Gareji, Mghvimevi, and Pirghebuli, where residential, economic, and defensive functions are closely interconnected (Chubinashvili 1936; Chubinashvili 1961; Gaprindashvili 1957; Abramishvili & Vacheishvili 1964; Khakhutaishvili 1964; Khakhutaishvili 1970; Gaprindashvili 1987; Khakhutaishvili 1989; Bakhtadze 2001; Bakhtadze 2007).

The planning of the Chivchavi complexes also points to such an organized environment. The caves are connected by narrow paths and terraces, creating an internal communication system. At the same time, the rocky landscape itself performed a natural defensive role. Similar spatial organization and adapted use of rocky terrain are well known both in Kvemo Kartli and in the cave complexes of Cappadocia (Gaprindashvili 1959; Verzone 1962; Kostof 1989; Bakhtadze 2002; Bakhtadze 2007).

At this stage, only High Medieval material has been identified within the Chivchavi complexes. However, this does not exclude the existence of earlier layers. Nodar Bakhtadze identified Bronze Age material in several rock-cut complexes of Kvemo Kartli and noted that such monuments often demonstrate multi-period use (Bakhtadze 1987; Bakhtadze 1991; Bakhtadze 2007). Therefore, it is possible that the Chivchavi complexes may also reveal a broader chronological picture in future investigations.

Cave Churches and Monastic Spaces

Signs of religious function are also visible in the Chivchavi complexes. Particularly important is the apsidal structure identified in Subcomplex II, built with worked basalt blocks and lime mortar. Its form and plan resemble a small chapel rather than a burial structure. Similar rock-integrated churches and small monastic spaces are known in many regions of Georgia (Tordia 1986; Bakhtadze 1998; Bakhtadze 2001; Bakhtadze 2007).

In Georgian rock-cut architecture, there are many cases where natural caves were later transformed into religious spaces. Such examples are known from Vardzia, David Gareji, Mghvimevi Monastery, Shiomghvime, Pirghebuli, and other rock-cut monastic centres (Lominadze 1953; Gaprindashvili 1962; Gaprindashvili 1969; Gaprindashvili 1987; Andghuladze & Mamaiashvili 1990; Bakhtadze & Kipiani 2000).

Similar rock-cut monastic systems are also known outside Georgia. The rock churches of Cappadocia, the rock-cut monasteries of Armenia, and the cave architecture of the Near East demonstrate that the use of rocky landscapes for religious and residential purposes was widespread (Thierry & Thierry 1963; Rodley 1985; Kostof 1989; Ousterhout 2005; Maranci 2015). These parallels place the Chivchavi complexes within a broader cultural context.

At this stage, it is difficult to determine the final function of the apsidal structure, since full-scale excavations have not yet been carried out. Nevertheless, the existing architectural evidence allows us to assume that a small chapel or monastic space existed within the complex.

The rock-cut complexes of Chivchavi most likely formed part of the broader settlement and communication system of Samshvilde. Residential, defensive, and religious elements are united within the same environment. This characteristic fits well within the general tradition of Georgian rock-cut architecture (Beridze 1974; Bakhtadze 2007). Future archaeological excavations and detailed research will clarify the chronology and functions of these complexes within the medieval landscape of Georgia.

Conclusion

The survey of the Chivchavi Cave Complex demonstrated that Subcomplexes I, II, and III were actively functioning during the High Middle Ages (11th–13th centuries) and represented a multifunctional space.

The architectural elements and ceramic material indicate residential, economic, and cultic purposes, which are distinguished within Subcomplexes I, II, and III. Particularly significant is the apsidal structure identified in Subcomplex II, which most likely served a religious function. Despite the archaeological investigation, its form and apsidal layout show similarities to Early Medieval architecture.

The analysis of the coin and ceramic assemblages provides a chronological framework dated to the 11th–13th centuries.

The proximity of the cave complex to the Samshvilde settlement raises the hypothesis of a connection between the two sites (economic, defensive, religious, etc.). In order to determine the exact function and developmental phases of the complex, further stratigraphic archaeological investigations are essential.

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Between Archaeology and Speleology: Exploration and Survey of a Medieval Well-Cistern in Peschiera Del Garda (Verona, Italy)

Davide Ricci [1], Giovanna Falezza [2], Simone Liguori [3], Davide Brombo [3]

1 Gruppo Speleologico Montecchia, Verona, Italy

2 Archaeologist official of SABAP, Verona, Italy

3 Archaeologist of Ar.Tech. Srl, Verona, Italy

Reference Author: Ricci Davide, davidericci96@gmail.com, tel. +39 3490637302

Abstract

Archaeological investigations began in 2024 inside the complex known as Caserma XXX Maggio, located in Peschiera del Garda (Verona, Italy) and consisting of Caserma XXX Maggio, Caserma La Rocca and Bastione Cantarane. A private renovation and redevelopment project is underway in the area. The investigations are revealing a chronological sequence of occupation of the site that begins in the Roman era and continues to the present day.

In August 2025, during excavations inside the courtyard of the Caserma La Rocca, a circular well with a diameter of approximately 2.80 m, dating back to the Middle Ages, emerged just below the current floor level, set within a quadrangular wall structure. The well was initially investigated using an inspection camera inserted into an open hole in the dome that sealed it, showing the water level a few centimeters below the mouth of the well. In agreement with the Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Verona, Rovigo e Vicenza, the archaeological firm involved a speleological team for the exploration of the underground site. After excavating the dome and emptying part of the well of water, five speleologists descended inside and conducted an initial exploration of the structure, taking approximate measurements of the bottom and creating a topographical 3D survey using LiDar.

The exploration was complicated by the presence of water, the risk of possible gas leaks, due to the incomplete emptying of the well, and the impossibility to set up a "classic" rig for a speleological progression on the archaeological structures.

The article presents the combined unpublished data from archaeological and speleological investigations, compared with several known case studies, which led to the formulation of hypotheses regarding the origin of the hydraulic work, its functions and the motivations for such a complex construction in an area where an easier water supply was certainly not lacking

Keywords: well-cistern; ancient hydraulic structures; water management; former military barracks and prison XXX Maggio; LiDar

Historical and archaeological context

Peschiera del Garda is a town in the province of Verona, in northern Italy, on the southern shore of Lake Garda at the beginning of the Mincio River. In 2017 it was included in the UNESCO World Heritage List in the transnational serial site "Venetian Works of Defence between the 16th and 17th Centuries: Stato da Terra - Western Stato da Mar", consisting of six components in Italy, Croatia and Montenegro, which protected the domains of *La Serenissima*, the Republic of Venice[1].

The heart of the Peschiera bastioned fortress is represented by the Caserma La Rocca, currently part of a complex, together with the Caserma XXX Maggio and the Bastione Cantarane, where a private renovation and redevelopment project is underway (Fig. 1). Since these properties are protected under the provisions of the Italian Code of Cultural Heritage and Landscape (Legislative Decree No. 42 of 22 January 2004), the Soprintendenza Archeologia Belle Arti e Paesaggio per

1 A detailed description is provided on the official UNESCO website <https://whc.unesco.org/en/list/1533>, last consulted: 07 May 2026.

le province di Verona, Rovigo e Vicenza has required the execution of archaeological investigations in all areas affected by excavation works, conducted by the archaeology firm Ar.Tech. of Verona[2].

Between August 2025 and April 2026, the research was carried out inside the "Caserma La Rocca", whose origins date back to the Middle Ages[3]. The ancient layout is well represented in a drawing made in 1579 by the topographer Cristoforo Sorte (Fig. 2), who depicted the project of the pentagonal Venetian fortress overlapped on the *castrum Pischeriae*, developed under the Scaliger lordship of Verona (13th-14th century). On the map, the medieval town appears to be spread across two islands, surrounded by the waters of the Mincio River; the largest part of the settlement is located on the right bank island, with a complete defensive system. At the southern tip is the Rocca, separated from the village by a wide moat, defended by a double curtain wall with towers at the four corners, within which stands the older nucleus of the Rocchetta. In 1551, the Republic of Venice, which had controlled Peschiera for more than a century, began the construction of the pentagonal bastion fortress[4]; the project envisaged, in the area of the Rocca, the reuse of some of the previous defensive structures: the Rocchetta was incorporated into the construction of the mighty Cavaliere d'artiglieria (Cavalier), while two buildings with an L-shaped plan, mirrored opposite each other, were built in the courtyard, still delimited by the Scaliger walls, which were partly used for the construction of the western wing. The Rocca area remained the heart of the military fortress even under French (1801-1814) and Austrian (1814-1866) rule: first Napoleon's engineers and then, above all, the Habsburg Genietruppen, continued to strengthen the defensive system of Peschiera, but kept the original layout substantially unchanged, so much so that even today one can see the works not only of the Venetians, but also of the Scaligeri.

The archaeological research conducted inside the barracks focused in particular on the central courtyard, which, as a parade ground, was apparently free of structures at least throughout the modern era. The excavation covered an area of 1,200 m², to a depth of approximately 5 m, and revealed a complex chronological sequence, predating the Middle Ages (Fig. 3). The earliest phase of occupation dates back to the Roman era, when the *vicus* of Arilica was located in Peschiera[5]. The construction of a building, only partially exposed, dates back to this period; it covers an area of approximately 560 m² and consists of numerous small rooms, defined by cobblestone and brick walls preserved only at the foundation level, with some traces of *opus caementicium* floors inside.

Fig. 1. Aerial view of the historic centre of Peschiera del Garda, taken by Google Earth Pro, showing the complex affected by the works: Caserma La Rocca (1), Caserma XXX Maggio (2), Bastione Cantarane (3) (graphic Liguori S.)

The abandonment of the building was followed by the formation, between Late Antiquity and the Early Middle Ages, of the so-called "dark layers", a sign of a "ruralization" of the landscape[6]. The subsequent phases are particularly complex: the study of the discovered finds and the results of the radiocarbon analyses, currently underway, will allow a more precise reconstruction of the site's history. The survival and continuous development of the settlement, known in the 7th century by the name of Ariolita, later changed to Piscaria in a 9th-century document[7], are evidenced by numerous traces of residential structures (postholes, some with preserved wooden elements) and productive structures (lime kilns), some infant burials and the construction of a mighty quadrangular masonry structure, probably a defensive tower, later supplanted by the foundation

2 Technical Direction was carried out by D. Brombo (Ar.Tech.), Scientific Direction by G. Falezza (SABAP).

3 For the medieval phases of Peschiera, see Bozzeto, 1997, pp. 39–59; Prospero & Prospero, 2016.

4 For the construction of the fortress and its evolution in the following centuries, see Bozzeto, 1997, pp. 69–261.

5 The first traces of the settlement, which developed between the Early Imperial Age and Late Antiquity, were accidentaly discovered in 1974 in the nearby Piazza Ferdinando di Savoia, where non-extensive investigations were conducted between 1999 and 2016 (Bruno & Meloni, 2020).

6 The same dynamics were detected in the excavations carried out in Piazza Ferdinando di Savoia (Bruno & Meloni, 2020, p. 156).

7 Bruno & Meloni, 2020, pp. 157–159.

Fig. 2. Plan of the bastioned fortress of Peschiera drawn by Cristoforo Sorte in 1579 (photo Archivio di Stato di Venezia)

Fig. 3. Orthophoto plan of the different structures uncovered during the archaeological investigations within the courtyard of the Caserma La Rocca (graphic Brombo D.)

of a large structure overlooking a gravel road. The entire area was subsequently affected by the deposition of soil layers, leading to a raising of the occupation level by over 2.5 m. In these layers, medieval structures emerged, just below the current level. In the centre of the courtyard (and therefore also of the Scaliger fortress), a quadrangular semi-underground structure was discovered, measuring 9.50 m on each side. It consisted of walls made of cobblestones and limestone blocks, arranged in a herringbone pattern, alternating with layers of mortar with limestone slabs[8]. Inside there was a perfectly preserved circular structure (Fig. 4), with an external casing of mortared bricks, 4 m in diameter, sealed by a dome built at a later date, as indicated by the different types of bricks and mortar. The empty space inside the enclosure, to a depth of 2 m, was filled with rubble after the structure had been built, but before the addition of the dome.

Well investigation

From the outset, it became necessary to clarify the nature and characteristics of the structure, not only for scientific reasons, but also in response to the client's needs, since the redevelopment project includes the construction of an underground parking facility extending beneath the entire courtyard area, potentially hindered by the presence of this structure.

An initial minimally invasive investigative method involved the creation of an approximately 4 cm-wide opening at the top of the dome, through which an inspection camera was lowered along the entire length of the cable (approximately 15 m). The structure proved to be filled with water, with the level reaching just below the top, preventing direct observation of the internal masonry texture. A simultaneous depth measurement, carried out by lowering a plumb bob attached to a measuring line, indicated a depth of about 42 m, leading to the identification of the structure as a well.

Since the initial method yielded no results, and with the authorization of the Soprintendenza the archaeological firm involved the Gruppo Speleologico Montecchia di Crosara (Verona)[9] in order to design and carry out a more detailed exploration campaign. Scaffolding was erected around the well, and part of the dome was dismantled, creating an opening of approximately 1 m to allow access to the structure. Initially, a gradual emptying of the well was planned, taking into account the risk of collapse, since the prolonged presence of water, in this case for centuries, played a structural role in the stability of the construction. Using a 750 W submersible pump capable of operating to a depth of 15 m, approximately 50 m³ of water were removed over the course of three days. Throughout the subsequent period, it was observed that the refill rate was particularly slow, with the water level rising by about 10 cm per week in the absence of rainfall.

On 13 December 2025, a direct exploration of the emptied section was carried out through a secured descent conducted by five cavers. The operations proved extremely complex from a logistical standpoint, as the

8 This construction technique has been found in other medieval defensive structures discovered in the Rocca area.

9 The association has been active in the Verona area for more than 50 years and has recently contributed to the survey of several natural and artificial cavities using LiDAR technology for research and educational purposes.

Fig. 4. View of the well located within the semi-underground structure (photo Brombo D.)

Fig. 5. Detail of the structure on which the rigging system for descending into the shaft was installed. Note the opening for the manhole access, the two "V"-shaped inverted Innocenti tubes resting directly on top of the dome and secured to the surrounding scaffolding (photo Ricci D.)

particular access conditions made the use of conventional anchoring systems, such as a tripod, impracticable. The descent system was set up by positioning a scaffolding tube (scaffold pole) above the access to the well, anchored to the scaffolding and stabilised by two pairs of tubes arranged in an inverted "V" configuration, resting on the dome (Fig. 5). A pulley was secured to this structure, through which a rope anchored to the installation was redirected.

This primary system was complemented by a second pulley with a corresponding recovery rope, equipped with a hoist intended to facilitate progression in case of emergency. This was properly attached to the harness and served to allow the speleologist to be recovered in the event of difficulties or obstacles during descent and ascent manoeuvres.

This arrangement also ensured that the operator could manage rope progression independently, while facilitating documentation activities inside the well.

Before proceeding with the descent, a preliminary assessment of the internal atmospheric conditions was conducted by lowering a four-gas detector (MSA brand) into the shaft, in order to evaluate the possible presence of hazardous gases or oxygen depletion. The instrument monitored oxygen concentration, carbon monoxide, sulfur dioxide, and LEL (Lower Explosive Limit) gases.

This operation was necessary because the emptying of a well that had remained water-filled for a long period inevitably leads to a destabilisation of the confined atmosphere within it; the removal of large volumes of water can promote the formation and release of gas pockets of various types, such as carbon dioxide, carbon monoxide, and flammable gases.

Once suitable conditions had been confirmed, a first exploratory descent was carried out[10]: a speleologist was lowered independently, but secured to a secondary rope for possible recovery, down to the water level, in order to assess the stability of the structure. At the same time, a water sample was collected for analysis, which is currently underway.

After the first speleologist had ascended, a second route was set up to lower a pair of operators simultaneously, with the aim of carrying out the three-dimensional survey.

Survey and exploration results

The aim of the exploration was to document the interior of the well through a topographic survey using LiDAR technology, in order to understand its construction features, verify any possible water supply points, and assess its stability conditions and levels of fragility.

One of the speleologists was secured to a rope redirected through a pulley and lowered using a descender controlled from the surface, to allow manoeuvrability of the instrument during the scanning operation. The descent and direction of the speleologist were guided by a colleague already present at the bottom of the well, who handled the operator's rope to bring him closer to the structure's walls and/or rotate him.

Meanwhile, the other three speleologists coordinated the lowering operation from the top, ensuring safety and operational control throughout the procedure.

The three-dimensional survey was carried out using an

10 Since the presence of residual gas pockets could not be completely ruled out, the detector was continuously kept attached to the operator's harness during the descent.

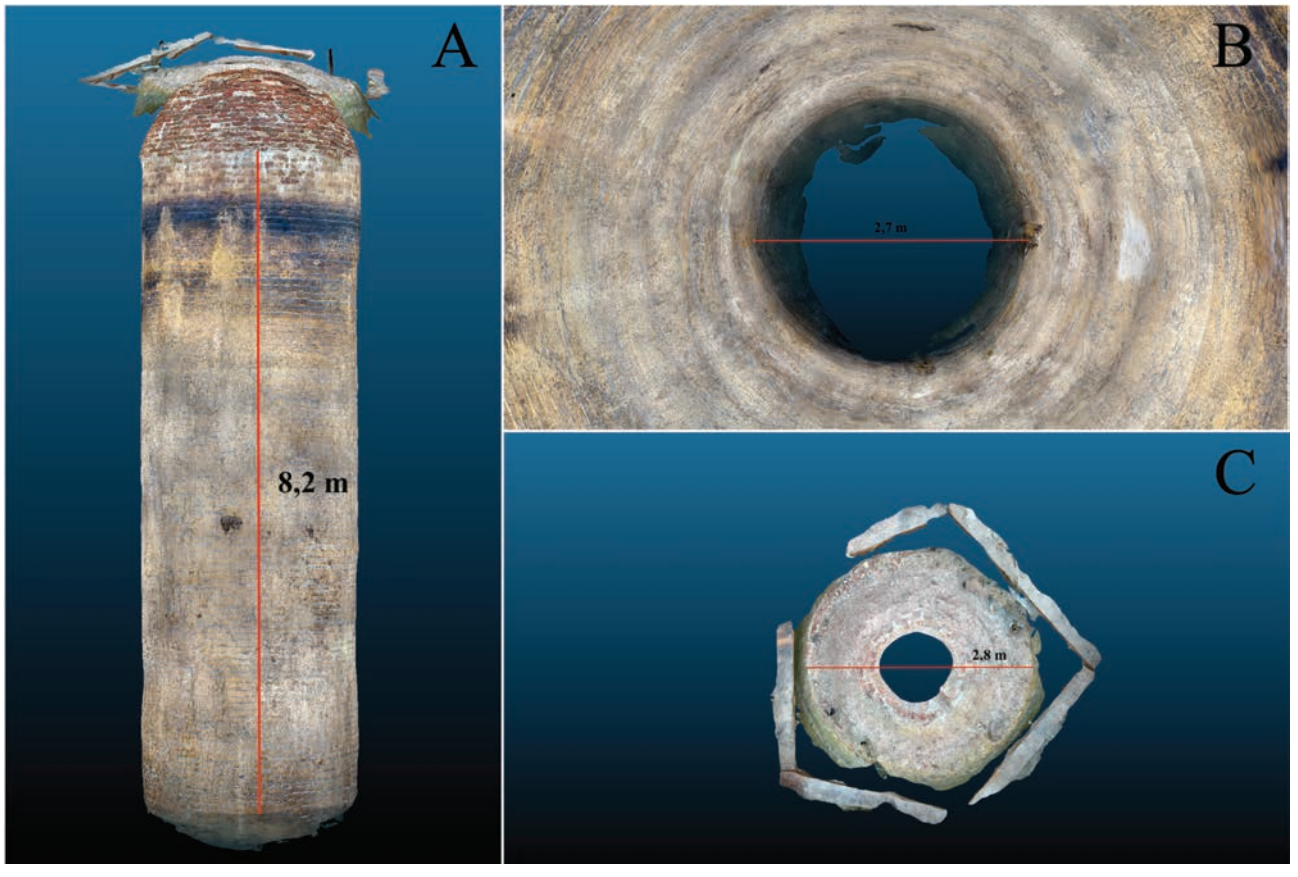

Fig. 6. 3D survey of the well in .obj format: section view of the shaft (A), plan view at the depth reached before encountering water (B), top view plan of the shaft (C) (graphic Ricci D.)

iPhone, with the Scaniverse[11] application, which enabled real-time preview of the scan. This made it possible to immediately apply any necessary corrections or perform a second scan if required, thereby optimising the quality of the documentation.

The results of the LiDAR survey are summarised in fig. 6[12]. Of particular interest is the section of the well (Fig. 6, A), where two distinct construction phases are clearly identifiable. The difference in workmanship between the interior of the shaft, where the bricks appear to be of a light-colored fabric, and the dome, which is composed of red bricks bonded with a considerable amount of mortar, like you can see in Fig. 7.

The original shaft of the structure, almost vertical, visible down to a depth of 8.2 m (corresponding to the water level at the time of the first exploration), is internally defined by the construction of regular courses of light-coloured bricks bonded with mortar layers. The internal surface is covered by particularly developed encrustations, while a dark band located at a depth of approximately 30 cm below the mouth of the well indicates the level at which water had stagnated up to the emptying operations (Fig. 7). At the top of the structure, flush with the well opening, four rectangular recesses were identified, likely intended to house a wooden superstructure used for water drawing.

During the exploration, a more accurate measurement of the structure's dimensions was also carried out. The bottom of the well was recorded at a depth of 39.7 m, although it was not possible to determine whether this corresponded to the groundwater level reached during the original excavation of the structure, to a deposit of anthropogenic material, or to an accumulation of natural sediments.

More significant, however, are the considerations arising from the measurements of the well's plan (Fig. 6, B and C). At the mouth, the diameter is approximately 2.8 m, while at the explored depth limit it reduces to about 2.7 m. This 10 cm difference, when related to a vertical development of approximately 8 m, suggests that the diameter at the bottom may be in the range of 2–2.2 m, a characteristic that provides important indications regarding the construction technique employed.

As regards the condition of the structure, no particu-

11 Scaniverse – 3D Scanner is an iPhone application provided by Toolbox AI, copyright 2026 Niantic Spatial, Inc.

12 The processing of the survey into an .obj file was carried out using CloudCompare, a Windows and Mac application for the processing of photogrammetric data and point clouds. The version used was CloudCompare 2.13, alpha [macOS 64-bit].

Fig. 7. Detail of the inner surface of the well, showing the two different construction phases and the water stagnation level (graphic Ricci D.)

lar critical issues were identified. Despite the partial removal of the water, an element that, as noted, had become structurally significant over time, the well showed no signs of deformation, also thanks to the consolidating effect of the calcareous deposits formed along the internal surface.

In addition, the archaeological excavation works carried out around the semi-subterranean structure allowed for a further reduction of the surrounding soil pressure on the well, enabling the partial drainage of the water.

The absence, along the investigated section, of any evidence of artificial inflows such as channels, pipes (*fistulae*), or conduits strengthens the hypothesis of direct groundwater recharge. Only in certain areas does a higher concentration of encrustations suggest localised seepage, which is no longer active today. The slow but steady rise in the water level (approximately 10 cm per week) appears to confirm a supply from the base.

Conclusions

Based on the data collected during the exploration, the structure identified at the centre of the medieval fortress of Peschiera del Garda can be interpreted as a phreatic well, a type of hydraulic structure designed not to collect water from shallow aquifers, but rather to reach the deeper groundwater table directly. The water level, recorded just below the top of the structure, together with the slow yet constant recharge observed following the partial emptying operations, also enabled near-surface water storage without the need for deep extraction, a feature that also characterises the well as a cistern. The construction technique of these hydraulic structures, well known in the Roman period[13], was particularly suitable for highly humid environments[14]: it initially involved an excavation several metres deep, followed by lining the walls with bricks in order to make it almost impermeable.Excavation then continued from the bottom, gradually removing material beneath the masonry lining, which slowly descended, progressively isolating the upper aquifers intercepted by the structure[15].

Examples of this type of well are known in Italy since the pre-Roman period and continued into the Middle Ages. The Etruscan well of Perugia (also known as Pozzo Sorbello), dating to the 3rd century BC, is 37 m deep, with a diameter of 5.6 m in the upper portion, for the first 16 m, and approximately 3 m at the bottom[16]. In Urbino, during the 1980s, a well built in the 15th century within the Courtyard of Honour of the Ducal

13 Vitruvio, *De Architectura*, VIII, 1-6.

14 The presence of a brick lining, associated with evident lime scale deposits, is consistent with Roman construction techniques based on the use of *opus caementicium*, a material with hydraulic properties that allowed its use even in highly water-saturated environments and in deep structures such as wells and cisterns.

15 For a detailed analysis, see: Trevor Hodge 2002, pp. 48–92.

16 Stopponi 1973; Binazzi 2018.

Palace was explored[17]: it was more than 20 m deep and completely separate from the rainwater collection system located in the courtyards.

This type of well guaranteed a constant water supply, unlikely to dry up and characterised by a high degree of water purity. The search for a reliable and secure water source would explain not only the construction of such a complex structure in an area where water was certainly abundant, being surrounded by natural resources (Lake Garda and the Mincio River), but also its precise location within the fortress, since water represented a fundamental element in the event of a siege.

As for the semi-subterranean structure containing the well, it is possible that it functioned as a well-house, namely a structure built above or around a well for the protection, management, and control of the water supply, particularly attested in medieval fortified contexts[18].

The abandonment of the structure most likely occurred during the construction works of the Venetian fortress, when the courtyard was transformed into a parade ground[19]. The considerable depth would also explain the sealing of the well by means of a masonry dome, rather than the more common backfilling with inert materials usually attested in cases of the abandonment of underground structures.

Although the investigation conducted inside the well was only partial, as it was not possible to explore it down to its bottom, the data collected thanks to the involvement of the speleological group made it possible to integrate and better interpret the archaeological evidence, contributing to the reconstruction of an important aspect of the medieval fortress of Peschiera, such as its water supply system[20].

This successful example of interdisciplinary collaboration also highlighted certain bureaucratic issues associated with interventions of this kind: at present, there is no specific legislation in Italy regulating exploratory activities carried out in a professional context, making it necessary to rely on specialised third parties for operations of this type. In this case, the exploration of the well was made possible thanks to the convergence of different interests among the parties involved, particularly the Soprintendenza and the client, both motivated, albeit for different reasons, to improve the understanding of the structure, for which a restoration and consolidation project aimed at its musealisation is planned.

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17 Fabbri et al., 1999.

18 On well-houses in medieval fortified contexts, see Hull, 2006, pp. 117–125; Gleue 2008.

19 The existence of an open space devoid of buildings is documented in historical cartography from the 16th century through to the detailed surveys conducted by the Austrians in the 19th century.

20 Before this discovery, the only known hydraulic structure was a well with a rainwater collection system located in the inner courtyard of the Rocchetta (Bozzeto 1997, pp. 56–57).

The Unusual Tiny Grave in the Church Göreme 31 (Cappadocia, Turkey)

Danil Shevchenko[1], Alexey Ostrovsky[2], Vladimir Shkondin[3]

[1]Hunan University of Technology (Zhuzhou, China), shevchenko.danil1979@gmail.com
[2]Independent researcher (Tbilisi, Georgia), satai@akauri.com
[3]Independent researcher (Fethiye, Turkey), v.shkondin@gmail.com

Abstract
This brief report is devoted to a tiny grave located in the Christian rock-cut church Göreme 31 (Cappadocia). The unusual tiny dimensions of the grave, as well as its specific arrangement, raise some questions about its attribution and features of the funerary cult in Cappadocia in the Byzantine era. Taking into account that the grave pit does not contain any osteological material, it is very complicated to make unambiguous conclusions.

Keywords: Rock-cut churches, burials, funerary cult, children's graves, ossuary

Introduction

Göreme 31 is a small rock-cut church located in the Kılıçlar valley near the Göreme Open Air Museum (38°38'40.30»N, 34°50'39.40»E) (Fig. 1). First, it was described by the French Byzantinist Guillaume de Jerphanion at the beginning of the 20th century. He mistakenly identified Göreme 31 as a chapel and took just two photos of murals of the vault (Jerphanion 1925, Texte 254-258, Planches pls. 54.2, 59.3, 59.4). In the early 2000-s, Catherine Jolivet-Lévy visited Göreme 31 but could not get inside because of the cheer cliff, which makes climbing dangerous. However, she published very important comments and additions based on photos taken by Pierre Lucas, who was able to squeeze into the church in 2003 (Jolivet-Lévy 2015, I 63-64; II 56-57). In 2014-2015, and then in 2018 we managed to visit the church, and in 2021 we published a detailed report based on our study *in situ* (Shevchenko et al. 2021).

Brief description of graves in Göreme 31

Göreme 31 is divided into three zones–a barrel-vaulted room served as a naos (A), a narthex (B) and a small funeral chamber (C) attached to the narthex from the South (Fig. 2). In the church, we found eleven graves: seven graves in the narthex, and four more graves in the funeral chamber, all of them excavated and looted. The funeral chamber did not contain any osteological material, but the graves in the narthex still preserved multiple human bones as well as pieces of funeral ceramics. Ten graves have a typical West-East orientation, while one grave in the narthex is oriented over the South-North axis. Most likely, this grave was cut down later than others, when the limited space of the narthex already did not allow any other arranging.

A tiny grave in the funeral chamber

One small burial pit in the funeral chamber is oriented over the West-East line, obviously misaligned compared to the other graves (Fig. 2; Grave 1). It slightly expands towards the West and has tiny dimensions (30 × 13 × 12 cm). It is important to note that the tomb was cut into a big niche decorated with a fresco of St. Anna who is a patroness of newborns and highly venerated Christian saint among pregnant women (Fig. 3). We see three general versions of the possible purpose of such a small grave: it could be a primary burial belonging to a premature baby (a fetus), or it could be an infant ossuary, or it could be a cenotaph. While the case of

Fig. 1. Göreme 31. View from the West. (photo D. Shevchenko, 2014)

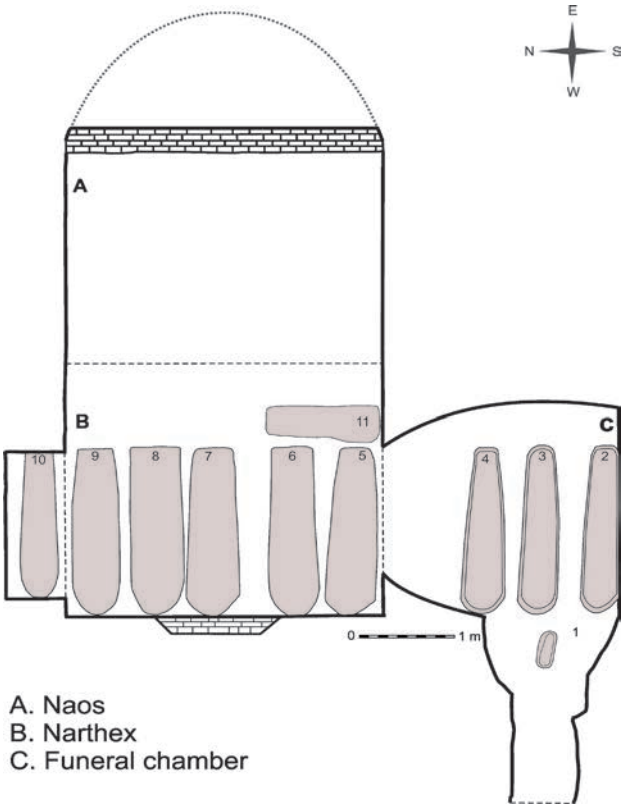

Fig. 2. Göreme 31. Layout

Fig. 3. Grave 1 in a niche with a fresco of St. Anna. Funereal chamber. (photo D. Shevchenko, 2015)

cenotaph is quite trivial and obvious, let us discuss the first two suggestions in more detail.

1. A grave of a premature baby

G. Jerphanion assumed that this grave belongs to a child, but he did not provide any details on that (Jerphanion 1925). However, after detailed consideration, the attribution of this grave as a grave belonging to a premature baby does not seem to be credible. Both the overall length of the buried body and the diameter of its cranium are limited by the dimensions of the pit. The length of the burial pit is 30 cm that complies with a maximum fetal age around 20–21 weeks when the average crown-heel length (CHL) is 25–27 cm (Moore et al. 2020, 108). The average head circumference for that fetal age is 18.5–19.0 cm (Loughna et al. 2009, 165), which corresponds to the diameter of 5.9–6.1 cm and fits the pit width and depth (13 and 12 cm). Therefore, the grave could be made for a body of the maximum fetal age of 20–21 weeks. It is extremely unlikely that such a young preemie could survive even for a short time in the Middle Ages to receive the baptism immediately after the preterm birth (or miscarriage, as it is 20th–21st week). We could not find any canonical requirements for the time when exactly a newborn should have been baptized[1], so we cannot rule out this possibility completely, and in such a case, indeed, he or she could be buried within the church space.

Therefore, the question of how realistic was baptizing of a 21-week-old fetus remains opened, and we cannot completely exclude this version, especially counting that a child might belong to a reputable family of the church's patrons.

2. An ossuary

Another possibility for the purpose of the tiny grave in Göreme 31 is an ossuary. Keeping of holy relics and different human remains was a widespread funeral practice in Cappadocia and as well as in various Christian regions.

In Cappadocia, multiple ossuaries are situated in narthexes under the floor, placed in niches along walls and clustered around temples. In some cases, like in the well-known Açiksaray complex, primary burials are combined with ossuaries (Figs. 4–5). A typical ossuary is much bigger and deeper compared to the tiny grave from Göreme 31, but at the same time, smaller than a primary burial (Fig. 6). Usually, the orientation of an ossuary pit does not comply with the cardinal directions, and it may have one of two shapes - a rounded

1 However, for example, the Bishop Nifont of Novgorod who lived in the 12th century recommended not postpone this rite and do it as soon as possible right after birth (Mikhaylov, 2010: 153).

Fig. 4. Açiksaray complex. Primary burials. (photo D. Shevchenko, 2019)

Fig. 5. Açiksaray complex. Ossuary. (photo D. Shevchenko, 2019)

Fig. 6. Looted ossuary cut into a wall. Soğanlı Valley (photo D. Shevchenko, 2018)

Fig. 7. Burial complex. anlı Kilise (photo V. Shkondin, 2017)

rectangle and an oval. As was pointed out before, in our case, the grave does not follow strictly the West-East axis.

Even if this grave is an ossuary, it must belong to an infant, as its dimensions are not enough to keep remnants of an adult person.[2] Since the ossuary in question belongs to an infant, it cannot hold holy relics and must be used just as a grave. Also, the high number of ossuaries in Cappadocia allows one to suggest that they generally belong to highly respected persons, not necessarily saints. Therefore, we think it is necessary to raise the question of function of ossuaries in Cappadocia–whether they usually store holy relics, or whether we see an alternative burial tradition.

Despite we cannot completely exclude possibilities of a fetus burial and a cenotaph, we think that the version of an infant ossuary is the most plausible one.

Conclusion

In Christian Cappadocia, the funeral tradition is characterized by diversity and complexity. According to R. G. Ousterhout, the *local landscape is riddled with tomb of all sorts* (Ousterhout 2009, 87) (Fig. 7). However, it seems that the case of the small grave of Göreme 31 is very rare if not unique for Cappadocia. We attribute this grave as an infant ossuary, which allows us to raise the question of function of numerous ossuaries in Cappadocia.

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2 The minimum diameter of a cranium of an adult person exceeds 15 cm, the length of the biggest bones exceeds 35 cm, the shortest dimension of pelvis exceeds 20 cm, and the shortest dimension of rib cage exceeds 15 cm, so the grave in question cannot be dedicated to holing remnants of an adult person.

Subterranean Hiding Complexes as a Jewish Defensive Strategy During the Three Revolts Against Rome in the Galilee (Israel)

Yinon Shivtiel
Zefat Academic College
Uri Berger
Israel Antiquities Authority
Yinon1950@gmail.com Tel: 972-54-4388598

Abstract
In our paper in Hypogea 2017: *"Hiding Complexes in the Galilee, Israel: Artificial Refuge Caves in the Early Roman Period"*, the defensive strategies employed by Jews during the Roman period in times of emergency and distress were first outlined. The principal method involved quarrying out underground hiding complexes beneath Jewish homes in numerous settlements across the Land of Israel. Over the past decade, substantial information has been gathered, and numerous finds from excavations within these hiding complexes have been analyzed. In the last five years, the authors conducted an intensive excavation of a particularly large hiding complex in the ancient Jewish settlement of Huqoq in Galilee. The historical context of these periods of distress, combined with archaeological findings and their scientific analysis, suggests that these hiding complexes served as public underground shelters during three distinct periods of crisis, each stemming from Jewish rebellions against Roman rule. This article presents the Huqoq hiding complex and the evidence supporting this interpretation.

Keywords*: Galilee, Roman period, hiding complex, Gallus Revolt, Bar Kokhba Revolt*

Introduction

Hundreds of rock-hewn subterranean cavities discovered across the Land of Israel have been identified as Jewish hiding places dating primarily from the Roman period. These installations, often concealed beneath settlements or agricultural features, reflect a distinctive strategy of defense and survival developed in response to Roman military and administrative pressure. Scholarly research has traditionally focused on the Judean foothills, where hundreds of hiding complexes have been documented and securely associated with the Great Revolt and the Bar Kokhba Revolt.

Although the Galilean hiding complexes are fewer in number, they present greater interpretive challenges due to debated chronology, construction methods, and contextual uncertainties. These difficulties are associated with limited excavation, later disturbances, and a scarcity of diagnostic finds. Nevertheless, accumulating evidence indicates that, as in Judea, Galilee experienced the systematic construction of subterranean hiding complexes during periods of crisis.

Subterranean concealment installations fall into three types: (1) natural refuge caves in the Judean Desert; (2) cliff shelters in Galilee; and (3) purpose-hewn hiding complexes under or near Roman-period settlements. This study focuses on the latter, defined by narrow tunnels, multiple chambers, concealed entrances, and limited access.

This study seeks to reassess the chronology and function of Galilean hiding complexes independently from the Judean model, prioritizing regional data over assumed parallels. Broader comparisons will be addressed following the presentation of Galilean evidence.

Hiding complexes in the Galilee

The primary objective of this study is to present updated archaeological data concerning Roman-period hiding complexes in Galilee. Two main research questions are addressed: (1) What is the precise of the construction and use of these hiding complexes? (2) What function did they serve during recurring periods of crisis? While some Judean hiding complexes can be definitively linked to specific revolts (Kloner & Zissu 2009), Galilean systems often lack such direct chronological markers.

Special attention is devoted to the hiding complex at Huqoq, which constitutes one of the most extensively excavated and best-documented examples in Galilee. The complex provides rare evidence for repeated use across three periods of rebellion and serves as a key case study for understanding long-term patterns of subterranean defensive behavior in the region.

Historical sources for the three Jewish revolts

Josephus and the Great Revolt (66–70 CE)

Flavius Josephus provides the principal historical account of events in Galilee during the Great Jewish Re-

volt against Rome. His descriptions appear primarily in two works: The Jewish War (composed c. 79–81 CE) and The Life of Josephus (c. 94–96 CE). Together, these texts constitute the most detailed contemporary narrative of the revolt and its immediate aftermath. Josephus was appointed commander of Galilee and the Golan shortly before the Roman invasion led by Vespasian and Titus (War II.571–669). In both The Jewish War (II.572–576) and The Life of Josephus (187), he reports that upon his arrival in Galilee, he undertook extensive efforts to prepare caves as refuges. Josephus does not explain the precise nature of these caves. However, archaeological investigations conducted by the present authors have documented hundreds of natural caves with openings along the steep limestone cliffs of Galilee. Excavations and surveys within these cliff shelters have produced substantial evidence for Jewish use during the Early Roman period, including pottery assemblages, coins, arrowheads, rope-fastening installations, lamp niches, plastered bell-shaped cisterns, and ritual baths (*miqva'ot*). These findings strongly suggest that Josephus's references pertain to the large-scale utilization of natural cliff shelters as temporary refuges during the Great Revolt. The density of material remains indicates that these caves accommodated significant numbers of refugees and functioned as an integral component of the Galilean defensive strategy during the late first century CE (Shivtiel 2019, 15–80).

Cassius Dio and the Bar Kokhba Revolt (132–136 CE)

The most important historical account of the Bar Kokhba Revolt is provided by Cassius Dio, whose *Roman History* covers events up to the reign of Alexander Severus in the early third century CE. Although Dio devotes only a brief passage to the revolt (less than three pages), his testimony is of exceptional value, as it represents the only near-contemporary historical record of the conflict. Dio describes the revolt as a prolonged and violent struggle that erupted following Hadrian's refoundation of Jerusalem as Aelia Capitolina. His account includes a detailed description of Jewish defensive preparations:

They occupied 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 underground; and they pierced these subterranean passages from above at intervals to let in air and light (Cassius Dio, Roman History 69.14.1–21; trans. Cary & Foster).

This description corresponds remarkably well with the archaeological characteristics of hiding complexes documented throughout Judea and, increasingly, in Galilee. These installations typically consist of narrow, low tunnels, concealed entrances, ventilation shafts, and multiple chambers designed for temporary concealment rather than prolonged habitation. While Dio refers explicitly to Judea, archaeological data indicate that similar systems were also prepared in Galilee. Hundreds of hiding complexes have now been identified in both regions, and finds from several Galilean examples–including pottery, coins, and architectural features–indicate use during the early second century CE. These data support the interpretation that Galilee participated, at least indirectly, in the broader defensive response to the Bar Kokhba Revolt. Furthermore, several scholars have already suggested that when the third-century CE historian Dio Cassius used the word Judea, he was actually referring to the province of Judaea, which also included Galilee. Scholars concluded this based on the knowledge that after the Great Revolt, the Romans divided their area of control in the Land of Israel so that the entire region from Judea in the south to Pereia in the east, and to Upper and Lower Galilee, was under one province named Judaea (Shivtiel 2023, 480–482).

The Gallus Revolt (351–352 CE): fragmentary sources and archaeological implications

In contrast to the Great Revolt and the Bar Kokhba Revolt, historical documentation of the Gallus Revolt is extremely limited. The rebellion, which erupted in 351–352 CE, is mentioned only briefly in Late Roman and early Christian sources, leaving major questions unresolved regarding its causes, leadership, geographic extent, and the degree of Jewish involvement.

According to the available evidence, the revolt may have originated in Diocaesarea (Sepphoris/Zippori), where a Jewish leader named Patricius was reportedly proclaimed king. Aurelius Victor notes succinctly that *"the revolt of the Jews, who impiously raised Patricius to royalty, was crushed"* (Stern 1980, 500–501). The suppression of the revolt was entrusted to Ursicinus, a senior Roman commander sent by Constantius Gallus. Jerome (Chronicon 282) reports the destruction of at least fifteen villages, primarily in Lower Galilee, while later sources expand on the scale of violence. Socrates Scholasticus describes Roman reprisals against Jewish communities in Diocaesarea, Lod (Diospolis), and Tiberias, emphasizing the devastation inflicted upon urban centers. Jerome further records mass killings and the destruction of cities and villages throughout the region. Despite the paucity of written sources, archaeological evidence increasingly suggests that the Gallus Revolt constituted a genuine period of crisis for Galilean Jewish communities. Coin hoards dated to the mid-fourth century CE have been discovered at multiple sites in the region, including Qatzrin, Korazim, Sepphoris, and the area surrounding Huqoq. The discovery of a mid-fourth-century coin hoard within the Huqoq hiding complex provides the first direct evidence for the reuse of a Roman-period hiding complex during the Gallus Revolt, and the first archaeological proof of a hiding complex reused during this uprising (Bijovsky 2007).

The hiding complex at Huqoq

The historical sources discussed above provide a critical framework for interpreting the archaeological record of Galilean hiding complexes. Although literary testimony is uneven and often brief, the convergence between historical descriptions and material evidence is notable. The following section presents the hiding complex at Huqoq as a detailed case study, illustrating how a single subterranean system was adapted and reused during three distinct periods of rebellion against Roman rule.

The remains of the Jewish settlement at Huqoq (biblical Hokuk; Joshua 19:34(, dating from the Second Temple period, extend across two adjacent hilltops. The settlement's core was situated on a prominent hill at an elevation of approximately 30 m above sea level, overlooking the Gennesaret Valley (Fig. 1). From this vantage point, the site commands extensive views toward Arbel, Magdala, Tiberias, Akhbara, Safed, and Yavnit–Jewish settlements mentioned by Josephus in his description of Galilee during the Great Revolt (War II.573–574).

To date, three subterranean hiding complexes have been identified at Khirbet Huqoq. Two of these complexes are located inside the synagogue's water cisterns, which are situated at the summit of the tell. The cisterns associated with these complexes predate the construction and mosaic flooring of the synagogue, which has been dated to the fifth century CE (Magness et al. 2018). A limited probe excavation of the complexes beneath the synagogue revealed that they were hewn into the walls of a cistern. Narrow hiding tunnels of the developed type (Shivtiel 2016) suggest a date of use following the destruction of the Second Temple, possibly indicating preparation for the Bar Kokhba Revolt (Shivtiel & Osband 2019; Shivtiel 2021). A tunnel in one of these systems leads to a vertical shaft with hewn ascending steps. This shaft was blocked no later than the Late Roman period, when the synagogue's mosaic floor was laid above it (Shivtiel 2016; Magness et al. 2018).

The third hiding complex (Fig. 2) is the largest and most sophisticated of the three systems at Huqoq. It is located on the northern slope of the hill, approximately 115 m from the synagogue, and has been excavated since 2019 by a joint expedition of the Israel Antiquities Authority and Zefat Academic College. This hiding complex was already known to members of nearby Kibbutz Huqoq during the 1970s and served as a frequent destination for hikes and educational tours for the local youth. Visitors reported finding numerous pottery sherds and coins, including silver Crusader coins, which were collected and displayed in a local exhibition room. At some point, this room was destroyed by fire, and the finds were lost (Fogelson 2003; oral testimonies of veteran kibbutz members). Initial mapping of this system was done during the 1980s (Tepper, Der'in & Tepper 2000, 72–86) and the early 2000s (Shivtiel 2019, 133–135; Kisilevitz et al. in print). These surveys identified that the entrance to the hiding complex was through a rock-cut ritual bath (*miqveh*).

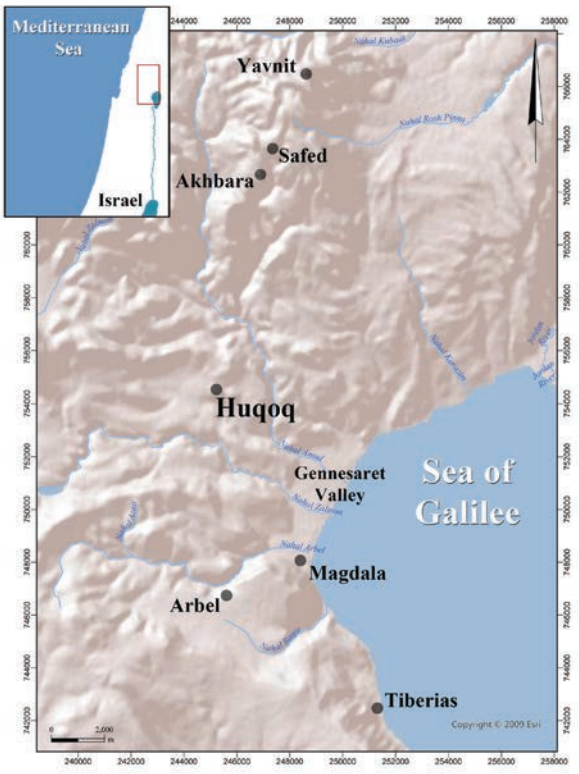

Fig. 1. Map of Huqoq and other Galilean Jewish settlements mentioned by Josephus (ESRI map, edited and drawn by Anastasia Shapiro and Uri Berger [Israel Antiquities Authority], published with permission)

Architectural description of the northern hiding complex

A partial archaeological excavation east of the *miqveh* entrance revealed the remains of residential structures dating from the Byzantine period (Shivtiel et al. 2022, 119–121). This excavation removed the sediment filling the *miqveh* to expose the rock-cut steps descending from the entrance to the immersion chamber, as well as its plastered floor and walls (Zingboym & Badichi 2022).

Ten chambers (A–I and BC) connected by low, narrow tunnels (Fig. 2–5) have been identified within the complex. As identified in earlier surveys, access to the subterranean hiding complex was through a rock-cut ritual bath (Chamber A). The *miqveh* is rectangular in plan and coated with at least two layers of hydraulic plaster. Although no diagnostic finds were recovered from within the *miqveh* itself, its gray hydraulic plaster indicates that it was hewn and used during the Early Ro-

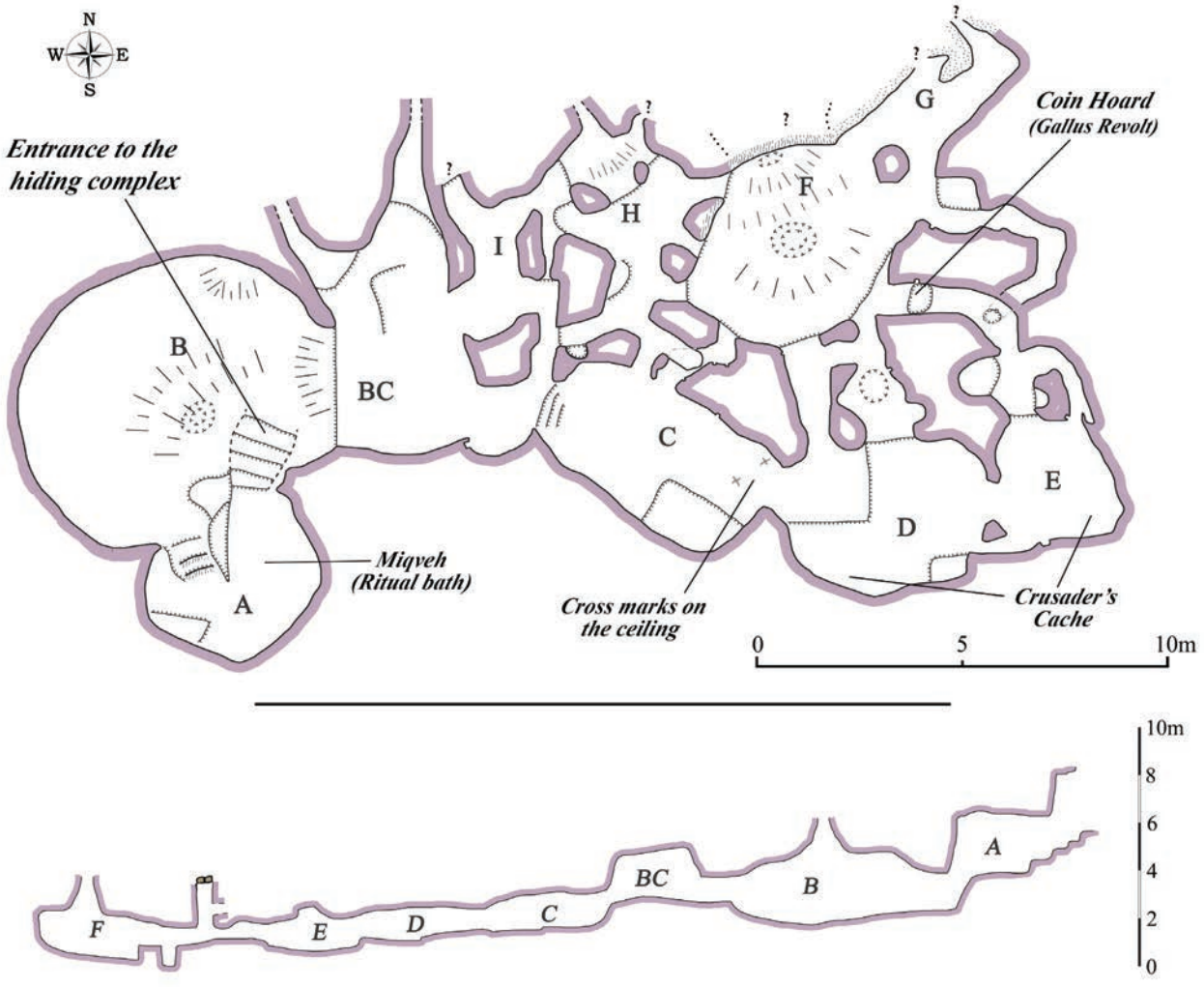

Fig. 2. The hiding complex at Huqoq, plan and section

man period, specifically the first and second centuries CE (Porath 2002, 35; Tsuk, Bordowicz & Kohn-Tavor 2017, 591). At a later stage, the northern wall of the *miqveh* was crudely breached, creating an opening into a large, round bell-shaped cistern (Chamber B). Two steps were cut into the breach to facilitate movement between the different floor levels. This breach rendered the cistern incapable of holding water and, consequently, eliminated the *miqveh*'s ability to function as a ritual installation. In our view, this intentional abandonment of ritual purity requirements reflects a period of acute distress, during which the inhabitants prioritized survival over religious observance. The steps cut into the breach differ markedly from the carefully dressed steps of the *miqveh* entrance. They are roughly hewn, lack ergonomic consideration, and appear to have been hastily excavated. The ceiling and opening of the cistern were plastered. An additional oval-shaped opening of the cistern was found blocked with a conglomeration of stones bonded with mortar. A further breach in the northeastern wall of the large cistern led into an additional, irregularly shaped chamber (BC). Within this chamber, sparse fragments of human bone were found alongside coarse pottery sherds and fragments of decorated jars bearing incised bands characteristic of Early Bronze IB. These finds indicate that this portion of the system originally functioned as a subterranean burial cave during the Early Bronze Age. Differences in ceiling height within Chamber BC suggest the collapse of the eastern half of the original burial cave at some point between its Early Bronze Age preparation and its later incorporation into the hiding complex during the Roman era. Simple hewn cavities with no attempt to finish them to a high standard are typical of the Great Revolt (Shivtiel 2019, 7). Similar simple cavities carved out within water cisterns are quite common from that period in the Galilee (Shivtiel 2019, 8, 98–101, 125, 134, 143).

Chambers C, D, and E are similar in plan and appear to form a sequence of three rectangular rooms hewn in a row and connected by relatively wide openings. From the northern walls of all three chambers, narrow,

Fig. 3. Tunnels at the junction between Chambers BC, C, and H

low and winding tunnels branch off, some with sharp turns, all leading toward Chamber F (Fig. 6). In one of the tunnels connecting Cistern F and Chamber E, the high-quality carving techniques employed by the people of Huqoq are distinctly evident. In this tunnel, a vertical rectangular shaft featuring climbing niches was identified, designed to assist individuals seeking to exit the complex (Fig. 5).

In the tunnel connecting Chambers C and F, two different phases of hewing were identified (Fig. 7: a).

Fig. 4. Crawling through the Huqoq complex tunnels

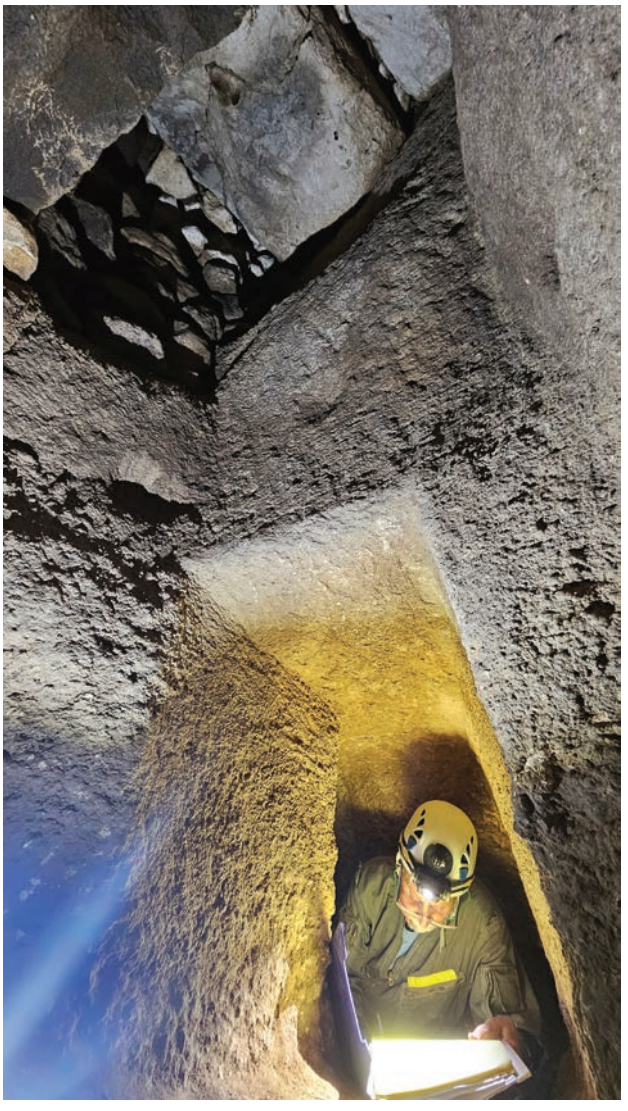

Fig. 5. A carefully finished tunnel leading from Chamber E to Chamber F. Note blocked shaft with 'climbing niches'

Fig. 6. Cistern F and the tunnels leading into and out of it

Fig. 7. Chamber C: (a) View from Chamber C towards Chamber D. Two phases of carving are visible on the roof adjacent to the tunnel entrance. (b) The sealed shaft. (c) Cross marks made with soot near the entrance to Chamber D

Fig. 8. The gemstone ring

A blocked shaft (Fig. 7: b) was identified in the tunnel roof. It may represent the remains of a burial shaft predating the hiding complex, possibly belonging to the Early Bronze burial complex. Chamber F (Fig. 6), like Chamber B, appears to have functioned originally as a public water cistern. Its roof was plastered, and its oval opening was found sealed. Examination of charcoal fragments sampled from this plaster[1] indicates that the cistern in Chamber F dates from the second century CE. An opening blocked with accumulation was identified in the northern wall of Chamber F. Excavation at the eastern end of this opening led to a large chamber (G) or cave with a smoothed roof. This cavity was found filled with sediments containing numerous pottery finds, mainly holemouth jars, juglets, and jugs, along with flint and stone tools, dated to Early Bronze IB and similar to the finds from Chamber BC, although in much larger quantities. The cavity's excavation was curtailed before we were able to fully understand its entire plan. Accumulations in Cavities H and I contained mixed pottery finds dating from the Roman, Byzantine, and Early Bronze Age–evidence for the Jewish villagers reuse of cavities hewn by the first settlers of the site, during the fourth millennium BCE.

Throughout the tunnels and in several chambers, oval niches for oil lamps were carved into the walls; traces of soot were preserved in some of them. On the roof of Chamber C, near the entrance to Chamber D, two cross-like signs made of soot were detected (Fig. 7: c). We assume that they were the latest additions to the hiding complex, which were probably drawn during the Crusader period (Shivtiel, Ehrlich & Berger 2024).

The excavation and its results

Excavation of the hiding complex yielded a substantial ceramic assemblage spanning three distinct chronological horizons. The earliest horizon consists of coarse potsherds and flint tools characteristic of Early Bronze IB and closely corresponding to ceramic and lithic assemblages known from burial contexts of this period

Fig. 9. Tunnel and niche where the Gallus hoard was found

1 Radiocarbon analysis for the samples was carried out in the Weizmann Institute laboratories (RTD 12434) revealing the primary probability range of c. 125–204 CE.

Fig. 10. The hoard on its discovery

(Golani 2003, 92–97, 101–107; Covello-Paran 2011, 6–11). The second horizon is represented by ceramic material that includes cooking pots characteristic of the second century CE, a period associated with the Bar Kokhba Revolt (Berger & Shivtiel 2024, 6–62). In addition to the ceramic finds from this period, the excavation yielded a bronze ring with a gem setting (Fig. 8) and a small iron knife, both dated to the early second century CE. Comparable rings and gemstones have been identified at Gamla and Caesarea and dated to the Early Roman period (Amorai-Stark & Herschkovitz 2016a, 101; Amorai-Stark & Herschkovitz 2016b, 375).

The third horizon dates from the early Byzantine period and is represented by a rich pottery assemblage of jars, bowls, lids, cooking pots, and oil lamps dated to the fourth century CE. These vessels are consistent with domestic pottery used for food preparation and short-term habitation, indicating human presence within the hiding complex during a time of crisis rather than ritual or funerary activity. In addition to this ceramic assemblage, an 'emergency hoard' was found in a deep hewn niche (in a tunnel leading from Chamber F to Chamber E (Fig. 9). The hoard contains 22 coins, some bearing portraits of the emperors who reigned at around the time of the Gallus Revolt (Constantine II and Constans I; Figs. 10, 11; Shivtiel et al., 2025). These coins provide firm numismatic evidence for activity within the hiding complex during the mid-fourth century CE and constitute the first documented case of a Gallus Revolt-period coin hoard discovered inside a Roman-period hiding complex.

The final phase is represented by a medieval cache: a hoard of 24 Crusader coins (Fig. 12), primarily minted in Jerusalem under Baldwin III and dated from 1140 to 1163 CE, which was recovered near the entrance to Chamber D and inside Chamber E. The coins were wrapped in fabric and concealed within sediment accumulated in these chambers. This hoard was hidden deep within the complex. It is plausible that the two cross signs found on Chamber C's roof marked the doorway to the hoard's hiding place. The individual intended to retrieve them, but apparently never returned (for further discussion of the hoards and their context within the Crusader kingdom, see Shivtiel, Ehrlich & Berger, 2024). These medieval finds demonstrate repeated reentry and reuse of the subterranean system centuries after the Jewish revolts against Rome, when they served as a secret cache.

Discussion

With the exception of the earliest and latest phases– during which the cave functioned as an Early Bronze Age burial installation or as a secret Crusader cache– the excavation results present a pattern consistent with that observed in other Galilean hiding complexes. The Huqoq complex is one of approximately 80 hiding complexes identified to date in Galilee that were prepared for periods of crisis during the Roman period, paralleling similar phenomena documented in Judea and southern Samaria (Shivtiel 2019; Raviv 2023).

Approximately 20 Galilean hiding complexes have yielded finds dating from both the Great Revolt and the second century CE (Shivtiel 2019). These complexes frequently display a combination of both rough and

Fig. 11. The Gallus Revolt hoard

Fig. 12. Coins from the Crusader hoard

carefully executed quarrying techniques, indicating at least two phases of use corresponding to two distinct periods of crisis (Shivtiel & Osband 2019). In 16 excavated complexes, archaeological finds date primarily from the first and second centuries CE, with a strong emphasis on the second century CE. These complexes tend to exhibit more sophisticated quarrying techniques, including narrow, low tunnels with sharp turns–features characteristic of hiding complexes associated with the Bar Kokhba Revolt (Shivtiel & Osband 2019; Shivtiel 2021, 471–475).

The Huqoq hiding complex fits well within this pattern. Huqoq was a Jewish settlement located near other Jewish villages in Lower Galilee. During the period leading up to the Great Revolt, the inhabitants appear to have prepared a modest hiding complex, likely intended for one or several families, utilizing an earlier burial cave and water installations whose water supply was diverted or drained. One or two tunnels may have led to this initial hiding chamber. In preparation for the Bar Kokhba Revolt, the complex was significantly expanded. Additional tunnels were cut–this time, narrow, low, and carefully finished (Fig. 5)–and new chambers were hewn to shelter multiple families. This expansion reflects a longer preparation period and greater organizational capacity, consistent with patterns observed in Judea. Given the absence of detailed historical sources regarding Galilean participation in the Bar Kokhba Revolt, archaeological evidence such as this becomes the primary basis for interpretation. The typological comparison of Galilean hiding complexes with those in Judea places the Huqoq complex among similar ones used during both the Great Revolt and the second century CE. Ceramic finds recovered from within the tunnels support the conclusion that the complex was actively used during the Bar Kokhba Revolt. The discovery of a coin hoard dating from the time of the Gallus Revolt within the complex represents a unique contribution to the study of this poorly documented uprising. Although the Gallus Revolt appears brief, the archaeological evidence suggests that it was sufficiently traumatic to prompt the reuse of existing hiding complexes. The Huqoq complex was thus adapted for hiding on at least three separate occasions, each corresponding to a period of Jewish rebellion against Roman authority.

Conclusions and Summary

The excavation of the Huqoq hiding complex has enabled the identification of at least six distinct phases of activity (Table 1):

Phase I–Early Bronze IB: First entry to the site's underground world with the excavation and hewing of shaft tombs and other cavities whose use is unclear. This phase is characterized by numerous, assorted pottery finds comprising mainly holemouth jars, juglets, and jugs.

Phase II–The Second Temple period and its aftermath (first–second centuries CE):

the Jewish villagers of Huqoq dig bell-shaped water cisterns and a ritual bath (*miqveh*) into the bedrock.

Phase III–The Great Revolt (66–70 CE): the *miqveh* and the adjacent water cistern are breached; the cistern's eastern wall is cut open to reveal an Early Bronze cavity, which is used as a hideout. The abandonment of ritual purity by disabling the *miqveh* reflects a conscious prioritization of survival over religious observance during a time of extreme danger.

Phase IV–The Bar Kokhba Revolt (132–136 CE): interconnecting tunnels are cut between the water cis-

terns; earlier cavities are reshaped as the people of Huqoq develop a more sophisticated underground hiding complex.

Phase V–The Gallus Revolt (351–352 CE): in the mid-fourth century CE, the complex initially carved by the ancestors of the Jewish villagers is re-entered and reused. Storage jars and cooking pots, among other vessels, are brought into the underground chambers. A deep niche is cut as a cache for an emergency hoard.

Phase VI–The Crusader period (twelfth century CE): in the depths of the underground complex, the inner chambers are used as a secret cache.

This complex of hiding places in Huqoq is one of the largest and most sophisticated examples of its kind in the Galilee. The combination of the different types of hiding patterns – the earlier and simpler one, and the extensive architectural modification characteristic of the Bar Kokhba – period systems – the rare bronze ring, and the unprecedented Gallus Revolt coin hoard confirms that this complex formed part of a long-term Jewish defensive strategy which, as a communal shelter, was re-entered in times of distress. The archaeological evidence from Huqoq's underground complex shows that Galilean communities actively prepared for and repeatedly responded to existential threats by adapting and reusing subterranean landscapes to survive.

Table 1: Phases of activity in Huqoq's underground complex

Phase	Period	Activity and use	Chambers
I	Early Bronze IB	Initial subterranean use: shaft tombs, caves with smoothed roofs	BC, C, G, H, I
II	Second Temple period	Initial excavation of water installations: *miqveh* and bell-shaped cisterns	A, B, F (?)
III	Great Revolt	Initial use as hiding place: water installations repurposed; a modest complex for one or a few families	BC
IV	Bar Kokhba Revolt	Enlarged hiding complex: *miqveh* and cisterns intentionally disabled; narrow, low, carefully finished galleries and new chambers for multiple families	C–F, H, I
V	Gallus Revolt	Re-entry and reuse of the hiding system in time of crisis. Cache of coin hoard	C–F, H, I
VI	Crusader period	Cache of coin hoard in secure subterranean location	C–E

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From Funerary Monument to Industrial Space: The "Lions' Tomb" at Horvat Burgin (Israel)

Boaz Zissu
Bar-Ilan University, Ramat-Gan, Israel, 5290008
Boaz.Zissu@biu.ac.il

Abstract

This article presents Burial Complex P at Horvat Burgin ("the Lions' Tomb"), a large and partially unfinished rock-cut complex in the Judean Shephelah. The complex exhibits a sequence of use, comprising a late Hellenistic–Early Roman burial system, Byzantine Christian appropriation, subsequent adaptation as a columbarium, and final modifications through quarrying activities.
Through detailed architectural analysis and comparison with the subterranean landscapes of the Beth Guvrin–Eleutheropolis region, the study reconstructs the multi-phase development of the complex and situates it within broader patterns of long-term reuse. Particular attention is given to the engraved lion figures and the cross–tree graffito, which provide insight into the symbolic and cultural frameworks associated with the funerary and later Christian phases.
The evidence demonstrates that the columbarium represents a secondary, utilitarian installation unrelated to the original burial function, while the quarrying phase marks a more radical transformation involving the partial dismantling of earlier structures.
The Lions' Tomb is thus interpreted as a dynamic subterranean space shaped by successive processes of reuse and redefinition. More broadly, the complex provides a case study for the *longue durée* of subterranean activity in the Judean Shephelah, illustrating the flexibility and enduring significance of rock-cut environments within changing cultural, religious, and economic landscapes.

Keywords: Horvat Burgin; Judean Shephelah; rock-cut tombs; columbarium; bell-shaped quarries

Introduction

The Judean Shephelah (Judean Foothills) preserves an exceptionally dense and varied subterranean landscape, shaped by the interplay between geology and long-term human activity. The soft chalk bedrock (*kirton*), capped by a harder *nari* crust, facilitated extensive rock-cutting from the Iron Age period onward. As a result, rock-cut tombs, columbaria, quarries, cisterns, and hiding complexes form an underground network of artificial cavities that was repeatedly modified over centuries. These cavities constitute palimpsests in which earlier spaces were reinterpreted and adapted to changing social, religious, and economic needs.

Horvat Burgin (Khirbet Umm Burj), located approximately 7.5 km northeast of Beth Guvrin–Eleutheropolis and 17 km southwest of Hebron, provides a particularly instructive case within this regional context. (Fig. 1) The site occupies the summit of a hill overlooking the fertile valley of Nahal Hakhlil, a regional routeway in antiquity, and extends over c. 3 hectares. (Fig. 2) It preserves extensive remains spanning from Iron Age II through the Ottoman period, with particularly rich evidence from the Hellenistic, Roman, and Byzantine periods. Horvat Burgin formed part of the wider settlement network associated with Beth Guvrin–Eleutheropolis, a major regional center throughout the Roman and Byzantine periods.

As at other sites in the Judean Shephelah, the most significant remains at Horvat Burgin are subterranean. Dozens of rock-cut cavities and underground complexes were hewn into the soft limestone bedrock, including storage chambers, cisterns, quarries, columbaria, hiding complexes, and rock-cut burial systems. These installations, created and modified over many centuries, form a complex and stratified underground landscape reflecting repeated processes of use, abandonment, and reuse.

Previous surveys and excavations (1995–1997; 2004–2008) have shown that Horvat Burgin functioned as a substantial Jewish rural settlement during the Hellenistic and Roman periods. In Late Antiquity, the site underwent significant transformation, marked by renewed Christian occupation, the construction of a stratified church (monastic?) complex, and the reuse of earlier cavities, frequently marked by crosses and inscriptions. Later Byzantine and Early Islamic phases are represented by the excavation of bell-shaped quarries, which often cut through earlier installations, reflecting intensified economic exploitation of the landscape (Zissu 2005; Zissu & Ganor 2008; Zissu et al. 2013).

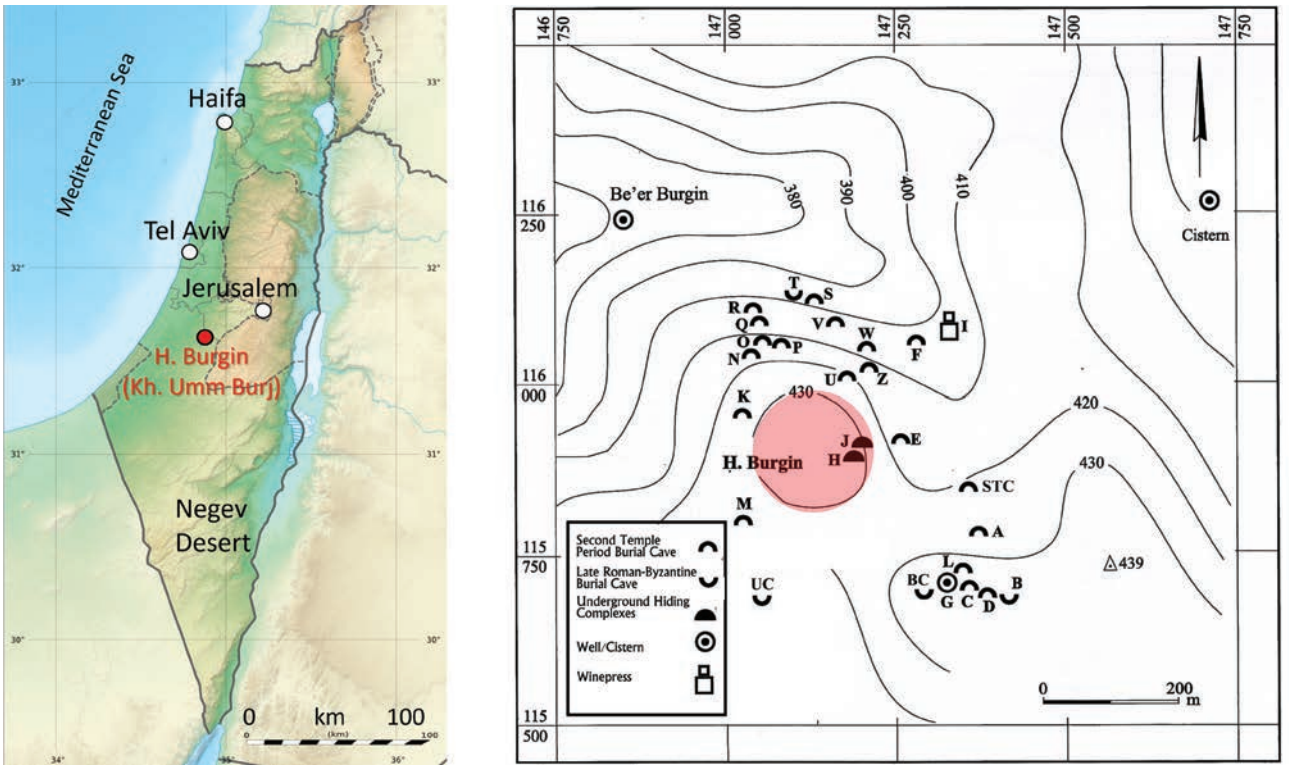

Fig. 1 Location of Horvat Burgin and general plan of the subterranean complexes at the site (after Zissu et al. 2013, corrected by the author)

The cemeteries surrounding the site include at least 25 rock-cut tomb chambers and burial complexes, many of them associated with Jewish funerary practices of the Hellenistic and Roman periods. These typically comprise *kokhim* (loculi), *ossilegium* niches, and, in some cases, ossuaries, reflecting well-established Judean burial customs (Kloner & Zissu 2007). The architectural diversity of these tombs - ranging from relatively simple chambers to elaborate multi-chamber complexes - indicates varying levels of investment in funerary architecture and suggests a degree of social differentiation within the local population.

Within this broader context, Burial Complex P ("the Lions' Tomb") stands out as a monumental, though poorly preserved, subterranean complex of considerable interpretive value. It encapsulates, within a single installation, the *longue durée* of underground activity characteristic of the Judean Shephelah. The complex was briefly noted by Zissu and Ganor (2008, Tomb P) and is presented here in detail for the first time.

Burial Complex P: Architectural Description and Multi-Phase Analysis

The burial complex is a large and elaborate rock-cut complex whose quarrying was never completed. It originally comprised a trapezoidal courtyard (P1; c. 8 × 17 m), now filled with alluvium, collapse debris, and later Ottoman-period construction (Figs. 3, 4a-b).

Openings leading to antechambers were cut into three sides of the courtyard - the southern (P2.1), eastern (P3.1), and western (P4.1) walls. These rectangular antechambers were intended to provide access to separate burial units. Of these, only the southern complex (P2; P2.2: "The Lions' Tomb") was completed, while the eastern and western complexes remained only partially hewn and apparently never reached full functionality.

The antechamber in the eastern wall (P3.1) measures 3.0 × 3.1 m. Its walls are generally well preserved. On the northern wall, two carefully hewn rectangular niches (P3.1.1; P3.1.2; c. 50 × 60 cm) were carved. Similar installations are known from other burial complexes at the site and elsewhere and are commonly interpreted as *ossilegium* compartments intended for the individual collection of bones in secondary burial (fig. 5).

Originally, an opening in the southern wall of this antechamber led into a rectangular chamber (P3.2; 3.8 × 4.2 m; maximum preserved height up to the accumulation: 1.9 m), which was likely the intended burial chamber. This opening was probably sealed by a blocking stone, one example of which is located in the debris filling the chamber. In a later phase, typical columbarium niches were cut into the eastern and western walls of this chamber, indicating a secondary use (see discussion below) (Fig. 6).

Subsequently, an oval bell-shaped cavity (P5; c. 7 × 6.6 m; maximum height above the debris: 7.5 m) was quarried from the surface, cutting through and damaging the southern wall of the columbarium chamber (P3.2). This cavity was accessed via a stepped *dromos*,

Fig. 2. Aerial view of Horvat Burgin and its surroundings, looking south. Burial Complex P marked in red (photo by the author)

Fig. 3. Burial Complex P, looking south: courtyard (P1) filled with later walls and debris (photo by the author)

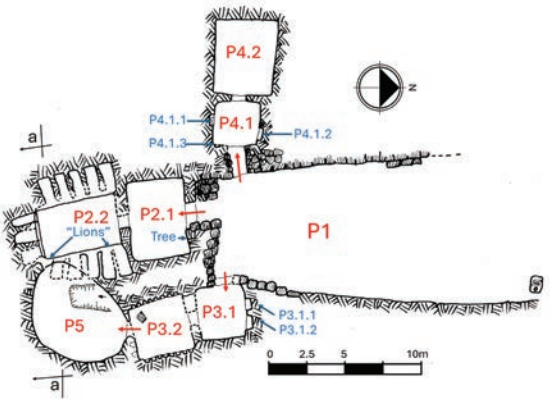

Fig. 4a. Plan of Burial Complex P (plan by the author)

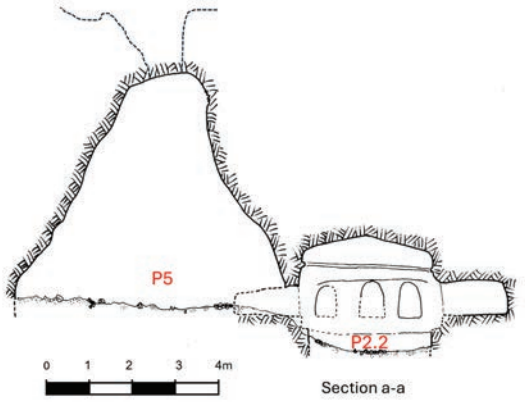

Fig. 4b. Section a–a in Burial Complex P (section by the author)

apparently belonging to an earlier rock-cut installation that was largely obliterated during this phase. Only a large rectangular opening and traces of steps along the southeastern wall survive. The function of this earlier installation remains unclear. The bell-shaped cavity (P5) clearly represents the latest phase of activity in this part of the complex, as it postdates and cuts through both the columbarium chamber (P3.2) and earlier burial features, including loculi in the eastern wall of P2.2 (see below) (Fig. 7).

The antechamber in the western wall (P4.1) measures 2.8 × 3.1 m and leads into a rectangular chamber (P4.2; 5.4 × 4.4 m; maximum preserved height up to the accumulation: 1.7 m), whose walls remain intact and lack typical burial installations such as loculi or benches.

Within the walls of antechamber P4.1, three carefully carved rectangular niches were identified. One niche (P4.1.1; c. 60 × 60 cm) is particularly well executed, with an arched ceiling and a trough-shaped base. A second niche (P4.1.2) is somewhat larger, while a third is markedly smaller (P4.1.3; c. 35 × 20 cm) and may have been intended for the collection of a child's bones (Figs. 8a-b).

The consistent appearance of such niches in both the eastern and western antechambers- combined with the absence of installations typically associated with primary burial, such as loculi or funerary troughs - raises important questions regarding the original function and intended use of these wings within the overall burial complex (P1–P5).

At the center of the southern wall of the courtyard (P1) - the principal façade of the complex - an entrance (c. 1.7 m wide, with doorposts c. 1 m wide) leads into the burial complex designated by us as the "Lions' Tomb" (P2). The entrance is covered by an arched ceiling and opens into a rectangular antechamber (P2.1; 3.7 × 5.4 m; height c. 3 m), whose upper third is adorned with a projecting cornice, (Fig. 9) a feature repeated in the inner burial chamber (P2.2). A circular motif is incised at the center of the ceiling of P2.1 (Fig. 10)

From antechamber P2.1, an opening - later enlarged by quarrying - leads into the main burial chamber (P2.2; c. 3.4 × 5.6 m; maximum preserved height up to the silt accumulation: 3.5 m), which is covered by an arched ceiling forming a gable at its southern end (the façade of burial chamber P2.2). Thirteen loculi were cut into its walls. These loculi have trapezoidal sections and arched or gabled ceilings (average dimensions: 0.7 × 1.9 m; height 0.9 m). Preservation varies: five loculi in the western wall are damaged, three in the southern wall are almost completely destroyed, and five were cut into the eastern wall, of which only three survive, due to extensive destruction caused by the cutting of the adjacent bell-shaped quarry P5. Around the openings of two loculi in the eastern wall, traces of recessed arched frames are preserved (Figs. 11-13).

On the cornice of the eastern wall of P2.2, near its southern and northern corners, two schematic animals are incised in thin lines, depicted in profile and facing north. Each figure measures approximately 12–15 cm in length and 5–7 cm in height. Despite their simplified execution, the general body form and the indication of a mane support their identification as lions, giving the tomb its modern designation (both lions shown separately: Figs. 14-15).

The northern figure is shown in a leaping posture and is accompanied by thirteen short vertical incisions, the significance of which remains unclear. Both figures appear to have been executed by the same hand, as indicated by their technique and style.

Their placement along the cornice creates the impression of a procession, reinforced by their depiction in motion. Together with the patina covering the engravings, this supports their attribution to the original phase of use of the burial complex.

No finds were recovered from the complex. However,

Fig. 5. Eastern wing (P3): antechamber (P3.1) with ossilegium niches (P3.1.1–P3.1.2) (photo by the author)

Fig. 6. Eastern wing (P3): columbarium niches in chamber P3.2, looking south (photo by the author)

Fig. 7. Eastern wing (P3): bell-shaped quarry (P5) cutting earlier installations, looking north (photo by the author)

Fig. 8a. Western wing (P4): antechamber (P4.1) with ossilegium (?) niches (P4.1.1–P4.1.3) (photo by the author)

its elaborate architectural layout - comprising multiple halls - recalls the burial complexes of the Hellenistic period at Tel Maresha (Peters & Thiersch 1905; Oren & Rappaport 1984; Zissu & Kloner 2015; Zissu & Kloner 2025). It is therefore possible that the lions' engravings should likewise be dated to this period and compared, at a general level, with the decorative program of the "Sidonian Tomb." Nevertheless, whereas the latter presents a richly executed procession of animals and human figures painted by a skilled artist, the figures here are rendered in a markedly more rudimentary and schematic manner.

Lion imagery is well attested in Greek and Roman funerary contexts, where it functions both as a marker of status and as an apotropaic guardian of the tomb (e.g., Vermeule 1972; Toynbee 1973; Hunter 2001). The presence of the schematic lions may therefore be understood within this broader symbolic framework, as will be discussed further below.

At the center of the eastern wall a large, engraved cross is present, while near the entrance a further engraving depicting a schematic cross, from whose upper shaft emerges a branching, tree-like form, can be observed (see discussion below; and Figs. 12, 16-17)

Discussion

The history of Burial Complex P can be reconstructed as a sequence of four principal phases: (I) a Hellenistic / Early Roman period burial system; (II) Byzantine Christian reuse; (III) the installation of a columbarium; and (IV) destruction and modification by a bell-shaped quarry.

Monumental burial complex

The original phase represents a monumental rock-cut burial complex belonging to the Judean tradition of family tombs with loculi (*kokhim*), characteristic of the late Hellenistic / Early Roman periods (Kloner & Zissu 2007). The architectural layout - comprising a courtyard, antechambers, and burial chambers - indicates

Fig. 8b. Western wing (P4): antechamber (P4.1), detail of ossilegium (?) niche P4.1.1 (photo by the author)

a carefully planned funerary complex, comparable in conception to those at Maresha (Peters & Thiersch 1905; Oren & Rappaport 1984; Zissu & Kloner 2015; Zissu & Kloner 2025).

The engraved animal figures may also belong to this original phase and can be compared, at a conceptual level – albeit in a highly schematic execution – with the painted frieze of the Sidonian Tomb at Maresha. That hypogeum, dated to the mid-3rd century BCE, is distinguished by an extensive decorative program featuring a continuous procession of real and fantastical animals arranged in dynamic compositions and often accompanied by Greek captions (Peters & Thiersch 1905; Jacobson 2007; Erlich 2009). Drawing on Hellenistic artistic traditions and reflecting connections with the eastern Mediterranean and Ptolemaic Egypt, this program represents one of the most elaborate examples of figurative decoration in a funerary context in the region.

A further perspective for understanding the appearance of the lions is provided by their well-documented role in Greco-Roman funerary art, where they function both as markers of status and as apotropaic guardians of the tomb.

Lion imagery is well attested in Greek and Roman funerary contexts, where it appears both as a marker of status and as a protective, apotropaic device. Archaic examples, such as the lion associated with the Tomb of Menecrates at Corfu (late 7th–6th century BCE; Tribulato 2017), already demonstrate the placement of lion sculpture within a necropolis as a grave marker. This tradition became widespread in Greek and, especially, Roman funerary art, where lions frequently flank tombs, sarcophagi, or entrances. Their formalized postures - seated, recumbent, or vigilant - convey a sense of watchfulness, permanence, and control, closely tied to elite commemoration and the monumentalization of the dead.

Fig. 9. The "Lions' Tomb" (P2): antechamber (P2.1), view looking west, cornice (photo by the author)

Fig. 10. The "Lions' Tomb" (P2): view looking east, cornice and ceiling of antechamber (P2.1) with incised circular motif (photo by the author)

In Classical Greek funerary contexts, lions constitute the most prominent category of sculpted animals, particularly in Attica. As Vermeule has shown, these figures are not naturalistic representations but highly idealized forms shaped by long-standing artistic traditions that combine Near Eastern influences with Greek sculptural conventions (Vermeule 1972, 49–59). Their consistent association with funerary monuments, together with their scale and visual dominance, underscores their symbolic role as guardians of the dead, expressing strength, commemoration, and the enduring presence of the deceased within the funerary landscape (Bliquez 1975, 381–384).

Fig. 11. The "Lions' Tomb" (P2.2): burial chamber, looking south (photo by the author)

Fig. 12. The "Lions' Tomb" (P2.2): engraved cross between two loculi with recessed arched frames, eastern wall (photo by the author)

Beyond their role as markers of status, lions clearly carried a pronounced apotropaic function. Across the Mediterranean, including in closely related Etruscan contexts, they are consistently interpreted as protective guardians of the tomb, safeguarding both the burial space and the deceased in the transition to the afterlife. This function aligns with the broader use of apotropaic imagery in Greco-Roman architecture and ritual, in which powerful and potentially threatening figures were employed to ward off evil influences and protect liminal spaces. Within this framework, funerary lions should be understood as active visual agents mediating between the world of the living and the dead, asserting the inviolability of the tomb (Vermeule 1972, 49 - 59).

In Roman funerary art, this dual symbolism becomes particularly explicit. As Toynbee has demonstrated, lions function simultaneously as symbols of the destructive, "ravening" power of death and of its ultimate defeat (Toynbee 1973, 65 - 69). Motifs such as lions attacking prey or elaborate lion-hunt scenes on sarcophagi operate as allegories of the struggle against death, often interpreted as representing the victory of the soul over mortality and evil. At the same time, lion masks and sculpted lions placed on sarcophagi or tomb monuments reinforce the protective dimension of this imagery, combining ferocity with guardianship. In many cases, the same visual language conveys both threat and protection, encapsulating the ambivalent nature of death itself.

This combination of symbolic and apotropaic meanings is particularly evident in the Roman provinces. As Hunter has shown, funerary lions appear in a wide range of contexts - including free-standing statues, architectural elements, and sarcophagus decoration - continuing a long-standing Mediterranean tradition while adapting it to local conditions (Hunter 2001, 59 - 65). Their iconography frequently emphasizes domination over prey, thereby expressing themes of strength, mortality, and protection. Similarly, in the Danubian and Balkan provinces, lion sculptures often function as architectural components of funerary monuments, serving as crowning figures or flanking guardians. The lion depictions - typically rendered with frontal gaze, open jaws, and, at times, subjugated prey - convey both vigilance and aggression, and are widely interpreted as symbolic protectors of the deceased and their burial space (Popa & Totoianu 2013, 73–90). Rooted in earlier Eastern traditions yet fully integrated into provincial Roman artistic language, such representations articulate a coherent visual vocabulary of funerary protection.

Funerary art in the Roman world more broadly functioned as a key medium for the expression of social identity. Tomb monuments and associated imagery - including animal motifs such as lions - formed part of a wider system of representation through which individuals and families articulated status, cultural affiliation, and prestige (Perna 2019, 314–322). The deployment of lion imagery must therefore be understood within this broader social and ritual framework: it simultaneously signaled elite identity, engaged with widely shared symbolic traditions, and performed a protective, apotropaic role within the funerary sphere.

Taken together, the evidence indicates that the lion in Greek and Roman funerary contexts operated on multiple, overlapping levels. It marked status and commemoration, embodied the power and danger of death, and, crucially, served as a guardian figure protecting both tomb and deceased. Its persistent presence across regions and periods reflects not only the durability of the motif but also its effectiveness as a visual expression of the fundamental tensions inherent in funerary representation - between vulnerability and protection, mortality and transcendence.

Against this broader background, the engravings in Burial Complex P are markedly schematic and lack the narrative and artistic complexity characteristic of both

Fig. 13. The "Lions' Tomb" (P2.2): burial chamber looking east towards breach created by later cutting of P5, arrows indicate location of lions (photo by the author)

Fig. 14. The "Lions' Tomb" (P2.2): northern lion engraved on the cornice, eastern wall (photo by the author)

the Maresha paintings and the majority of Greco-Roman parallels. Nevertheless, the very inclusion of lion figures within a funerary context may be understood as a distant and highly simplified echo of this wider symbolic and apotropaic tradition, adapted in a local and reduced visual language.

The presence of lion imagery in this context is particularly intriguing in light of the question of the identity of the tomb's owners. If the complex and its engravings are to be dated to the Hellenistic period and associated with a non-Jewish population, the appearance of such figurative representations is readily understandable; however, if they belong to the Early Roman period and reflect a Jewish context, they would constitute a rare instance of animal depiction, given the well-documented avoidance of figural imagery in Jewish art from the Hasmonean period through the Bar Kokhba revolt, often associated with a strict interpretation of the Second Commandment (Hachlili 1988; Fine 2005).

The second phase is marked by Byzantine Christian reuse, as indicated by an engraved cross and a related combination of a cross and a tree (discussed below). These symbols reflect the transformation of subterranean spaces into *loci* of Christian activity, a well-documented phenomenon, in which earlier Jewish rock-cut tombs and other subterranean installations were reoccupied, reinterpreted, and integrated into a Christian sacred landscape (Zissu 1999; Di Segni 2007).

Across the Judean Shephelah and adjacent regions, burial complexes originally hewn and used during the late Hellenistic - Early Roman periods underwent a process of cultural and theological reconfiguration. This transformation extended beyond pragmatic reuse, reflecting a deliberate appropriation of the material remains of the past within emerging Christian systems of sanctity, memory, and sacred geography.

Archaeological evidence demonstrates that such reuse took multiple forms, ranging from the simple marking of earlier tombs with crosses to the full architectural conversion of tomb complexes into churches and chapels (Di Segni 2007). A key example is provided by Horvat Qasra, where a monumental Jewish burial complex of the first–second centuries CE- featuring a courtyard, decorated façade, and burial chambers - was extensively transformed in the Byzantine period into a Christian cult complex (Di Segni & Patrich 1990; Kloner 1990; Taylor & Zissu 2023).

At Horvat Qasra, the modifications included the construction of an atrium and vestibule, the installation of a baptistery and water system, and the conversion of burial chambers into a subterranean chapel. The earlier funerary architecture was not erased but reinterpreted: burial spaces were adapted into liturgical settings, and the internal organization of the complex was reconfigured to accommodate Christian ritual practices, including the installation of a chancel and designated areas for clergy and worshippers. Such transformations indicate a deliberate and systematic integration of earlier structures into a new religious and architectural framework.

The Christian phase of these complexes is most clearly expressed through symbolic and epigraphic additions. Engraved and painted crosses, staurograms, and inscriptions invoking Christ or saints served to mark the space as Christian and redefine its meaning. At Horvat Qasra, the cave chapel preserves a rich corpus of graffiti in Greek, Syriac (Christian Palestinian Aramaic), and Arabic, reflecting prolonged devotional activity and the multilingual character of the local population (Di Segni & Patrich 1990; Drori 1990; Naveh 1990).

Many of these inscriptions follow standard formulae of supplication, invoking divine mercy or the intercession of saints. Particularly significant are inscriptions addressed to Saint Salome (Ἁγία Σαλώμη), indicating that the tomb had been reidentified as her burial place and functioned as a locus of veneration (Ameling et al.

Fig. 15. The "Lions' Tomb" (P2.2): southern lion engraved on the cornice, eastern wall (photo by the author)

2018, nos. 3792, 3793, 3794, 3797, 3798). The presence of liturgical arrangements - such as a chancel, nave-like organization, and martyrium - suggests that the complex was structured around the cult of relics (Wilson 1984).

This transformation is closely connected to the phenomenon of *inventio loca sancta*, that is, the identification of ancient tombs with biblical or early Christian figures. As noted by Di Segni, this process had a distinctive impact in Byzantine Palestine, where earlier tombs were reinterpreted as the burial places of scriptural figures, often leading to the establishment of memorial churches that functioned as centers of pilgrimage and devotion (Di Segni 2007, 381 - 401).

In contrast to other regions of the Christianized Roman Empire, where such identifications were typically associated with martyrs, in Palestine they often focused on biblical figures. The visible antiquity of rock-cut tombs played a crucial role in this process, lending credibility to their identification with revered personages. The transformation of the Horvat Qasra burial complex into the Chapel of Saint Salome thus fits within a broader pattern of Christian appropriation of earlier Jewish funerary landscapes.

Comparable, though often less elaborate, forms of reuse are attested at other sites. At Horvat Burgin, crosses and Christian symbols carved into the walls of earlier burial caves indicate their reoccupation by Christian communities, including monks or anchorites, during Late Antiquity (Zissu & Ganor 2008; Tchekhanovets 2010). In one case, inscriptions in Asomtavruli Georgian script suggest continued use of underground spaces into the medieval period, pointing to long-term continuity of Christian presence.

Such reuse was frequently embedded within broader ecclesiastical and monastic contexts. At Horvat Qasra, the cave chapel appears to have formed part of a larger complex, possibly associated with a monastery serving local or regional pilgrims. Similar configurations are known from sites such as Bir el-Qut and Horvat Hani (Dahari 2003; Di Segni 2007, 391), although these complexes were not necessarily located along major pilgrimage routes and may have functioned primarily within local devotional networks.

An additional dimension of this phenomenon is its persistence into the Early Islamic period. At Horvat Qasra, the cult of Saint Salome continued into the eighth–ninth centuries CE, as evidenced by Arabic inscriptions employing Christian formulae (Drori 1990). These inscriptions reflect processes of linguistic and cultural transformation, including the Arabization of Christian communities, prior to full Islamization. The continued use of such sites underscores the durability of their sacred status across shifting political and religious contexts.

Taken together, the archaeological and epigraphic evidence demonstrates that the Byzantine reuse of Jewish rock-cut tombs was a complex and intentional process, involving not only the physical adaptation of earlier structures but also their symbolic redefinition within a new religious framework. This phenomenon reflects a profound transformation of the landscape, in which the material remains of the Jewish past were appropriated and reinterpreted as part of a distinctly Christian sacred geography.

Within this broader symbolic and devotional context, the engravings documented in the present complex may be more closely considered.

One of the most notable motifs is a prominently carved cross on the eastern wall, accompanied near the entrance by a second, more schematic composition. This latter engraving depicts a cross from whose upper shaft emerges a branching, tree-like form. The vertical shaft, extending from just above the lower bedding joint to the branching zone, measures approximately 11 cm in height, while the crown of branches extends to a width of c. 6 cm. The execution is linear and highly schematic, yet the compositional logic - an axial element generating vegetal offshoots - is clear.

This representation may be understood in light of the early Christian identification of the Cross with the *lignum vitae*, the life-giving Tree of Life. The underlying typology is already clearly articulated in Irenaeus, who contrasts the tree through which humanity became indebted to God with the tree through which redemption is effected (Adversus Haereses V.17.3). In later Christian tradition, the identification becomes more explicit: the Cave of Treasures describes the Tree of Life in Paradise as a figure of the redeeming Cross, "the veritable Tree of Life." Modern scholarship has shown that this association remained central to Late Antique and Byzantine visual and theological conceptions of the Cross (Reijners 1965; Baranov 2015; Jensen 2017). The present rendering may therefore preserve a simplified and local expression of this broader symbolic tradition.

Columbarium and the economic reuse of subterranean space

The third phase in the history of Burial Complex P is marked by the conversion of part of the complex into a columbarium. This intervention represents a clear functional shift from funerary and cultic functions to economic activity and must be understood as a secondary reuse of an earlier subterranean installation.

At Horvat Burgin, as elsewhere in the Judean Shephelah, the reuse of pre-existing underground cavities for new purposes is well attested (Zissu et al. 2021). In the case of the "Lions' Tomb," the insertion of a columbarium into the burial complex does not reflect any functional or symbolic continuity with its original funerary role. Rather, it represents a later and entirely different use of the space, following the abandonment of its primary function as a burial installation.

Columbaria (dovecotes) constitute one of the most characteristic features of the subterranean landscape of the Judean Shephelah. Archaeological surveys have identified approximately one thousand installations in Israel, of which nearly nine hundred are concentrated in this region alone (Tepper 1986, 177). These installations, dated from the Hellenistic period through the Early Islamic period, appear in both rock-cut subterranean forms - particularly suited to the chalk geology of the Shephelah - and in freestanding-built structures (Zissu 1995).

Earlier interpretations occasionally proposed funerary or cultic functions for such installations. However, these suggestions have been consistently rejected by archaeological analysis. The absence of cremation practices among local populations, the clear architectural distinction between columbarium niches and burial loculi, the lack of human remains in well-preserved contexts such as Maresha, and the impracticality of large-scale cremation in a fuel-scarce environment all argue decisively against a funerary interpretation (Kloner 2003, 45; Kloner & Zissu 2013; Kloner et al. 2023).

Instead, there is broad scholarly consensus that columbaria functioned for the large-scale breeding of pigeons. This interpretation is supported by archaeological finds, ethnographic parallels, and textual evidence (Hirschfeld & Tepper 2006; Tepper et al. 2018). Excavated installations have yielded pigeon remains, while similar structures remained in use into modern times in Egypt and Iran and Cappadocia under comparable environmental conditions (Boak & Petersen 1931; Beazley 1966; Amirkhani et al. 2010; Tok & Yamaç 2015; Bixio et al. 2023).

The primary economic function of these installations was the production of fertilizer. Pigeon manure, rich in nitrogen, phosphorus, and potassium, constituted a highly valued agricultural resource, particularly in the

Fig. 16. The "Lions' Tomb" (P2.2): detail of engraved cross, lower part cut by later quarrying (photo by the author)

limestone soils of the Shephelah. Each bird could produce approximately 10 kg of manure annually, and installations containing hundreds or thousands of niches were capable of generating substantial quantities (Tepper 1986, 188–189; Tepper 2007). Classical agronomic writers - including Varro (Rerum Rusticarum 1.38.1; 3.7–8), Columella (De Re Rustica 2.14.1), and Pliny (Natural History 17.50–52) - explicitly emphasize the agricultural value of pigeon dung.

The scale and distribution of columbaria in the Shephelah indicate that pigeon breeding formed a significant regional economic sector. At Maresha alone, more than eighty-five rock-cut columbaria have been documented, containing over fifty thousand niches (Kloner 2003, 45; Kloner & Zissu 2013). This concentration reflects both favorable geological conditions and the integration of pigeon breeding into broader systems of agricultural production.

Although doves and pigeons also held ritual significance - appearing in biblical sacrificial legislation (Lev 1:14; 5:7; 12:8) and in rabbinic discussions of pigeon breeding (Safrai 1994, 99–100, 174–179) - such associations do not define the primary function of columbaria. In the archaeological record of the Land of Israel, these installations are overwhelmingly agricultural in nature and are typically integrated into broader rural infrastructure, alongside cisterns, presses, and storage facilities (Tepper 1986; Tepper et al. 2018).

Rare cases in which columbaria appear within funerary or cultic contexts - such as the mausoleum at Mazor (Zissu 2025) or epigraphic evidence from Syria and Transjordan (Di Segni 1988; Gatier & Vérilhac 1989) - demonstrate that symbolic or ritual associations could occasionally intersect with economic functions. However, such examples remain exceptional and should not be taken as representative of the general phenomenon.

In the case of Burial Complex P at Horvat Burgin, the evidence clearly supports the interpretation of the

Fig. 17. The "Lions' Tomb" (P2.2): schematic cross–tree graffito near the entrance (photo by the author)

columbarium as a secondary, utilitarian installation, unrelated to the original funerary function of the cave. Its insertion reflects a broader pattern of adaptive reuse in the Judean Shephelah, whereby abandoned burial caves and other subterranean spaces were repurposed for agricultural and economic activities.

The transformation of the "Lions' Tomb" from a burial complex into a columbarium thus illustrates a fundamental shift in both the use and meaning of subterranean space, from commemorative and symbolic functions to practical and productive ones. In this respect, the complex provides a particularly clear example of the economic reutilization of earlier cavities within the long-term development of the Shephelah landscape.

Bell-shaped chalk quarrying and the industrial reconfiguration of subterranean space

The final phase in the history of Burial Complex P is represented by the intrusion of a bell-shaped quarry, which caused substantial damage to the earlier architecture. Such quarries are characteristic of the Judean Shephelah and frequently intersect earlier subterranean systems, marking a decisive transformation in both the function and meaning of these spaces.

Hundreds of examples are known, particularly in the vicinity of Beth Guvrin (Ben-Arieh 1962; Kloner & Frumkin 1989; Zissu & Kloner 2014a). Their morphology reflects the geological conditions of the region, where a hard calcrete (*nari*) layer overlies softer limestone (*kirton*), creating optimal conditions for underground quarrying. Extraction typically followed a standardized procedure: a narrow vertical shaft was first cut through the *nari* crust, after which the cavity was expanded laterally within the softer chalk, producing the characteristic bell-shaped profile. The quarrying process left clear and diagnostic traces, including stepped extraction surfaces and recessed cutting scars that document the sequence of block removal.

These underground systems often reflect prolonged and multi-phase quarrying activity. In many cases, earlier installations- such as burial caves, hiding complexes, columbaria, and storage facilities - were cut through during quarrying and remain visible along the walls of the cavities at various heights (Kloner & Zissu 2003; Zissu & Kloner 2014a; Zissu & Kloner 2014b). At times, such preexisting features were deliberately exploited by quarrymen, who used them to bypass the hard *nari* layer and gain more rapid access to the workable chalk below. Over time, individual cavities, sometimes originating in different periods, were interconnected to form extensive underground systems, enhancing extraction efficiency, although occasional collapses may also have contributed to such connections.

Current evidence suggests that the earliest bell-shaped cavities date to the Hellenistic period, particularly at Maresha (Kloner 2003; Kloner & Zissu 2013), while the majority belong to the Roman, Byzantine, and Early Islamic periods (1st–8th centuries CE). This chronological distribution corresponds closely with phases of intensified urban development in the region, especially the expansion of Beth Guvrin–Eleutheropolis. The quarried chalk blocks were widely used in construction and were transported across the Coastal Plain, supplying major urban centers such as Ramla, Yavneh, and other sites (Zissu & Kloner 2014a).

Despite their abundance, the precise dating of individual bell-shaped cavities remains methodologically challenging. Several approaches, however, provide useful chronological indicators. Relative dating may be derived from the stratigraphic relationship between quarrying activity and earlier installations that were cut or partially destroyed during excavation. More precise evidence is provided by inscriptions and symbols engraved by quarrymen at elevated positions on cavity walls during the extraction process. Christian symbols, personal names, and inscriptions attest to activity during the Byzantine period, while Arabic inscriptions in Kufic script invoking Allah indicate continued quarrying into the Early Islamic period. In cases where both types of inscriptions appear on the same surfaces - as at Luzit (Deir-Duban) - they provide compelling evidence for continuity of quarrying activity across these periods (Sharon 1997; Zissu & Kloner 2014a).

Following the cessation of extraction, exhausted cavities were frequently subjected to extensive secondary

reuse. Documented transformations include their conversion into cisterns through plastering and hydraulic modification; their adaptation as columbaria, with the addition of niches for pigeon breeding; their use for storage and industrial activities, including oil production and refuse disposal (Zissu et al. 2021); and their incorporation into religious contexts, serving as chapels or hermitages during the Byzantine period (Zissu 1999; Zissu & Gass 2022).

The walls of these cavities preserve abundant evidence for their prolonged and multi-functional use. Engraved symbols, personal names, occupational marks, and pilgrimage graffiti provide valuable insights into the identities and activities of quarrymen, craftsmen, and later users. The stable microclimatic conditions within these underground spaces have enabled the preservation of such inscriptions over long periods, rendering bell-shaped cavities important archives of social, economic, and religious activity across multiple historical horizons.

In the case of the "Lions' Tomb" at Horvat Burgin, the intrusion of a bell-shaped quarry represents the most radical transformation of the complex. Unlike earlier phases of reuse, which adapted the existing structure to new functions, quarrying activity actively dismantled and reconfigured the original burial complex. This phase reflects a fundamental shift from commemorative and symbolic uses of subterranean space to large-scale industrial extraction, illustrating the final stage in the long-term transformation of the site.

Conclusions

The analysis of Burial Complex P ("the Lions' Tomb") at Horvat Burgin demonstrates that the complex is best understood as a multi-phase installation reflecting a long sequence of cultural transformations. The architectural and contextual evidence allows the reconstruction of a coherent developmental trajectory, in which successive phases of use were superimposed upon one another, each redefining the function and meaning of the subterranean space.

The original phase, dating to the late Hellenistic–Early Roman period, represents a carefully planned and architecturally elaborate burial complex, belonging to the well-established Judean tradition of rock-cut family tombs with *kokhim*. Its scale, layout, and decorative features - including the unusual animal engravings, most notably the schematic lions, as well as the cross–tree graffito - place it within the broader cultural milieu of the Maresha–Beth Guvrin region, while also suggesting a degree of local adaptation and variation within this tradition. These elements further provide important insight into the symbolic and cultural frameworks associated with both the original funerary phase and its later reinterpretations.

The subsequent Byzantine phase marks a significant conceptual shift, in which the burial complex was reinterpreted within a Christian religious framework. The addition of crosses and related symbols reflects a broader regional phenomenon, whereby earlier Jewish funerary spaces were incorporated into a Christian sacred landscape. This process, closely associated with the phenomenon of *inventio*, involved not only the physical reuse of existing structures but also their symbolic redefinition as *loci* of sanctity, memory, and devotional practice. Within this context, the cross–tree graffito may be understood as a local and schematic expression of the widespread early Christian identification of the Cross with the *lignum vitae*, further reinforcing the symbolic transformation of the space. In this respect, the Lions' Tomb participates in a wider pattern of cultural appropriation and reinterpretation characteristic of Late Antique Palestine.

The third phase, represented by the installation of a columbarium, introduces a fundamentally different mode of use. Unlike the Byzantine phase, which reinterpreted the symbolic significance of the cave, the columbarium reflects a pragmatic and economic reutilization of the space. The evidence clearly indicates that this installation was unrelated to the original funerary function of the complex and should be understood as a secondary adaptation of an abandoned burial cavity. This phase exemplifies a broader pattern in the Judean Shephelah, in which subterranean spaces were incorporated into agricultural production systems, particularly for pigeon breeding and fertilizer production, thereby integrating them into the economic infrastructure of the region.

The final phase, marked by the intrusion of a bell-shaped quarry, represents the most radical transformation of the complex. In contrast to earlier phases of reuse, which adapted the existing structure to new functions, quarrying activity actively dismantled and reconfigured the original burial installation. This phase reflects a shift from symbolic and commemorative uses of subterranean space to large-scale industrial extraction, corresponding to broader processes of economic intensification in the Beth Guvrin–Eleutheropolis region during the Roman, Byzantine, and Early Islamic periods.

Taken together, these phases illustrate a continuous and dynamic process of spatial redefinition. The sequence - burial, religious reinterpretation, economic reuse, and industrial exploitation - represents a cumulative and interconnected transformation of the subterranean environment. Each phase both preserved and altered elements of the preceding one, producing a complex palimpsest in which earlier meanings were not entirely erased but recontextualized within new cultural frameworks.

More broadly, the Lions' Tomb provides a particularly clear and well-documented example of the *longue durée* of subterranean use in the Judean Shephelah. It illustrates the remarkable flexibility of rock-cut spaces, which could be repeatedly adapted to changing social, religious, and economic conditions. In this respect, the complex serves as a representative microcosm of the broader regional landscape, in which subterranean installations functioned as enduring and mutable elements within the historical development of settlement, economy, and religious practice.

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ANCIENT HYDRAULIC WORKS

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Bridging Different Technologies to Survey a Culverted Stream in a Historical Center of Great Cultural Value (Genoa World Heritage Site, Italy)

Francesco Faccini[1, 2*], Andrea Ferrando[3], Andrea Rimassa[4], Stefano Saj[2, 5], Martino Terrone[4], Stefania Traverso[4]
[1] *University of Genoa, Department of Earth, Environmental and Life Sciences, Italy*
[2] *Underground Research Center, Genoa, Italy*
[3] *University of Modena and Reggio Emilia, Department of Geological and Chemical Sciences, Italy*
[4] *Municipality of Genoa, Digitalisation Technologies Department and Smart City, SIT office, Italy*
[5] *Opera Ipogea, Journal of Speleology in Arficial Cavities, Italian Speleological Society*
**Corresponding author: faccini@unige.it*

Abstract

The city of Genoa is internationally well known because between the Middle Age and the Modern Age it was an important maritime republic: since 2006, Genoa's historic centre has been declared a UNESCO World Heritage Site, with its "Le Strade Nuove and the system of the Palazzi dei Rolli".
The physical-geography setting, characterised by the amphitheatre-like morphology between the "Lanterna" (Lighthouse) to the west and the Carignano hill to the east, and emphasised by the 17th-century "Mura Nuove" (New Walls), has influenced the development of the historic city.
In this area of just 8.5 km^2, there are eight watercourses with catchment basin ranging from 0.49 km^2 to 2.36 km^2: the hydrographic network flows into the port of Genoa with water discharge between 27 m3/s and 103 m3/s for a return period of 200 years.
These streams have been subject to human interference since the Middle Age, with diversions, rectifications and canalisation; today, the hydrographic network is almost entirely culverted, flowing beneath the streets and buildings of the historic centre. The names of some alleys recall their presence, which would otherwise be really imperceptible.
The construction of these culverts over time and urban changes in subsequent centuries have led to a reduction in the hydraulic section, which can cause the water to circulate under pressure and consequently lead to a risk of flooding in the alleys of the historic centre.
A correct assessment of these culverted streams is essential not only for the enhancement and conservation of cultural heritage, but also for the hazards and risks assessment.
The research shows insight on new surveys carried out in Sant'Anna stream, with an area of 0.72 km^2 and a elevation difference of approximately 220 m.
It is a composite basin with two stream branches, called conduit Caffaro and conduit Sant'Anna, which join in Piazza Portello and are divided by the ridge crossed by the upper and lower Sant'Anna rise. The right creek flows under Via Caffaro, while the left one affects the route of the Portello-Magenta funicular railway. After joining, the two creeks flow through the UNESCO World Heritage Site, descending Via Luccoli, Piazza Campetto, Via Orefici and Piazza Banchi, and flowing into Piazza Caricamento.
The lower part of the basin, following intense and short-duration rainfall and due to the hydraulic inefficiency of the culvert, occasionally causes flooding in the ground floors of buildings.
The first systematic and comprehensive survey was carried out using traditional topographic techniques in 1980. In 2000, as part of the Civis Project, the survey was restored and updated in digital format. Finally, very recently, new surveys have been carried out, both using innovative techniques and new direct observations in the underground environment.

Keywords: Genoa; culverted streams; hydraulic heritage; urban flooding; UNESCO World Heritage

Introduction

Artificial cavities represent a significant part of the underground heritage of many Mediterranean cities (Parise et al. 2013; Varriale et al. 2022; Galeazzi et al. 2025). Among them, culverted watercourses constitute a peculiar category of anthropogenic underground landscape, resulting from centuries of interaction between natural geomorphological processes and urban development (Brandolini et al. 2020). Earlier characterized by open channels draining small coastal catchments, many urban streams were progressively diverted, rectified and also culverted in order to provide new building areas, improve sanitary conditions and facilitate the expansion of urban settlements (Bixio et al. 2015). Although these interventions contributed to urban growth, they also generated complex underground systems whose geometry, state of preservation and hydraulic functionality are often only partially known (Fabiano et al. 2026).

The city of Genoa (NW Italy) represents a particularly significant case study. Developed within a natural amphitheater overlooking the Ligurian Sea and bounded by steep slopes, the historic urban fabric expanded over a dense hydrographic network composed of short and steep catchments (Lanza 2003; Faccini et al. 2023a). Since the Middle Ages, most of these watercourses have undergone extensive anthropogenic modifications and today flow beneath streets, squares and historical buildings, including areas belonging to the UNESCO World Heritage Site "*Le Strade Nuove and the system of the Palazzi dei Rolli*" (Faccini et al. 2023b). Previous studies highlighted how these culverted streams represent both a valuable component of urban geoheritage and a potential source of hydro-geomorphological hazard, mainly in relation to intense rainfall events and climate-change-induced increases in flood frequency and magnitude (Bixio et al. 2017).

Over the last decades, the underground hydrographic network of Genoa has been progressively investigated through historical research, direct speleological explorations, topographic surveys and GIS-based inventories (Brandolini, Sbardella 2001). Important contributions have concerned the reconstruction of the historical evolution of the waterways, the assessment of flood-related hazards and the documentation of the underground environment (Brandolini et al. 2018; Faccini et al. 2021). Nevertheless, several sectors remain difficult to access or inadequately documented because of operational constraints, safety issues and hydraulic conditions.

Recent technological developments offer new opportunities for the investigation of underground environments. In particular, confined-space drones equipped with high-resolution cameras and LiDAR sensors allow the acquisition of detailed geometric and visual information in areas where traditional surveys may be difficult, time-consuming or unsafe (Conejo-Martín et al. 2015). These systems are increasingly used for industrial inspections, mining applications and infrastructure monitoring, but their use in artificial cavities and urban underground waterways remain relatively limited.

Within this framework, this preliminary research focuses on the Sant'Anna Stream, one of the culverted watercourses crossing the historical center of Genoa (Fig. 1). The study integrates historical documentation, previous surveys, direct underground observations and a recent survey carried out using the Elios 3 confined-space drone. The aim is to evaluate the contribution of drone-based technologies to the documentation of complex underground environments and to discuss their integration with traditional speleological and topographic methods in the perspective of heritage conservation, risk assessment and urban underground management.

The Sant'Anna Stream Basin

The Sant'Anna Stream drains a small catchment located within the historical morphological amphitheatre of Genoa, between the Polcevera and Bisagno valleys. The basin covers approximately 0.72 km² and is currently almost entirely urbanized. Despite its limited extension, the stream has played an important role in the historical development of the city because its valley represented one of the natural drainage pathways descending from the hills towards the ancient harbour (Fig. 2).

From a geomorphological point of view, the catchment is characterized by steep slopes and a marked elevation gradient between the upper sectors and the coastal area. The original hydrographic network developed on flysch formations belonging to the Ligurian Apennine geological units, while the lower sectors are occupied by anthropogenic deposits and urban infrastructures built-up during centuries of city growth.

Historical cartography and documentary sources indicate that the Sant'Anna Stream originally flowed in an open channel through what is now one of the most densely urbanized sectors of Genoa (Barbieri 1938; Grossi Bianchi & Poleggi 1982). The progressive expansion of residential areas and road networks led to the gradual covering of the watercourse, a process that probably began during the late medieval period and continued throughout the modern age. Today, the stream is entirely culverted and flows beneath buildings, roads and public spaces.

The basin presents a composite configuration. Two main branches originate in the upper part of the catchment and converge near Piazza Portello. The western branch develops below Via Caffaro, while the eastern branch follows the alignment of the Portello–Magenta funicular.

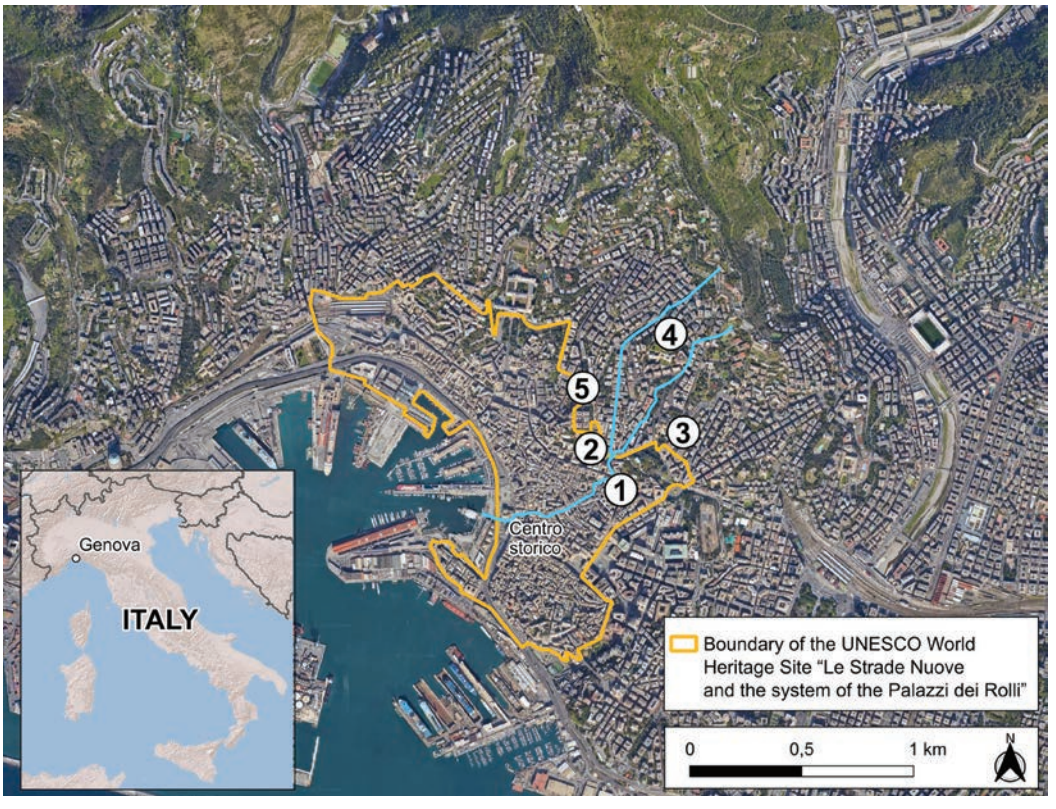

Fig. 1. Geographic setting of the study area showing the course of the Rio Sant'Anna (in blue), the perimeter of the Historic Centre of Genoa UNESCO World Heritage site (in yellow), and the following landmarks: (1) Fontane Marose Square; (2) Portello Square; (3) Convent of the Holy Father of the Capuchin Friars; (4) Convent of Sant'Anna of the Carmelite Friars; (5) Castelletto Esplanade (base map: Google Earth Pro; graphic by A. Ferrando and S. Saj)

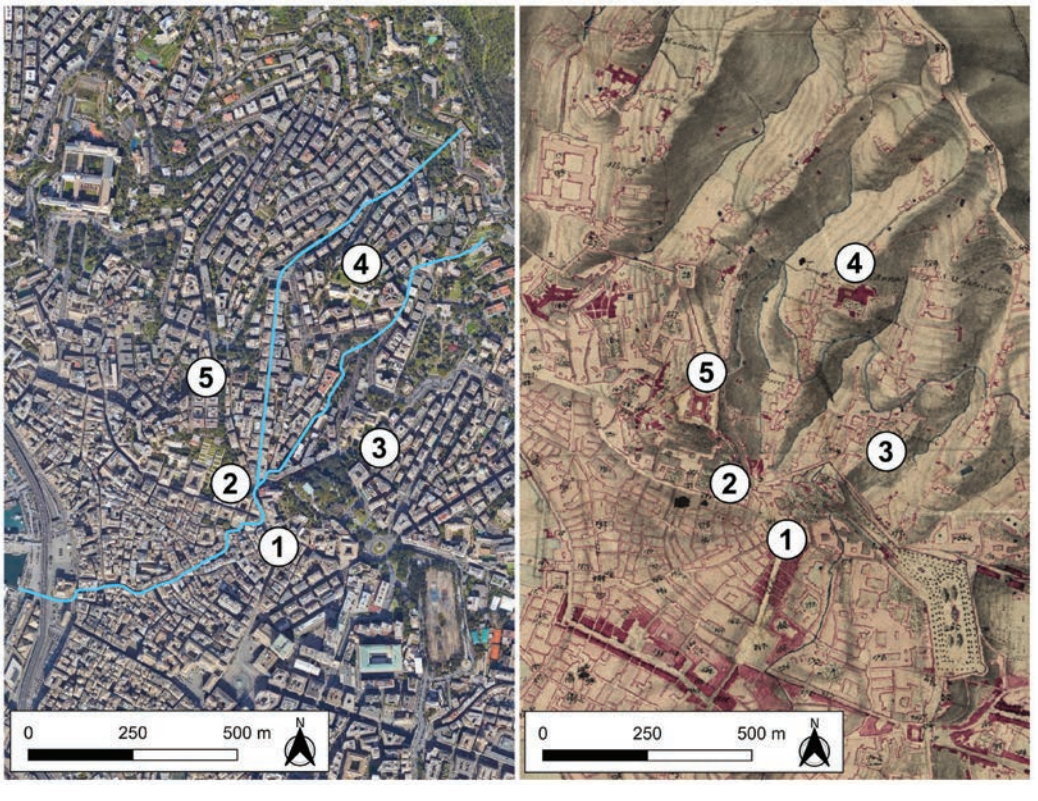

Fig. 2. (left) Detail of the urban setting of the study area showing the following information: Rio Sant'Anna (in blue); (1) Fontane Marose Square; (2) Portello Square; (3) Convent of the Holy Father of the Capuchin Friars; (4) Convent of Sant'Anna of the Carmelite Friars; (5) Castelletto Esplanade (Orthophotomap base map; graphic by A. Ferrando and S. Saj) / (right) Identical detail of the study area in 1816 displaying the same information (map base: "Carta di Genova degli Stati Sardi"; graphic by A. Ferrando and S. Saj)

Fig. 3. Underground rooms of Palazzo San Giorgio, once traversed by the Rio Sant'Anna (Centro Studi Sotterranei' s Archive; photo by G. Bologna, 1996)

Downstream of their confluence, the stream continues beneath Via Luccoli, Piazza Campetto, Via Orefici and Piazza Banchi before reaching the waterfront area near Piazza Caricamento.

In ancient times, the Sant'Anna River flowed beneath Palazzo San Giorgio (Fig. 3) – a 13th-century building that once housed the Bank of Saint George and is now the headquarters of the Western Ligurian Sea Port Authority (Fig. 4) – before emptying into the harbor basin (Fig. 5).

The present underground course (Fig. 6) crosses sectors of exceptional historical and cultural value. Large portions of the conduit lie beneath the UNESCO World Heritage Site and under buildings that constitute an important part of Genoa's architectural heritage Consequently, knowledge of the geometry and condition of the culvert is relevant not only for hydraulic purposes but also for the management and preservation of the urban historical underground landscape.

From a hydraulic perspective, the Sant'Anna Stream represents one of the critical elements of the historical center drainage system. Previous studies highlighted the occurrence of localized flooding in the downstream sectors of the basin during intense rainfall events (Bixio et al. 2017; Faccini et al. 2023a). These conditions are related to the limited hydraulic capacity of some sections of the culvert, the progressive urbanization of the catchment and the high runoff rates typical of Mediterranean urban basins (Fabiano et al. 2026).

The estimated peak discharge associated with a 200-year return period reaches approximately 44 m^3/s, a value that is significant considering the limited dimensions of the catchment. The interaction between natural hydrological processes, historical modifications of the riverbed and present-day urban constraints make the Sant'Anna Stream a significative case study for testing innovative survey methodologies aimed at improving the knowledge of underground waterways.

From Traditional Surveying to Digital Documentation

Knowledge of the Sant'Anna Stream has progressively developed through the integration of different survey approaches. The first systematic investigations were carried out during the late twentieth century using traditional topographic techniques and direct underground exploration. These activities provided the first comprehensive reconstruction of the underground course and represented a fundamental basis for subsequent studies (Studio Lotti 1980).

The survey performed in 1980 represented the first detailed documentation of the culverted watercourse (Fig. 7). Measurements were collected through conventional surveying methods, combining direct observations, topographic measurements and single control points on manhole covers. Although constrained by the technological limitations of the period, this work produced an accurate representation of the main conduit geometry and established the reference framework for future investigations.

A second important phase occurred within the Civis Project, promoted by the Municipality of Genoa around 2000. During this activity, the available documentation

Fig. 4. Palazzo San Giorgio (Centro Studi Sotterranei' s Archive; photo by R. Bixio, 2018).

Fig. 5. The historical outlet of the Rio Sant'Anna into the water body of the Porto Antico (Centro Studi Sotterranei' s Archive; photo by R. Bixio, 2018)

Fig. 6. Culverted sections of the Rio Sant'Anna (Centro Studi Sotterranei' s Archive)

concerning artificial cavities and culverted waterways was digitized and integrated into a GIS environment (Fig. 8). This process allowed the georeferencing of historical surveys and their comparison with the urban fabric, creating a valuable database for planning and risk-management purposes.

In parallel, direct underground inspections conducted by speleologists and technical personnel continued to provide updated information regarding the condition of the culvert, structural modifications and hydraulic criticalities. These explorations highlighted the presence of sectors characterized by limited accessibility, unstable deposits, hydraulic obstacles and confined spaces that complicated the execution of conventional surveys.

To overcome some of these limitations, an experimental survey was recently carried out in a sample section of the Rio Sant'Anna (Fig. 9), using an Elios 3 confined-space drone developed by Flyability. The system is specifically designed for operations in enclosed and GPS-denied environments and is protected by a collision-resistant carbon-fibre cage that allows safe navigation in narrow passages and irregular underground spaces (Young et al. 2024).

The survey was conducted through an existing access point located within the historical center (Fig. 10). After preliminary safety assessments and operational planning, the drone was deployed inside the conduit and remotely piloted along a selected sector of the culverted water-

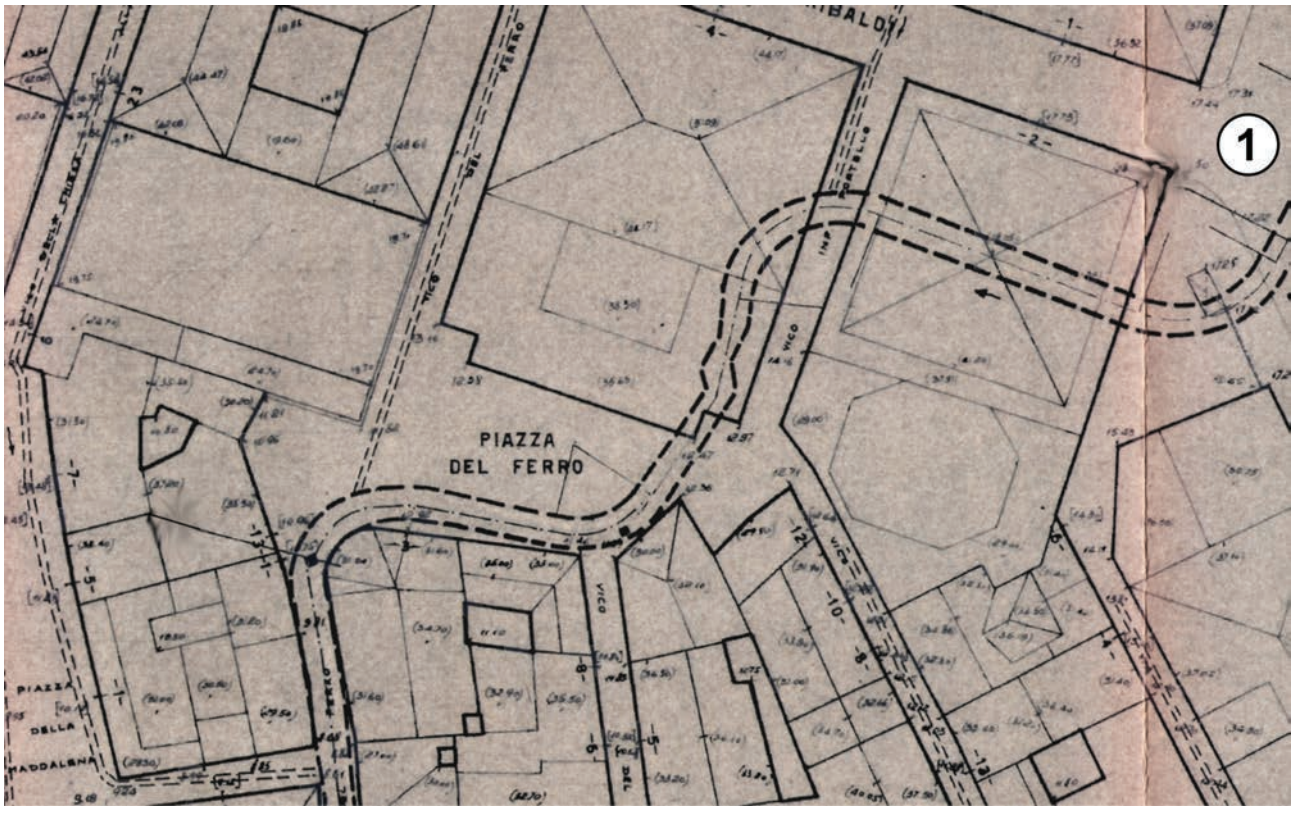

Fig. 7. Cartographic excerpt from the "Rilievo dei Rivi" (Survey of the Streams) of Genoa, by Studio Lotti & Associati of Rome, 1980 (graphic by A. Ferrando and S. Saj)

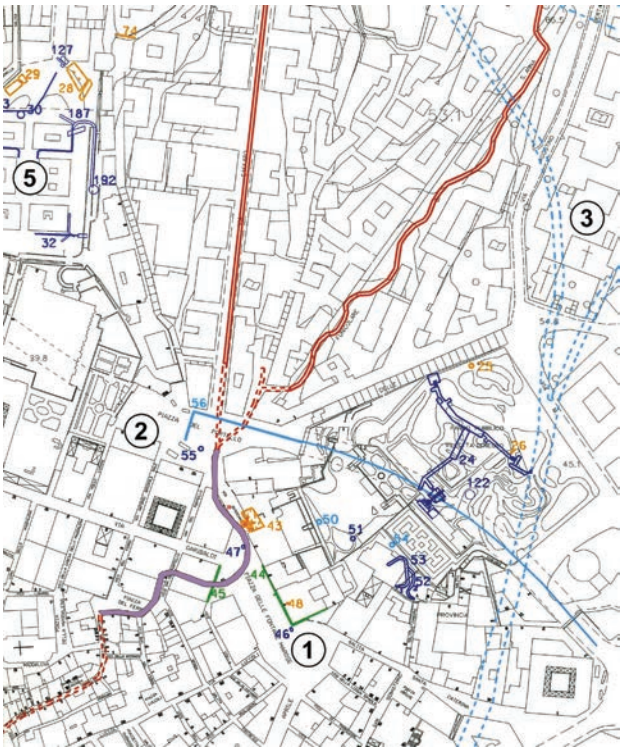

Fig. 8. Excerpt from the "Carta del sottosuolo" (Subsurface Map), developed in 2000 by the CIVIS Observatory of the Municipality of Genoa, also based on cartographic information provided by the Centro Studi Sotterranei (graphic by A. Ferrando and S. Saj)

course. The mission aimed at documenting portions of the stream characterized by difficult accessibility and obtaining a detailed digital representation of the underground environment.

The Elios 3 simultaneously acquired high-resolution video imagery and LiDAR data. The visual dataset provided detailed information on construction techniques, masonry conditions, sediment accumulation, hydraulic structures and evidence of maintenance interventions (Fig. 11). The LiDAR sensor generated a three-dimensional point cloud allowing the reconstruction of the conduit geometry with a level of detail unattainable through rapid visual inspections alone.

The resulting datasets were processed and integrated with previous surveys and cartographic information. Comparison between historical documents, GIS layers and the newly acquired point cloud enabled the verification of existing geometries and the identification of local discrepancies. The three-dimensional model also provided a valuable basis for future hydraulic analyses and structural assessments.

The adoption of drone-based technologies does not replace traditional speleological investigations. On the contrary, the experience acquired through decades of underground exploration remains essential for mission planning, interpretation of the acquired data and validation of results. The drone survey should therefore be considered as a complementary tool capable of extending the range of investigation and improving the completeness of documentation.

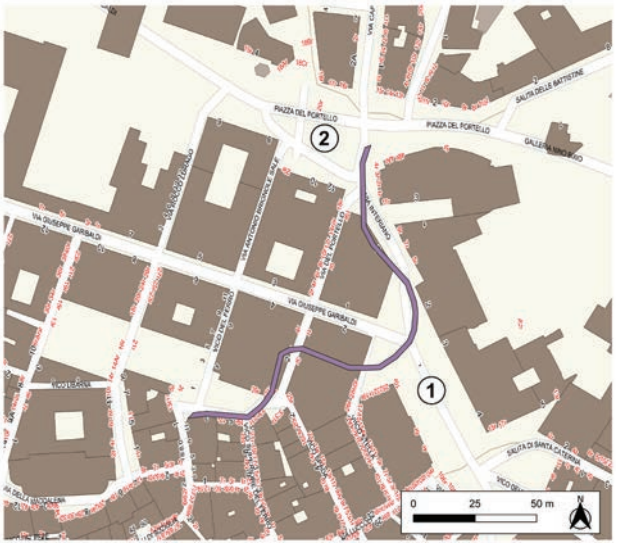

Fig. 9. Portion of the Rio Sant'Anna culvert where an experimental survey was conducted using a confined-space drone (Municipality of Genoa GeoPortal basemap; graphic by A. Ferrando and S. Saj)

Final Remarks

The Sant'Anna Stream represents one of the most significant examples of a culverted urban watercourse within the historical center of Genoa. Its underground development beneath a densely urbanized area and within a UNESCO World Heritage context makes it a particularly challenging environment for documentation, monitoring and management.

The integration of historical surveys, GIS databases, direct underground observations and drone-based investigations demonstrates the effectiveness of a multidisciplinary approach for the study of artificial cavities. Over more than four decades, different generations of survey techniques have progressively contributed to improving the knowledge of the watercourse, producing an increasingly detailed representation of its geometry and state of preservation.

The recent application of the Elios 3 confined-space drone marks a further step in this process. The possibility of acquiring high-resolution imagery and LiDAR data in difficult-to-access sectors significantly enhances the capability to document artificial cavities while reducing operational risks for personnel. The resulting point clouds and three-dimensional models provide information that can support future hydraulic analyses, structural evaluations and conservation strategies.

The experience also highlights some limitations. Drone operations in confined underground spaces require care

ful planning, experienced operators and adequate control of environmental conditions. Signal transmission, lighting conditions, water presence and physical obstacles may influence the quality of the acquired data and the extent of the survey. Consequently, drone-based investigations should be regarded as part of an integrated meth-

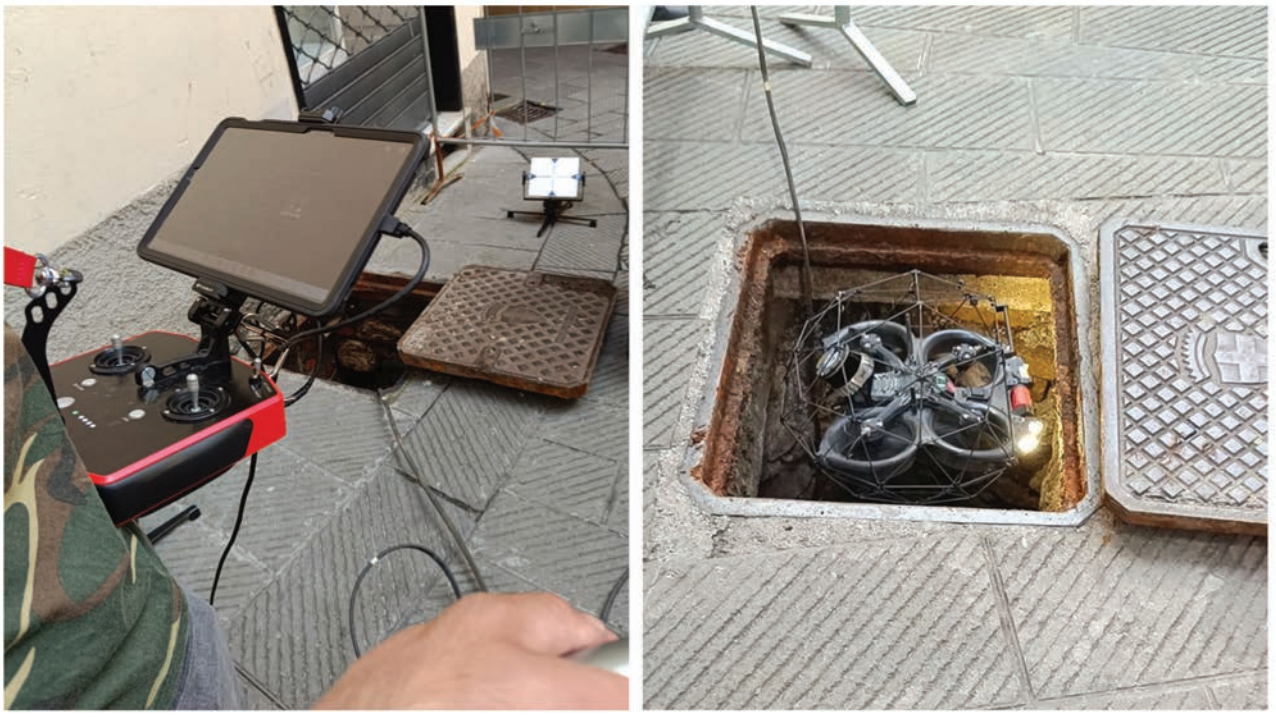

Fig. 10. Phases of the survey operation conducted by deploying the drone through a manhole within the framework of the POC Genoa OverUnderground / City-scale Underground Digital Twin project (photo by S. Saj)

odology rather than as a standalone solution.

From a broader perspective, the methodology adopted in the Sant'Anna Stream may be applied to several urban artificial cavities characterized by limited accessibility and significant cultural value. Culverted streams, historical drainage systems, underground canals and other artificial cavities represent important components of the hidden urban landscape whose documentation is increasingly relevant in the context of climate change adaptation and sustainable urban planning.

Future developments should include the extension of drone surveys to additional sectors of the Genoese underground hydrographic network, the integration of three-dimensional models into municipal GIS platforms and the implementation of monitoring systems capable of supporting both hazard assessment and heritage management. In this perspective, the combination of traditional speleological expertise and advanced digital technologies appears to be one of the most promising approaches for the investigation of complex artificial cavities.

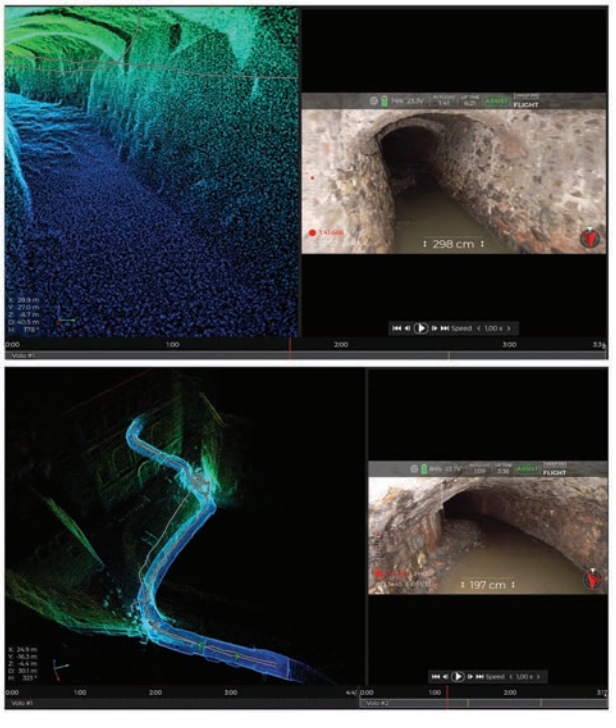

Fig. 11. Footage captured by the Elios 3 drone inside the culvert of the Rio di Sant'Anna, with the corresponding point cloud acquired by the LiDAR sensor displayed alongside (courtesy of Francesco Premi, SMART RDT srl)

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Discovery and Documentation of the Water Supply System of Ayvat (Turkey)

Ali Hakan Eğilmez [1], Ümit Günhan[2], Özlem Kaya [3], Kardelen Gülbenay Nurdoğan [4], Zeynep Kelpetin[5], Barkın İren [6]

[1] Archaeologist, Lecturer in Istanbul Technical University, Speleologist, member of GALERİ (*)
[2] Geomorphologist, Speleologist, member of EMAK (***)
[3] Architect in Miletus Excavation, *Yıldız Technical University,* Speleologist, member of İTÜMAK (**)
[4]Speleologist, member of İTÜMAK (**)
[5]Speleologist, member of GALERİ (*)
[6]Speleologist, member of GALERİ (*)
(*) GALERİ Galeri Mağara Araştırma Grubu (Galeri Cave Research Group)
(**) İTÜMAK İstanbul Teknik Üniversitesi Mağara Araştırma Kulübü (Istanbul Technical University Cave Research Club)
(***) Ege Üniversitesi Mağara Araştırma Topluluğu (Ege University Cave Research Club)

Reference author: Ümit Günhan, gunhan.umit@gmail.com
Özlem Kaya, ozlemkaya1265@gmail.com
address: Talimhane Sokak, No 25, Şişli, İstanbul. 34377. Turkey

Abstract

Water has been one of the most fundamental factors determining the establishment and sustainability of cities throughout history. Istanbul, as one of the world's most significant historical cities, possesses an extensive network of water-related structures. The Roman, Byzantine, and Ottoman civilizations constructed numerous hydraulic works to ensure access to clean water. Among the most important of these is the Kırkçeşme Water Supply System. Although a comprehensive survey of the system was conducted in 1988, the study primarily focused on aboveground structures. Consequently, a detailed investigation of the underground tunnels connecting these structures has remained necessary.

The project, initiated in May 2024 and currently ongoing, aims to document both underground and aboveground components of the Taksim and Kırkçeşme Water Supply Systems, including tunnels, shafts, aqueducts, reservoirs, and distribution chambers, through mapping, photography, and video recording. Along the water supply line, updated measurements are being carried out, while architectural deterioration–including structural damage, material decay, and vegetation-related degradation–is being identified and recorded. Comprehensive documentation and assessment of the current condition of these structures are essential for their long-term conservation.

In February 2025, Ayvat Dam and the water structures located along the western branch of the Kırkçeşme Water Supply System were surveyed and documented. The underground sections were mapped using a DistoX2 surveying device, while several aboveground structures, including ventilation shafts and a collecting reservoir, were documented through photogrammetric methods. With a total length of approximately 2 km, the system also provides habitat for numerous species associated with cave ecosystems.

Keywords: Kırkçeşme Water System, Ayvat Dam, water supply tunnels

Introduction

The development of Istanbul has been closely linked to its geographical setting and the engineering solutions devised to overcome environmental constraints. Surrounded by seawater on three sides, the city has historically depended on freshwater resources transported from distant catchment areas through gravity-fed hydraulic systems (Yıldız 2003). This process began during the Roman period under Emperor Hadrian and continued with the aqueducts and underground galleries constructed during the reigns of Valens and Theodosius I. Over time, these efforts resulted in a large-scale hydraulic network extending approximately 494 km, frequently described as the longest water supply system of the Roman world (Crow 2015). Following the Ottoman conquest of Constantinople in 1453, the existing water infrastructure was rapidly repaired and reactivated under the rule of Mehmed II. The city's hydraulic network was further strengthened through the rehabilitation and expansion of systems such as the Halkalı waterworks, which supplied water to the elevated districts of the city (Tabakoğlu 2015; Güngör 2021).

Within this historical framework, the Kırkçeşme Water Supply System represents one of the most significant

achievements of Ottoman hydraulic engineering. Integrated into the natural topography, the system constitutes an extensive network of dams, aqueducts, tunnels, shafts, reservoirs, and distribution structures that have functioned continuously for nearly five centuries (İSKİ 2005; Karakuş 2019). Constructed between 1554 and 1563 under the patronage of Sultan Süleyman I and designed by the chief architect Mimar Sinan, the Kırkçeşme System became one of the largest and most sophisticated hydraulic projects of the Ottoman period. As Istanbul continued to grow, the system was expanded through periodic maintenance and the incorporation of additional water sources, known as *katmalar*, to increase its capacity. An important phase of this development was the construction of the Ayvat Dam in 1765–1766 during the reign of Mustafa III, which further enhanced the efficiency and reliability of the network (Görcelioğlu 1985; Tabakoğlu 2015; Güngör 2021).

Despite its historical and engineering significance, the Kırkçeşme Water Supply System has previously been examined only through fragmented studies focusing on individual components. A comprehensive and systematic investigation of the entire network has remained lacking. The present documentation project originated in 2018 with the identification of ventilation shafts associated with the Kırkçeşme System within the northern and western sectors of the Belgrad Forest. Subsequent investigations demonstrated that the system should not be understood as a series of isolated channels, but rather as an integrated hydraulic network whose components function in close spatial and operational connection. The current phase of the project is being carried out under an official protocol signed in May 2024 between the Galeri Cave Research Group and İSKİ (Istanbul Water and Sewerage Administration). The principal contribution of this study lies in its direct investigation of the underground tunnel network. Rather than relying solely on the observation of surface structures, the project involves systematic exploration, surveying, and documentation within the tunnels themselves, enabling the *in situ* recording of a hydraulic heritage system that has remained largely inaccessible and insufficiently documented for centuries

1. Purpose of the Research

The primary aim of this research is to systematically investigate, survey, and document the underground components of the Kırkçeşme Water Supply System. Through detailed mapping, architectural recording, and photographic documentation, the study seeks to establish a comprehensive inventory of the system and to improve our understanding of its architectural, engineering, and archaeological characteristics.

Representing a synthesis of Roman and Ottoman hydraulic engineering traditions, the Kırkçeşme Water Supply System has functioned continuously for several centuries. Due to its integrated network structure, structural failure or deterioration occurring in one section may directly affect the performance and stability of the entire system. Therefore, the preparation of a comprehensive inventory and documentation record is essential for supporting future conservation planning, preventive maintenance, and potential restoration interventions.

2. Method of the Research

The underground survey was conducted using a digital, paperless cave-mapping methodology employing a DistoX310 laser surveying device integrated with the TopoDroid-X software platform (Heeb 2008; Corvi 2015). To accurately document variations in tunnel ge-

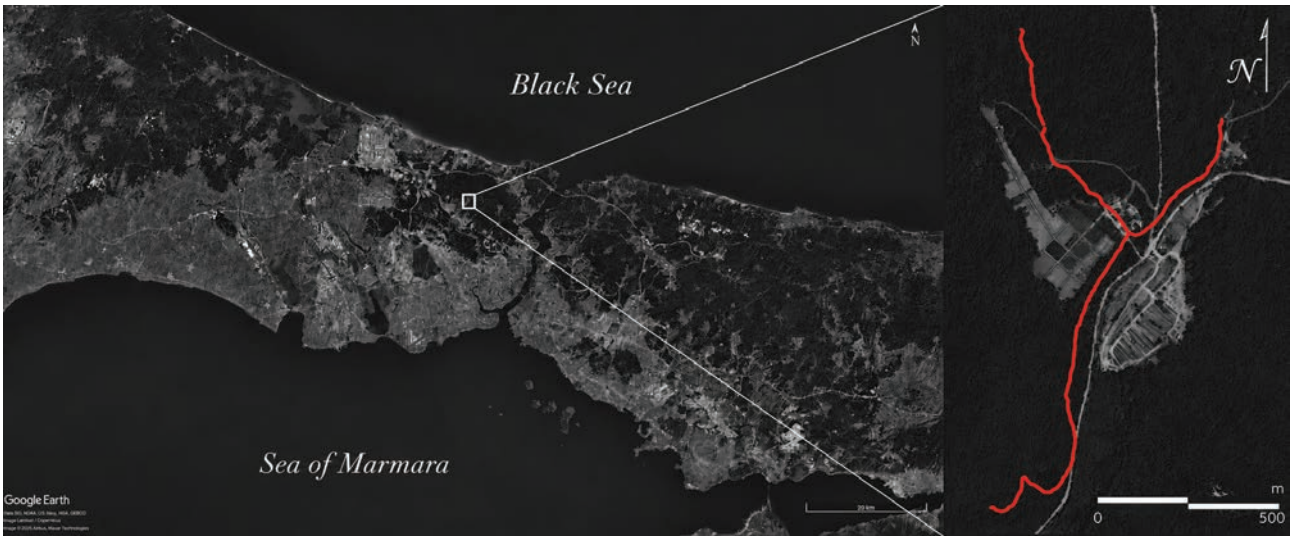

Fig. 1. Location of Istanbul Province and the Ayvat Branch, one of the principal water collection axes forming the western section of the Kırkçeşme Water Supply System (base map: Google Earth; adapted by Ü. Günhan and K.G. Nurdoğan)

ometry, numerous cross-sectional measurements were recorded throughout the survey. Over a period of three days, a total tunnel length of 2,022 m was surveyed.

To increase the level of detail and spatial accuracy of the map, 3,149 splay measurements were collected. Survey stations were established at short intervals in order to minimize measurement errors and maximize precision, resulting in a network of 340 survey stations.

During the survey, 57 ventilation shafts covered by concrete lids were identified, recorded, and georeferenced. To verify survey accuracy and reduce cumulative errors, coordinate control points were established through accessible shafts connected to the surface. The resulting survey data were subsequently processed and adjusted using Walls software, and identified deviations were corrected through loop-closure and coordinate verification procedures.

3. Discovery and Documentation of the Water Supply System of Ayvat

The first phase of the project focused on the western branch of the Kırkçeşme Water Supply System, extending between Ayvat Dam and the Kurt Aqueduct. Surveying and documentation work have been completed as far as Taşoluk, while field investigations continue toward the Eğri Aqueduct (Fig. 1). A total of 2,022 m of underground hydraulic structures were surveyed and documented. During the study, 57 ventilation shafts, one aqueduct, one settling basin, and the Taşoluk structure were identified, recorded, and mapped (Fig. 2).

The investigated section comprises three principal tunnel branches. Surveys were conducted along the northwestern and northeastern branches extending toward Ayvat Dam and continued until areas affected by significant collapse hazards and structural instability were encountered. Field observations revealed that the architectural integrity of the tunnels has been severely affected by modern anthropogenic activities, including highway construction, agricultural land use, and urban development (Figs. 3–4).

Detailed examination of these sections demonstrated that both the tunnel walls and vaults have undergone substantial alterations. In several locations, structural deformation, partial collapse, and modern repair interventions were documented, indicating the increasing impact of contemporary land-use practices on the preservation of the historic hydraulic infrastructure.

In contrast, the tunnel section extending southward from the Kurt Aqueduct to the Eğri Aqueduct has remained largely isolated from intensive human activity. As this segment primarily passes beneath forested areas and natural vegetation cover, the tunnel walls have preserved their original morphology, and the architectural fabric exhibits only limited deterioration. Variations in

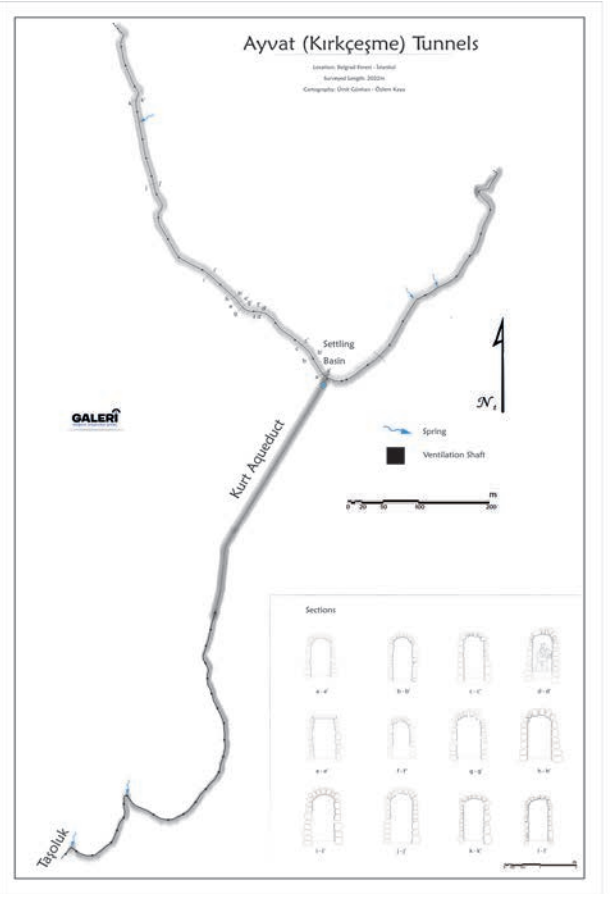

Fig. 2. Plan of the Ayvat (Kırkçeşme) tunnel system. The survey and documentation of the galleries between Ayvat Dam, Kurt Aqueduct, and Taşoluk were carried out by A. H. Eğilmez, Ü. Günhan, Ö. D. Akpınar and Ö. Kaya using a DistoX2 surveying device. The total surveyed length amounts to 2,022 m. Drawing by Ü. Günhan and Ö. Kaya

ceiling height are considerably less pronounced than those observed in the northwestern and northeastern branches. Furthermore, no major physical obstacles restricting movement within the tunnel were identified.

The water level within this section varies seasonally. During dry periods, water depths generally remain at knee level, whereas during wetter seasons they may reach waist level in certain areas. Despite localized zones of deterioration, the overall state of preservation is good, and the tunnel remains structurally accessible for research, monitoring, and heritage-management purposes.

Evidence of illegal treasure-hunting activities was documented at several locations during the survey. Such interventions pose a significant threat to the preservation of the hydraulic heritage and may result in irreversible damage to archaeological and architectural features. Effective protection measures should therefore include increased public awareness, educational initiatives, and improved site visibility, accompanied by regular monitoring and conservation management. These measures may contribute to reducing the frequency of unauthorized excavations and associated damage.

The documented network incorporates construction

Fig. 3. Examples of structural deterioration observed within the tunnel system. The retaining wall exhibits lateral displacement caused by tree-root pressure, while sections of the original tunnel vault have been replaced with reinforced concrete due to construction activities and surface development above the tunnel line (Photo: Ü. Günhan)

Fig. 4. Examples of structural deterioration observed within the tunnel system. The retaining wall exhibits lateral displacement caused by tree-root pressure, while sections of the original tunnel vault have been replaced with reinforced concrete due to construction activities and surface development above the tunnel line (Photo: Ü. Günhan)

techniques attributable to different phases of development, including Byzantine, Classical Ottoman, and Late Ottoman interventions. Adaptation to local topographic conditions required the application of diverse excavation and construction methods throughout the system. Tunnel sections located more than 6–7 m below the ground surface were generally excavated as underground galleries and reinforced with vaulted masonry structures designed to withstand the overlying soil load. In contrast, sections crossing ridges or approaching the ground surface were constructed using the cut-and-cover technique.

An additional engineering solution identified within the system is a semi-open hydraulic control structure, referred to here as the *"waterfall/bypass"* system. This mechanism appears to have been designed to divert excess surface runoff and prevent damage to the tunnel network during periods of increased water flow (Figs. 5–6).

Several observations were made regarding the construction techniques and building materials employed within the underground structures. Rubble-stone masonry constitutes the principal construction material throughout much of the tunnel system (Fig. 7). In addition to Horasan mortar, traces of hydraulic plaster were identified in several sections, indicating the use of waterproofing measures within the hydraulic infrastructure.

An opportunity to examine the internal structure of the tunnel walls was provided by an area damaged through unauthorized excavation activities. In this section, the wall thickness was measured at approximately 66 cm. Fired bricks were also observed in various parts of the system, particularly within the ventilation shafts. Several of these bricks bear stamped marks, which may provide valuable evidence for future studies concerning production techniques, chronology, and construction phases (Figs. 8–9).

The preserved architectural features also offer insights into the construction process. The presence of clearly identifiable vault springing points suggests that the tunnel vaults may have been constructed using timber centering during the building phase. Although direct evidence of the construction method has not survived, the observed structural characteristics are consistent with this interpretation.

Evidence of multiple repair and restoration interventions is clearly visible throughout the underground structures. One particularly significant finding is an inscription located within the tunnel indicating that repair works were undertaken in November 1894 (Fig. 10).

Fig. 5. The Taşoluk structure represents a semi-open hydraulic control mechanism, referred to as the "waterfall/bypass" system, designed to divert surface runoff and protect the tunnel network from water-related damage (Photo: S. K. Parlak)

Fig. 6. The Taşoluk structure represents a semi-open hydraulic control mechanism, referred to as the "waterfall/bypass" system, designed to divert surface runoff and protect the tunnel network from water-related damage (Photo: S. K. Parlak)

Fig. 7. An unrepaired section of the tunnel illustrating the original rubble-stone masonry construction and vault structure (Photo: S. K. Parlak)

Fig. 8. A ventilation shaft and one of the stamped terracotta bricks documented within the tunnel system (Photos: S. K. Parlak and Z. Kelpetin)

Fig. 9. A ventilation shaft and one of the stamped terracotta bricks documented within the tunnel system (Photos: S. K. Parlak and Z. Kelpetin)

Fig. 10. Repair inscription inside the tunnel documenting restoration works undertaken in November 1894. The inscription was recorded and documented using photogrammetric methods by Ö. Kaya

As these repairs were carried out approximately four months after the 1894 Istanbul earthquake, the inscription provides direct evidence that the water supply system sustained damage as a result of seismic activity and subsequently underwent restoration.

Although no extensive or systematic structural deterioration was observed throughout the surveyed section, several localized conservation issues were identified. The most significant source of deterioration is related to tree-root activity within the surrounding forest environment. Roots penetrate the masonry through mortar joints and existing fissures, generating both superficial and deep cracks within the structure (Fig. 11). In addition to causing material deterioration, root growth exerts mechanical pressure on the masonry, resulting in localized displacement of structural elements.

These deformations require careful monitoring and timely intervention, as localized failures may compromise the stability of adjacent sections within the interconnected hydraulic network. Furthermore, various forms of material deterioration were documented on the load-bearing stone elements, including salt crystallization, biological colonization (moss growth), patina development, surface flaking, and material loss.

The observed deterioration processes remain largely localized and are currently manageable through preventive conservation measures and targeted repair interventions. The implementation of such measures would significantly contribute to the long-term preservation and structural stability of the Ayvat tunnel system.

Fig. 11. Historical repair intervention within the tunnel. Damage caused by plant-root growth was stabilized using timber structural elements (Photo: Ü. Günhan)

4. Conclusions

The research conducted on the underground structures of the Ayvat Branch of the Kırkçeşme Water Supply System constitutes the first step for future studies. During the research process, the structures were identified, documented, and the related issues were recorded. This study has enabled a more detailed understanding of the system's operational principles. The natural and human-induced deterioration observed within the structures highlights the importance of addressing these impacts and implementing appropriate conservation measures.

In conclusion, this comprehensive research on the underground structures of the Kırkçeşme Water Supply System represents an important step toward documenting these structures and relating them to the overall system. The data obtained will contribute to a better understanding and preservation of these historically and archaeologically significant structures.

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The Hydraulic Systems of the Hrazdan River Gorge (Armenia)

Ani Saratikyan[1], Roberto Dan[3], Artur Petrosyan[1], Avetis Grigoryan[1], Boris Gasparyan[1,2]
[1] Institute of Archaeology and Ethnography of the NAS RA,
[2] Yerevan State University,
[3] ISMEO – The International Association for Mediterranean and Oriental Studies, Italy

Abstract

The Ararat Depression assumed a pivotal role as a major political and economic centre within the Kingdom of Van following the expansion of Urartian dominion north of the Araxes River in the 8th century BC, under the reign of King Argišti I. The Urartians directed their efforts towards the development of agriculture, with a particular emphasis on horticulture, recognising the potential of the fertile plateau and the foothills of the depression. These regions boasted favourable spatial-landscape and climatic conditions conducive to agricultural growth. The primary objective of the aforementioned activities was the establishment of viticulture. In addition to the establishment of vineyards and orchards, the Urartians undertook the construction of essential infrastructure to facilitate these economic endeavours. This infrastructure included the design and organisation of irrigation networks, as well as the construction of hydraulic systems comprising a series of canals along the Hrazdan River Gorge and its tributaries. The Hrazdan River (also known as Zangu) is the left tributary of the Araxes. The river's source is located in Lake Sevan, from which it flows in a general southwest direction (Fig. 1). The river's length is 141 km, and it traverses Gegharkunik, Kotayk provinces, the city of Yerevan (Fig. 2), and then Ararat Province, before flowing into the Araxes River. Some components of these structures have survived to the present day and, in certain instances, continue to function. Consequently, they serve as exceptional illustrations of hydroengineering solutions and technologies from antiquity. The most impressive features are the rock-cut tunnels, which range in length from a few dozen to several hundred metres. The water supply installations built along the canals are also of interest, as are the artificial terraces, which serve to minimise the negative impact of the slope process and maintain stability for the main routes of the canals.

Keywords: Urartu; Ararat Depression; irrigation; viticulture

Introduction

The irrigation system, when considered in conjunction with the terraced vineyards on the gorge slopes and the mound gardens in the flatland areas of the relief, serves to illustrate the agricultural concepts that were extant in the Armenian Highlands during the Bronze and Iron Ages. This evidence should also be considered within the broader framework of ancient water technologies, in which irrigation systems, hydraulic infrastructures, and water-management strategies played a fundamental role in the development of agricultural landscapes and early complex societies (Mays 2010, 1–4). Furthermore, the inhabitants of the Kingdom of Van utilized snowmelt and spring-water sources on the mountain slopes to establish supplementary water reserves, with the objective of "strengthening" the irrigation supply during diverse seasonal periods. The utilization of dams and lakes, in conjunction with other water bodies, has been evidenced in the vicinity of the fortified settlements, thereby providing direct evidence for the diversified water management practices of that era. Similar integrated systems of dams, reservoirs, canals, and water-control structures are well documented in the Urartian hydraulic landscape of the Van region (Orhan et al. 2006, 346–347). The presentation herein offers a reconstruction of the hydraulic landscape structured around the Hrazdan River Gorge, with a view to examining its long-term transformations. The starting point for the investigation is the Urartian network (8th–7th centuries BC), which is based on diversions from the Hrazdan and its tributary, the Akunk River, and a dense system of canals, including Mamri/Mamur, *Dalma*, Abuhayat and Echmiadzin/Umešini. This network is further augmented by a collecting reservoir, such as Lake Tokhmakhan or Vardavari Lich, which served the water supply and irrigation systems connected with Erebuni and the Teišebai URU/Karmir Blur.

The Urartian state was producing large quantities of wine - being an object of exchange and trade, one of the elements of "flow of goods" system and spreading of prosperity. Viticulture and winemaking were among the most important economies exploited by peoples of the Near East as a whole. This was a historical period, when viticulture and wine-making reached their final phase of formation in the Armenian Highlands, as they became the monopoly of the nobility and the "royal court" and an important source of economic management and "consumption of goods". Urartian written sources describe planting vineyards and building wine-cellars, that happened after men established powerful irrigation networks and reservoirs. The Minua/Šamiram Canal, which conveyed water over more than 50 km from the Gürpınar area to the Van plain, represents one of the most impres-

Fig. 1. Start of the Hrazdan River from Lake Sevan (Authors' property)

Fig. 2. Main view of the Hrazdan River gorge in the administrative limits of Yerevan from the North (drone image, Authors' property)

sive examples of Urartian hydraulic engineering in the Van region. Its long-distance water conveyance, bedrock-cut sections, retaining walls, and irrigation capacity made possible the cultivation of orchards and vineyards in otherwise dry areas (Orhan et al. 2006, 348–349; Mays 2010, 19). Since the 8th century BC especially, during the rule of Argišti I (ca. 785/780–756 BC), vine cultivation became one of the most important branches of agriculture. The total capacity of 480 pithoi, found from Karmir blur, was over 50 000 decaliters. About 350-400 hectares of irrigated land was needed to produce that much wine (Arutyunyan 1967). According to Urartian inscriptions of Zvartnots, Rusa II (first half of the 7th century), Argišti's son, said: "There was no cultivated land in the field of Kuarliny country (in the valleys of present-day Araxes and Hrazdan Rivers). I planted this vineyard, harvested the fields, created orchards and surrounded the cities with them by the order of Khaldi. I constructed a canal from Ildaruni (Hrazdan) River. Its name is Umeshini". Further, the inscription describes everything sacrificed to the gods when opening the canal (Piotrovskiy 1969; Piotrovskiy and Janpoladyan 1956).

Study aim

The primary objective of this article is to analyze and systematize the main archaeological evidence, and to propose diagnostic criteria for distinguishing Urartian installations from later reuse, repair, and rebuilding in an urban context that has erased much of the original record. Armenia's topography, which is characterized by mountains, lakes, and rivers, has played a pivotal role in shaping ancient landscapes and human settlements. Archaeological evidence frequently reveals the presence of settlements situated near riverbanks, thereby signifying a reliance on these waterways for sustenance and economic activity. These structures are indicative of the strategic importance of waterways to ancient societies, with implications for settlement patterns, resource utilization and trade.

Methods

The present study is founded upon a multi-level methodological approach, incorporating archaeological, historical, and landscape-spatial analytical tools. Firstly, a comprehensive literature and archival source analysis was conducted, with a particular focus on materials related to Urartian hydraulic engineering. Secondly, spatial analysis was conducted utilizing contemporary cartographic resources, satellite imagery, and topographical data. This methodology enabled the reconstruction of the potential routes of ancient canals, in addition to the comprehension of their relationship with the natural topography, encompassing river channels, slopes, and plains. Thirdly, the integration of archaeological field data (survey and excavation reports) was utilised for the documentation of canal, tunnel, and reservoir remains. Particular attention was devoted to the analysis of rock-cut tunnels and artificial terraces, which are recognized as significant indicators of Urartian engineering technologies. Fourthly, a comparative method was employed, through which water management structures from different periods (Urartian, Early Medieval, Yerevan Khanate, and Soviet periods) were compared in order to distinguish original constructions from later modifications and reuse. In addition, construction stratigraphy (at least three to four phases) is visible on many of the hydraulic structures of the Hrazan River Gorge and our aim was to connect them with specific historical periods, which are possibly the Urartian, Early Medieval, Yerevan Khanate and Soviet period.

Description of the Urartian hydraulic landscape around the Hrazdan River

In addressing the urban planning issues of Erebuni/Yerevan, researchers also has addressed the problems of ancient water supply, focusing their studies particularly on Urartian irrigation systems (Musheghyan 1971). Within the framework of examining the water supply system,

Fig. 3. Main view of the citadel of Erebuni (drone image, Authors' property)

Fig. 4. Lake Tokhmakan (Vardavari lich) in the proximity of Erebuni (Authors' property)

the Erebuni fortress is of primary importance, the location of which was chosen on the northeastern edge of the Ararat Depression, on the most dominant elevation in the surrounding area. From this vantage point, the mountains begin to the northeast, while to the southwest, with a certain slope toward the Araxes River, the Ararat Plateau stretches (Fig. 3). The citadel is located approximately five kilometres from the Hrazdan River, which flows through the gorge. The archaeological monuments in the Hrazdan River basin span various historical periods, with the earliest evidence dating back to the Paleolithic era (Adler et al. 2012). Yerevan, a city with a history stretching back millennia and continuously inhabited since at least the Bronze Age, offers a distinctive vantage point for examining the interrelationship between ancient societies and their hydrological environments. The history of Yerevan (Erebuni) extends back to the 8th century BC, and its strategic location on the Hrazdan River furnished its early inhabitants with essential resources. The city's transformation from a modest settlement to a prominent urban centre during antiquity was significantly influenced by its proximity to water sources. It is evident that rivers, springs and reservoirs played a pivotal role in agricultural practices, commercial activities and the daily lives of the inhabitants. These elements were instrumental in facilitating the growth of complex societies. Archaeological surveys have revealed evidence that the community exhibited a sophisticated understanding of water management. Archaeological excavations at Urartian locations, including the ancient settlement of Erebuni, Teišebai URU/Karmir Blur, have revealed structures that were associated with water management and storage. A review of the extant historical evidence suggests that the primary function of irrigation in Urartu was viticulture and water supply of residential centers like the Tokhmakhan Lake or Vardavari lich (Figs. 4). This assertion is also substantiated by the discovery of wine storage vessels in Teišebai URU/Karmir Blur (Fig. 5, 6) (Piotrovskiy 1969). As stated above, the construction inscription of Rusa II found near Zvartnots records that uncultivated lands were transformed into vineyards, orchards, and fields. This was achieved through the construction of a canal, known as the Umeshini (Echmiadzin canal) (Musheghyan 1971), which means that alongside the architectural features of temple and fortress construction, particular importance is attached to the systems within them that serve to meet the economic needs of the population (Burney 1972; Kanetsyan 2021; Çifçi and Gökce 2023).

Fig. 5. The citadel of Teišebai.URU/Karmir Blur (drone image by Roberto Dan)

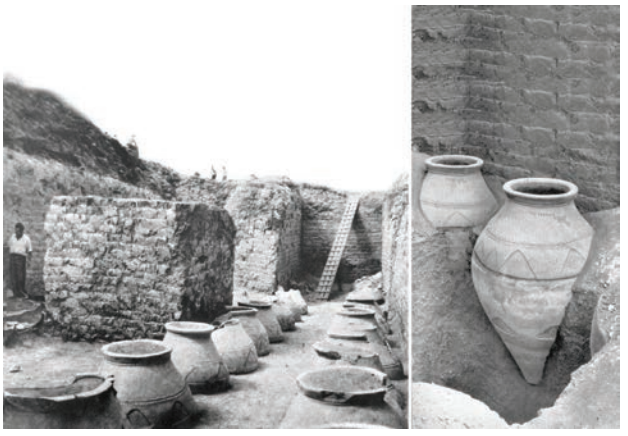

Fig. 6. Wine cellar number 28, the citadel of Teišebai. URU/Karmir Blur (after Piotrovski, 1970)

Fig. 7. A rock-cut tunnel at the start of the Marmri and Abuhayat canals on the left side of the Hrazdan River gorge near the village of Getamej (Authors' property)

Fig. 8. Small tunnel of the Dalma canal on the right side of the Hrazdan River gorge in Yerevan (drone image by Roberto Dan)

Our surveys and fieldwork activities along the middle reaches of the Hrazdan River gorge recorded very well-preserved remains of canals, including rock-cut tunnels incorporated to their system. One such outstanding examples is the tunnel complex on the left bank of the river, near the village of Getamej of the Kotayk Province of Armenia (Fig. 7). The system was modified during the Soviet period; major sections were blocked by concrete, and converted into part of the water-circulation system of the Arzni hydropower plant. It is highly probable that, the tunnel system is the initial sector of the Mamri and Abuhayat canals.

Dalma is probably the oldest vineyard area of Yerevan, with a history of several thousand years. It was repeatedly destroyed, abandoned, revived, and restored. The word dalma appeared in the times of Persian rule. It means a culvert or a tunnel. We think, it is related to the canal of the same name that starts from the right bank of the Hrazdan River, built or fundamentally reconstructed during the period of King Rusa II, son of Argišti (first haf of the 7th century BC). The structure is so firm and complex that at the beginning of the 19th century 1000 people worked for several years to repair it by order of Ḥusayn Khan, the Persian Sardar of Yerevan, who named it Dalma in 1815. At least two tunnels of the canal – The Big Tunnel and The Small Tunnel are still functioning today, supplying water to the Dalma gardens (Fig. 8, 9). Another canal that served for the irrigation of the terraced vineyards along the left-bank slopes of the Hrazdan River gorge, is Mamri. Passing through very complex relief, it is closely adapted to the local viticultural landscape, sometimes divided into several branches at different levels. Today one can see very well preserved sections of Urartian masonry bearing traces of later repairs. They served a dual function – to stabilize the hydraulic structure from the negative impact of slope processes as well as walls to direct the water (Fig. 10, 11, 12).

Thus, the most important precondition for development of agricultural traditions in the Armenian Highlands was the use and development of irrigation systems that culminated in the period of Van Kingdom, when canals and tunnels dug in the rocks reached a high level of sophistication, which was characteristic to highly centralized societies. The people of Urartu irrigated large areas of arable land, using the full range of technologies available at the time: primitive culverts, pipes, tunnel canals, perhaps also possibly also lifting devices (Piotrovskiy 1959). They constructed huge reservoirs, without which

Fig. 9. Portion of the Dalma gardens (vineyards) in Yerevan (drone image by Artur Petrosyan)

Fig. 10. Portion of the Mamri canal on the left side of the Hrazdan River gorge (drone image by Artur Petrosyan)

Fig. 11. Very well preserved section of the masonry of the Mamri canal (Authors' property)

Fig. 12. Mamri canal in the context of terraced vineyards in the limits of Yerevan (drone image by Roberto Dan)

the irrigation systems would be incomplete, and developed the water infrastructure. The kings of Van founded their fortresses on solitary hills, situated in fertile fields, constructing dense irrigation networks. Some of those canals and reservoirs (Sardarapat, Ejmiatsin, *Dalma*, Kyanki aru, Mamri and Ashtarak) work even today. Another important engineering structure of the Urartian period, preserved in the district of Yerevan, is the canal of Ejmiatsin, starting from River Hrazdan, known from Rusa II's inscription as Umešini. These and other canals irrigated the neighboring vineyards in the Early Medieval period, were used by the Holy See of Ejmiatsin until the Late Middle Ages and were restored during the Soviet Era.

Conclusions

The study suggests that the hydraulic systems of the Hrazdan River Gorge constituted an integrated and highly organised irrigation network already in the Urartian period (8th–7th centuries BC). This system appears to have contributed significantly to the economic development of the Ararat Depression, particularly through the expansion of viticulture and horticulture. The analysis suggests that Urartian hydraulic engineering was not confined to the construction of simple canals, but encompassed a complex infrastructure of rock-cut tunnels, diversion channels, reservoirs, and artificial terraces. Collectively, these elements would have ensured long-term water management and landscape stability. Spatial and comparative analysis demonstrates that numerous elements of the ancient irrigation system were strategically adapted to the natural topography of the Hrazdan River Gorge, thus indicating a high level of environmental knowledge and engineering skill among Urartian builders. The research also indicates that several components of the ancient water-management system survived through later historical periods, often being reused, repaired, or modified. The study emphasizes that the Hrazdan River Gorge is a key archaeological landscape for understanding long-term water-management traditions in the Armenian Highlands, offering valuable insights into continuity and transformation.

The dry continental climate has always made irrigation essential for the development of viticulture and winemaking in Armenia. Artificial irrigation was especially important for the Ararat Depression, where the history of irrigation goes back to ancient times, possibly as early as the Stone Age. In all periods, during and after the Kingdom of Van, as well as today, substantial resources and labour were necessary to maintain the functionality of these systems. Nowhere in historical Armenia was the struggle for water as intense as in the Ararat Depression, where low precipitation made agricultural activity – including cereal cultivation, orchards, and melon growing impossible without artificial irrigation.

Although the Urartian canal system in the middle reaches of the Hrazdan River underwent significant transformations and renovations during the Soviet period, some original sections, mainly tunnels, are still preserved and remain impressive today. They demonstrate the considerable skill of Urartian hydraulic engineers in exploiting gravity flow to transport water across difficult terrain, a principle widely attested in ancient hydraulic technologies (Mays 2010, 1-4).

Acknowledgements

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Water Cisterns of Some Monastic Communities in Mount Athos, Halkidiki, Greece

Alexey Zhalov
Bulgarian Caving Society, Sofia, Bulgaria
azhalov@gmail.com

Konstantin Stoichkov
Speleo Club „Helictite", Sofia, Bulgaria
k.stoichkow@gmail.com

Abstract
known at Mount Athos peninsula, Northern Greece where an Eastern Orthodox community of monks live. In Eastern Orthodox religion there are 3 types of monastic communities: cenobitic - where monks live together; skete - small community of two or three monks living under an Elder and Eremitic - where monks living in total solitude. Well-functioning water supply was necessary for societies survive. Originally, early settlements relied on natural sources such as springs and watercourses. But to progress, societies needed to transform, re-organize and expand the water supply by augmenting it and creating artificial sources - man-made water supply installations as wells, qanats, catchments and cisterns. Speaking for Mount Athos, up to date very little researches has been done on man-made water supply underground constructions, their function and use. The paper dicribed few rainwater harvesting cisterns used for water supply of different tipe of Monastic Communities in Holly Mount Athos, Greece and surveyed during our long term project. In this work the cistern refers to a statically situated waterproof container constructed below ground to store water. Cisterns held water that had been received from an external source - usually rainwater and were not intended to receive a constant inflow or facilitate a constant outflow. The Description of the construction, the form and dimentions of the cisterns are made together with the calculation of the collected and stored volume of water.

Keywords: water supply, underground reservoirs, construction, Holy Mountain, monasticism

Introduction

Mount Athos, or the „Holy Mountain" in Greece, is the oldest surviving centre of Orthodox monasticism, with organized monastic life beginning in the middle of 10-th Century. Then, step by step 20 monasteries and tens of skits which belong to them were established. All of these settlements had a vital need for reliable water supply. Originally the monks relied on natural sources mostly of springs. The approximate data for the number of different kind of springs in Athos we found in (Stamatis 1996). Two hundred springs were found in the peninsula but the majority of them had low to very low discharge. Therefore, the monasteries were forced to satisfy their needs from several water sources. Such is the example of the Simonopetra Monastery, which has captured in the past, 40 small springs spreaded out in the mountainous part of the Monastery. (Friends Of Simonopetra Athonite Foundation). Seasonal structure of the annual precipitation is: wet season (Oct–Mar): ~65–75% and relatively dry season (April - September). There are prolonged droughts, especially summer extending into autumn often <10% of annual total rainfalls (meteoblue 2026). So, the springs' capacity has sharply decreased, and some of them are even drying up! In these cases, the water supply to the monasteries begins to suffer serious difficulties. The gradual increase in the number of monks on Athos has exacerbated the water supply problem as well. An example is absolutely enough to illustrate the process of the growing. In the year 963, the first monastery in Holy Mount was founded first monastery (Great Lavra) was founded. Then there were 80 monks in it. In year 976 they became 120, in 978 their number grew to 150 and in the middle of the 11th century the number of monks increase to more than 700. So over time the monastic societies was forced to transform, re-organize and expand the water supply by augmenting it and creating artificial sources - man-made water supply installations as wells, qanats, (Zhalov 2019) catchments and cisterns. The use of rainwater tanks dates back to the Neolithic period, when water-resistant lime plaster tanks were built in the floors of houses in rural areas of the, passing through antiquity and the middle Ages and its subsequent historical periods. Levant (Miller 1980,

Angelakis &Spyridakis 2010).

The aim of this article is to present some of the rainwater tanks discovered during our speleological researches made during the long term project of Bulgarian Caving Society „Exploration of the caves of Mount Athos".

General remarks

In general, the build of the rainwater harvesting cisterns can be attributed to the period in which the monastic dwellings (monasteries, sketes, cells) arose, namely the period 10-14 centuries. There is no doubt that the construction of cisterns and the techniques of their erection, as well as knowledge and practical experience, were acquired by previous generations. It is well known that in ancient Hellas and during the Byzantine period and later the construction of rain-collecting cisterns was very widespread. (Yannopoulos et al, 2017). We will briefly discuss some of the design features. There are two main types of shapes of the overlying profiles - „conical-shaped" and „chamber - shaped". The conical type of tanks almost exactly copied the „body" of the so-called Erlenmeyer flask, also known as a cone flask. Like them they had a flat bottom (base), a conical shape, and a narrow cylindrical neck. The bottom of the second type of the cisterns is also flat. Their upper arch is semi-circular in shape. In both cases, the throat is narrow, which aims to limit access and evaporation. Conical or chamber shaped, the inner surfaces of the rainwater harvest tanks, are plastered with a waterproof material - in all cases a fine lime-mortar coating. Their height, circumference, and capacity are different. The cisterns were totally or partly cut into rocks or dig underground. That location was rather for saving space in the above-ground areas and to be as low as possible to provide better and larger collection. In addition the subterranean construction provided the essential strength of the structure to support the huge loads of the water pressure on the side walls. Rainwater was first collected from the flat roofs of the buildings and subsequently channelled to the cisterns via drains and/or channels (Bitis 2013). In some of the cases we have examined, the roofs of the buildings and the drainage facilities to the cisterns have not been preserved. In other parts, no traces of channels and pipes leading to the cisterns have been found and it is assumed that the rainwater was collected in another way and transported to the cisterns. As we will see, there are two exceptions! Very interesting is the method by which rainwater falling on a sloping rock surface was captured and transported to a reservoir. The water tanks we studied belong to abandoned monastery structures and are not currently in use. They were certainly „dug" in parallel with the construction of the monastic „dwellings", but today (with few exceptions) it is difficult to say when they ceased to be used.

Fig. 1. Map of the location of the explored structures (cisterns)

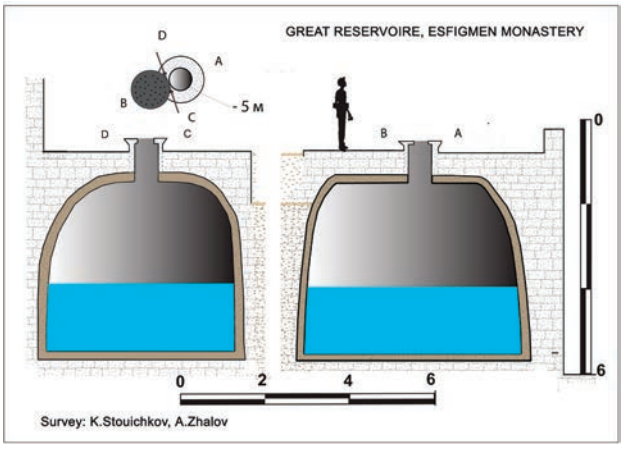

Fig. 2. The Great Cistern of Esfigmen (Map. K.Stoichkov, A.Zhalov)

Overview of the studied sites.

The cisterns were studied in parallel with our classical speleological surveys. In this case, 4 different points on the Athos peninsula were explored. In the northwest part were explored - the vicinities of the Monasteries of Efsigmen, Chilandar and Zograph. In the endmost Southeast we survey the surroundings of the hermitage of St. Anna (Fig. 1).

Near the Esfigmen Monastery to the west, there is a rocky hill range named Samaria. Over the rocks, there are the ruins of eight small abandoned huts-hermitages. Under the rocks there is a church built in 1849 and dedicated to St. Anthony of Pechora, founder of the Kiev-Pechora Laura in Ukraine, with adjacent buildings. Two cisterns (Great & Small one) have been explored

Fig. 3. System of the collecting of rain water

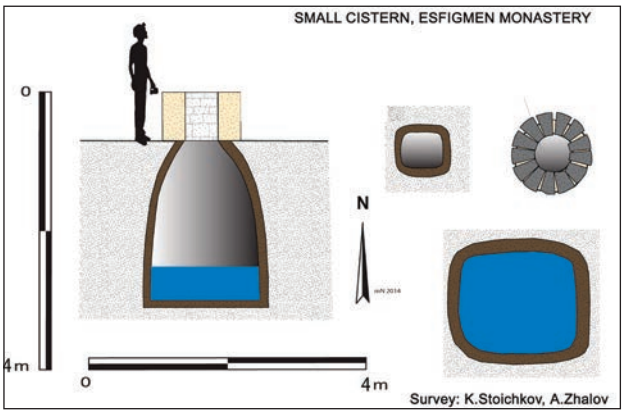

Fig. 4. The Small Cistern of Esfigmen (Map. K.Stoichkov, A.Zhalov)

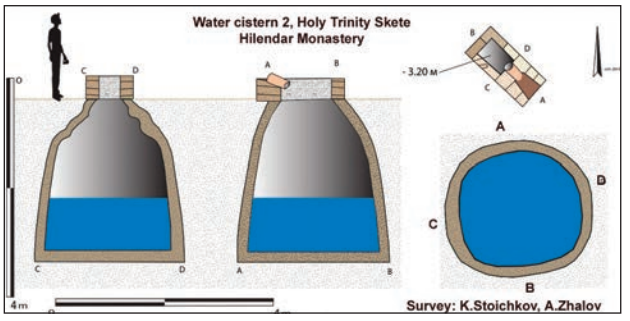

Fig. 5. The Small Cistern of Holy Trinity Skete (Map. K.Stoichkov, A.Zhalov)

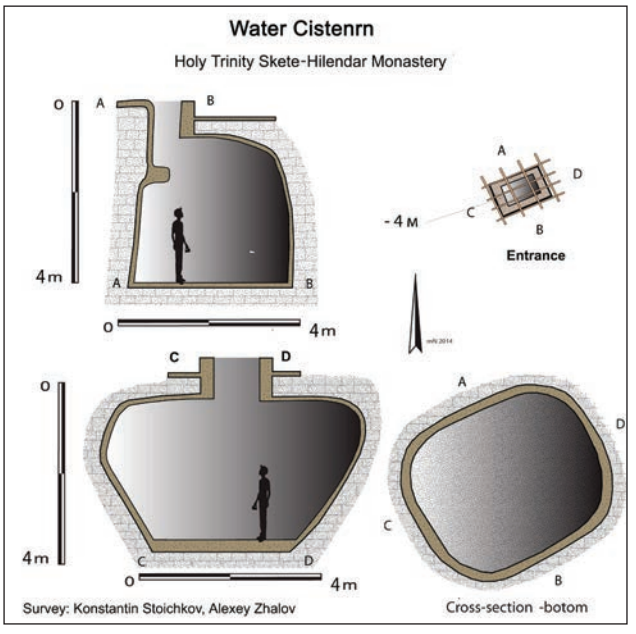

Fig. 6. The Great Cistern of Holy Trinity Skete (Map. K.Stoichkov, A.Zhalov)

in this area. We suppose that they probably had served the monks living there - a place quite far from the monastery. The Great one looks like a chamber (Fig. 2). The depth together with the neck is 5 m. The shape of the bottom is a rectangle with rounded corners. Its dimensions are 5x5 m, respectively, it has an area of about 25 m^2, and a useful volume (provided it is full to the lower end of the neck) of about 85 m^3. Rainwater falling on the rock surface above the reservoir was captured and led to it through peculiar channel created from pieces of bricks, cemented to the rock with mortar. (Fig. 3). The connection between the end of the canal and the cistern appears to be broken. The Small cistern is conical. Its neck is about 0.7 m high and leads to the chamber which depth is about 2.30 m. The surface of the bottom is about 2 m2. The useful capacity is 1.5 m3. (Fig. 4)

The Holy Trinity Skete, better known as Spasova Voda, is located about southern of the Chilandar Monastery in a mountainous area. The hermitage is uninhabited today. It consists of the Church of the Holy Trinity, the ruins of a small chapel, a larger dormitory and tower. So, as before, two cisterns have been studied here - a small and a large one. The small one has the already familiar shape of a truncated cone. After the neck, one enters a cavity with a depth of 2.70 m. The bottom is round and has an area of 4.5 m^2, (Fig. 5) The approximate volume is 5 m3. Unlike all other cases, here we find a channel coming from the ruins of a nearby building, which directly pours the captured water into the cistern! The larger cistern (Fig. 6) is under the ruins of the dormitory. The profile of the entrance opening is rectangular, followed by a shaft of the same shape with a depth of 0.90 m. This passage leads to the actual part of the cistern – an irregularly shaped cavity, whose height is 3.20 m The shape of the bottom is a rectangle with rounded corners and has area of about 11 m^2.

The maximal capacity is ~ 40 m^3. What is known for sure is that the hermitage has existed since the 13th century, which suggests that the described reservoirs date from this period.

Southeast of the Holy Trinity Skete is located the Bulgarian monastery of „St. Georgi Zograph, whose foun-

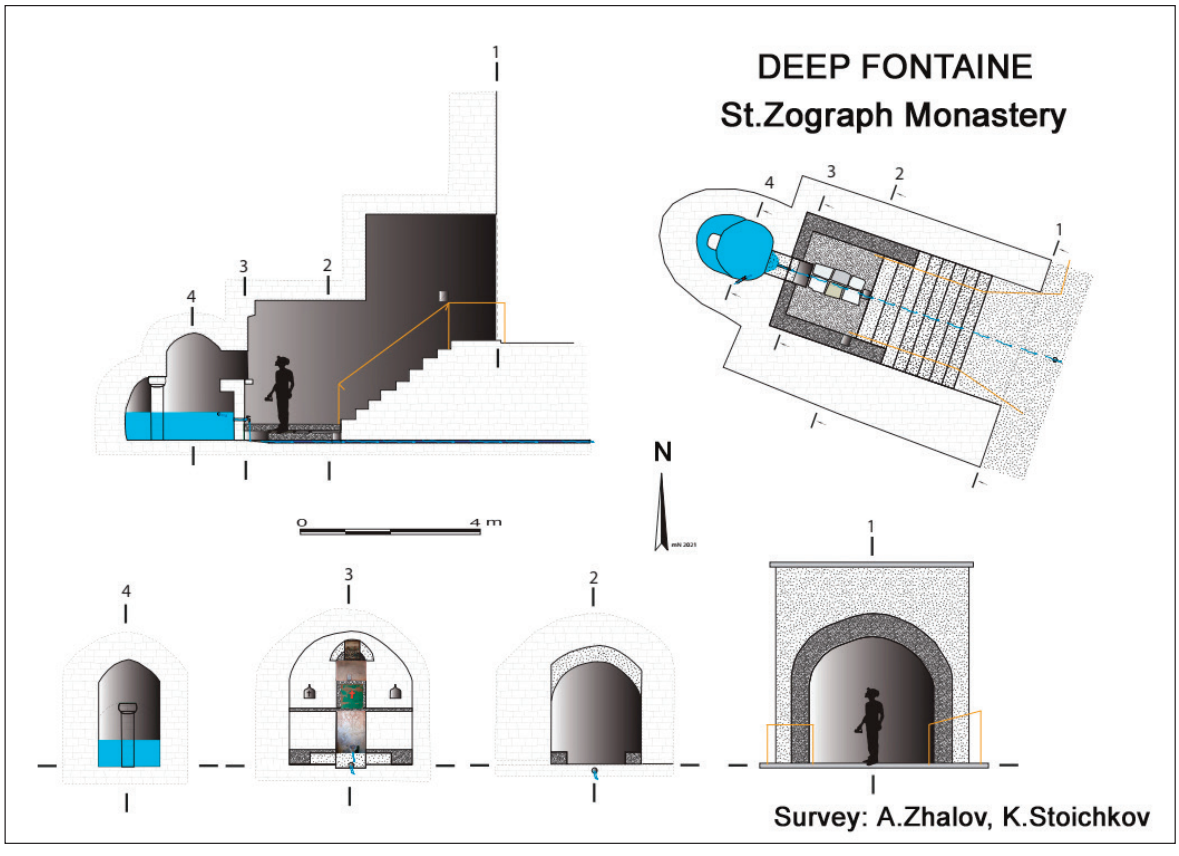

Fig. 7. The Deep fountain Cistern, Holy Zograph Monastery (Map. A. Zhalov, K. Stouchkov)

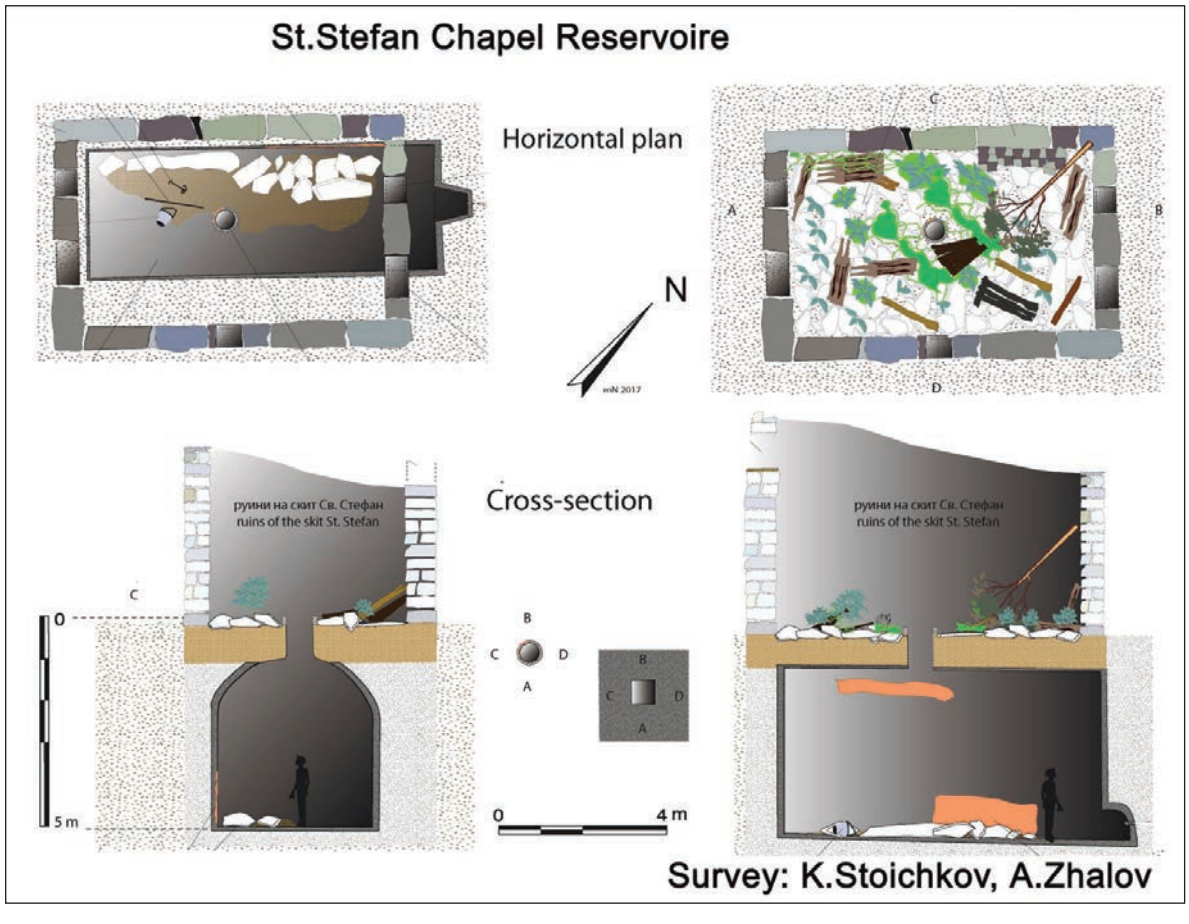

Fig. 8. The St. Stephen's Chapel Cistern, Zograph Monastery (Map. K.Stoichkov, A. Zhalov)

dation dates back to the 10th century. Some types of underground reservoirs have been found on the territory of the monastery and its surroundings. Two reservoirs were studied in detail. The first one is so called "The Deep fountain" (Fig. 7). It is located in the inner courtyard of the "St. Georgi Zagraph" monastery. This structure is an inclined tunnel that provides access to the actual fountain. It is known that the fountain is fed by a spring that was captured when the monastery was founded. The water is collected in a tank located behind the facility. The water enters the cavity through a small pipe protruding from the wall, which most likely originates from the spring. The spring itself is inaccessible. The area of the tank is 2.5 m². During the inspection of the structure in September 2021, the water column was 0.64 m, respectively there was about 1.6 m³ of water in the tank. The maximum capacity of the reservoir can reach 3.6 m³.

The largest cistern studied so far by us is located about 700 m northeast of the monastery near the St. Stephen's Chapel (Fig. 8). It is situated in the ruins of a complex consisting the ruins of two houses. On the floor, almost in the middle of one of them, there is a circular opening with a diameter of ~ 0.5 m. Below there is a vertical shaft with a cylindrical shape and a depth of 1 m which opens in the ceiling of the underground reservoir. Its height is 4.13 m. The bottom is rectangular with a slight slope to the northeast. The length of the cistern is 8.40 m and its width is 3.90 m, therefore the surface is about 33 m². Considering that the shape of the reservoir is not an ideal parallelepiped, its useful volume is calculated to be 114.8 m³ (Zhalov 2019).

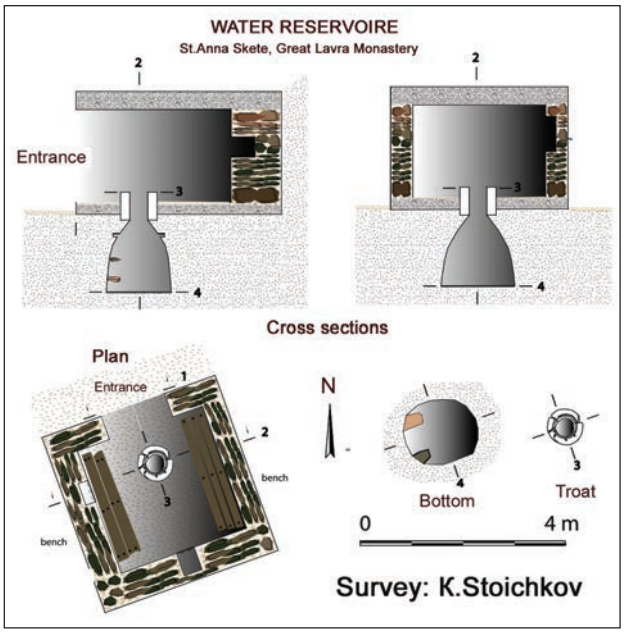

Fig. 9. The cistern on the path from St. Anna to Athos (Map. K. Stoichkov)

The smallest cistern documented by us is located on the path between the St. Anne's Monastery and Mount Athos (2030 m a.s.l.). It is embedded in a small shelter, providing a place to rest for pilgrims

who climb to the summit. It is conical-shaped. The throat is constructed from a thick, circular marble frame. Its internal diameter is 0.5 m. The length of the neck is the same. Next is the cavity, which is 1.40 m deep. The surface of the bottom is 1.5 m². (Fig. 9) This structure can hold about 2.2 m³ of water. The exploration did not provide an answer as to how the cistern was supplied with water.

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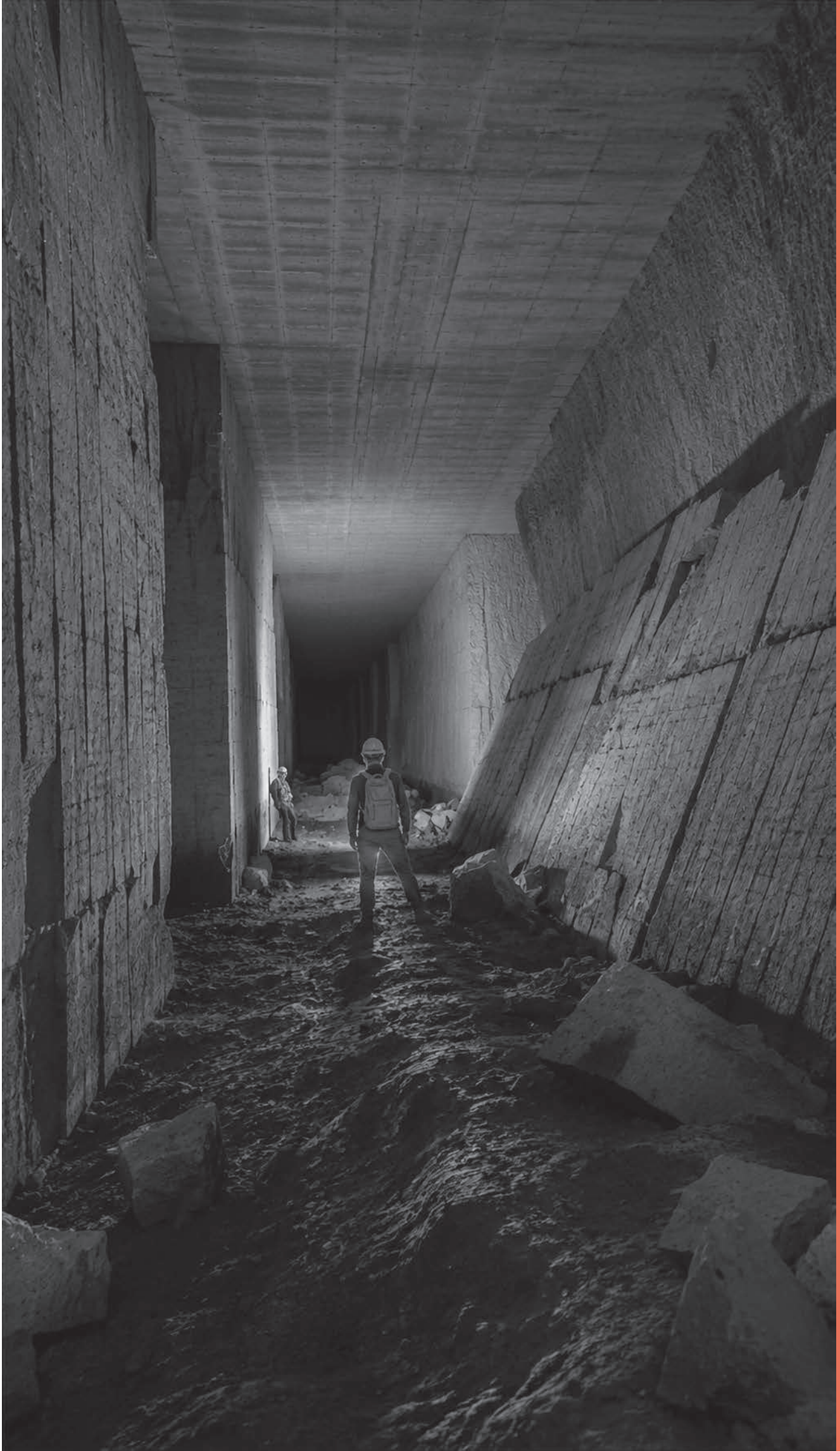

MINING/EXTRACTION WORKS

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The "Sulphur" Museum of Perticara (Italy): A Paradigm Shift from Passive Industrial Repository to Active Interdisciplinary Research Hub

Matteo Giordani[1], Eleonora Benà[2], Cesare Bianchi[3], Maria Cristina Agostini[3], Fabio Peruzzi[4]

[1]Department of Pure and Applied Sciences, University of Urbino Carlo Bo, Via Cà le Suore 2/4, 61029 Urbino (PU), Italy
[2]Department of Geosciences, University of Padua, Via G. Gradenigo, 6, 35121 Padua (PD), Italy
[3]Museo Sulphur, Cantiere Certino Perticara, Via Montecchio, 20, 47863 Novafeltria (RN), Italy
[4]Rovereta S.r.l., Via Rovereta, 32, 47853 Coriano, (RN), Italy

Abstract
The "Sulphur" Mining Historical Museum of Perticara (Rimini, Italy) represents a transformative model for industrial heritage. Situated within a premier sulphur district of the Northern Apennines, the site evolved from a 15th-century extraction works into a massive industrial complex with over 100 km of tunnels, before the end of all mining activities in 1964. Established in 1970 as a pioneer of Italian industrial archaeology, the museum has transitioned from a local commemorative space into a "living laboratory" that bridges the gap between historical memory and international scientific research.

This study examines how the museum facilitates high-impact research by providing a unique interface between in situ geo-heritage (underground tunnels accessible with limitations, and industrial remains), and ex situ assets (mineralogical collections and technical archives). The methodological framework is inherently interdisciplinary, involving collaborations between speleological groups, sector specialists, private companies and a network of european universities. Research activities integrate geological mapping, the investigation of environmental matrices, natural radioactivity, biology, human health, with advanced analytical techniques and radiometric monitoring to assess mineral neoformation, and the environmental legacy of the mine developed in the Gessoso-Solfifera Formation. The Perticara case challenges the traditional hierarchy of heritage institutions. Despite its local scale, the museum acts as a catalyst for scientific outputs of international standing, including publications in Q1 journals. Key findings have highlighted the cytotoxic risks of naturally occurring fibrous epsomite and documented complex radionuclide distributions within abandoned tunnels. Unlike larger institutions worldwide, Perticara offers a uniquely integrated platform where raw data from field campaigns is immediately contextualised by centuries of mining archives, creating a multidisciplinary synergy between geosciences, biology, and public health.

Beyond pure science, the museum functions as a neutral ground for knowledge transfer and citizen science. Research outcomes are translated into educational protocols and evidence-based narratives, reframing "industrial scars" as scientific assets. This model fosters societal resilience and sustainable geotourism by empowering the local community through scientific literacy. By mediating complex data on environmental health and mineralogy into accessible cultural heritage, the museum demonstrates that minor mining sites can serve as global research hubs. This integrative approach–combining conservation, continuous monitoring, and academic networking–provides a replicable template for the sustainable management and scientific valorisation of underground industrial landscapes worldwide.

Keywords: Sulphur mining, Industrial archaeology, Geo-heritage, Interdisciplinary research, Public health, Sustainable valorisation

Introduction

The historical trajectory of the Perticara mining district, located in the Rimini province of Italy, offers a profound case study in the evolution of industrial heritage. Once the cornerstone of European sulphur production, the site reached its industrial apogee during the 20th century under the management of the "Montecatini" company. At the height of its productivity, the mine was a massive socio-economic engine, employing a workforce of over 1,600 individuals and developing a labyrinthine underground infrastructure that spanned more than 100 kilometers of galleries. The cessation of mining activities in 1964 did not mark the end of the site's significance; on the contrary, the establishment of an initial museum in a nearby area in 1970, followed by its relocation in 2002 to the original "Certino" mining facilities adjacent to the Vittoria well, ensured the preservation of these emblematic structures (Fig. 1), setting a pioneering example in the field of industrial archaeology in Italy (Fabbri, 2000; Biagianti, 2003).

Beyond its role as a guardian of memory, the museum occupies a position of immense geological significance. It is embedded within the Messinian Gessoso-Solfifera Formation, a distinctive stratigraphic sequence that provides essential insights into the geodynamic and paleoenvironmental shifts of the Northern Apennines (Roveri et al., 2008). This unique setting allows the institution to manage a dual heritage: in situ assets, comprising the physical remains of the industrial landscape and accessible subterranean environments, and ex situ assets, which include world-class mineralogical specimens and a vast repository of technical documentation and archives.

The "Sulphur" Mining Historical Museum of Perticara has undergone a transformative shift, moving beyond its initial commemorative purpose to establish itself as a research nexus of international caliber. While small-scale regional museums are frequently overshadowed by larger national entities, Perticara serves as a compelling counter-example. It demonstrates that a locally-embedded institution can function as a powerful catalyst for high-impact scientific inquiry. By synthesizing the disciplines of industrial archaeology, applied geosciences, and environmental monitoring, the museum has created a living laboratory. This integrated platform effectively bridges the divide between the preservation of the past and the demands of modern scientific research, facilitating interdisciplinary studies that address global challenges in mineralogy, public health, and sustainable geo-tourism.

Fig. 1. The "Certino" mining yard and the well "Pozzo Vittoria" in the background

Methodology

The methodological architecture of the research conducted at the Perticara site is defined by its deep interdisciplinarity, merging traditional mining history with cutting-edge analytical sciences. This framework is sustained through an international cooperation network that bridges academic institutions, speleological associations, and industry partners.

The investigative process is structured into four primary methodological pillars:

(I) Advanced Mineralogical and Geochemical Characterization - To decipher the complex chemical environment of the sulfur deposits, the research employs high-resolution analytical techniques. As an example, X-ray Diffraction (XRD) is used to identify the crystalline phases of both primary minerals and those formed through secondary alteration processes (neoformation). This is complemented by Scanning Electron Microscopy combined with Energy Dispersive Spectroscopy (SEM-EDS), which allows for a detailed examination of mineral habits and micro-topographies. This microscopic focus is crucial for detecting trace elements and chemical impurities that can significantly alter the geochemical behavior of the minerals within the Messinian Gessoso-Solfifera host rock.

(II) Environmental Radiometrics and Gas Dynamics - A critical component of the methodology involves the assessment of the radiological signature of the underground environment. Monitoring campaigns were conducted to quantify the presence of natural radioactivity, with a specific focus on the decay products of uranium and thorium series. Furthermore, the research investigates ^{222}Rn gas dynamics, analysing how ventilation

patterns and geological faulting influence gas accumulation within the abandoned galleries. These measurements are vital for establishing safety protocols for both scientific personnel and future heritage preservation efforts.

(III) Toxicological Assessment and Bio-interaction - The methodological framework extends into the realm of life sciences through Biological and Toxicological Assays. By conducting in vitro experiments, researchers evaluate the cellular response to mineral dusts and fibres found within the mine. These studies utilize cytotoxicity and genotoxicity tests to determine whether the natural morphology of minerals, such as fibrous epsomite, triggers different biological pathways compared to commercially produced synthetic salts. This comparative approach is essential for identifying specific health risks associated with the particular mineralogical habit of the site.

(IV) Transdisciplinary Archival and Field Integration - A distinctive feature of the Perticara methodology is the archival-to-field loop. Scientific data collected in situ is systematically cross-referenced with the museum's extensive Historical Archive. This includes the analysis of 19th and 20th-century technical maps, stratigraphic sections, and mining journals. By integrating these historical records with modern geospatial data, researchers can reconstruct the spatial evolution of the mine, providing a temporal context that enhances the interpretation of current environmental and geological data.

(V) Logistical Synergy and Field Integration - The implementation of these diverse methodologies is facilitated by the museum's technical staff, who serve as a connection between theoretical research and field operations. Their role is pivotal in navigating the specific conditions of underground sampling, ensuring that all academic interventions are seamlessly integrated with the site's historical and physical context. This collaborative model establishes the Sulphur Museum as an active partner in the scientific process, rather than a mere facilitator.

Key Scientific Results

The strategic synergy between the Perticara Museum and its academic partners has yielded high-caliber scientific contributions, evidenced by numerous publications in top-tier (Q1) international journals. These results transcend local history, providing data that influences global debates in environmental science and medicine. One of the most innovative research lines has focused on the interaction between biology and secondary minerals, particularly on epsomite (Salucci et al., 2024; Giordani et al., 2025). Studies conducted on naturally occurring fibrous epsomite have revealed a significant paradox: while magnesium sulphate is generally considered safe in its synthetic form, the natural specimens from Perticara exhibit a marked cytotoxic potential. The research highlights that this increased toxicity is not merely a function of chemical composition but is intrinsically linked to the mineral's habit–its physical, needle-like morphology–and the presence of trace metallic impurities. These findings have profound implications for occupational health and the safety of personnel operating in similar geological environments worldwide.

Fig. 2. Example of conference helded by Sulphur museum in 2025

A further innovative aspect is related to the environmental radiochemistry in post-mining areas. The subterranean and surficial investigations have provided a detailed mapping of the radiological fingerprint of the rock formations (Giordani et al., 2022; Giordani et al., 2024). The documentation of anomalous concentrations of radionuclides, particularly isotopes like Polonium-210, has redefined the environmental understanding of abandoned industrial sites. This research provides a fundamental dataset for long-term site management, demonstrating that former industrial areas retain complex chemical and radioactive signatures. Studying these characteristics through ongoing scientific observation is essential for a comprehensive understanding of the site's evolution and for informed heritage conservation. Moreover, a major success of the Sulphur museum's model is its ability to perform knowledge trans-

fer. The museum acts as a translator, converting dense, high-level analytical data into accessible educational frameworks. By developing evidence-based narratives, the institution has successfully integrated scientific literacy into the local identity. This process transforms the perception of the mine from a site of past labour into a contemporary resource for citizen science, fostering a community that is both resilient and informed about its own environmental context.

Finally, beyond empirical data, a significant result is the institutionalization of the museum as a hub for collaborative innovation. By organizing and hosting international conferences and technical workshops as showed as an example, in Fig. 2, Sulphur Museum provides a neutral ground where diverse stakeholders–ranging from theoretical physicists and geologists to public administrators and the general citizenry–can converge. This multidisciplinary exchange has proven that local heritage sites can lead the way in fostering global scientific networks, effectively breaking the isolation of regional cultural institutions.

Conclusions

The experience of the Perticara Sulphur Museum challenges traditional hierarchies in heritage management, proving that minor institutions can generate "major science" when they strategically leverage their unique assets. The integration of research, conservation, and public outreach transforms the site from a passive repository into an active engine for innovation. Looking ahead, the museum aims to expand its environmental monitoring and digital heritage initiatives. This integrative model offers a replicable template for the sustainable management of industrial landscapes worldwide, demonstrating that mining heritage can contribute meaningfully to contemporary scientific discourse and societal resilience.

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Revisiting the Dating of the Huk Mine – a Previously Unknown Mine in Odesa City (Ukraine)

Igor Grek
speleological club "Poshuk", Odesa city, Ukraine
grekigor19@gmail.com

Nataliia Moldavska
speleological club "Poshuk", Odesa city, Ukraine
m.nataliya.at@gmail.com

Abstract

Odesa catacombs are extensive underground cavities of various purposes located beneath the city blocks and nearby the suburbs of Odesa. The longest of these underground spaces are mines. Therefore, the term "catacombs"is most frequently used in the strict sense referring specifically to these mining sites.
Limestone is an excellent building material. The stone stratum lies almost horizontally beneath the city (with a dip of approximately 1-2 degrees to the south). It outcrops at the sea shore or along the slopes of deep valleys (ravines). Elsewhere, it sits at depths ranging from 5 to 40 meters, depending on the terrain.
The catacombs (i. e. mines) do not form a single connected underground system beneath the city. As of September 2021, 105 individual mines were known within the city limits (Pronin 2021). They had been developed from the early 19th century until the 1950s.
The old mines in Moldavanka district are among the earliest and most fascinating parts of the Odesa city catacombs. They have been described very briefly and are far from being completely explored, primarily because many underground systems currently lack accessible entrances, meaning that their precise locations are unknown. Eventually, such underground systems become accessible -most frequently when they are uncovered during construction works to undergo subsequent support setting.
In September 2023, speleologists from the "Poshuk" club became aware of a previously unknown and unexplored underground system in Moldavanka district. Among the miners' inscriptions on the mine walls, surname "Huk" (written as "*Гукъ*" - spelling common to the pre-reform period - prior to 1917) appears repeatedly. Thus, the underground system we explored was named the "Huk Mine".
Important discoveries were made there, shedding light on the history of mine development and their utilization as shelters. While these materials had been previously published by the authors (Grek et al. 2025; Grek & Moldavska 2025; Grek & Mishchenko 2025), the study of the mines continued, leading to new and interesting findings.
One of the most compelling problems the researchers faced was determining the exact period of the mining operations. The authors employed several distinct methods to solve it. Configuration of the mines was analyzed based on cartographic material. Tool marks on the walls revealed the technologies used to extract stone blocks. These technologies had been changing across different time periods. Critical conclusions were also drawn through the analysis of numismatic material. Inscriptions and drawings on the mine walls represent a traditional source of chronological information; these discovered images are analyzed in the present paper. Analysis of archival records constitutes another key method applied by the authors.
Based on the collected data, the authors concluded that the discovered underground system refers to the category of public municipal mines. Originally, it consisted of five separate mines, the latest of which dates back to the late 1840s.

Keywords: Odesa catacombs, the Huk Mine, dating of mines, wall inscriptions and drawings in mines

Introduction

Odesa catacombs constitute one of the longest labyrinths of old mine workings in the world. Located directly beneath urban quarters as well as in the immediate vicinity of the city, these mines were worked throughout the 19th and 20th centuries. Numerous questions remain unanswered regarding the chronological tracking of these systems. For instance, the exact starting date of underground limestone extraction - effectively the origin date of the Odesa catacombs - remains a matter of ongoing debate. Identifying the timeframe when specific mine sections were worked, tracing the evolution of technological processes, and understanding how these spaces served as shelters for both combatants and civilians are all areas of significant interest. These issues are tightly linked both to preservation of cultural heritage and to practical engineering tasks aimed at mitigating

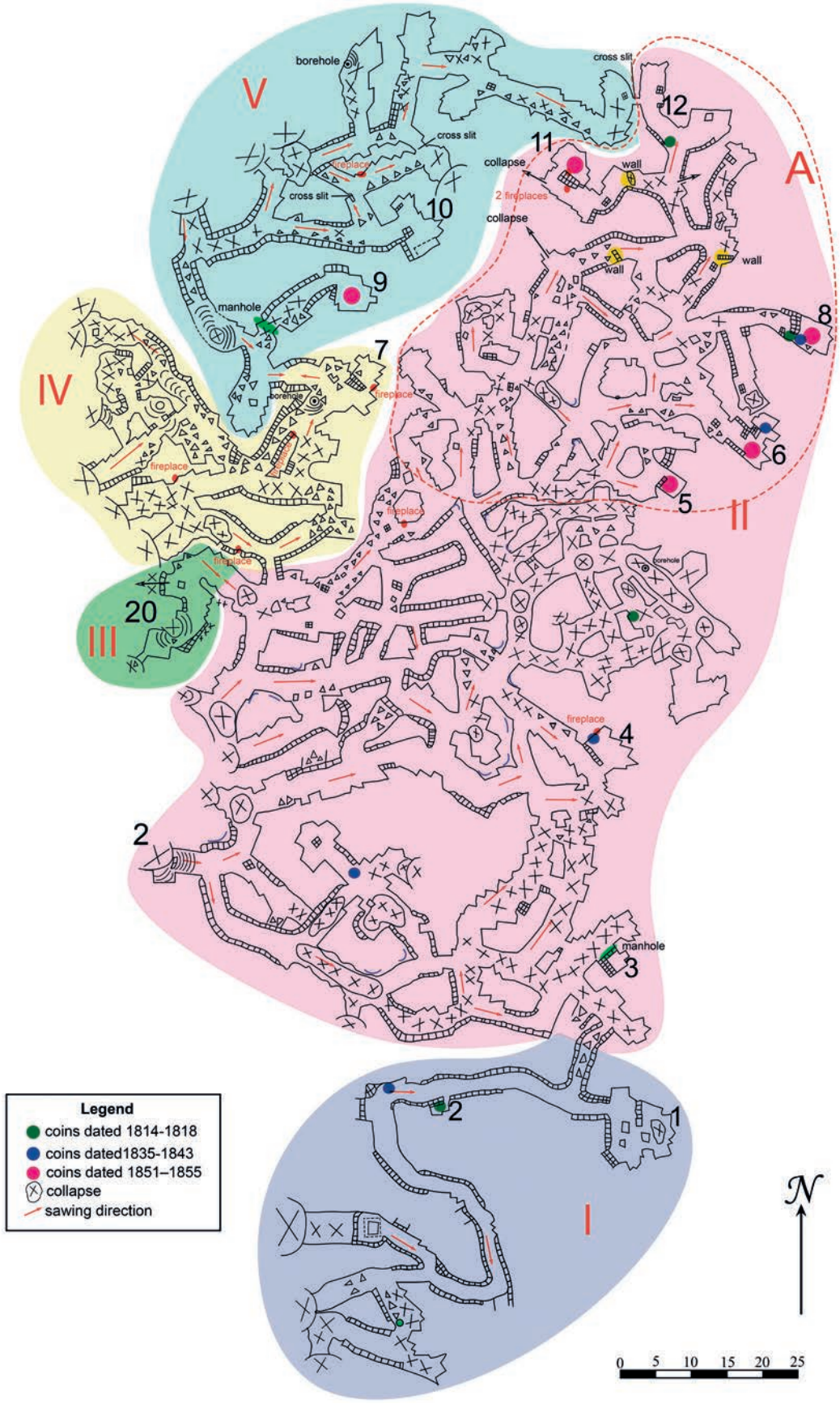


Fig. 1. The Huk Mine. Mapping by N. Moldavska, 2025

Fig. 2. Drawings on the mine walls. The Huk Mine (photo Moldavska N.)

the impact of the catacombs on urban development.

Dating the Odesa Mines

In practice, providing precise dates for the origin of the catacombs is a highly complex task. Some underground systems consist of mines from entirely different eras, meaning these individual mines must be distinguished within a broader underground system.

Spatial configuration of mines, as well as changes in technological methods used to extract stone blocks, can be used to reconstruct relative chronology of the workings.

Finds allowing to date a mine directly, such as coins, are extremely rare in catacombs. Furthermore, they are of insignificant value in underground systems that remained accessible and consequently were being visited over a prolonged period.

19th-century records preserved in Odesa archives are typically formatted in a manner that makes them incredibly difficult to use today, primarily due to challenges regarding localization. Most frequently, locations of historical sites are mentioned under old toponyms that have long since been out of common use.

Miners' inscriptions and drawings on walls remain the most frequently applied method of dating. In practice, however, isolating these early images from subsequent layers of graffiti is not a simple task. The most reliable way to date mines is by survey marks made on the walls by mining engineers. This method can only be applied to mines of the late 19th century onward, as such markings only began appearing after the establishment of the Odesa Mining District in 1883. In earlier underground systems, dates carved into the stone are exceedingly rare, and there are very few text inscriptions due to low literacy rates among the general population. Nevertheless, certain drawings allow for indirect dating of the workings (Pelovina 2021).

The Huk Mine and Its Dating

In September 2023, speleologists from the "Poshuk" club discovered a previously unknown and unexplored underground system in Moldavanka district, which was named "the Huk Mine".

The layout of the underground system is shown in fig. 1. It was established that the system consists of 5 individual mines connected by cross slits. Evidently, the section marked with letter A in figure 1 is of a later period, as it bypasses the mine workings of sections 3, 4, and 5.

The discoveries made within the underground system indicate that the mines were actively used (and visited) for some time after stone extraction had completely ceased. This is evidenced by small underground shelters (camps) discovered inside. Their location in the most remote, dead-end sections of the mine, combined with the nature of the recovered artifacts, points to the fact that they had been used by miners. In these locations, intriguing wall inscriptions and drawings in a primitive style have been preserved (Fig. 2).

Among all the recovered artifacts, a collection of coins holds the greatest interest for dating of the mines.

Total number of the coins found is 39. Nearly all of them, except for three, on which the dates were completely illegible, were preserved in a satisfactory condi-

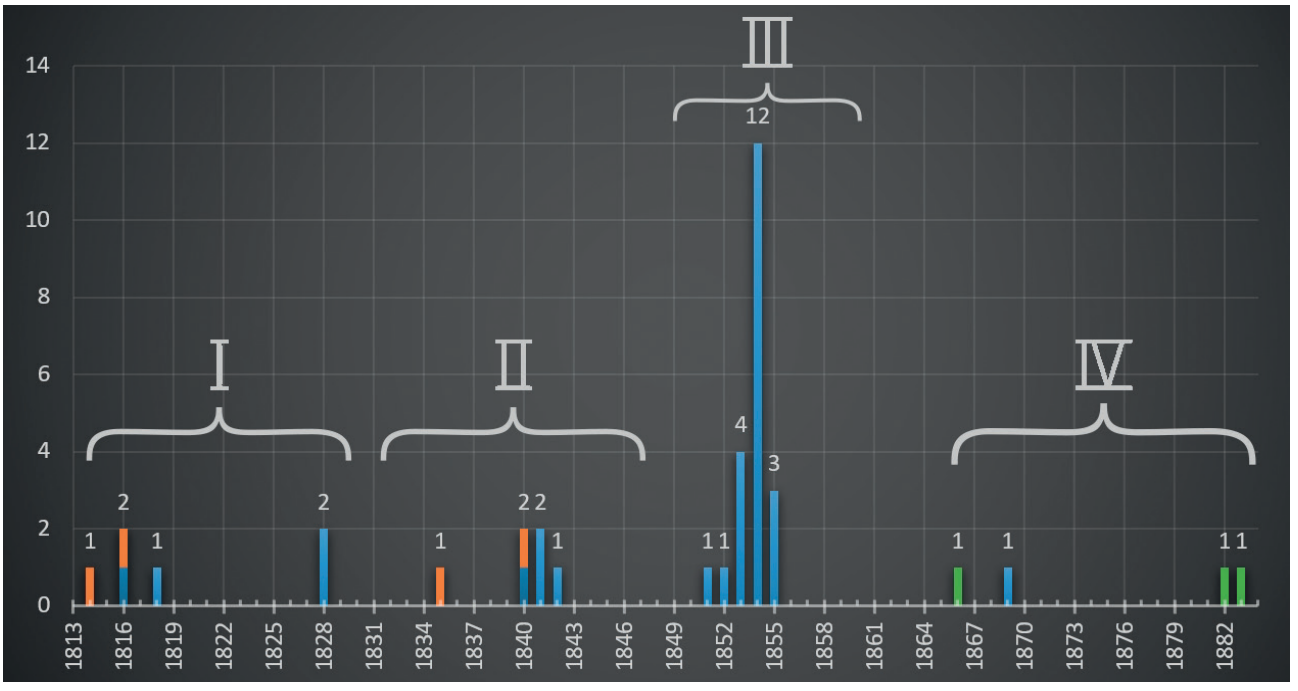


Fig. 3. Coin distribution diagram (graphic Moldavska N.)

tion that allowed for reliable identification. Their years of minting range from 1814 to 1883. All of these coin types had remained in circulation until 1917, meaning our subsequent reasoning must rely primarily on probabilistic analysis.

For analytical purposes, we categorized all the discovered coins into three groups: those found directly at the underground camps (indicated in blue on the diagram), those found on the floor outside the camps (indicated in orange), and those recovered from borehole backfills or areas washed out by water from the surface (indicated in green). The distribution of coins by year of minting is presented in the diagram in fig. 3. Out of the 36 identified coins, 29 were discovered directly at the camp sites.

The coins found in the backfill material (marked in green) form a distinct cluster on the diagram representing the latest specimens found in the underground system. These are connected neither to the active operations of the mine nor to the usage of the camps; instead, they pinpoint the timeframe of the borehole (or sinkhole) backfilling: no earlier than 1883.

Peak 3, formed by a significant number of coins discovered at the camp sites that make up a separate group, comes to a sharp end in 1855. This allows us to date the latest period of use for these underground camps exactly to the specified year - 1855. In our view, this strongly points to local residents utilizing the catacombs as a shelter during the Crimean War (1853–1856). Historical memoirs that corroborate this practice were written (Chizhevich 1894; De Ribas 2005).

Four coins discovered directly on the mine floors are, in our opinion, associated with the actual mining operations and belong to the two earliest coin groups on the diagram. Initially, we hypothesized that the two peaks in the distribution diagram within the intervals of 1814–1818 and 1835–1843 were linked to two distinct periods of active mining. However, if that were the case, we should have observed a clustering of earlier coins strictly within the older, primary sections of the underground system. In reality, coins from both groups are distributed relatively evenly across the entire mine, including the most remote i.e. latest sections of the old workings. Thus, this initial hypothesis was not confirmed. Consequently, we can only confidently state that the active mining there stopped no earlier than 1840.

A single coin that deviates from this general statistical trend is a 1-kopeck piece from 1869 discovered in Room 10. It points to another, later instance of the camp sites being used.

On the whole, with the exception of the underground camp areas, the explored underground system is quite sparse in epigraphic material. For the most part, the markings consist of miners' protective crosses, as well as a very small number of primitive drawings and calculations.

In section A, the latest part of the underground system, we discovered two sequences of numbers (Fig. 4). These images closely resemble dates, but in the first instance, one digit is clearly missing, while in the second instance, two characters appear superfluous. Both inscriptions were executed in charcoal of identical thickness and intensity, suggesting they may have been

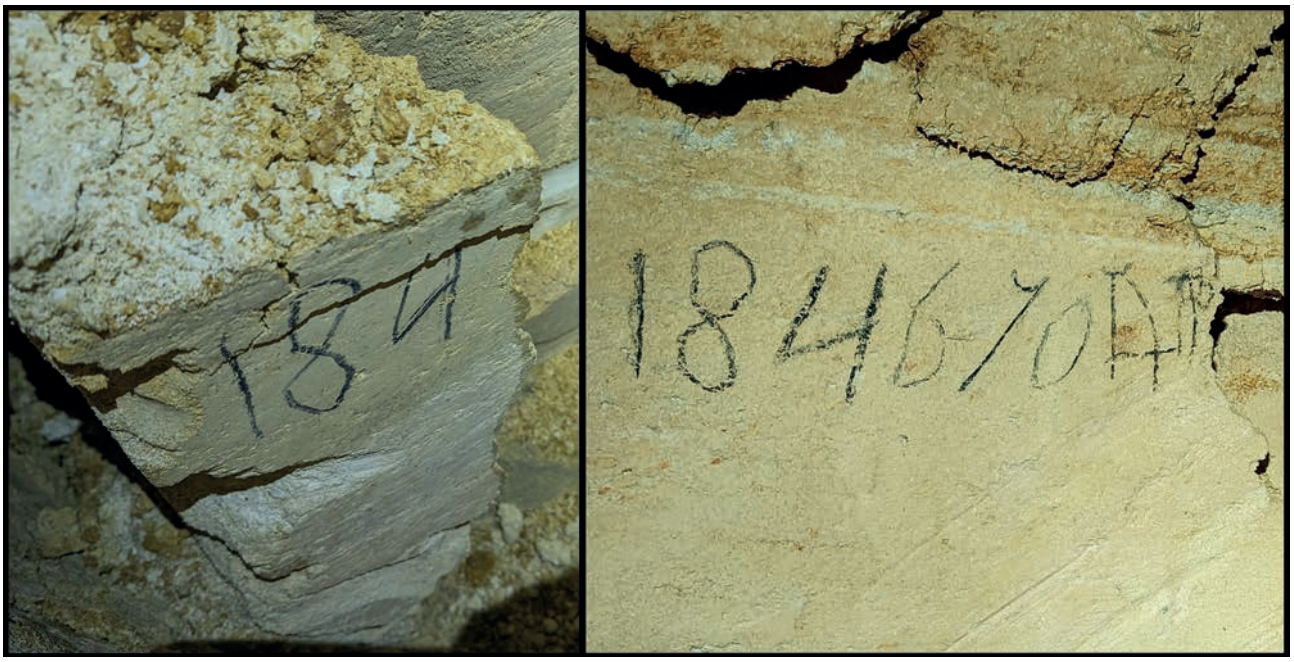
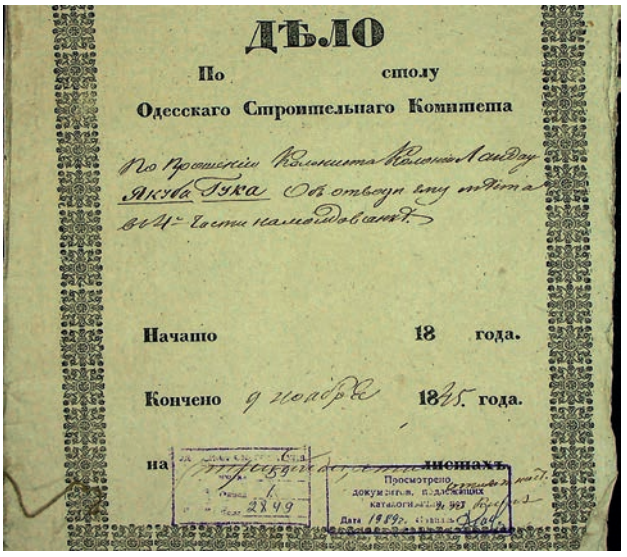


Fig. 4. Number sequences interpreted as dates on the mine walls. Section A, the Huk Mine (photo Moldavska N.)

Fig. 5. The missing digit found on a collapsed fragment of the mine wall (photo Moldavska N.)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Начато 18 года.
Кончено 18 45. года.

Fig. 6. Record from the archives of the Construction Committee of Odesa city on the allocation of a land plot to colonist Huk dated September 12, 1845 (photo Moldavska N.)

drawn by the same individual. On this very same pillar, just around the corner, the surname "Huk" (Гукъ) is written. Evidently, a person with this surname was in some way connected to the stone extraction operations in this specific area.

In the first case, a collapsed fragment of the wall containing digit "6" was discovered directly beneath the charcoal drawing (Fig. 5). In the second case, we hypothesized that the letter "г" (representing the word year - "годъ") was written with an error, flipped in the opposite direction. Thus, we are dealing with two dates: 1846 and 1847.

A record dated September 12, 1845, titled "On the allocation of a land plot in Moldavanka to colonist Huk..." was discovered in the archives of the Construction Committee of Odesa city (SAOO 1845). This archive entry (Fig. 6) indirectly confirms the likelihood of stone extraction being carried out for the specified individual within a public municipal mine.

In this same area, within section A, the year 1866 appears twice, soot-blackened onto the ceiling. These dates likely correspond to a later period of the mines being utilized or visited.

Conclusion

Thus, we have established that the latest section of the Huk Mine was being actively worked in 1846–1847. It is evident that the sections closer to the original entrances of the explored underground system had been worked even earlier, possibly no later than the 1830s. At the same time, the period of active utilization of these mines by the civilian population as a shelter likely extended until the 1870s. Subsequently, the entry shafts to the mine were filled in, and the system remained completely inaccessible until the present day.

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History of Underground Quarries at Cutrofiano (Apulia, Southern Italy) and Related Hazards

Francesca Lagna[1], Francesco Ligori[2], Isabella Serena Liso[3,*], Mario Parise[3]

[1] *Apulian Speleological Federation, Italy*
[2] *Freelance Geologist, Cutrofiano, Italy*
[3] *Department of Earth and Environmental Sciences, University Aldo Moro, Bari, Italy*
[*]*serenaliso.uniba@gmail.com*

Abstract

Among the different typologies of artificial cavities that may potentially induce sinkhole occurrence, underground quarries and mines are the most dangerous in southern Italy: since they typically developed during the last century, and were later abandoned, their loss of memory by local communities brought to degradation and weathering of the rock masses, with repeated collapses. In this contribution we examine the area of Cutrofiano (Lecce province, Apulia, south-eastern Italy), one of the most important quarrying districts of the region. There, calcarenites have been extracted for decades from the underground, in order to save the surface for agricultural purposes. Due to the local geological setting, the stratigraphic succession dips southward, so that the most significant portion of the calcarenite rock mass varies from depth of 7-8 meters (close to the town) to more than 45 meters below the ground, further south. An extensive network of underground galleries, covering several tens of kilometers, has been realized; after closure of the quarrying activities, sinkholes started to occur, and serious damage had to be registered to buildings, infrastructures and communication routes. The present contribution illustrates the history of the Cutrofiano quarries, from the beginning of the extraction activities (initially by hand, and only later through the use of machineries), to their later evolution, after closure and abandonment, until the occurrence of several sinkhole events.

Keywords: artificial cavities, underground quarries, sinkholes, susceptibility, hazard

1. Introduction

The study of artificial cavities requires attention not only to their original function, but also to their long-term interaction with the overlying ground and with present-day land use. Within the general classification of artificial cavities (Parise et al. 2013; Galeazzi et al. 2025), underground quarries and mines (E1) represent a particularly critical category because their voids may be extensive, poorly documented after abandonment, and capable of producing surface instability. In Italy, chronological evidence of natural and anthropogenic sinkholes confirms the prevalence of such category in the development of hazardous ground failures (Vennari and Parise 2022).

This contribution focuses on historical aspects linked to the calcarenites quarrying activity carried out at Cutrofiano municipality, located in southern Italy, one of the most important mining districts of Apulia Region. The aim is to synthesize the historical, geological and technical elements that are necessary to fully understand the present hazard. A variety of information are contained in the historical sources, documenting that underground quarrying began in the 19th century, and lasted until 1998 (Toni and Quartulli 1986; Lagna 1988; Toni 2001; Astra Engineering S.R.L. 2004-2006).

The sources report that underground extraction of the local calcarenite was chosen in order to exploit the workable stone while leaving the land surface available for agricultural purposes. Over time, quarrying produced an extensive network of underground galleries, reaching several tens of kilometers. After closure and abandonment, sinkholes and subsidence phenomena affected the quarry district, causing damage to buildings, infrastructures and communication routes (Vennari and Parise 2022).

2. Geological and hydrogeological setting

The Cutrofiano area belongs to the Apulian foreland of southern Italy. The broader geological setting includes Cretaceous carbonate rocks, locally referred to the Altamura Limestone Formation, Miocene deposits such as Pietra Leccese, and Plio-Pleistocene units including the Gravina Calcarenite and the Subappennine Clays (Spalluto et al. 2015; Reina and Pedone 2015). The quarries were developed in the Gravina Calcarenite, a soft and porous rock mass suitable for the extraction of

building blocks.

The location and distribution of the underground quarries were conditioned by the quality of the workable calcarenite beds and by the thickness of the overburden. In the Cutrofiano district, the calcarenite layers of interest are overlain by yellowish silty-clayey sands, greenish silts and grey-blue clays, which may exceed 40 m in thickness. These deposits are separated from the calcarenite by a variable thickness of hard and resistant bio-calcarenite, locally called *mazzaro*. This latter formed the natural roof of the quarries and supported the overlying sandy-clayey sediments, making underground extraction possible (Toni and Quartulli 1986; Lagna 1988; Toni 2001; Astra Engineering S.R.L. 2004-2006). Due to southward dipping of the stratigraphic succession, the calcarenite body object of extraction is located at depths of about 7-8 m close to the town, deepening at more than 45 m further south; as a consequence, the shallowest and oldest cavities are located close to the urban center, whereas deeper quarries are in the southern sector of the domain. This variation is crucial for both the feasibility of underground quarrying and the mechanisms of surface deformation. Hydrogeological aspects have also a crucial role in inducing instability and contributing to the evolution of mechanical properties of the rock masses. The site shows a shallow phreatic aquifer in the upper deposits and a basal regional aquifer circulating in the fractured and karstified carbonate basement. Water infiltration, together with the porosity and low strength of the calcarenite, promotes weathering and progressive degradation around the pits, galleries and pillars (Lollino et al. 2012, 2013; Reina and Pedone 2015).

3. Historical aspects and functioning of underground quarries

3.1. History

The underground quarries are distributed almost entirely south of Cutrofiano (Fig. 1), in a broad area between the town, where the oldest cavities, realized after 1894-1895, are found between the province road S.P. 362 to Supersano and the route via Vecchia del Capo - via Salento. Inspections carried out in the 1990s and more recent surveys documented very old cavities, Aria Scura to the south, Masseria Piscopio Piccolo to the east and Cafari to the west. Attempts at underground extraction are also reported in the localities Lustrelle, C. Congedo,Villa Dolce and Pizzo, with gallery widths locally between 8 m and 10 m. Near Masseria Petrore, recent evidence indicates the presence of open-air extraction sites showing initial traces of underground exploitation, together with very ancient chamber quarries (Lagna 1988; Toni 2001; Astra Engineering S.R.L. 2004-2006; Ligori 2014, 2015). The associated underground gallery network is extensive, extending over several tens of kilometers and including more than 160 identified pits (Fig. 1), with spatial variability in both gallery depth and orientation.

Knowledge of quarry distribution and depth, and the associated weak elements as concerns instability (namely, the pits) is crucial in order to collect the essential data for evaluating the instability conditions in the different sectors. As a further element to be considered, vicinity of subterranean voids belonging to different pro-

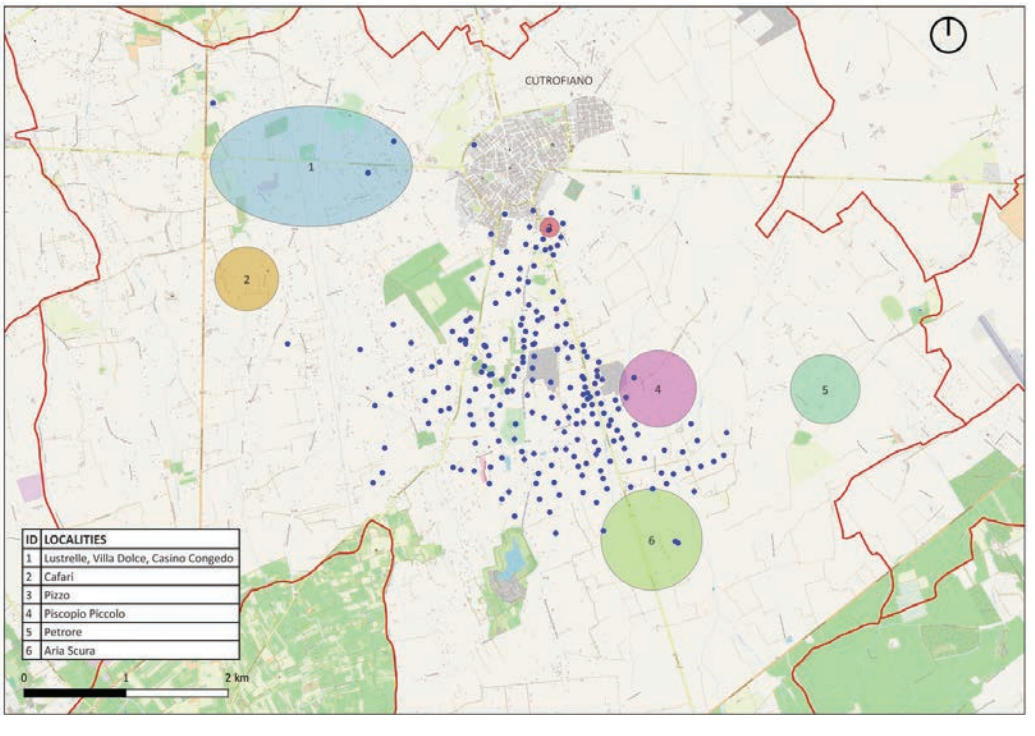

Fig. 1. Location map of Cutrofiano area with underground quarries and distribution of entrance pits (blue circles)

perties and owners brought to interconnections among the single quarries, that have eventually become part of the overall extensive network of underground galleries (Toni 2001). This means that failures at a quarry site might not be limited to the quarry itself, but rather involve also those nearby, with wider negative effects at the surface in terms of sinkhole occurrences.

3.2. Architecture and functioning

As regards the extraction techniques, the most widespread required access to the calcarenite bed through two distinct pits. The main one, of circular shape and with diameter of some 3 m, was used for extraction, and typically located near the center of the quarry site, while the adjacent and smaller pit, named *lanternino*, was used as entrance for the workers (Fig. 2). The excavation proceeded by hand in sections between about 1.5 m and 3 m high, depending on the characters of overburden deposits (sands, silts and clays). The pit was lined with rectangular-shaped stone blocks resting on the top of the *mazzaro* (Toni and Quartulli 1986; Toni 2001). Once reached the *mazzaro* layer, shape of the pit changed into a truncated pyramid, with a bell-like shape and a square base slightly larger than 5 m (Fig. 3). Due to the good mechanical properties of the *mazzaro* layer, it was left as the roof of the galleries to be excavated, in order to ensure safety of the working site.

The geometry of *lanternino*, on the other hand, changed over time. In the earliest phases it had a rectangular or sub-rectangular section, initially about 1.5 m by 0.60 m, later enlarged to about 2 m by 0.80 m. Descent and ascent were performed by workers using opposing

Fig. 2. Main pit (green arrow) and nearby access to lanternino (white arrow)

handholds and footholds cut into the lining. In the last decades of activity, the pit geometry often became circular, with a diameter of about 2 m. Access was provided by ladders resting on intermediate platforms every 4-5 m. It was connected to the bell-like shaped part of the pit, *campana* (Fig. 4), from which workers descended to the quarry floor by metal ladders, one of which generally rested on a rock pillar cut into the calcarenite (Toni 2001; Astra Engineering S.R.L. 2004-2006).

The opening phase was the most demanding stage of the quarry excavation, because it was entirely manual and required specialized workers who transmitted their knowledge across generations. Workers used pickaxes, shovels and hoes, while the blocks were brought to the surface through the *macinula*, a hand-operated winch

Fig. 3. Lanternino with rectangular shape on the left and circular shape to the right

Fig. 4. View of the bell-like shaped entrance to the underground system (photo by S. Sammali, FSP archive)

moved by two workers. The final layout consisted of orthogonal galleries (Fig. 5), with average width of about 5-6 m and height between 7 m and 8 m.

The distance between parallel galleries depended mainly on experience and judgement of the workers (Toni and Quartulli 1986; Toni 2001). This old system was used until the end of the 1940s and based on manual work, lacking the preventive design and presence of professional technicians responsible for the excavation works. Nevertheless, the development of subterranean voids was quite regular, and well adapted to the limits of the private properties at the ground surface, whilst only locally there were slight changes in their direction. From the 1950s until the end of quarrying activity, manual extraction was progressively replaced by mechanical techniques, a transition that also led to more frequent preventive planning and to an increased involvement of technical personnel aimed at improving both gallery stability and worker safety (Toni and Quartulli 1986; Toni 2001).

In quarries opened before the building boom of the 1960s, after the preparatory stage there was a phase of excavation through a head gallery known as *fassa*. This latter was about 5.25 m wide and 2 m high, and was dug with an electric machine equipped with a frontal steel disc, called *sgrottatrice* (Fig. 6).

The machine produced horizontal and vertical cuts on the advancement wall, and, after the manual detachment of the first three blocks, it kept going with cuts parallel to the wall itself. This allowed to obtain squared blocks of regular size, with limited residual material. After the *fassa* had been excavated and the pillars isolated, vertical exploitation of the calcarenite bedrock began. This phase used electrical machines already common in open-pit calcarenite quarries, like the saw. This latter, generally equipped with a double disc, made vertical cuts parallel to the gallery at variable spacings ranging from 20 to 32 cm, depending on the size and typology of the blocks to be extracted. Vertical cuts, orthogonal to the previous ones, were consistently spaced 50 cm apart. The machine, fitted with a vertical-axis disc, then detached the blocks from the base, progressively lowering the gallery floor. This procedure produced squared blocks of predetermined size much faster than manual quarrying (Toni and Quartulli 1986; Toni 2001). The resulting method was a single-level system with abandoned diaphragms or pillars, developed in opposite directions from the main pit. Gallery height reached a maximum of 9 m and width of about 5 m. Pillars were generally staggered; in the most recent quarries where the overburden thickness was greater, their section varied from 15 m to 25 m. Later, the regional regulations required quarry operators to maintain at least one support pillar with a doubled cross-sectional area in proximity to of the pits, which were identified as structurally vulnerable elements within the system and frequently exhibited early indicators of failure.

As regard the transport of material inside the quarries, it evolved from specific wheelbarrows to rubber-wheeled carts pushed by workers or drawn by horses, and finally to small electric locomotives capable of carrying about 1600 kg per loading cycle. The blocks were lifted to the surface through the main pit, initially through a mechanical tool powered by hand, and later by a winch connected to an electric crane with a rotating arm (Toni 2001).

3.3 Instability of quarries: subsidence and sinkholes

The end of quarrying activity left an extensive underground network beneath areas which, on the other

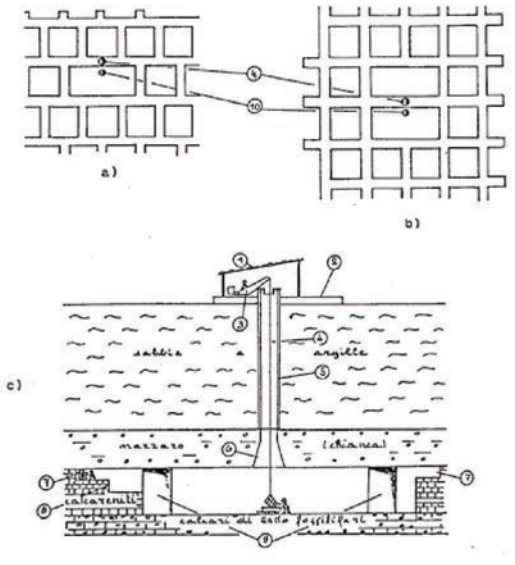

Fig. 5. a) Staggered-pillar quarrying layout; b) cross-shaped gallery arrangement; c) section of a quarry at the pit. Legend: 1 Light-weight cover. 2 External loading platform. 3 Crane. 4 Main pit. 5 Lining. 6 Bell-like shape pit. 7 Fassa. 8 Bench. 9 Galleries. 10 Lanternino (after Toni & Quartulli, 1986)

Fig. 6. Machine used for block extraction (after Toni, 2001)

hand, were in constant evolution as regards land use and surface modifications. The potential hazards linked with the extraction of materials from subsoil and the consequent creation of underground voids is mainly related to inappropriate actions and uses of such underground environments. The most recent history at Cutrofiano developed by the improper use of pits for illegally disposing wastes within the underground galleries, coupled with their progressive abandonment and the consequent loss of functional and cultural memory of the sites. In addition, closure of the pits brought to changes in the underground microclimate, inducing significant reduction of the geotechnical properties of the calcarenites.

Weathering and degradation of the rock masses, with development of open cracks and initial local failures in pillars and lateral walls (Fig. 7), combined to the presence of closed pits, created unfavorable conditions for stability, inducing sinkholes. The most critical conditions were associated with excessive gallery spans, poorly regularized layouts, weak pillars and pits, and changes in water circulation.

The mechanisms responsible for instability should not be ascribed solely to the presence of underground voids, but also to the spatial configuration of the closely spaced galleries, which can enhance adverse deformation patterns at the ground surface. Numerical and geological investigations at Cutrofiano suggest that sinkhole development is governed by multiple interacting factors, including gallery depth, presence/absence and thickness of a clayey-sandy cover, pillar geometry, water infiltration, and the progressive hydro-mechanical degradation of the calcarenite around the quarry accesses. In particular, a thick and deformable cover may alter the extent and morphology of the subsidence cone, whereas shallow galleries may facilitate upward stopping of failure (Lollino et al. 2012, 2013).

In the Cutrofiano quarry district, a well-documented example of failure is represented by the sinkhole that occurred during the night of July 15, 2008. At the time of its formation, the depression was about 1.20 m deep, and its width ranged from 25.10 m to 21.90 m. In the following years, the site has become a continuously monitored scientific case study on sinkhole processes related to artificial cavities. The long-term monitoring of this site has shown that hazard conditions may persist well after the end of quarrying activities, emphasizing the importance of integrating historical records, underground cavity surveys, and site-specific geological data in susceptibility and hazard assessments (De Pascalis et al. 2010; Reina and Pedone 2015).

The Cutrofiano case, therefore, shows how hazard assessment related to artificial cavities must integrate historical reconstruction, knowledge of quarrying techniques, geological setting and technical inspection of the void network, since all of these are necessary elements for understanding the susceptibility to sinkhole occurrence and properly evaluate the stability conditions of the galleries (Parise 2015).

Fig. 7. Typical gallery within the Cutrofiano quarries, showing failures from the walls (photo by F. De Salve, FSP archive)

4. Conclusions

The underground calcarenite quarries at Cutrofiano, Apulia, Southern Italy, represent a significant example of artificial cavities whose historical development is closely linked to the traditional way of building houses, agricultural land use, and present-day geohazard issues. Quarrying in this area developed between 1894–1895 and the late 1990s, driven by the availability of workable calcarenite beneath land that continued to retain agricultural value at the surface. The exploitation was made possible by the presence of the resistant *mazzaro* roof; however, over time, quarrying also produced a complex underground system of pits, galleries, and pillars.

The earliest quarries were manually dug and characterized by slightly irregular layouts, with local excessive extraction, particularly in the shallower sectors close to the town. These conditions explain the occurrence of early instability phenomena in the most vulnerable areas. The subsequent transition from manual to mechanized extraction led to more regular underground layouts, improved technical controls, and specific mining-office prescriptions, including limits on gallery width and the construction of larger pillars near the pits. Nevertheless, the progressive abandonment of the quarries, together with improper reuse, weathering, water infiltration, and the gradual loss of knowledge of the underground network, increased the susceptibility of the area to sinkhole formation, and the related surface damage as well.

The available historical, technical, and geological sources allowed a robust reconstruction of the main phases of quarry development, the evolution of the extraction techniques, the geological controls on excavation, and the principal mechanisms of instability. In the Cutrofiano area, such documentation is therefore essential not only for reconstructing the distribution and characteristics of underground cavities, but also for supporting susceptibility and hazard assessments. More broadly, the Cutrofiano case demonstrates that abandoned underground quarries should not be regarded as inactive remnants of past extraction, but as evolving anthropogenic systems whose long-term interaction with geological, hydrological, and land-use factors may continue to generate surface instability, even decades after the cessation of extraction activities, as testified by the most recent sinkhole that occurred in October 2025.

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The Rock-Hewn Hypogea with Vertical Bell-Shaped Excavations and Constructed Vaults, in the Area of the Eighteenth-Century Quarries of Matera (Southern Italy)

Giacomo Martines

Polytechnic of Bari, Department of Architecture, Construction, and Design.
giacomo.martines@poliba.it

Abstract
The urban morphology of Matera, a UNESCO World Heritage site, is defined by a unique symbiotic relationship between the city and underground spaces carved into the rock. While much of the fame of the Sassi districts is based on the adaptation of natural karst cavities, a distinct type of underground space exists within the quarry areas, which left traces since at least 1660 on the slopes of the karst Murgia rising from the alluvial plain of the Gravina stream north of the city, near the Roman Appian Way.
The specific phenomenon of underground spaces carved vertically into the rock, created not by the passive occupation and subsequent reshaping of pre-existing voids but by the active extraction of calcarenite blocks, is repeated several times in the quarry areas and, in fact, reflects the techniques of quarrying, in contrast to those of the settlement of the Sassi area. These structures, characterized by a bell-shaped profile and subsequently covered with vaults constructed from calcarenite blocks quarried from the same rock, represent a dual-purpose architectural strategy: the supply of building materials for the Baroque city and the simultaneous creation of underground spaces for quarrying related works, worship, and residential purposes.
The distinctive feature lies in the excavation method: in this case, it is not identified any derivation from regularized pre-existing cavities for human use. Rather, the underground space is preferably constructed on compact and homogeneous benches, and any stratifications encountered during excavation do not influence the geometry of the excavation itself. they, at most, today constitute a theme of differential degradation and geo-structural behavior, and conservation.
This construction method, therefore, stands in stark contrast to the horizontal adaptation of natural voids, regularized as described in the Giuffrè-Carocci "Code" and the Restucci Manual about traditional Matera's "material culture". The quarrymen began extraction from the surface, removing successive layers divided into "rows" and then into "blocks" of calcarenite. Each layer, equal in depth to the building block, traditionally a handbreadth high (about 24-26 cm), widens slightly compared to the previous one, with the characteristic "bell-shape" resulting from the inclination with which the "zuccotto" (a type of small pickaxe) was used to ensure maximum extraction volume and, in this case, optimal habitability of the resulting spaces. The chambers dug in this way presents sloping walls. This construction method is unique and deserves attention as it stands in stark contrast to the typical karst anthropization of the Apulian Murge, where irregular natural cavities were simply regularized and enlarged.
The study concludes with a specific topic related to the reinterpretation of the traces identifiable on the residual surfaces of the excavation, within the underground structures. These can be primarily classified into two categories: signs of workmanship, left by traditional tools in vogue until the first half of the twentieth century, and signs of use, such as the creation of functional niches or wall recesses designed to accommodate special structures for the protection of the habitable spaces or their functional "furnishings," or even significant signs: devotional, primarily in the form of crosses, inscriptions, or dedications.

Keywords: Cave dwellings in the Matera area (southern Italy); Excavation and construction methods; Traces of working; Anthropic use of natural caves; Connection between the quarry site and the historic city

The Context of the "Seventeenth-Eighteenth-Century" Quarries

The urban and peri-urban morphology of Matera and the "Natural Historical Archaeological Park of the Rupestrian Churches of Matera," a UNESCO World Heritage Site, is defined by a unique symbiotic relationship between the city and the underground spaces carved into the rock. While much of the fame of the Sassi neighborhoods is based on the adaptation of natural karst cavities, well-studied in the relevant literature[1], a unique type of underground space is found in the quarry areas, traces of which date back to at least 1660, as highlighted by research conducted by the Polytechnic University of Bari team, predating the establishment of quarrying activities in the area by about

1 Restucci 1991; Giuffrè, Carocci 1997, Restucci (a cura di) 1998

Fig. 1. Visible traces of the extraction system of the calcarenite bank by successive layers and reduction into blocks

Fig. 2. The rock altar of "Sant'Antuono delli Appisi" within the "Cave system

fifty years compared to the known data that referred to them as "eighteenth-century quarries." On the slopes of the karst Murgia, rising from the alluvial plain of the Gravina River to the north of the city, near the Via Appia, the main transit artery of southern Italy during the Roman era, are quarries whose materials reached the city via an ancient branch of the Roman road (later, with this use, known as the "*Via dei Cavamonti*") and the watercourse that has deeply carved the limestone rock, effectively creating a smooth path to the two large inlets (the so-called "Sassi") where the ancient city of Matera stands.

The specific phenomenon of underground spaces carved vertically into the rock, created not by passive occupation and subsequent reshaping of pre-existing voids, but by the active extraction of calcarenite blocks, is repeated several times in the quarry areas and, in fact, reflects the extraction techniques, in contrast to those of the "Sassi" settlement. These structures, characterized by a bell-shaped profile, typical of the quarrying process, and subsequently covered with vaults made from blocks of calcarenite quarried from the same rock, represent a dual architectural strategy: on the one hand, the supply of building materials for the baroque city and, on the other, the simultaneous creation of covered and protected spaces for convivial breaks from work, stables, dwellings, and places of worship.

The peculiarity lies in the excavation method: in this case, no derivation from pre-existing cavities regularized for human use is identified. Rather, the underground space is preferably realized on compact and homogeneous terraces, and any stratifications encountered during excavation do not influence the geometry of the excavation itself. At most, they constituted an incidental slowdown in the quarry's productivity, due to the need to remove layers of material unsuitable for construction, which had to be eliminated in any case to allow the continuation of the mining activity. Today, they constitute a source of differential degradation in terms of geostructural behavior and conservation.

This construction method, therefore, stands in stark contrast to the horizontal adaptation of natural voids, regularized as described in the Giuffrè-Carocci "Code" and Restucci's Manual on the traditional "material culture" of Matera[2] (Giuffrè and Carocci 1997; Restucci 1998).

The quarrymen began extracting the karst rock from its surface, removing successive layers divided into "rows" and then into "blocks" of calcarenite. Each layer, equal in thickness to the building block, traditionally a handbreadth thick (about 24-26 cm), widens slightly compared to the previous one, with the characteristic "bell shape" resulting from the inclination at which the "*zuccotto*" (a type of small pickaxe) was used to ensure maximum extraction volume and, in this case, optimal habitability of the resulting spaces (Fig. 1).

Chambers excavated in this way have sloping walls. This unique construction technique deserves attention as it stands in stark contrast to the typical karst anthropogenesis of the Apulian Murge, where irregular natural cavities were simply leveled and enlarged.

The social and productive context of the "quarry system"

Within the quarries, a veritable residential and productive system developed, with specialized rooms for living, animal shelter, and worship. Indeed, the altar of Saint Anthony stands in a particularly emblematic location, the center of a complex system of cave rooms, the only ones in this area of the complex carved horizontally into the limestone rock, as required by devotional tradition. The main cave, equipped with an altar and three framed panels that originally housed votive images, is enriched on the side walls and ceiling by three Marian pictograms of a blue flower, still faintly legible and likely attributable to later phases of use. In the following centuries, this area also became a hub of the

2 ibidem.

Fig. 3. The rock-hewn room serving the altar of Saint Anthony presents various levels of frequentation with remains of a fireplace, of a kitchen carved into a niche and of a well to connect two levels originally separated by a horizontal structure now lost

system of Marian devotional routes along the Appian Way, with the Church of *Santa Maria della Vaglia* and the Sanctuary of *Santa Maria della Palomba*. It is no coincidence, in this context, that the altar of *Sant'Antuono delli Appisi* was given a Marian re-symbolization through the addition of the mentioned blue six-petalled flower surrounded by a golden halo. This Marian symbol was depicted in pictograms on both sides and on the rocky ceiling of the altar (now almost completely disappeared), and it testifies to an overlapping of devotional meanings that have stratified over time. On the sides of the altar, highlighted by the creation of a cross in relief on the tuff rock above the excavated space, there are two other cavities: one, on the right, with a bench in line suitable for the offertory and for convivial breaks in the afternoon from work, the other on the left, on two levels: the upper one for residential use (it shows at least two phases of humanization until at least the mid-twentieth century), the lower one for storage (presumably a granary) (Fig. 2).

Among the cracks of the excavation, stratifications of usage levels of the rock-hewn or semi-hypogean environments suitable for workers' residence can be detected, whose traces remain imprinted on the walls of the rock-cut chambers and on the quarry faces, marking the phases of progressive deepening of the excavation (Fig. 3).

Inside the large rock cavity to the right of the altar of Sant'Antuono, the remains of a demolished fireplace can be seen, probably at a floor level several dozen centimeters higher than the current external ground level. Nearby, at a significantly lower floor level, lies a wall niche shaped as a kitchen, similar to others within the city's historic districts that continued to be used until the mid-twentieth century. The picture is completed by several storage shelves and numerous other signs of daily use. A pre-construction ground-penetrating radar survey of the ground revealed that the visible surface was the result of the filling of a pre-existing cellar (or storage room connected to votive offerings at the adjacent altar), perhaps originally conceived as a vaulted room and only later excavated into the current layout.

The area's water collection system is quite complex. At least three cisterns have been discovered, which remained functional until the final phase of the quarries'

Fig. 4. The cistern, originally created by subtraction from the calcar rock, is today partially above ground level and its summit conclusion required a reconstruction in addition architecture

Fig. 5. The series of underground rooms with clear signs of the quarrying process and built vaults

use. Today, the cistern immediately in front of the altar, which still retains its *cocciopesto* lining, was originally completely buried and remains semi-surface, while the surrounding soil has progressively subsided due to ongoing quarrying (Fig. 4).

Each functional and devotional element confirms the dual interpretation of the territory between the permanent elements: the road and water infrastructures, and the places of worship, which remain unchanged and respected by quarrying, while the ground level progressively descends.

The vertical quarry construction system with the "addition" vaults

As already specified above in the text, the extraction system is developed by removing successive layers of stone. The use of a "*zuccotto*" (a small pickaxe) or "double quarry axe" to create a lateral cavity around the rows of blocks to be detached, in which to insert the "*cugni*" that would allow them to be effectively detached in horizontal rows, effectively involves a "sacrifice" of a certain volume of material. This simple consideration leads to the execution of successive strat-

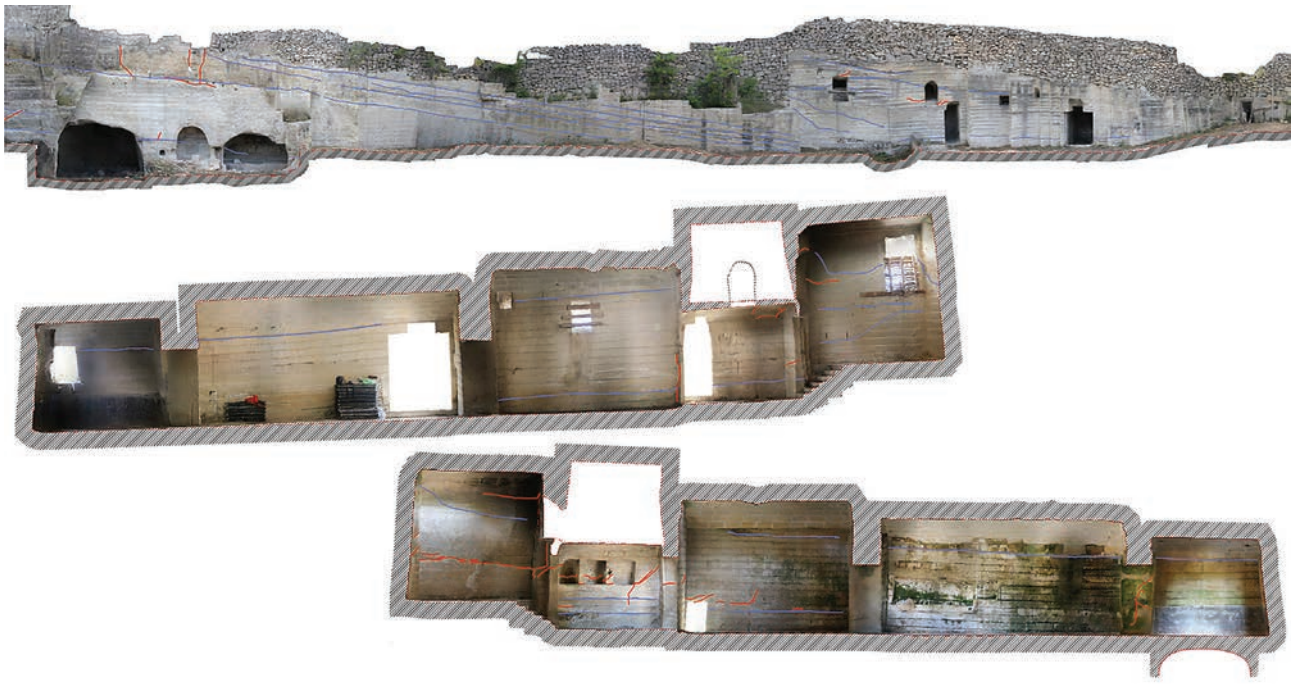

Fig. 6. The aggregation system of the largest complex of the vaulted hypogea typology present in the area

Fig. 7. The signs of workmanship visible on the surfaces of the living spaces

ifications that progressively enlarge the excavated surface with a "bell-shape" pattern, progressively enlarging the extraction surface as the excavation deepens.

The residual wall of the excavation is therefore sloping inward and marked by a series of regular stratifications corresponding to the dimensions of the blocks obtained from the quarry. In the area, a complex of "rooms" was identified, excavated using this technique, but "shaft-like," that is, with essentially closely spaced quadrangular rooms (and then connected by doors, also carved into the limestone mass). The dimensions of the vault springer (not constant or regular) were about one "cane" (approximately 2.65 m), which then widened as it descended towards the bottom of the excavation. At the top of the excavation, a profile was created with an inclination of approximately forty-five degrees, allowing for the installation of a vault, again made of contrasting limestone blocks, which made the room below habitable. In two instances (at least two of which survived), it was possible to identify rooms divided into two levels with intermediate vaults: one to separate a residential area on the upper floor from a stable area on the lower floor, and one to allow for a water collection cistern in the lower room (Fig. 5).

Fig. 8. Collection of traditional tools, private collection

This series of "vaulted hypogea" is located on the edge of the quarry areas in the later periods; in fact, the datings found refer predominantly to the post-unification period (the last decades of the 19th century). Their location is optimal for managing activities: near the quarry areas, close to the road used by carts to reach the Renaissance and modern city of Matera on one side, and the route along the river bed and the ravine on the other (and the Appian Way for territorial connections between the coasts of the three seas: Taranto on the Ionian Sea to the east and Brindisi on the Adriatic, and to the west towards the Tyrrhenian Sea) (Fig. 6).

The signs of material processing on the surfaces

Various other signs of excavation are present, depending on the different modes of human settlement. In another part of the quarry system, within hypogea constructed using traditional techniques–namely, with the primary purpose of creating a living space through horizontal excavation at the point of contact between a less compact upper calcarenite layer and a more coherent rock base, as is common–surfaces smoothed with wall rasps, worked with an axe, or with a "*zuccotto*" (a sort of little pickaxe). In this area, several inscriptions dating from "1884" to "1891" can be found.

The signs of workmanship are still evident on the surfaces, with linear or circular traces (Fig. 7).

The first and deepest traces visible in the image on the

Fig. 9. segni della collocazione di pali lignei per la realizzazione di tamponature leggere

right derive from the use of the "*zuccotto*", probably the main working tool of the "*cavamonti*" (Tuff digger): a type of small pickaxe with a rather short handle used for carving and roughing out. This is followed by smoothing with the "*zappetta da tufo*" (Tuff hoe), a tool resembling a small one-handed hoe with a narrow, slightly curved blade, or with the tuff axe: a tool that sometimes has a double head: a tool with a short wooden handle and a metal head featuring a vertical blade on one side and a horizontal blade (or an awl) on the other. The finishing (often absent) was done with a rasp (or tuff plane), a tool similar to today's "*french rabot*", made with a wooden board and iron strips inserted crosswise (Fig. 8).

Finally, some emblematic signs of civilian use can be identified: some traces of embedded posts with, around the post, wedges (also wooden) for pressure fixing. These wedges must have supported lightweight vertical partitions made of reeds or wooden planks that would have allowed the vertical closure of the cave rooms (Fig. 9).

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Survey and Mineralogical Study of the Mine Gallery from Grădina Zmeilor (Sălaj County, Romania)

Codruța Valea[1,2*], Tudor Tămaș[1,2], Mădălin Erhan[2]

1. Department of Geology, Babeş-Bolyai University, Cluj-Napoca, Romania
2. Montana Caving Club, Baia Mare, Romania
*corresponding author: codruta.alexandra.valea@stud.ubbcluj.ro

Abstract

Situated in Sălaj county, NW Romania, Grădina Zmeilor is a well known nature preserve due to a fine display of erosional features formed in sandstones and conglomerates, and includes a 423 m long abandoned coal mine, which is frequently visited. The present study focuses on the survey and mineralogical study of the mine, dug through deposits belonging to the Valea Almașului Formation (Late Oligocene - Early Miocene). The mine comprises a 298 m long directional gallery and three lateral ones (16, 48 and 56 m long). Microclimatic measurements recorded temperature (8.8 - 14.3°C), relative humidity (68.7 - 99.5%) and CO2 concentration (492 - 1733 ppm). Mineralogical investigations by X-ray powder diffraction and scanning electron microscopy identified secondary mineral associations dominated by sulphates (gypsum, hydronium jarosite, melanterite, rozenite, copiapite, alunogen, halotrichite, fibroferrite and epsomite) and iron oxi-hydroxides (goethite and ferrihydrite). These findings provide a first mineralogical characterisation of the secondary deposits in the mine gallery and may be a starting point for monitoring its evolution in the context of a protected natural reserve visited by 50-100 tourists daily.

Keywords: abandoned mine, nature reserve, brown coal, acidic environment, sulphates

Introduction and geological setting

Grădina Zmeilor is a natural reserve of national interest (cat. IV IUCN), located in Gâlgau Almașului, Sălaj county (NW Romania), at a short distance (10 km) from the city of Jibou (Fig. 1a). The nature reserve sits on a surface of 3 hectares, at an average altitude of 290 m. It contains a fine display of morphological features (hoodoos, spires, towers, etc) at the base of a retreating cliff face consisting of sandstones and conglomerates which created a residual landscape due to gravitational (landslides, collapses) and erosional processes (Ajtay 1995; Abrudan and Medve 2008). Included in the preserve is a 423 m long mine gallery (nowadays named *"The cave"*), probably dug to assess the reserves of brown coal intercalated in the detrital deposits. The complex presently consists of a parking lot, a few tourist amenities, is free to visit with no charge and gets an average of 50 - 100 tourists per day (Codrea et al. 2022). The mine is dug through a sequence of quartzitic - kaolinitic sandstones, conglomerates and brown coal with dark clay intercalations, belonging to the Valea Almașului Formation (Late Oligocene - Early Miocene). The succession at the entrance to the mine is made up of decimetric to metric medium-grained, parallel laminated and cross-laminated sandstones with erosional surfaces, with milimetric to centimetric conglomerate intercalations and iron hydroxide films. The coal seam may reach locally up to 0.6 m. Iron sulfides (dominantly pyrite) are present in the coal and adjacent host rocks (clays, sandstones) and because of air humidity and seepage water, have produced extensive deposits of secondary iron sulfate and oxi-hydroxide minerals. The deposits form a monoclinal structure, dipping SE by 5 - 10° (Petrescu et al. 1987). South of the nature reserve, the Gâlgău fault separates the deposits of the Valea Almașului Formation and the Miocene deposits of the Chechiș and Hida Formations composed of marine and brackish deposits (Fig. 1b). Coal mining in the area bean between 1896 and 1904 and by 1913 several mines were operational in the neighbouring villages (Papp 1915) and continued at various sites around the county along most of the XXth century (Varga 2010). We found so far no specific reference on the mine gallery in the Grădina Zmeilor reserve, but based on other sources on the coal extraction in the area, the earliest date for its inception may be the beginning of the last century.

The present study reports the survey of the mine galleries, preliminary measurements of microclimatic parameters (temperature, relative humidity and CO_2 concentration), as well as the characterisation of the secondary mineral associations found in the underground environment.

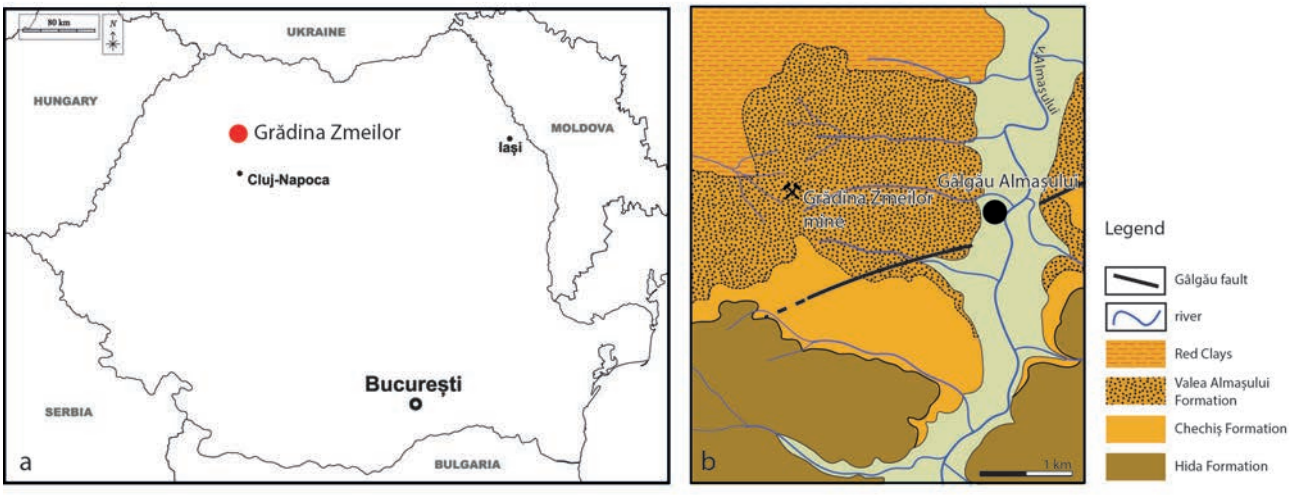

Fig. 1. a. Location of Grădina Zmeilor nature reserve in Romania; b. Geological map of the area (modified from Petrescu et al. 1975)

Methods

A detailed survey of the gallery was done using a modified DistoX2 laser rangefinder, using the Pocket Topo software (Heeb 2014). Air parameters (temperature, humidity and CO_2 concentration) were measured at 10 stations using a Dostmann 220E datalogger with an external CO_2 probe. Samples to determine wall lithology and mineralogy of the secondary deposits were taken from places of interest along the walls. They were studied by means of X-ray diffraction (XRD) and scanning electron microscopy (SEM).

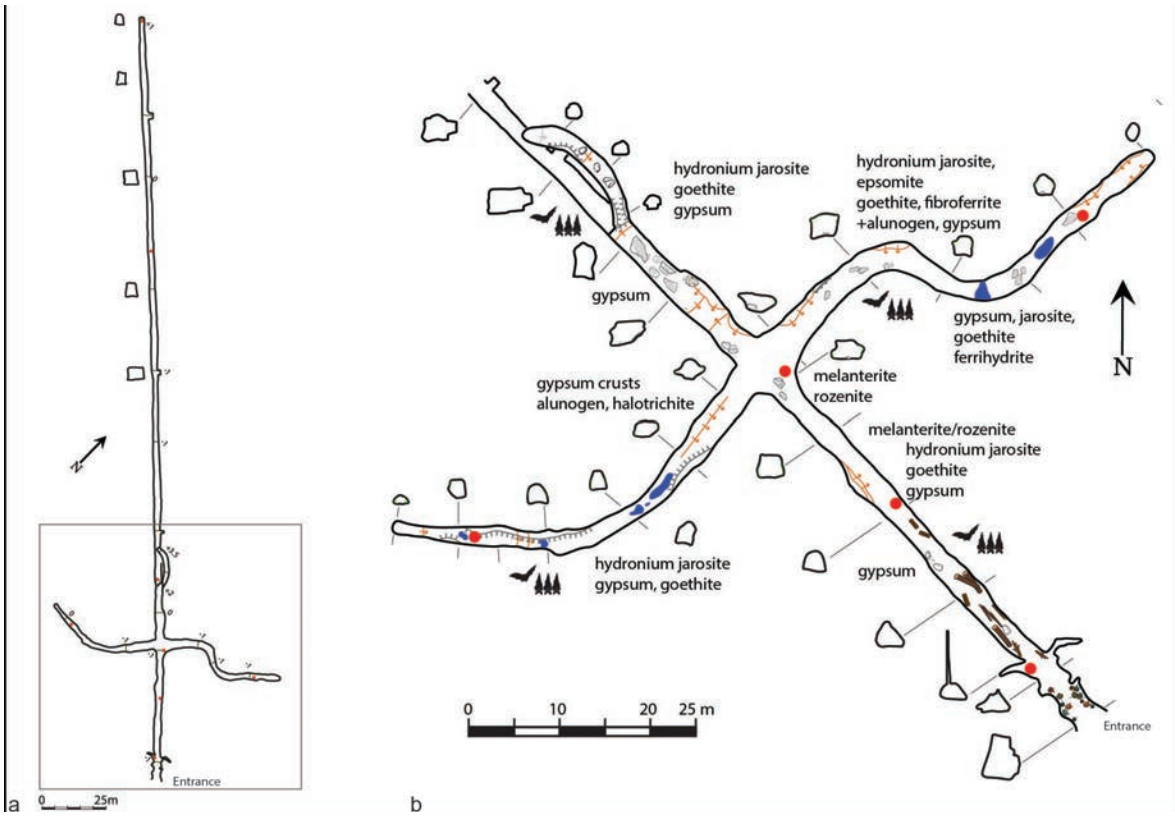

Fig. 2. a. Survey (plan view) of the mine in Grădina Zmeilor reserve; cross sections are double the scale of the plan. b. Enlarged view of the square in Fig. 2a indicating the measurement points for T, RH and CO2 concentration (red dots), general areas of the secondary mineral occurrences sampled, and bat sightings (cartography by C. Valea and T. Tămaș)

Cavity description

The general map of the mine is presented in Fig. 2a, while a detail of the part of interest with the sample locations is shown in Fig. 2b. Based on our survey, the mine is 423 m long and has a vertical extent of 5.8m (-1.8, +4), and consists of a quasi-horizontal 298 m long directional gallery oriented SE - NW and three lateral galleries, 56, 48 and 16 m long respectively (Fig. 2, 3). The entrance is 4.7 m high and 3.3 m wide. At 8 m from the entrance a large tension fracture is encountered running parallel to the cliff face and in this section the material fallen from the ceiling has created a descending step. The main directional gallery can be divided in two main sections. The first section is 86 m long, from the entrance to the 16-m lateral passage opened in the ceiling. It is on average 2.5 m wide and 2.5 m high (2 - 3.7 m high and 2.2 - 3.6 m wide), reaching 3.7m in height in its final part. The coal layer, with a maximum thickness of 0.6 m, occurs firstly at 30 m from the entrance and can be followed for 44 m along the main gallery and all along the lateral ones. The second section of the main gallery, which may have been dug at a later stage, has slightly smaller, more regular trapezoidal cross sections and is 212 m long. Along most of the floor of the main gallery, well preserved marks of railway sleepers are present. All three lateral galleries are following the extension of the coal seam. The first two of them, oriented NE-SW, were dug at 50 m from the entrance and extend for 56 and 48 m respectively. Their particularity is that they are not dug in a straight line: the one on the right starts toward the NE, then after 21.3 m turns SW then NE. The one on the left has one single large turn, from SW to W. Both of them have a few small ponds of water accumulating from seepage, probably through fissures parallel to the cliff face at the entrance. The third lateral gallery is smaller, nearly semicircular in cross section (1.6 x 1.7 m) and starts in the ceiling of the main gallery, at 75 m from the entrance, via a 2 m positive drop, in between two decimetric coal layers. It is slightly ascending from the entrance, following the low-angle dip of the deposits for 16 m, and ends at the highest elevation recorded in the survey, +4 m. The coal layer at its base is 0.3 m thick and is covered in similar secondary deposits as the ones in the main gallery.

Results

Air parameters

The air parameters measured on 24.04.2025 vary between 8.8 and 13.9°C (temperature - T), 79.3 - 99.5% (relative humidity - RH) and 1006 - 1733 ppm (CO_2 concentration). The values measured at the entrance to the mine were 14.3°C, 68.7% and 492 ppm respectively, which were relatively constant for the first 12 m inward. Past the entrance area, a 32-meter zone exhibited distinct shifts as the gallery descends by 1.8 m below the entrance, with a minimum temperature of 8.8 °C, a relative humidity of 98.1% and a CO_2 concentration of 1006 ppm. Morphology (slightly descending floor) and air stagnation within the two lateral galleries at 50 m from the entrance facilitate the accumulation of CO_2 (1405 -1733 ppm) and elevated RH (97.7% - 99.5%), with T ranging between 10.8 and 11.2°C. On the main gallery past the intersection, the temperature steadily increased with the distance from the entrance, from 10°C to 13.2°C at ca. 200 m, then to 13.9°C at 298 m. Relative humidity values along the main gallery past the intersection were stable at 88.2 - 89.7%, while the CO_2 concentration increased to 1414 ppm towards the end of the gallery.

Fig. 3. Gallery intersection at 50 m from the entrance to the mine: the coal layer is visible near the ceiling; whitish gypsum crusts form a band at the base of the left wall; the clay layer where the alunogen corraloids were sampled occurs top right, underneath the coal, and next to the caver on the left of the picture (photo T. Tămaş)

Mineralogy

The main mineral phases identified in the composition of the host rocks include quartz, muscovite, and feldspars, with subordinate calcite and clay minerals (kaolinite and chlorite). The clay layers contain quartz, muscovite, and chlorite, kaolinite and smectite in the clay fraction. Traces of pyrite have also been detected.

Significant deposits of secondary minerals were found associated with the coal and also related to the clay layers (Fig. 3, 4b). All the minerals identified are hydrated sulfates, except for two iron oxy-hydroxides: goethite and ferrihydrite (Table 1). Extensive displays of gypsum crusts and crystals, as well as hydronium jarosite, fibroferrite, melanterite, rozenite, and copiapite and sometimes alunogen and pickeringite were found, while sectors of the gallery walls are coated with goethite and ferrihydrite films. These minerals form earthy crusts, efflorescences, stalactites, flowstones, globular aggregates somewhat similar to coralloids, and crystal aggregates, generally termed minothems (Carbone et al. 2016; Galliano et al. 2022).

Gypsum is the most abundant secondary mineral found

Table 1. Secondary minerals identified by XRD analyses

Mineral	Formula	Occurrence	Frequency
gypsum	$CaSO_4 \cdot 2H_2O$	crusts, crystals	very common
hydronium jarosite	$(H_3O)Fe^{3+}{}_3(SO_4)_2(OH)_6$	earthy crusts	very common
melanterite	$Fe(SO_4) \cdot 7H_2O$	crystals	rare
rozenite	$FeSO_4 \cdot 4H_2O$	powdery deposits, crusts	rare
copiapite	$Fe^{2+}Fe^{3+}{}_4(SO_4)_6(OH)_2 \cdot 20H_2O$	crusts	very rare
alunogen	$Al_2(SO_4)_3 \cdot 17H_2O$	coralloids, crusts	rare
pickeringite	$MgAl_2(SO_4)_4 \cdot 22H_2O$	coralloids, crusts	rare
fibroferrite	$Fe^{3+}(SO_4)(OH) \cdot 5H_2O$	pasty deposit	rare
epsomite	$MgSO_4 \cdot 7H_2O$	Crystals	very rare
goethite	$Fe^{3+}O(OH)$	Crusts	very common
ferrihydrite	$Fe^{3+}{}_{10}O_{14}(OH)_2$	Crusts	rare

in the mine. It occurs along all the galleries in isolated millimetric to centimetric crystals or grouped in bundles or aggregates, and sometimes forming decimetric crusts (Fig. 3, 4a). *Hydronium jarosite* occurs as various yellow films and earthy crusts on coals or on associated clay and sandstones, giving the yellow colour

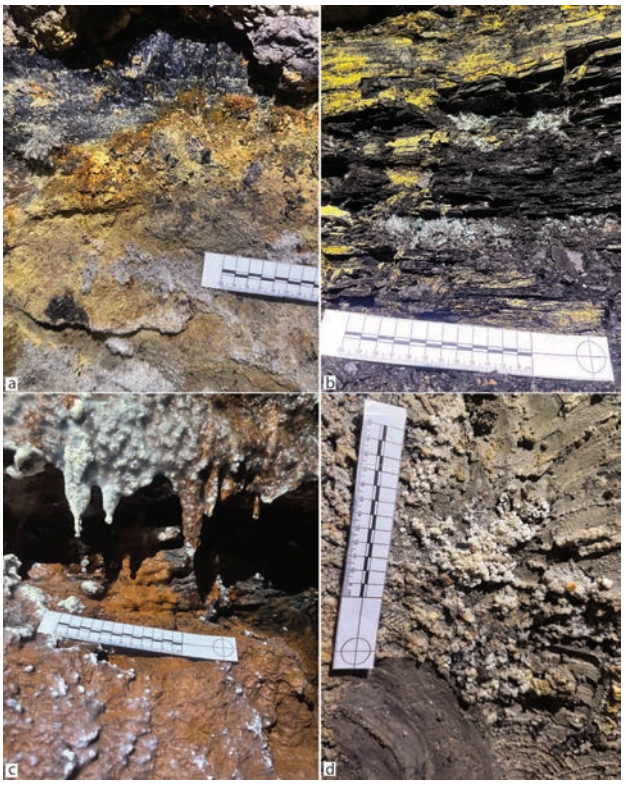

Fig. 4. Secondary minerals in the mine from the Grădina Zmeilor reserve: a. crusts of goethite and hydronium jarosite (brown and yellow) and gypsum crusts (white); b. melanterite (green) and rozenite (white) on coal; the yellow crusts are hydronium jarosite and copiapite; c. goethite and ferrihydrite in stalactites and massive crusts, partly covered by fibroferrite (white); d. alunogen and pickeringite corraloids and crusts on clay (Photos T. Tămaş)

to the passage (Fig. 4a, b, 5). In a different occurrence it is also the main component of isolated centimetric nodules in the conglomeratic layers from the ceiling of the main gallery. Its identification was based on XRD pattern and unit cell calculations (a = b = 7.312 Å, c = 17.114 Å). *Goethite* (Fig. 4a, c) forms crusts, rarely stalactites and flowstones in areas where percolation water reaches from the surface. In a few cases *ferrihydrite* is associated to goethite minothems (Fig. 5). *Melanterite* occurs as green translucent crystals up to 5 mm in size, resembling glass, directly on the coal; the crystals themselves or the coal in their vicinity may get periodically covered in a whitish dusty material, which was determined to be *rozenite* (Fig. 4 b, 5).

Fibroferrite was found as a main component in one sample collected on the right hand lateral passage, where it covers goethite and is associated with alunogen and gypsum. It forms a pasty deposit with white greenish colour on top of active goethite stalactites and crusts (Fig. 4c, 5).

Alunogen is the main component of crusts and coralloid - like aggregates (Fig. 4d, 6) developed at the surface of clay deposits underneath the coal layer on the left side gallery of the mine, where it is associated with epsomite and gypsum, and sometimes pickeringite. At SEM it appears as parallel aggregates of thin, euhedral or subhedral long prismatic crystals (Fig. 6).

Discussion and conclusions

Our study presents the survey of the coal mine from the Grădina Zmeilor nature reserve, together with an initial mineralogical characterisation of the secondary deposits formed through the alteration of coal and other host rocks (sandstones and clays), and a few measured val-

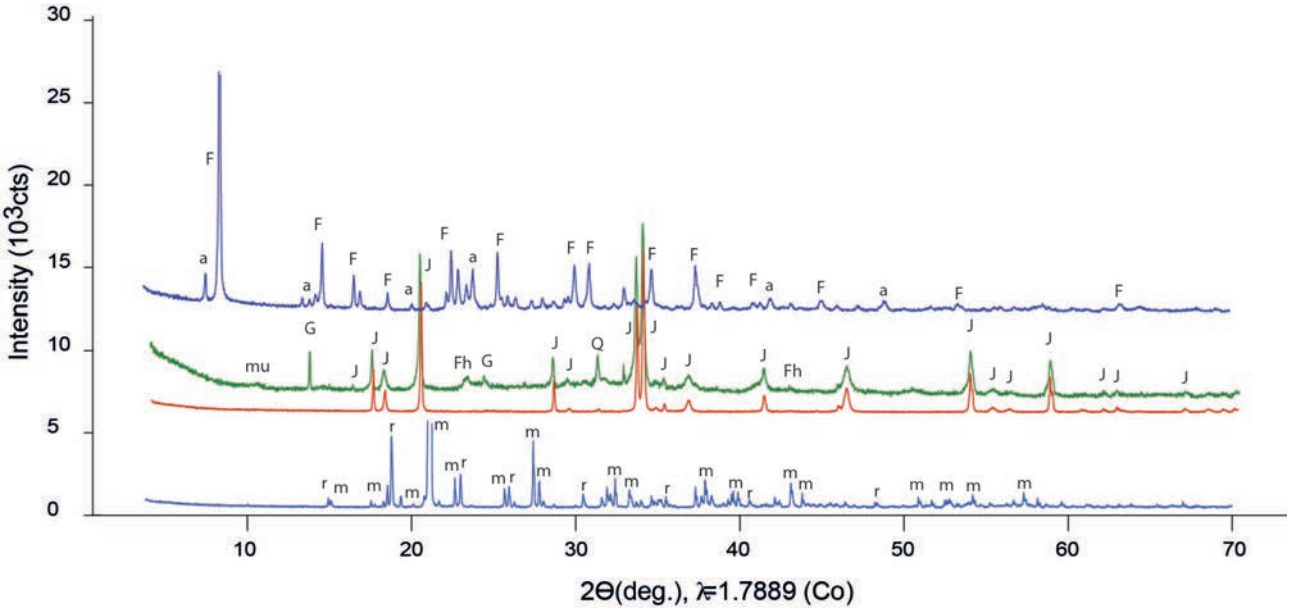

Fig. 5. XRD patterns of selected samples: m - melanterite, r- rozenite, mu- muscovite, G - gypsum, J - hydronium jarosite, Fh - ferrihydrite, F - fibroferrite, a - alunogen.

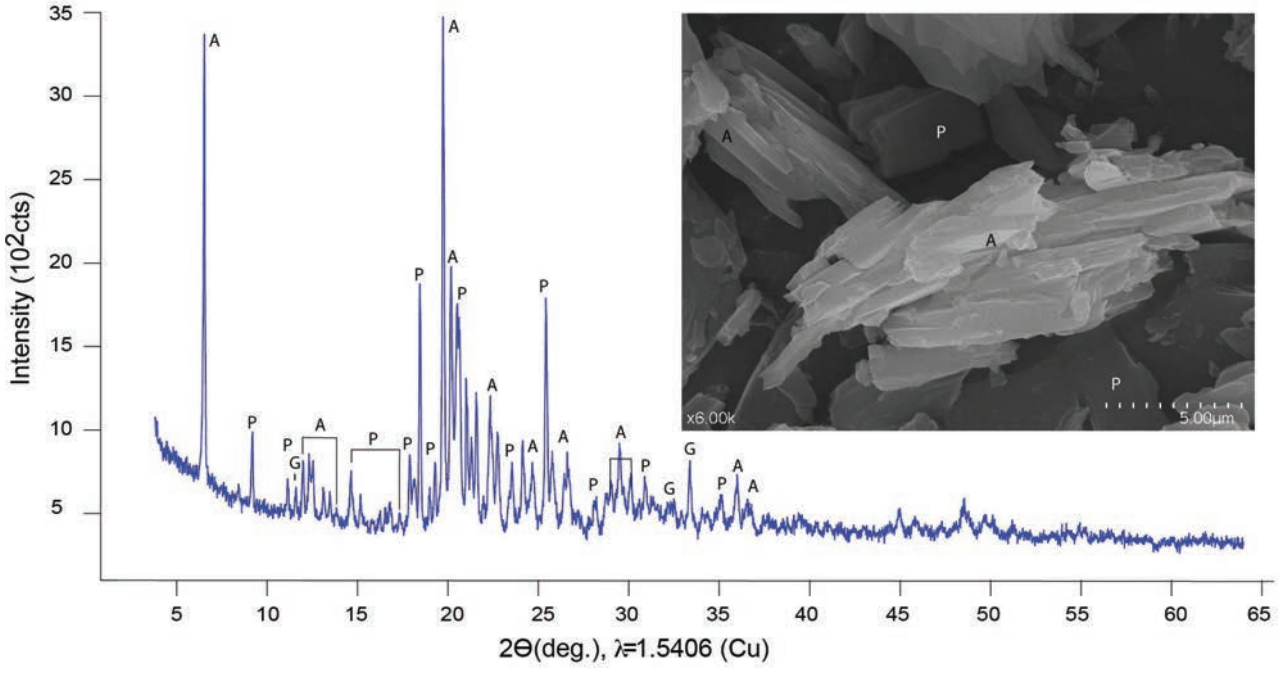

Fig. 6. XRD pattern of corraloids and SEM image of alunogen (A) and pickeringite (P) crystals

ues of air parameters. The mine has a length of 423 m and a total vertical extent of 5.8 m. The survey allowed the spatial mapping of air parameters from the mine entrance to the deeper, less ventilated areas. The only areas where humidity reached near saturation values (97.7% and 99.5%) were the two lateral galleries at 50 m, where the highest CO_2 concentrations were determined (1405 - 1733 ppm), which are however well within the normal range for such an environment and pose no danger to visitors (Osborne 1981). Measurement along a longer interval (over a year) would be able to provide more information on the dynamics of air parameters inside the mine.

The secondary minerals sampled in the mine belong to the oxi-hydroxide and sulfate classes and were formed due to the oxidation of pyrite disseminated mostly in the coals, but to a lesser extent also in the other host rocks exposed by the mine galleries (clays, sandstones and conglomerates) (Jambor et al. 2000). In this process, pyrite oxidation led to the formation of sulphuric acid and acidic solutions with high contents of metals (Alpers et al. 1994). After the oxidation of the initial iron sulphates,

the ferrous (2+) and the sulfate ion result into the formation of melanterite, rozenite, copiapite and halotrichite in the presence of seepage water. On the other hand, solutions containing the ferric ion (3+), in acidic environments and with considerable sulfatic input, precipitate jarosite and ferryhidrite (Hammarstrom et al. 2004). All samples investigated seemed to have a deficit of alkali ions, therefore hydronium jarosite is commonly occurring (Brophy and Sheridan 1965). The presence of fibroferrite, which is sensitive to variations in pH and RH, and of active stalactites of goethite in the mine from Grădina Zmeilor Complex shows that acid rock drainage in the host rocks above the mine gallery is active, although not in a significant amount, and was only observed on the lateral galleries. Alunogen, halotrichite, gypsum and epsomite were formed through the mobilization of Al, Mg and Ca by leaching of clay minerals and feldspars from the rocks in the vicinity of the coal layers (Parafiniuk 1991; Jambor et al. 2000). The variations in temperature and relative humidity may influence the abundance of the soluble sulfates present in the associations (i.e. melanterite/rozenite and fibroferrite).

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MILITARY AND DEFENSIVE ARTIFICIAL CAVITIES

Underground Çakmak Defence Line from Çatalca, Istanbul

Ali Hakan Eğilmez [1], İlker Gürbüz[2], Gülşen Küçükali [3], Şengül Aydıngün [4], Emre Kuruçayırlı[5], Mark Metin Albukrek [6], Özlem Kaya [7]

[1] *Arkeologist, Lecturer in Istanbul Technical University, Speleologist, member of GALERİ(*)*
[2] *Speleologist, member of GALERİ(*)*
[3] *Speleologist, member of GALERİ(*)*
[4] *Assoc. Prof., Kocaeli University, Faculty of Arts and Sciences, Department of Archaeology*
[5] *Ph.D., Archaeologist, Speleologist, member of GALERİ(*)*
[6] *Ph.D., Environmental Technology, Speleologist, Member of GALERİ(*)*
[7] *Architect in Miletus Excavation, Yıldız Technical University, Speleologist, member of İTÜMAK (**)*

(*) GALERİ Galeri Mağara Araştırma Grubu (Galeri Cave Research Group)
(**) İTÜMAK İstanbul Teknik Üniversitesi Mağara Araştırma Kulübü (Istanbul Technical University Cave Research Club)

Reference author: Ali Hakan Eğilmez, hakan@divebubbleclub.com
Address: Nakiye Elgün Sokak 36/4 Osmanbey- İstanbul

Abstract
The Çakmak Line, named after the Turkish Field Marshal and politician Mustafa Fevzi Çakmak, is a network of concrete fortifications, underground railways, artificial tunnels, obstacles, and weapon installations constructed by Turkey in Thrace during the 1940s. Rather than spanning the entirety of Thrace, the line was built across specific strategic locations within Istanbul's Çatalca district. This defensive system was modeled after the French "Maginot Line" built prior to World War II to counter German advancements.
Turkey established this line to allow its army to halt potential German invasions launching from the Bulgarian border. While the Çakmak Line was designed to be impervious to most forms of attack–including aerial bombardment and tank fire–it also featured state-of-the-art living conditions for garrisoned troops and internal underground railways.
However, the Çakmak Line proved strategically ineffective during WWII. After invading Bulgaria, German forces bypassed the line from the south by invading Greece instead of Turkey. Because no German attack materialized against Turkey, the Çakmak Line was never combat-tested and remained unfinished due to a lack of financial resources and materials. Today, parts of this underground system and various surface bunkers remain visible.
The core Çakmak line system is divided into three main branches containing a narrow-gauge railway system. The tunnels descend into a rocky hill with a total internal length of approximately 1.5 km (with the primary explored sector measuring 700 meters). This formation currently hosts a bat colony. During our study, this important but forgotten historical underground system was fully investigated, explored, and mapped.

Keywords: Defense Line, War Works, Çatalca

Introduction

Following the defeat of the Ottoman Empire in World War I, the newly founded Republic of Turkey struggled to maintain a policy of strict neutrality between the Allied and Axis powers at the outbreak of World War II. Field Marshal Fevzi Çakmak, a former Ottoman general who served as the Chief of the General Staff of the Republic, knew the strategic importance of the Çatalca region for defending Istanbul from his past wartime experiences.

As the winds of war swept across Europe prior to WWII, Germany emerged as a formidable military threat. To halt Germany's highly effective war machine, Turkey initiated work in the Çatalca region to replicate the concept of the 200-kilometer-long French "Maginot Line." Turkey's second president, İsmet İnönü, who also came from a military background, viewed the project with skepticism. He filed a dissenting opinion based on high costs and engineering difficulties. Because the young Republic faced severe resource and industrial shortages, available state funds were heavily restricted, prioritizing immediate weapon procurement over massive infrastructural lines. Despite these internal divisions within the Turkish government, construction of the defensive line was pursued over an extended period utilizing highly scarce resources.

The strategic layout of the Çakmak Line was heavily informed by the 1st Balkan War (1912) fought between the Ottoman Empire and the Balkan League. During that conflict, the Çatalca region served as the Ottoman Empire's final line of defense and witnessed bloody engagements.

The geography of the region naturally facilitates military defense:

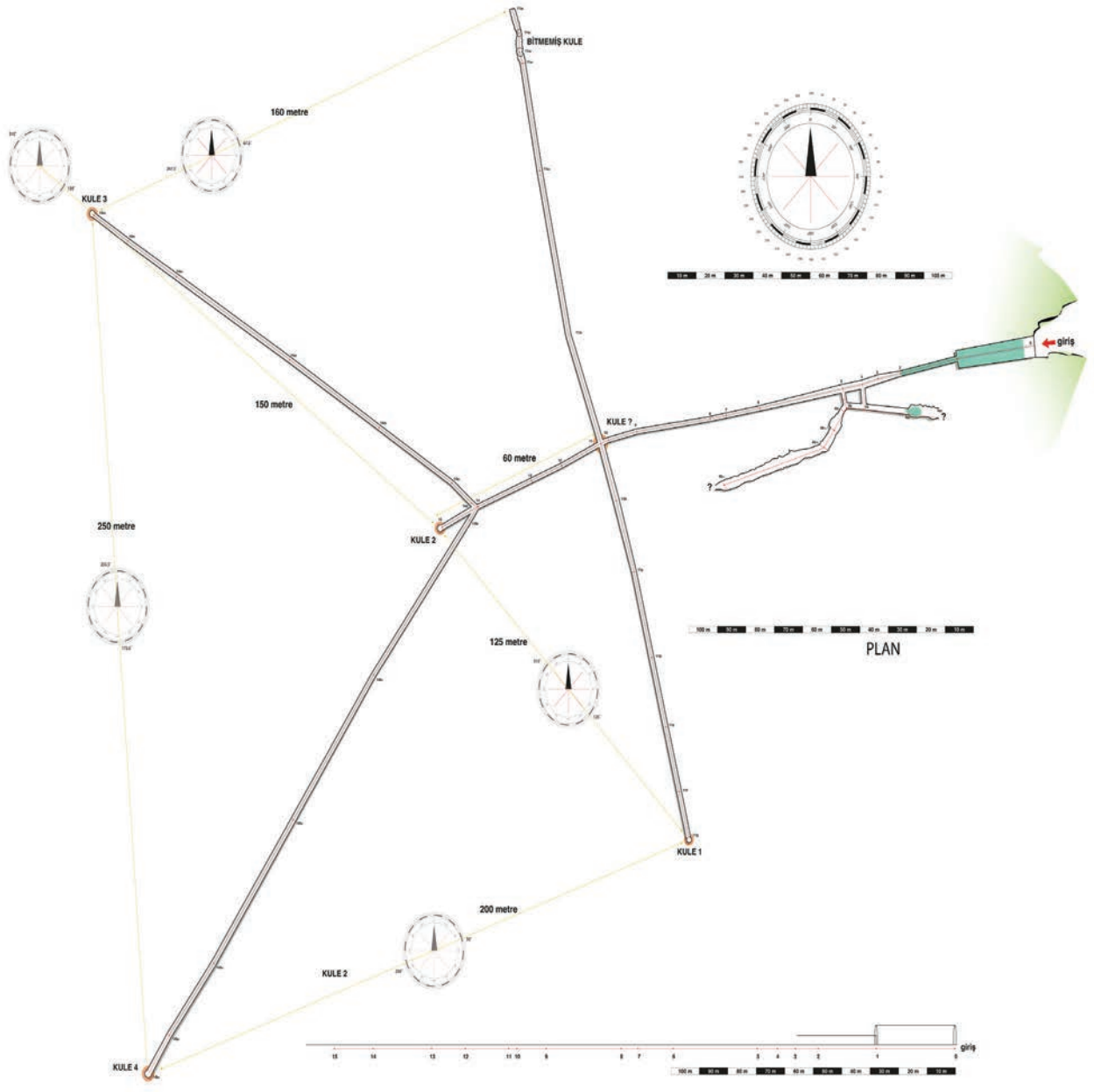

Fig. 1. Surveyed using traditional measurement techniques by A.H. Eğilmez, G. Gürbüz, and İ. Gürbüz; drawing prepared by İ. Gürbüz

- **North:** Secured by the Black Sea coast and Lake Terkos.
- **Center to South:** Guarded by three high ridges aligned on a North-South axis.
- **South:** Bounded by Büyükçekmece Lake extending to the Sea of Marmara.

These high-altitude ridges and dense forests provided natural defensive dominance, acting as combined anchors for trench warfare to halt enemy advances. However, the low-altitude sector situated between the villages of Dağyenice and Yazlık–occupying the center of the line–offered a critical 270-degree field of fire. This key position was where the heaviest casualties were suffered during the Balkan War, and it remains the site of a military cemetery for the fallen soldiers of that conflict. Following those bitter historical experiences, the Ottoman General Staff initiated early plans to build permanent and effective trenches in this sector. The defensive installation located on this hill features an internal tunnel length approaching 700 meters.

1. General Characteristics of the Çakmak Defense Line

The defensive line runs along a North-South axis roughly 45 km from central Istanbul (Sultanahmet Square). Moving southward along the front, the eastern heights lack forest cover but form the eastern flank of the deep,

Fig. 2. Pillbox inscription (Photo: A.H. Eğilmez)

wide valley created by Büyükçekmece Lake. As the terrain rises at a 5% gradient in this central sector, a series of open, star-plan pillbox (*korugan*) networks were constructed at varying elevations to maintain mutual lines of sight (Fig. 1).

Pillbox Network: It is estimated that approximately 400 pillboxes were distributed across the entire region. The highest designation number identified during our field surveys was **No. 336** (bearing the inscription date: **12-6-943**) (Fig. 2).

Troop Concentration Calculations: Based on field surveys, assuming 40 soldiers per pillbox across the 400 installations, 4 soldiers per infantry trench, and factoring in reserve troops for open positions, a minimum infrastructure for roughly 100,000 to 138,000 infantry and artillery personnel must have been deployed along the line during the war years. (Note: During the Ottoman-Bulgarian War, 138,000 troops actively served in this zone). Throughout the WWII mobilization years, villages across Thrace were evacuated, and the terrain was declared a restricted military security zone.

Structural Specifications: The pillboxes were constructed as robust, two-story reinforced concrete structures with walls 1 meter thick. Surface observations indicate that the lower level (basement) served as troop living quarters, equipped with independent, hand-dug water wells. The upper floor housed artillery and machine gun mounts. Target identification charts were painted directly onto the interior walls, indicating precise mil measurements and elevation angles for firing adjustments (Figure 3-4).

Secured Access: Entering these bunkers required passing through a heavy cast-iron outer door, followed by a secondary iron-grated inner door. Historical accounts indicate that due to the enclosed concrete environment, troops experienced severe hearing difficulties during artillery discharge tests.

Logistical Infrastructure: Near the village of Yazlık, the defensive lines are hidden in two parallel rows within the dense forest. Because the regional climate is prone to heavy rain, the soil easily turns to thick mud, which historically caused heavy ammunition vehicles to become bogged down. To resolve this, soldiers constructed wide roads paved with large, square-cut cobblestones to transport supplies reliably from the hilltop ammunition depots to the front line. While portions of these stone roads remain intact today, significant sections were dismantled by local villagers over the decades for use as domestic building materials.

2. Investigation of The Underground Tunnel System

The Çakmak underground tunnel network is an engineering feat designed on a dominant ridge. It features a star-burst layout spreading across six main gallery branches, with its primary entrance facing east. The system was engineered as a closed tunnel network be-

Figs. 3–4. Different typologies of external pillbox architecture. (Photo: A.H. Eğilmez)

Fig. 5. Main entrance door. (Photo: İ. Gürbüz)

Fig. 6. Incomplete inter-pillbox connection (Photo: İ. Gürbüz)

cause the overhead soil clearance was minimal, and the design allowed direct underground transit to the ammunition depots stretching along the east-southeast axis. Furthermore, it provided a 270-degree panoramic view of the landscape, enabling sweeping artillery control over the valley.

Current Preservation and Abandonment Status

Until roughly 20 years ago, the Turkish Armed Forces maintained this entire region as an active military zone. Subsequently, the military consolidated its perimeter around the uppermost apex ammunition depots, completely abandoning the outer trenches, pillboxes, defensive tunnels, and anti-tank obstacles. Today, local villagers utilize these historic concrete bunkers as agricultural storage or livestock barns.

Detail of the Internal Galleries and Rail Infrastructure

The main entrance opens at standard mining gallery dimensions, narrowing slightly before expanding inward. It tracks a straight east-west trajectory along a gentle downward slope (Fig. 5).

- **Decovil Railway Tracks:** The floor of the main tunnel features light decovil (narrow-gauge) railway tracks embedded in mud. Two decovil train sets remain inside the system; one set is permanently trapped beneath a reinforced concrete ceiling beam that collapsed inward (Fig. 6).
- **The Unfinished Branches:** Approximately 50 meters from the entrance, a side gallery branches left into two incomplete sections. Half of the right-hand branch remains bare rock; it was excavated but never reinforced with concrete lining. The left-hand branch is roughly half-lined with concrete, ending abruptly in a vaulted ceiling where the raw rock face narrows. Floor water has pooled at this terminus, likely fed by standard groundwater seepage during excavation.
- **Troop Quarters:** Deep within the tunnels, individual rooms designed to house soldiers remain in various stages of construction. Some chambers are finished with masonry stonework, while others remain rough-hewn rock.
- **The Intersection and Bunkers:** Deeper along the main line, past the collapsed beam, the tunnel reaches a major intersection splitting into three distinct galleries:
  1. **Center Branch:** Continues for 10 meters before ending at a spiral staircase leading to a surface pillbox. The iron stairs are heavily corroded (Fig. 7).
  2. **Right Branch:** Follows a decovil track for 150 meters, terminating at a spiral staircase chamber that connects to a surface bunker. These shafts have a narrow radius of roughly 1.5 me-

Fig. 7. a spiral staircase leading to a surface pillbox, heavily corroded (Photo: İ. Gürbüz)

Fig. 8. Architectural structure of the underground tunnels (Photo: İ. Gürbüz)

ters, meaning the transport of heavy artillery shells depended entirely on manual human labor. Near the end of this branch, a colony of 300 to 500 bats has settled. Heavy accumulation of guano is present, and ambient temperatures rise noticeably. This branch terminates near an unfinished upper gallery that failed to complete its connection to its corresponding surface bunker.

3. **Left Branch:** Extends for approximately 160 meters toward another pillbox (Fig. 8). The spiral staircase here is in relatively good condition, allowing ascent to the top floor (though safety harnesses are mandatory due to age). The decovil tracks here are well-preserved and run at a lower incline matching the exterior topography. The external walls of this specific pillbox were fully exposed two years ago during municipal excavations.

3. The Ahmediye Redoubt (Kale Sector, Bahşeyiş Village)

Located northeast of Büyükçekmece Lake behind the modern village of Bahşeyiş, a heavily forested hill holds a dominant elevation of 150 meters. Field surveys of the surrounding star- and triangle-shaped open trenches indicated that this site, locally referred to as "the castle," is actually the historical **Ahmediye Redoubt (*Ahmediye Tabyası*)**. Having played an active role during the Ottoman-Bulgarian Balkan War, it was thoroughly overhauled and integrated into the modern Çakmak Defense Line due to its exceptional value as an artillery command and observation post.

The redoubt features a semi-elliptical inner tunnel infrastructure running on a northeast-southwest axis. It contains artillery casemates (*top odaları*) and extensive masonry brickwork matching layouts seen in the historical Kırklareli Redoubts. Recognizing its exceptional value as an artillery command and observation post, the twentieth-century Turkish military integrated the old Ottoman redoubt directly into the Çakmak Defense Line. They reinforced the outer walls, dug deep perimeter ditches, and positioned modern machine gun nests and infantry foxholes directly in front of the old fort (Fig. 9).

Key Archaeological Findings

- **Defensive Masonry:** The exterior brick walls utilize a sophisticated vault-layering technique designed to deflect and absorb the impact of incoming artillery shells. This historic structural engineering functions identically to the modern sloped or reactive plate armor seen on high-tech main battle tanks today (Fig. 10).

Fig. 9. The Ahmediye Redoubt features a bedrock-cut tunnel system (Photo: A.H. Eğilmez)

- **The "Şahbaz" Bricks:** Inside the interconnected tunnel system–which links six separate artillery rooms equipped with ventilation shafts and hearths–investigators identified high-heat kilned bricks bearing the stamped logo of the **"Şahbaz"** factory, a prominent Ottoman brick manufacturer of the era.
- **Current State of Neglect:** Despite its historic value and intact tunnel network, the Ahmediye Redoubt is currently in a state of severe neglect. Due to a complete lack of preservation, local populations refer to it simply as "the castle", unaware of its true name or military history. The surrounding area is marred by litter, temporary improvised latrines, and its unauthorized use as an open firing range.

4. Discussion and Evaluation

The Çakmak Defense Line represents a hybrid framework in military architectural history. It merged the reinforced concrete bunker technology of the French Maginot Line with the permanent fortification layouts of the late Ottoman era (as seen in the adaptation of the Ahmediye Redoubt) into a singular defense doctrine. The star-plan geometry of the tunnels aimed to draw advancing enemy forces into narrowing angles, creating highly effective crossfire zones (death fields).

However, much like the Maginot Line that inspired it, the Çakmak Line proved strategically ineffective. The German army's advance through Greece rather than Turkey bypassed the line from the south (via the Aegean/Mediterranean). Consequently, the line was never tested in combat, remaining an unfinished military monument curtailed by financial exhaustion.

Today, this site faces a critical cultural heritage risk. Since the Turkish Armed Forces consolidated their perimeter around the uppermost apex ammunition depots roughly 20 years ago, the outer trenches, pillboxes, defensive tunnels, and anti-tank obstacles have been completely abandoned. Pillboxes are used by local villagers

Fig. 10. The exterior wall constructed with a vault-layering technique (Photo: A.H. Eğilmez)

as agricultural barns or livestock storage. The underground tunnels and the historic Ahmediye Redoubt are deteriorating rapidly due to neglect, severe littering, use as temporary latrines, and unauthorized use as open firing ranges.

Conversely, the fact that these human-made tunnels have developed a natural cave microclimate over time–turning them into a protected ecosystem for threatened bat colonies–highlights that the site must also be preserved for its ecological and biological value.

5. Conclusion And Recommendations

The Underground Çakmak Defense Line and its integrated historical fortifications in Çatalca constitute a unique military cultural heritage site. It stands as a physical record of Turkey's geopolitical stance during World War II, the engineering capabilities of the era, and a massive defensive effort achieved despite severely restricted economic resources. An integrated underground military tunnel network of this scale, featuring preserved decauville rail lines, is entirely unprecedented in Turkey.

To halt the destructive degradation of the site, the following measures are recommended:

- The underground tunnel systems and the Ahmediye Redoubt should be immediately designated as a "First-Degree Monumental Structure and Military History Archaeological Site" by the Regional Cultural Heritage Preservation Boards.
- The internal decauville rail tracks, remaining train components, spiral iron stairs, and the specialized "Şahbaz" masonry brick walls should undergo immediate architectural stabilization and restoration.
- The complex should be safely integrated into cultural tourism under an "Open-Air Military History and Speleological Museum" concept, implemented with strict measures to protect the sensitive bat ecosystem inside the galleries.

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Underground Military Objects in Serbia

Nemanja Milosavljević

The Speleological Committee of the Mountaineering Association of Serbia
nemanja84@hotmail.com

Abstract

Due to its political and geostrategic position, The Socialistic Federative Republic of Yugoslavia (SFRY), constrained by the two blocks of the Cold War period, made considerable investments in developing underground military facilities as a strategic means of protecting the country. Each of the Yugoslav republics had many objects of different purpose, ranging from general headquarters, storehouses and atomic shelters to underground airports and weapon factories. SFRY had inherited the historical legacy of fortification architecture as well as underground military architecture from the Habsbourg Monarchy and, in recent history, the Kingdom of Yugoslavia, and in a considerable number of objects from the Nazi occupying forces in its very capital – Belgrade.
After the breakup of SFRY in the nineties, due to general economic conditions and a new policy of Serbia as a transitional society at the beginning of the 21st century, many underground objects either became abandoned from the army or had their function changed, which made them more accessible to potential explorers. The object which have been explored so far are located at different strategic locations, in different stages of construction, from excavations to finished and used objects. They provide a complete picture of the underground military architecture in its function and form within the context of historical and political events in Serbia.

Keywords: tunnel, hall, excavation, blast-absorption, defense

Underground objects as elements of Serbia's and Yugoslavia's defense strategy

In order to understand the motives and selection of locations for construction, as well as the structure and function of underground defense facilities located on the territory of present-day Serbia, it is necessary to consider the broader context of geographical, historical, and political circumstances, primarily related to the former state of Yugoslavia, of which Serbia was a constituent unit.

The Kingdom of Yugoslavia was created on the foundations of the victory achieved by the Serbian army in the First World War. The experiences of trench warfare and the liberation of the country achieved through offensive breakthroughs of the Salonika Front, clearly did not significantly influence a change in defense strategy of the newly formed state. This proved disastrous in 1941 during the aggression of Nazi Germany. The construction of more complex underground military infrastructure during this period was almost non-existent. The only initiated project from that period was located in Serbia and was intended for the needs of the supreme command in case of war.

After the Second World War, the Republic of Serbia was one of the six republics of the Socialist Federal Republic of Yugoslavia (SFRY), which had a unified defense system and strategy. As a country that declared itself for a *"third path"* (officially from 1961 through the Non-Aligned Movement), it was positioned not only politically between the capitalist West and the communist East, but also geographically surrounded by NATO member states on one side and Warsaw Pact countries on the other. Strategists of the Yugoslav People's Army (JNA) believed that Yugoslavia's borders were vulnerable, and that the country's defense strategy should rely on the advantages of mountainous terrain and guerrilla warfare, following the model applied by Tito's partisans during World War II, but with more modern technology.

Such a defense strategy was accompanied by the idea of constructing large underground complexes of various purposes across the country, primarily in Bosnia and Herzegovina, which was geographically central and characterized by mountainous terrain, envisioned as the center of resistance. These were not just basic fortification systems of trenches, bunkers, and machine-gun nests, but complexes capable of accommodating large numbers of people, military equipment, and meeting the challenges of modern warfare. Major defense projects included the *"Atomic War Command"* (ARK D-0) in Konjic (Bosnia and Herzegovina), the underground airbase *"Željava"* (Object 505) in Bihać (Croatia), underground complexes on the island of Vis (Croatia), and Object G-3 in Han Pijesak (Bosnia and

Herzegovina). All of these were designed to meet high standards of modern warfare, including resistance to nuclear strikes, protection from contaminated air (radioactive particles, chemical agents, biological threats), energy autonomy, independent water supply, and capacity to house military equipment and large numbers of personnel for months.

Serbia, as a republic of the SFRY, bordered three Warsaw Pact countries (Hungary, Romania, Bulgaria). After the political conflict between the Communist Party of Yugoslavia and Stalin and the USSR, and the Cominform Resolution of 1948, the threat of a Soviet invasion increased. During this period, significant fortifications and underground structures were built along Serbia's eastern border. However, after Stalin's death and officially in 1955, relations between Yugoslavia and the USSR improved, eliminating the real threat from the east. Due to this improved political climate and financial constraints, many underground military construction projects were halted.

After the breakup of Yugoslavia and the dissolution of the JNA, and following the bloody civil wars, many underground military facilities lost their importance for the armies of newly formed states. Over time, they were abandoned and devastated. Some were repurposed by local entrepreneurs, often for mushroom cultivation, while a few, such as Tito's bunker in Konjic, became tourist attractions.

Research methodology

For most underground military facilities in Serbia, there is no publicly available historical documentation, which is understandable since they were strictly guarded military secrets for nearly half a century. Apart from a few recent newspaper articles, information about their construction and purpose is largely part of local oral tradition. Certain assumptions and conclusions are based on analogies with similar structures or general knowledge of military engineering. All plans presented in this paper are the result of the author's own topographic measurements.

Kamena devojka

Known today as the Karađorđević Underground City, during construction it bore the codename *"Kamena devojka"* (eng. Stone Maiden). This complex is located in the municipality of Mali Zvornik in western Serbia, near the border with Bosnia and Herzegovina, on the slopes of Mount Boranja along the Drina River. It was intended as a wartime command center and secret shelter for the royal family and the political and military leadership of the Kingdom of Yugoslavia. The location of the complex was chosen by military strategists, believing that a facility of this purpose and importance should be located in the geographical center of the country, which is approximately what the area around Mali Zvornik was.

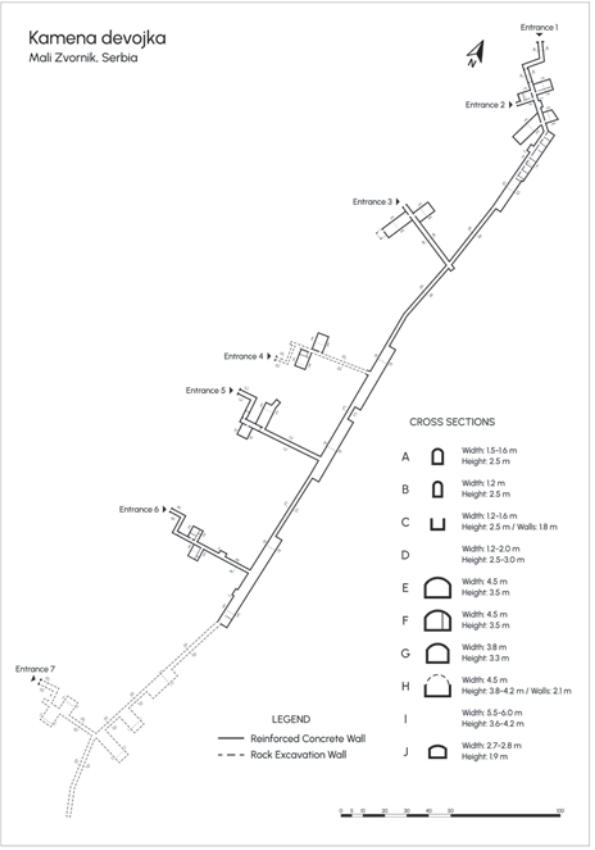

Fig. 1. Plan and cross sections of *Kamena devojka* (graphic Nemanja Milosavljević)

Construction was ordered by King Alexander I Karađorđević in 1931. Works lasted from 1932 until his assassination in Marseille in 1934, when about two-thirds of the complex had been completed. According to unofficial sources, construction was carried out in strict secrecy, and only a few high-ranking officials were aware of its true purpose. The workforce consisted of prisoners brought from various parts of Yugoslavia, working under the design of an unnamed Russian mining engineer. Although unfinished, the facility was briefly used after the German invasion of Yugoslavia on April 6, 1941. The last session of the Yugoslav government was held there on April 9–10, and King Peter II spent his last night in Serbia there before going into exile (Subašić 2015).

It cannot be determined with certainty whether it was known to the German occupying forces during the occupation from 1941 to 1945 and whether it was used, although the local population denies this. It is certain that this complex, due to its primary function, was not of interest to the new communist government after 1945. For a short period of time, it was used as a warehouse for a pharmaceutical company and a beverages,

Fig. 2. Reconstruction of the military dormitory, *Kamena devojka* (photo Nemanja Milosavljević)

and then it was devastated and forgotten. After the restoration that lasted from 2014 to 2020, the space was put into tourist function and is the only facility of its kind in Serbia. Today, the facility houses a museum display of furniture and exhibits from the period between the two world wars.

The complex (Fig. 1) extends parallel to the Drina River and the Loznica–Ljubovija road. It has around 7 main entrances, many concealed within residential buildings. It was excavated in limestone rock, with reinforced concrete tunnels, halls, and rooms. In the largest part of the excavation, reinforced concrete walls and semi-circular arches were formed, which form tunnels, halls and rooms, while a smaller number of tunnels remained with an unfinished ceiling or were completely without a masonry structure. The main tunnel is connected to 6 side corridors that have a connection to the outside. It is also connected to about 20 halls and rooms of varying size and purpose. One room was designed as a chapel with an altar apse. This is the only room in the entire complex that had painted ornamentation on the walls. The purpose of other rooms was reconstructed, and today it is known that the complex contained a royal apartment, an infirmary, a meeting room, dormitories for the guards (Fig. 2), and a storage area. It also had its own internal water supply from a well.

Underground structures of the Gornjak Gorge

The Gornjak Gorge is located in eastern Serbia along the Mlava River, between Petrovac na Mlavi and Žagubica towns. Three underground facilities are located in the surrounding mountains, Ježevac and Vukan. According to unwritten testimonies, the construction of one of these facilities was started by the German occupiers during World War II (in the period from 1942 to 1944) with the aim of developing infrastructure facilities for the security support of the planned railway route that would connect to Bor as a significant mining center. After the war, the Yugoslav People's Army (JNA) continued the work and built two more facilities with the intention of housing an arms and ammunition factory in them. The works were suspended in 1953 used after the German invasion of Yugoslavia on April 6, 1941. The last session of the Yugoslav government was held there on April 9–10, and King Peter II spent his last night in Serbia there before going into exile (Subašić 2015).

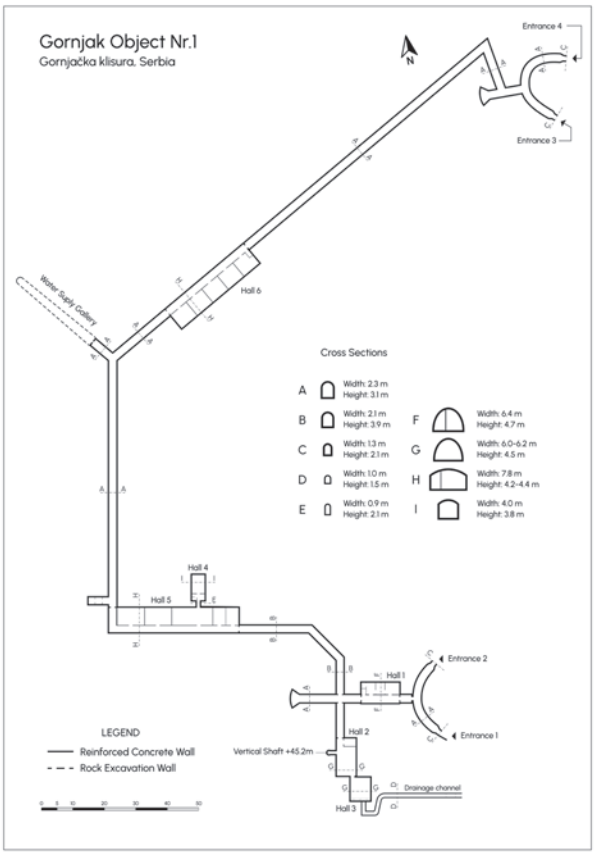

Fig. 3. Plan and cross sections of Object no.1, Gornjak Gorge (graphic Nemanja Milosavljević)

Object No. 1

Object No. 1 (Fig. 3) is structured around a main tunnel (Fig. 4) that serves as a corridor for the movement of personnel and the transport of equipment, with rooms and halls connected laterally to it. The main tunnel extends into the mountain in the form of a broken line and communicates with the outside environment through secondary semicircular tunnels located at both of its ends. These semicircular tunnels, each with two entrances (Fig. 5), hereinafter referred to as blast-absorption tunnels, are situated at the ends of the main tunnel and are designed to absorb explosions occurring in their immediate vicinity, thereby reducing damage to the interior of the facility.

The structure contains three large halls (Fig. 6) intended for the accommodation of personnel and equipment, subdivided by partition walls into smaller rooms. Of particular functional importance is the machinery hall,

Fig. 4. The main tunnel, Object no.1, Gornjak Gorge (photo Jelena Jovanović)

Fig. 5. Walled entrance and part of the blast-absorption tunnel, Object no.1, Gornjak Gorge (photo Jelena Jovanović)

Fig. 6. Hallway in hall no.5., with remains of mushroom growing sacks, Object no.1, Gornjak Gorge (photo Jelena Jovanović)

Fig. 7. Ventilation shaft, Object Nr.1, Gornjak Gorge (photo Jelena Jovanović)

which housed equipment responsible for circulating air between the facility and the outside environment.

A smaller tunnel (1×1 m), located below floor level and extending from the machinery hall, is presumed to have served as a drainage or sewage conduit. Also extending from this hall is a vertical ventilation shaft (Fig. 7) of circular cross-section, which simultaneously served as a secret exit due to the installation of ladders within it. This shaft leads to a small structure concealed in the forest above the facility. The facility also contains a channel of specific purpose, largely left unlined, in which groundwater was captured, thus providing autonomous water supply for the complex.

Object No. 2

Object No. 2 (Fig. 8) differs structurally from Object No. 1, suggesting that its function was also different. The central zone of this facility consists of three large halls arranged in parallel. Only the central hall was fully completed, and three smaller auxiliary rooms are attached to it. In the other two halls, the construction process is visible. The first phase is represented by the excavation of two tunnels between which there is a rock as a support for the ceiling and a reinforced concrete wall is built. The second phase is where the rock support is partially removed. And the third phase is where the rock is completely removed and a reinforced concrete vaulted ceiling is built (Fig. 9). The central hall has a direct connection to the outside along a straight excavation, although reinforced concrete lining was constructed only partially along its length. At its end, preparatory excavation work is visible for the construction of a blast-absorption tunnel. This tunnel continues from the central hall deeper into the mountain along the same azimuth, indicating that the complex may originally have been planned on a much larger scale than its current dimensions suggest.In the two remaining halls, although the vaulted structures were fully constructed, the earth that served as natural support during construction was never removed. The facility also includes a sub-unit consisting of an unfinished blast-absorption tunnel that leads into a system of shorter tunnels and halls connected to the main tunnel. The dimensions of the main tunnel, the size of the entrances, and the right-angle intersections of tunnel branches–which significantly restrict vehicle maneuverability–indicate that these facilities were not intended for the storage of heavy mobile military equipment such as tanks, howitzers, or armored vehicles. The size of the halls, which were not subdivided into smaller rooms, suggests instead that they were intended to house industrial machinery, light weapons, or ammunition rather than personnel. All findings derived from spatial analysis support oral accounts that this facility was constructed as an underground factory.

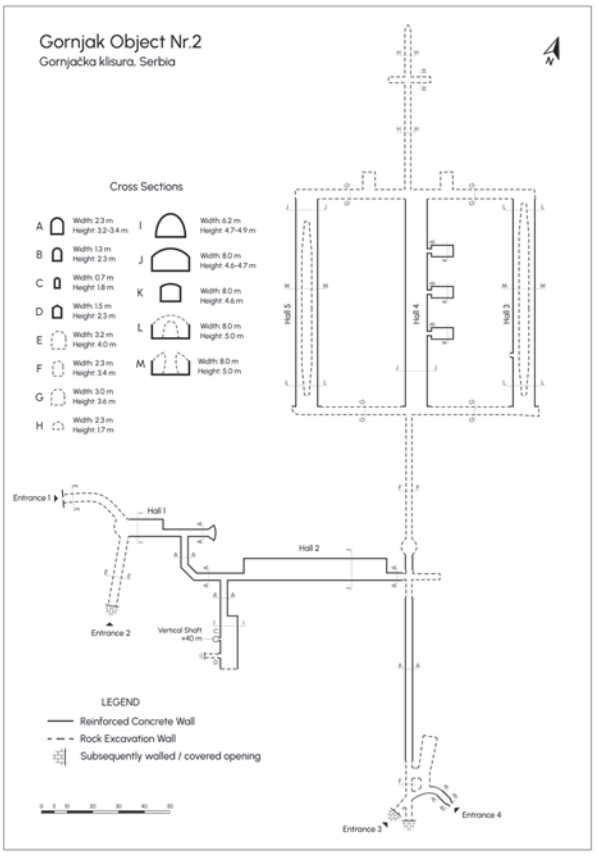

Fig. 8. Plan and cross sections of Object no.2, Gornjak Gorge (graphic Nemanja Milosavljević)

Fig. 9. The excavation and construction process in hall no.5, Object no.3, Gornjak Gorge (photo Jelena Jovanović)

Object No. 3

The core of Object No. 3 (Fig. 10) consists of four halls connected by a cruciform tunnel layout. These tunnels have a direct connection with the outside environment and lack the usual intermediary blast-absorption tunnels found in Objects No. 1 and No. 2.

Instead of a semicircular blast-absorption tunnel, there is a simple straight tunnel with two entrances posi-

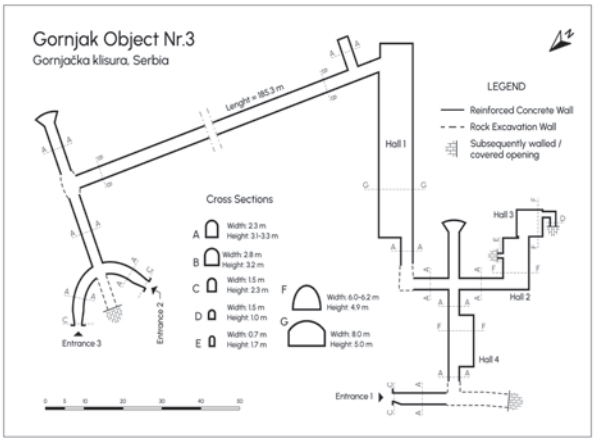

Fig. 10. Plan and cross sections of Object no.3, Gornjak Gorge (graphic Nemanja Milosavljević)

Fig. 11. Hall no.1, Object no.3 in Gornjak Gorge (photo Jelena Jovanović)

tioned perpendicular to the direction of the main tunnel. The second entrance to the facility is equipped with a blast-absorption tunnel connected to a T-shaped tunnel with a relatively long branch (185.3m), which joins the largest hall (Fig. 11) within the complex. The purpose of this facility remains unknown.

Underground structures in Niš

Two underground facilities of unknown purpose are located near the city of Niš. Object No.1 is completely finished, while in object No.2, certain sections were completed only up to the stage of excavation and partial construction of the reinforced concrete structure. The analysis of the spatial plan shows the application of an identical construction method, and the conclusion is drawn that they are parts of an integral project and that they were built in the same period.

Object No.1

Object 1 (Fig. 12) is located in the village of Kamenica. The main tunnel extends in the direction of the broken line, and it is connected to the outer middle by an absorption tunnel and a side entrance, which is located at a higher altitude than the main entrance and is hidden in the forest. Overcoming unevenness between the main and side entrances was solved by building a staircase (Fig. 13) as an integral part of the main tunnel. The main tunnel is connected to 4 larger halls, two of which are divided into smaller rooms and are probably intended for housing people. One larger hall was positioned along the direction of the main tunnel, while the other was placed perpendicular to it and housed the machine plant. Along the main tunnel, 8 niches of smaller dimensions were formed laterally in the walls. From the power (engine) hall, there is a double vertically oriented ventilation channel with vents through which you can go to the surface. In the center of the en-

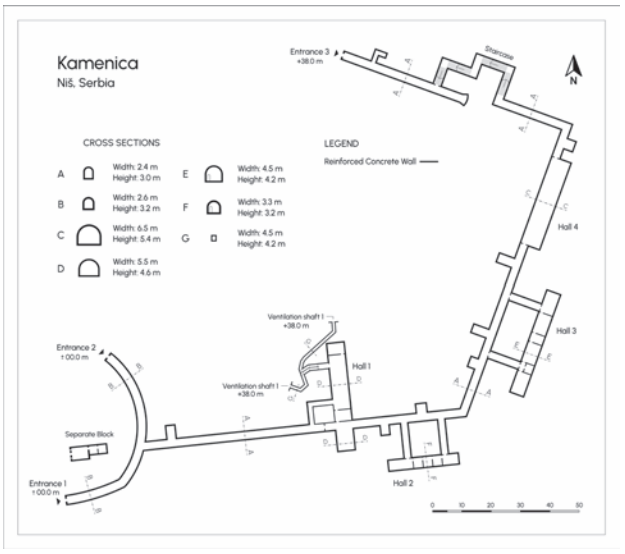

Fig. 12. Plan and cross sections of undergroun object in Kamenica Niš (graphic Nemanja Milosavljević)

Fig. 13. Staricase in underground object in Kamenica, Niš (photo Nemanja Milosavljević)

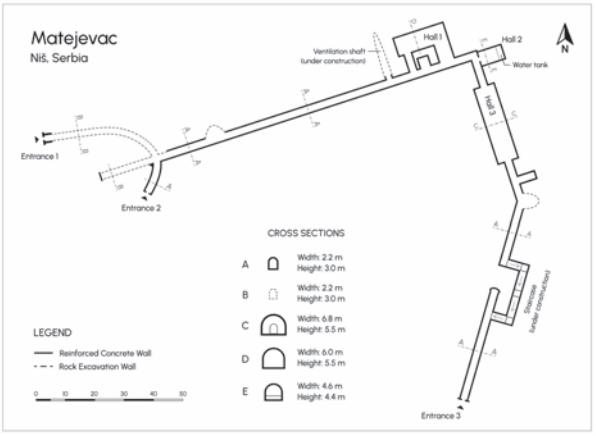

Fig. 14. Plan and cross sections of underground object in Matejevac, Niš (graphic Nemanja Milosavljević)

trance absorption tunnel, oriented towards the outer environment, there is a separate room that does not have a direct physical connection with the inner tunnels, but is connected to them by a channel that extends along the entire floor of the main tunnel. This channel has the purpose of collecting groundwater and waste water. There is no source of water supply in the facility, but the spring Srećkovo vrelo is in the immediate vicinity, from where the supply was probably planned.

Object No. 2

Object no. 2 (Fig. 14) is located in the village of Matejevac. Although it is similar in construction concept to the building in Kamenica, it is significantly smaller in size. One arm of the absorption tunnel was completed only in the excavation, and the staircase of the main tunnel that goes up to the side entrance was not completed at all. At the place of the planned staircase a genuine cave flowstone was formed. Three halls and two niches were completely constructed. The specificity is the *"water hall"*, in which water is collected from the soil and conveyed to the trough by a system of incisions on the front wall of the hall. There are three excavations in the side walls that were intended for niches and a ventilation shaft.

Underground structures in Kučajna

In the village of Kučajna, in the municipality of Kučevo, there is an unnamed underground facility whose intended purpose remains unknown. Construction work was halted during the excavation phase, and apart from several partially built semi-vaulted reinforced-concrete hall structures, no other construction work was carried out.

This facility (Fig. 15) is particularly significant because its present condition makes it possible to understand the construction process used in other underground facilities. The main tunnel extends from the entrance in a west-southwest direction. After a certain distance, it splits into two parallel passages that continue to the final point of excavation, forming a kind of twin-tunnel configuration.

This indicates that the rock mass separating these twin tunnels was intended to serve as temporary support for the roof until the reinforced-concrete lining–consisting of walls and a vaulted ceiling–of a single unified tunnel was completed.

From this main communication corridor, three parallel twin tunnels branch off toward the south. Based on the spacing between the twin tunnels, the widened sections within them, and the presence of massive arched reinforced-concrete structures, it can be concluded that this area was planned for the construction of three large halls.

Conclusion

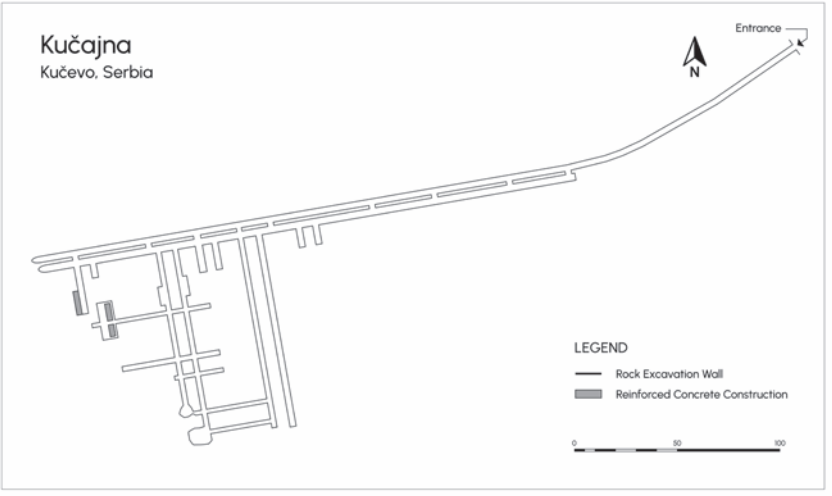

Fig. 15. Plan of underground structures in Kučajna, Kučevo (graphic Nemanja Milosavljević)

In most of the facilities discussed in this paper, a recurring general pattern can be observed with regard to site selection, spatial organization, choice of materials, and construction methods. All facilities were consistently located in well-concealed positions within gorges, beneath forested hills, in easily excavated limestone formations, and in close proximity to rivers. Structurally, the central axis–or backbone–of each facility is formed by a main tunnel serving as the primary corridor for the movement of personnel and equipment. Depending on the function of the facility, halls, rooms, and niches are connected to the main tunnel either directly or via secondary tunnels, forming the principal storage and accommodation units. All facilities have at least two entrances in order to enhance security, provide more favorable defensive conditions, and enable rapid evacuation. From a construction standpoint, all facilities were built of reinforced concrete, with tunnels characterized by vertical side walls and semi-vaulted roofs. Two principal hall construction types can be distinguished: halls with a cubic geometry consisting of vertical walls and a vaulted ceiling, and halls of entirely semi-cylindrical form.It should be emphasized that there is a significant difference between the *"Kamena devojka"* complex, constructed before the Second World War, and all of the facilities built later. Although they are structurally comparable, the *Kamena devojka* lacks blast-absorption tunnels, which became an essential feature in later facilities in response to the destructive power of more advanced weaponry. In the more recent facilities, a conical expansion is regularly found at the end of the entrance passage where it joins the blast-absorption tunnels. This space served as a firing position or breastwork for defenders tasked with preventing enemy advancement deeper into the facility. *Kamena devojka* is the only facility constructed in an urban setting, whereas all other facilities are located at a distance from settlements. It is also the only facility situated in western Serbia, while all the others are concentrated along the country's eastern border. Given that it was intended to accommodate the King and the General Staff, it can be said that *Kamena devojka* was modest in scale compared with the facilities later constructed in the Socialist Federal Republic of Yugoslavia for the state leadership. For example, the construction of Tito's Bunker, which lasted 26 years, cost approximately 4.6 billion U.S. dollars at the time (equivalent to roughly 10 billion dollars today). In comparison with the major military complexes built during the SFRY, primarily in Bosnia and Herzegovina and Croatia, it can be concluded that the facilities examined in this study on the territory of Serbia were of considerably more modest importance. They were intended to accommodate smaller units or had less strategic significance for the defense of Yugoslavia. This is further supported by the fact that most of them remained unfinished and, as such, were probably never put into operational use.

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NEW TECHNOLOGIES FOR ANALYZING AND DOCUMENTING THE ARTIFICIAL CAVITIES

HYPOGEA
TBILISI•2026

Integrated Multi-Sensor Geomatic Approaches for the Documentation and Monitoring of Georgian Rock-Cut Heritage

Luisa Beltramone[1], Mikheil Lobjanidze[2], Mikheil Elashvili[2,3], Riccardo Salvini[1]

[1]University of Siena, Department of Physical Sciences, Earth and Environment and Centre of GeoTechnologies (CGT), Italy; [luisa.beltramone@unisi.it]
[2]Ilia State University, School of Natural Sciences and Medicine, Cultural Heritage and Environment Research Center, Georgia
[3]Bridgewater State University, Bartlett College of Science & Mathematics, USA

Abstract

Georgia preserves an extensive rupestrian cultural heritage composed of monasteries, churches, cave settlements, and rock-cut architectural complexes excavated into weak sedimentary rock masses and volcanic deposits. Many of these sites are affected by progressive weathering, erosion, rocky block detachments, and geomorphological instability processes, which threaten both the cultural heritage and the surrounding landscape. Their documentation and monitoring are often complicated by limited accessibility, complex morphologies, and the fragile nature of the excavated environments.

This contribution presents the results of an integrated geomatic survey campaign conducted across six Georgian rock-cut heritage sites, including Shiomgvime, Uplistsikhe, Vardzia, Vanis Kvabebi, Dodo Rqa, Natlismtsemeli, and Sabereebi. Different acquisition strategies were adopted according to the geomorphological characteristics, dimensions, and accessibility conditions of each site, combining terrestrial laser scanning (TLS), drone photogrammetry, GNSS surveys, and high-resolution three-dimensional reconstruction techniques.

The integrated datasets enabled the generation of dense 3D point clouds, digital surface models, orthophotos, and detailed three-dimensional representations of both natural and excavated sectors. The combination of photogrammetric and TLS-derived data improved the reconstruction of partially inaccessible areas and enhanced the spatial characterization of erosion features, structural discontinuities, surface degradation patterns, and instability-related morphologies. Multi-temporal datasets acquired in selected sites also supported assessments of ongoing geomorphological changes affecting cliff sectors and carved structures. In selected case studies, the integrated geomatic datasets additionally supported preliminary numerical slope stability modelling and the interpretation of instability processes affecting the rupestrian environments.

The study demonstrates the potential of integrated geomatics approaches for the documentation, monitoring, and support for conservation of vulnerable rupestrian heritage environments. The proposed workflow highlights the importance of adapting survey strategies to site-specific geomorphological and operational conditions, contributing to the long-term preservation and digital documentation of Georgian artificial cavities.

Keywords: Georgian cultural heritage, rock-cut artificial cavities, terrestrial laser scanning, drone photogrammetry, geomatic monitoring

Introduction

Georgia preserves an extensive rupestrian cultural heritage comprising monasteries, churches, cave settlements, and rock-cut architectural complexes excavated into sedimentary rock masses and volcanic deposits. These sites represent an important component of the cultural and religious landscape of the Caucasus region and include cultural landscapes characterized by significant archaeological, historical, architectural, and geomorphological value. Many of the investigated complexes developed along steep cliff sectors and remote mountainous environments, where natural morphologies strongly influenced the evolution of excavated architectural spaces and monastic settlements.

Several Georgian rupestrian sites are currently affected by progressive weathering, erosion, water infiltration, rocky-block detachments, and geomorphological instability processes that threaten both the cultural heritage and the surrounding landscape. Weak lithologies, steep morphologies, structural discontinuities, and long-term environmental exposure contribute to surface degradation and localized instability phenomena affecting carved architectural sectors, cliff facades, frescoes, and internal spaces of excavated monasteries. In many cas-

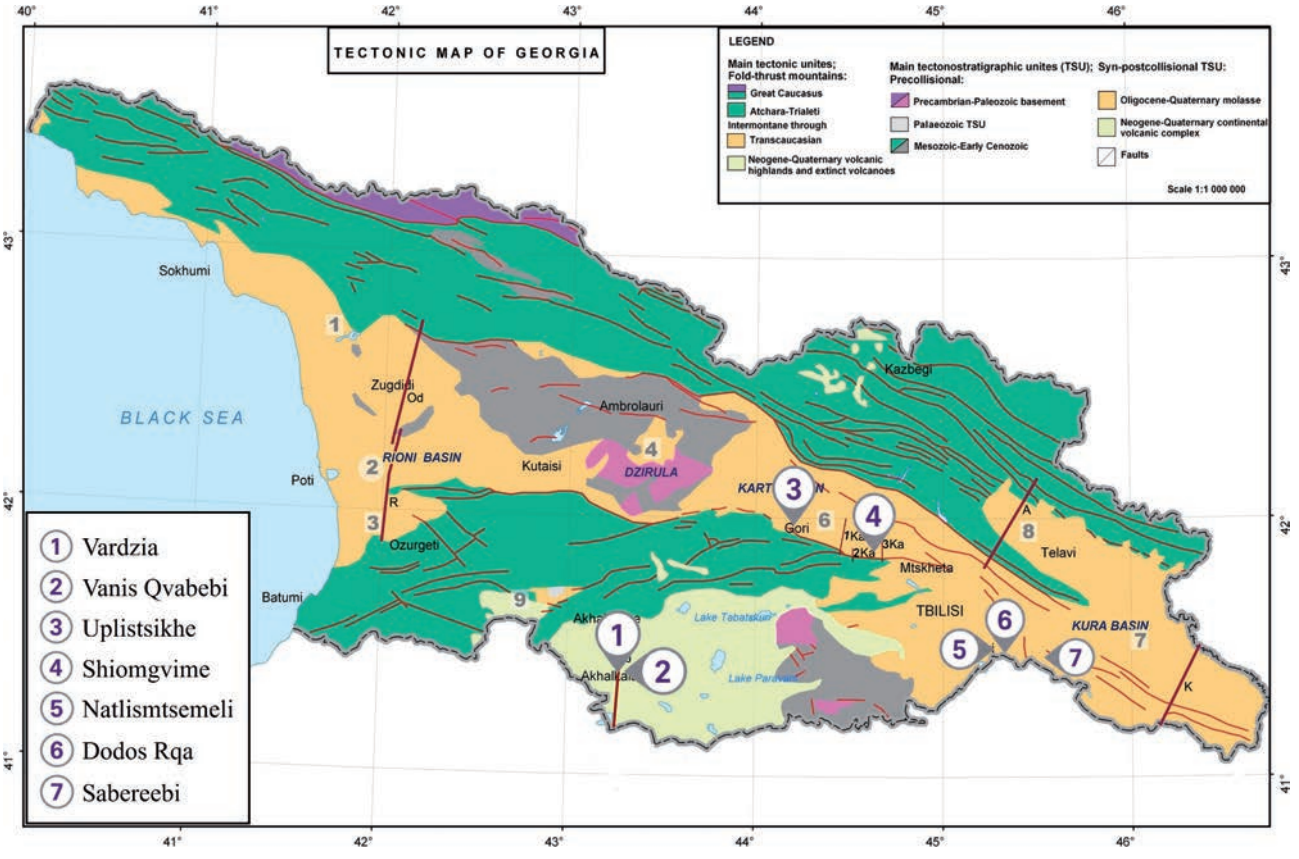

Fig. 1. Location of the investigated Georgian rock-cut heritage sites (numbered pins indicate the sites location). The basemap is the "Tectonic map of Georgia", scale 1:1,000,000; squares and circles represents locations of the lithostratigraphic columns; location of cross-sections: Od, Odishi; R, Rioni; Ka, Kartli; A, Alazani; K, Kura; Kv, Kvabebi. Modified from Adamia et al. (2010)

es, the conservation and monitoring of these environments are additionally complicated by limited accessibility, irregular morphologies, fragile surfaces, and the coexistence of natural and anthropogenic elements.

In recent years, integrated geomatics approaches have increasingly supported the digital documentation, study, monitoring, and conservation-oriented investigation of vulnerable rupestrian heritage environments. The combined and multi-temporal use of drone photogrammetry, terrestrial laser scanning (TLS), topographic surveying by Total Station and Global Positioning Satellite System (GNSS), enables the acquisition of high-resolution spatial datasets suitable for three-dimensional reconstruction, geomorphological interpretation, instability assessment, and virtual exploration, even under difficult operational conditions.

We present preliminary results of multi-sensor geomatic survey campaigns conducted across several Georgian rock-cut heritage sites, including Shiomghvime, Uplistsikhe, Vardzia, Vanis Qvabebi, Dodos Rqa, Natlismtsemeli, and Sabereebi. The general workflows were adapted to the geomorphological characteristics, accessibility conditions, and study objectives for each site, integrating drone photogrammetry, TLS, GNSS surveys, and selected multi-temporal studies to support documentation, monitoring, and planning of conservation strategies in complex rupestrian environments.

Geographical and geological framework

The investigated rupestrian sites are distributed across several regions of Georgia (Fig. 1) and include cave settlements, monasteries, and large-scale rock-cut architectural complexes characterized by distinct geomorphological settings, accessibility conditions, and conservation issues. Uplistsikhe is located in the Shida Kartli region of central Georgia, whereas Dodos Rqa, Natlismtsemeli, and Sabereebi belong to the David Gareja monastic system in southeastern Georgia. Shiomghvime is situated near Mtskheta in the Mtskheta-Mtianeti region, while Vanis Qvabebi and Vardzia are located in the Samtskhe-Javakheti region of southern Georgia.

The geological evolution of Georgia produced heterogeneous lithological and geomorphological settings strongly influenced by the tectonic evolution of the Caucasus region. Most investigated rupestrian environments developed within weak sedimentary successions associated with molassic depositional systems composed of sandstones, conglomerates, clays deposits affected by intense weathering and erosion processes (Margottini et al. 2020; Frodella et al. 2021; Domej et al. 2022; Frullini 2022; Koiava et al. 2025). These relatively weak and easily excavated lithologies favored the development of rock-cut settlements, monastic com-

plexes, and artificial cavities, particularly within the David Gareja complex, but also typical for Shiomghvime and Uplistsikhe monuments (Popov et al. 2022).

In contrast, Vardzia and Vanis Qvabebi are primarily carved into volcanic rocks: pyroclastic formations of andesitic–dacitic composition associated with the Goderdzi Suite in the case of Vardzia (Okrostsvaridze et al. 2016) and partially into quaternary volcanic formations of the Akhalkalaki Suite in the case of Vanis Qvabebi (Frodella et al. 2021). The lithological and morphostructural characteristics of these rock masses strongly influence weathering processes, cliff retreat, water infiltration, localized detachments, and instability phenomena affecting both natural slopes and excavated architectural sections. Steep morphologies and partially inaccessible cliff sectors additionally represent significant operational constraints for documentation and monitoring activities.

Historical and cultural framework

The investigated sites span different phases of the historical, religious, and cultural development of Georgian rupestrian architecture, from the 1st millennium BC to the Late Middle Ages. These environments represent significant examples of the interaction between landscape adaptation, religious practices, defensive strategies, and excavated construction techniques developed under different geological and geomorphological conditions.

Uplistsikhe originated as a pagan rock-hewn settlement and later evolved into an important Christian center between the Early Iron Age and the medieval period. Several investigated monastic complexes, including Dodos Rqa, Natlismtsemeli, and Shiomghvime, are traditionally associated with the “13 Assyrian Fathers”, who contributed to the spreading of monastic life in Georgia during the 6th century (Tvalchrelidze and Murgulia 2020; Khoshtaria 2023). Vanis Qvabebi and Sabereebi developed during the medieval expansion of Georgian monasticism between the 8th and 10th centuries (Tumanishvili 2013; Frodella et al. 2021), whereas the large-scale Vardzia complex was completed during the Georgian Golden Age of the 12th-13th century (Bakhtadze 2019).

Many investigated rupestrian complexes preserve mural paintings, carved architectural elements, inscriptions, and decorated ecclesiastical spaces of significant historical, archaeological, and artistic value. These fragile environments are particularly vulnerable to weathering, moisture infiltration, biological colonization, surface erosion, and material decay processes, highlighting the importance of high-resolution digital documentation and long-term conservation-oriented monitoring strategies. Several sites also remain active religious and cultural centers todays, preserving important evidence of the long-term interaction between Georgian rupestrian traditions and the surrounding natural landscape.

Materials and methods

The adopted workflow combined Unmanned Aerial Vehicle (UAV) photogrammetry, TLS, GNSS surveys, and three-dimensional digital modeling techniques (Fig. 2).

Different acquisition strategies were implemented depending on the operational and geomorphological characteristics of the investigated environments. UAV photogrammetry was the primary acquisition method applied to all the studied monuments, particularly at large-scale or difficult-to-access sites such as Vardzia, where extensive cliff sections and excavated architectural complexes are better preserved and required wide aerial coverage for inspection. In addition, integrated UAV and TLS surveys were conducted in sites highly endangered including Sabereebi, Natlismtsemeli, Shiomghvime, Uplistsikhe, and Vanis Qvabebi to collect highly detailed information on unstable cliff sectors, inaccessible excavated environments, and rock-cut architectural elements. TLS was also applied to survey natural, near vertical cliff of Uplistsikhe as a source of progressive erosion, imposing the major thread on the monuments.

Drone surveys were conducted using a DJI™ Mavic 2 Pro equipped with a Hasselblad® L1D-20C camera (1-inch sensor, 20 MP, 10.26 mm focal lens). Both nadiral and oblique imagery were acquired to improve the reconstruction of vertical cliff sectors and rupestrian environments. TLS acquisitions were carried out using a Trimble™ X8 laser scanner to generate high-density point clouds of both natural and excavated sectors. GNSS surveys, executed thanks to a Stonex™ S9III Plus device, were used to measure Ground Control Points (GCPs) necessary to align and georeference the multi-sensor datasets.

Photogrammetric processing was conducted by Agisoft™ Metashape software using Structure-from-Motion and Multi-View Stereo algorithms for bundle block adjustment, absolute orientation and 3D dense point-cloud generation (Agisoft LLC 2023). The resulting datasets supported the generation of digital surface models, orthophotomosaics, textured meshes, and integrated three-dimensional reconstructions suitable for geomorphological interpretation, rock deterioration assessment, and conservation-oriented solutions.

In selected case studies, available multi-temporal 3D point-cloud datasets acquired during previous survey campaigns were also used to assess geomorphological change through Multiscale Model-to-Model Cloud Comparison (M3C2) analysis (CloudCompare 2024). Preliminary numerical slope stability modeling was

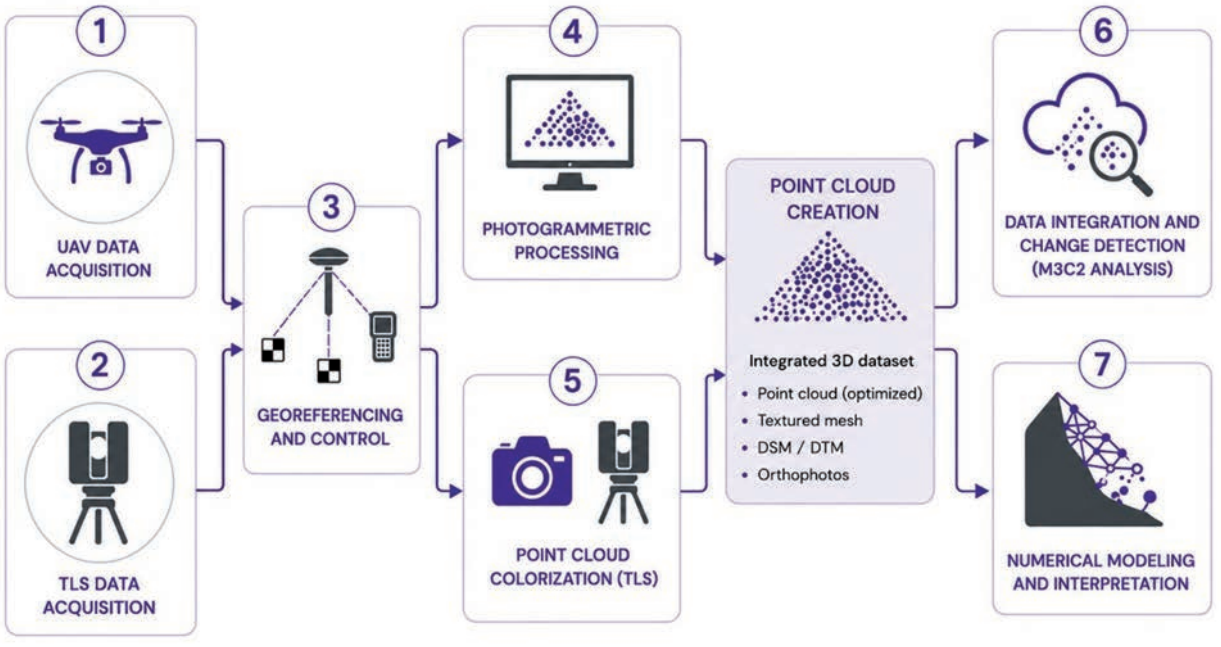

Fig. 2. Example of integrated survey, processing, and analysis workflow

also performed in selected rock environments using geometrical constraints derived from the integrated geomatic datasets together with engineering-geological data derived from previous studies and empirical approaches available in literature.

Results

The integrated geomatic surveys enabled the generation of high-resolution three-dimensional datasets for the investigated rupestrian sites, including 3D dense point clouds, digital surface models, orthophotomosaics, textured meshes, and integrated multi-sensor reconstructions. The acquired datasets are currently being progressively processed and analyzed to support geomorphological interpretation, deterioration assessment, and the identification of weathering processes, localized detachments, erosion sectors, and instability-related morphologies affecting both natural cliffs and excavated architectural environments.

The adopted multi-sensor workflows demonstrated significant flexibility in relation to the different geomorphological, operational, and conservation-related characteristics of the investigated rupestrian settings. UAV photogrammetry proved particularly effective for documenting extensive cliff systems and external rock-cut sectors such as those at Vardzia and Uplistsikhe but also the surrounding terrains for the smaller scale monuments (Fig. 3A), where drone photogrammetric coverage enabled the reconstruction of steep volcanic cliff facades and excavated architectural elements. Moreover, the combined UAV and TLS datasets supported the identification of modeling of unstable cliff sectors, hardly accessible excavated environments, and rupestrian architectural elements affected by weathering and surface erosion in sites including Sabereebi, Natlismtsemeli, Shiomghvime, Uplistsikhe, and Vanis Qvabebi.

Depending on the specific characteristics and investigation objectives of each site, the generated datasets enabled large-scale geomorphological documentation, three-dimensional reconstruction of rupestrian interiors, characterization of inaccessible cliff sectors, and preliminary assessment of rock deterioration affecting carved and most importantly painted architectural rock complexes. Interactive three-dimensional visualization environments generated within the Trimble Realworks™ Viewer framework (Trimble Realworks 2024) enabled virtual exploration of selected sites and facilitated the sharing of spatial datasets among researchers and heritage specialists (Fig. 3B).

Among the investigated sites, the Sabereebi monastic complex currently represents one of the most advanced case studies for integrated geomatic documentation, multi-temporal monitoring, and instability interpretation. Preliminary multi-temporal point-cloud comparisons using M3C2 analysis have highlighted localized surficial detachments, cliff retreat patterns, and rock deterioration affecting different sectors of the cliff facade and rock carved structures. Preliminary volumetric estimations of detached materials highlighted one major erosional sector with an estimated detached volume of approximately 31 m³, between 2018 and 2025,

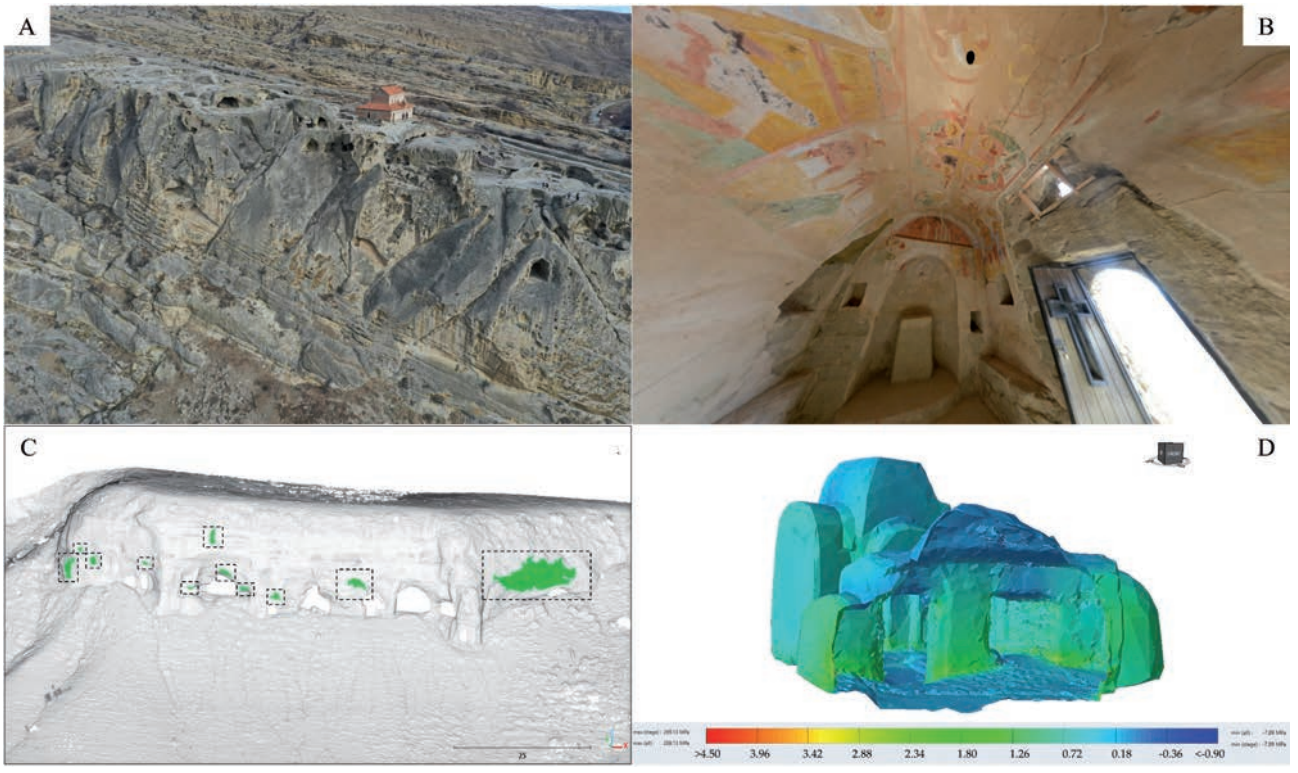

Fig. 3. Examples of site-specific geomatic applications across the investigated Georgian rupestrian heritage sites: (A) UAV-based photographic acquisition of the Uplistsikhe cliff; (B) Trimble RealworksTM Viewer virtual tour and data exchange tool for Dodos Rqa monastery interior spaces; (C) preliminary M3C2 analysis at Sabereebi monastic complex; (D) interior rock slope stability modeling at Sabereebi for conservation-oriented investigations

while most localized detachments remained below 1 m³ (Fig. 3C). Preliminary numerical slope stability modeling was also applied to support the interpretation of instability-related processes affecting the weak sedimentary rock mass and to provide an initial framework for understanding the role of environmental and geomorphological factors in ongoing degradation processes. The models highlighted localized stress concentrations (σ^1) around excavated chambers and cliff facade irregularities, with calculated principal stress values generally ranging between approximately −0.9 and 4.5 MPa, remaining below the adopted sandstone compressive strength thresholds (14 Mpa) and suggesting geometry-controlled stress redistribution rather than critical large-scale instability conditions (Fig. 3D).

Discussion

The survey campaign underscored the need to tailor acquisition strategies to the specific geomorphological, geological, and operational characteristics of each rupestrian environment. Wider cliff complexes such as Vardzia and Uplistsikhe required extensive UAV coverage to document large, rock curved sections, whereas smaller monastic complexes benefited from integrating TLS, UAV photogrammetry, and GNSS-supported surveys to improve reconstruction of partially inaccessible sectors and numerical modeling.

The combined use of multi-sensor geomatic datasets significantly improved the study and the documentation of complex rupestrian environments and supported the identification of rock weathering processes, structural discontinuities, erosion patterns, localized detachments, and instability phenomena affecting both natural slopes and carved architectural sectors. Comparative multi-temporal analyses also demonstrated the potential of point-to-point cloud comparison techniques, including M3C2, to detect ongoing structural changes and support long-term monitoring of these fragile cultural heritage sites. Interactive three-dimensional visualization environments also facilitated dataset sharing, remote exploration, and the dissemination of information about complex rupestrian environments among researchers, conservators, and cultural heritage administrators and stakeholders.

The generated datasets also provide a valuable foundation for future interdisciplinary investigations involving archaeologists, conservators, geologists, geomatics specialists, and heritage managers. High-resolution photographic datasets may support future studies focused on the progressive degradation of frescoes, painted surfaces, and carved architectural elements. Future integration of thermal, multispectral, and hyperspectral imaging techniques could further improve monitoring and detection of moisture-related deterioration, material decay, surface alterations, and conservation problems affecting rupestrian environments.

The integrated geomatic datasets also support the hazard assessment and planning of site-specific conservation and stabilization measures, contributing to a more comprehensive understanding of damaging processes affecting both natural and excavated sectors. In this context, the long-term conservation of Georgian rupestrian heritage requires close interdisciplinary collaboration among geomatics experts, geologists, archaeologists, conservators, and local heritage stakeholders.

Conclusions

Integrated multi-sensor geomatic approaches proved effective for documenting and monitoring vulnerable rupestrian heritage sites characterized by complex morphologies, limited accessibility, and active degradation processes.

The integration of UAV photogrammetry, TLS and GNSS surveys, and multi-temporal analyses enabled the generation of high-resolution three-dimensional datasets suitable for geomorphological interpretation, damage assessment, and conservation-oriented studies across different geological and historical contexts.

The proposed workflow demonstrates the importance of adapting acquisition and processing strategies to site-specific operational and geomorphological conditions and provides a transferable methodological framework for investigating and managing fragile rock-cut heritage environments.

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Geomechanical Analysis and Stability Assessment of Phrygian Temples and Troglodyte Spaces, Anatolia, Turkey

Luis Jorda Bordehore
Departamento de Ingeniería y Morfología del Terreno, Polytechnic University of Madrid, 28040 Madrid, Spain
l.jorda@upm.es (corresponding author)
Ercan Emir
Eskisehir Osmangazi University. Mining Engineering Department, Meselik Campus, Eskisehir-Turkiye. Email: eemir@ogu.edu.tr
Abdelmadjid Benrabah
Departamento de Ingeniería y Morfología del Terreno, Polytechnic University of Madrid, 28040 Madrid, Spain, abdelmadjid.benrabah@alumnos.upm.es
Melih Iphar
Eskisehir Osmangazi University. Mining Engineering Department, Meselik Campus, Eskisehir-Turkiye. Email: miphar@ogu.edu.tr

Abstract

The Phrygian Valley in Central Anatolia, Turkiye, is home to one of the most remarkable rock-cut heritage landscapes in the eastern Mediterranean. The Phrygian civilization reached its zenith between 1200 and 700 BC, peaking in the 8th century BC under the legendary King Midas. Its capital, Gordion, along with a vast network of monuments carved into volcanic tuff. Today, these ancient structures are threatened by weathering and geomechanical instability, making systematic monitoring and conservation a priority. This research outlines a preliminary geomechanical analysis of several key Phrygian sites. We combined low-cost remote scanning using smartphone sensors (iPhone) and digital photogrammetry with well-established empirical geomechanical classification systems from mining and tunnelling engineering. The analysis indicates that some temples and chambers are experiencing localized instabilities, pointing to a need for targeted monitoring and preventive conservation. We also found that geomechanical classification systems, though designed for modern underground excavations, can be adapted for these archaeological contexts, particularly when modified for irregular, non-engineered spaces. The digital models we created can be shared in online repositories and viewed with Augmented Reality tools, making the science more accessible and supporting heritage management efforts.

Keywords: empirical analysis, augmented reality, rock mechanics, heritage

Introduction

Located in Central Anatolia, the Phrygian Valley is a landscape defined by its extraordinary rock-cut cultural heritage. The Phrygian civilization flourished here from roughly 1200 to 700 BC, with its cultural peak occurring in the 8th century BC under King Midas. The capital at Gordion and the region's monumental architecture, carved directly from volcanic tuff, stand as a testament to the ingenuity of ancient Anatolian societies. With the arrival of Alexander the Great, the region entered the Hellenistic period (4th–1st centuries BC) and saw a profound cultural shift, merging Anatolian traditions with Greek influences. This history has left behind an exceptional archaeological legacy of temples, façades, and troglodytic spaces hewn from the rock. While these monuments have stood for millennia, they are now increasingly vulnerable to weathering and geomechanical stresses that threaten their long-term survival. Incidents of rockfalls and collapses in similar tuff landscapes across Anatolia, like Cappadocia, underscore the urgent need for a systematic approach to monitoring and structurally assessing this irreplaceable heritage.

Location and geological context

The Phrygian Valley stretches across the provinces of Afyonkarahisar, Eskişehir, and Kütahya in west-central Anatolia. Its landscape of open plateaus, rolling hills, and deep valleys is dominated by volcanic tuff and other soft sedimentary rocks from ancient eruptions. This soft, easily workable stone is what allowed the Phrygians to carve their temples, tombs, and dwellings directly into the outcrops. The result is a unique environment where geology and human history are inextri-

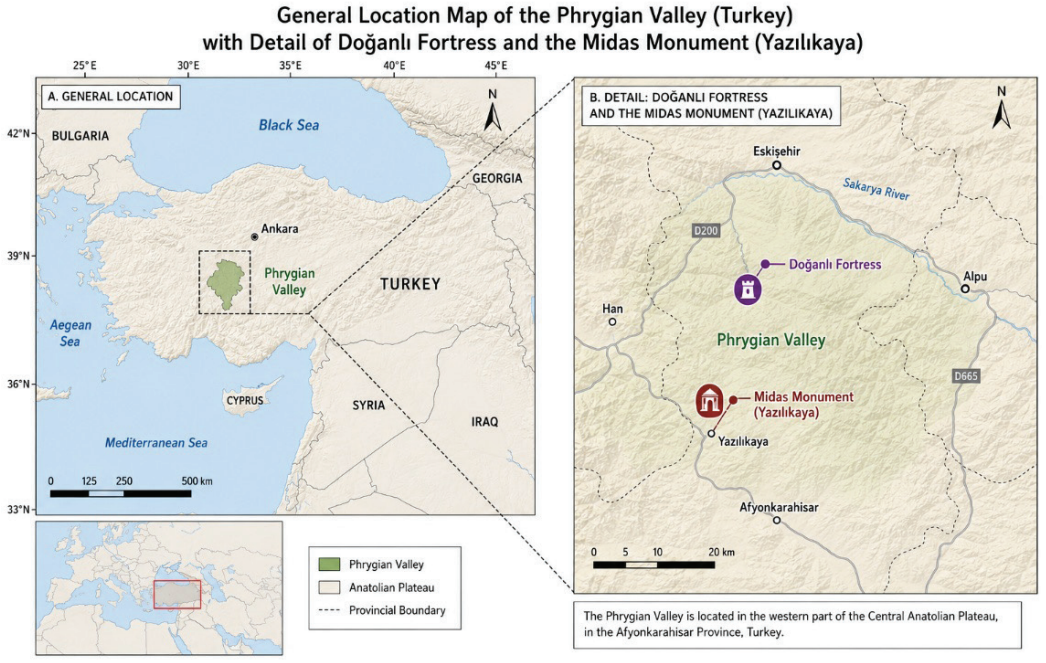

Fig. 1. Location of study sites (image created assisted by IA)

cably linked, creating one of Anatolia's most distinctive cultural landscapes (Eskişehir Governorship Provincial Directorate of Culture and Tourism 2007).

Materials and methods

The methodology used to assess the stability of the underground spaces in this study is based on geomechanical classifications and empirical analysis using rock quality versus span (hole size) graphs (Benrabah et al. 2024). Geomechanical classifications have been used worldwide since the 1970s to evaluate the stability of tunnels and mines. Based on a "score" of the rock mass according to agreed-upon parameters, a preliminary assessment can be made of whether an excavation is self-supporting or requires support measures such as rock bolts, shotcrete, or steel arches (Bieniwaski 1973, Barton et al. 1974). In the figure below we show a modification of the tunnel stability graph proposed by Grimstad and Barton in 1993 (Fig. 2). To analyze the stability of an opening using the graph in the following Fig. 2, it is first necessary to determine the Q index, following the methodology proposed by Barton et al. (1974) and widely used worldwide to evaluate tunnels, mines, and even natural caves (Fig. 2, Jorda 2017).

In parallel with the geomechanical fieldwork, we conducted photogrammetric surveys of the sites to create detailed digital twins. The idea is to have a digital model of each outcrop to supplement field observations in inaccessible locations, such as high slopes, cave ceilings, etc.

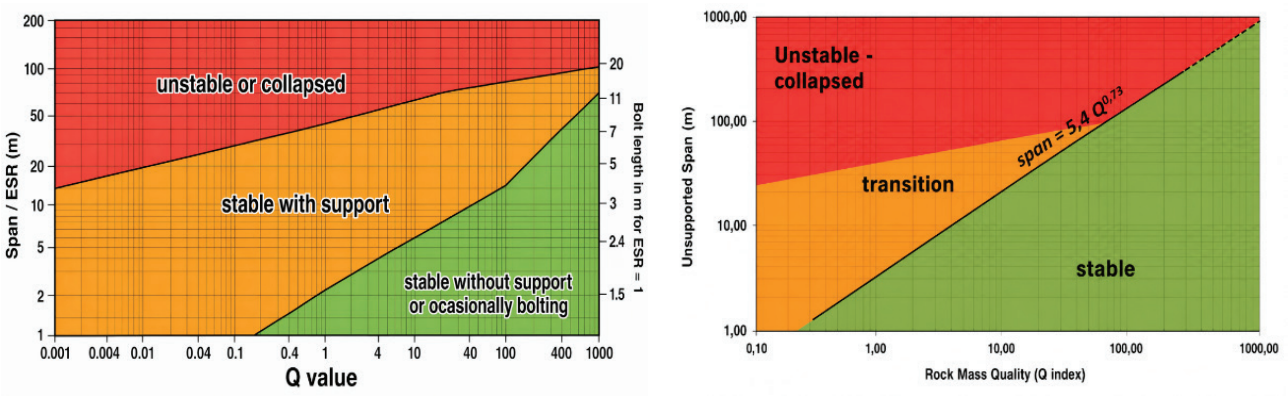

Fig. 2. Left: Stability chart for span of the cavity/tunnel and the rock quality Q (modified from Grimstad and Barton 1993 using IA). Right: Stability chart for span of natural caves and the rock quality Q (modified from Jorda 2017 using IA)

Fig. 3. Left: The Doganli Fortress, visited in 2025. Right: Midas "temple"

Study sites

Doganlı Castle is a rock-cut structure carved into a natural volcanic tuff cone. This multi-story ancient fortress features numerous interior rooms, steps, and passageways used for defense and habitation. The site reflects the incredible rock-cut architecture typical of the Phrygian and Byzantine eras (Fig. 3).

The second site chosen for the investigation is a cistern carved into the rock located in the vicinity of the so-called "Monument to Midas" or "City of Midas" - dating from the Phrygian period, mainly between the 8th and 7th centuries BC. Also located in the Phrygian valley, it is situated near the present-day village of Yazılıkaya (which means "inscribed rock"), in the province of Eskişehir.

Results

Table 1. Rock quality Q index determined in each site

Parameter / Site	Doganli Fortress	Midas "temple" cistern
Rock Quality Designation RQD%	Less that 1 joint per meter RQD = 100%	Joint per meter λ=6 RQD = 85%
Joint nomber Jn	Massive, no or few joints Jn = 1 Jn multiplied by 3 for crossing of galleries- window etc	Two joint sets plus random joints Jn = 6
Joint Roughness Jr	Rough, irregular, planar Jr = 1,5	Rough, irregular, planar Jr = 1,5
Joint alteration Ja	Slightly altered joint walls. Non-softening mineral coatings Ja = 2	Slightly altered joint walls. Non-softening mineral coatings Ja = 2
Water reduction factor Jw	Dry. Jw = 1	Dry. Jw = 1
Stress Reduction Factor SRF	Low stress. Close to surface SRF = 2,5	Span bigger than deph, shallow conditions SRF = 5
Q value	$Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}$; $Q = \frac{100}{3 \times 1} \times \frac{1,5}{2} \times \frac{1}{2,5} = 10$	$Q = \frac{85}{6} \times \frac{1,5}{2} \times \frac{1}{5} = 2,1$
ESR value	For public access: ESR = 0,8	For public access: ESR = 0,8
Span B (m) maximum	8 m	12 m
Span / ESR	10 m	15 m

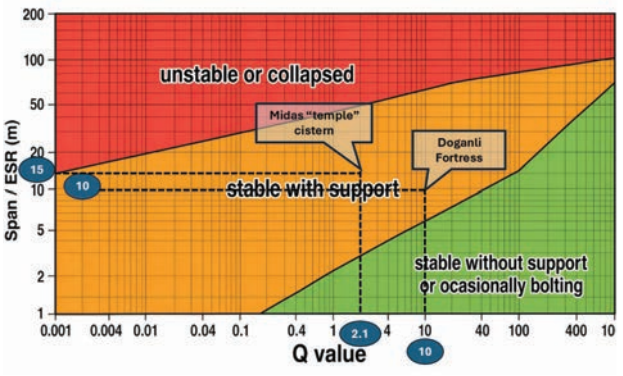

Fig. 4. Results plotted into the stability chart for span of the cavity/ tunnel and the rock quality Q (modified from Grimstad and Barton 1993 using IA)

The image above shows the stability analysis results for the two Phrygian underground structures, using the Grismtad and Barton methodology and approach for tunnels. It is important to note that the span is scaled and larger than the actual width due to the ESR factor. According to this table, both underground spaces, the cistern and the temple, require reinforcement. This seems reasonable for the cistern, where slabbing instabilities are evident, but we consider it overly conservative for the Doganli temple.

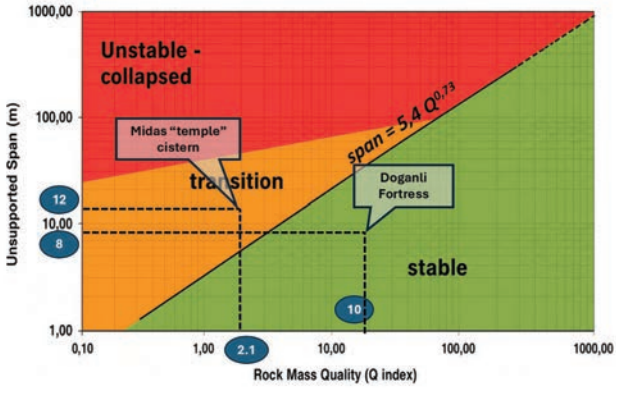

Fig. 5. Results plotted into the stability chart for span of natural caves and the rock quality Q (modified from Jorda 2017 using IA)

The image above (Fig. 5) shows an analysis similar to that in Fig. 4, but using the abacus for natural caves. This analysis focuses on a transition towards instability rather than reinforcement, and the width is shown as actual, not scaled. The result is more realistic: the cistern is in transition to instability. After 2,000 years, it hasn't collapsed, but significant slabs have been detaching like an onion layer, compromising its long-term stability. The presence of these slabs makes visiting the cistern inadvisable. On the other hand, the Doganli temple appears stable to the naked eye; no problems are visible, and it is located in the "green" zone of the graph.

https://skfb.ly/pxKvP https://skfb.ly/pxKCy

Fig. 6. Doganli fortress scanner and cistern scaner

Discussion

The difference in results between the two stability charts (Fig. 4 and 5) is significant. The standard tunnel stability chart, designed for freshly excavated and geometrically regular civil engineering projects, appears too conservative when applied to ancient, irregularly shaped rock-cut heritage. These troglodytic spaces have existed for centuries, and their current state reflects a long-term equilibrium with their environment, unlike a new tunnel that has just disturbed the *in-situ* stress field. The chart adapted for natural caves, which does not prescribe specific reinforcements (Fig. 5) but rather assesses a transition toward instability, provides a more realistic framework.

Conclusions

This study successfully demonstrated that a combination of modern, low-cost scanning techniques and adapted empirical geomechanical classifications offers a practical and effective method for assessing the stability of rock-cut heritage sites. Our analysis concluded that the Midas cistern exhibits clear signs of instability that warrant further attention, while the Doğanlı Fortress remains largely stable.

Acknowledgements

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Some Examples of Experimental Diagnostics and Conservation Assessments for Planning the Maintenance and Promotion of Rock Art in the Hypogeal Churches of the Apulia Murgia (Southern Italy)

Giacomo Martines[1], Vito Basile[2], Loreta Calia[2], Mariagrazia Cinelli[3], Filippo Lomurno[2], Domenico Lorusso[2], Remo Pavone[1], Chiaramaria Spinelli[1].
[1]Polytechnic of Bari, Department of Architecture, Construction, and Design.
[2] Geoatlas S.r.l.
[3] Superintendency of Archaeology, Fine Arts and Landscape - Metropolitan City of Bari
giacomo.martines@poliba.it

Abstract
This paper describes the initial research results from the ongoing S.H.I.E.L.D. (Saving Heritage through Imaging and Environmental Long-term Diagnostics) project (2025-2027), implemented by the private business group Tecnosoft S.r.l., e.RATIO S.r.l., and Geoatlas S.r.l., the latter with the scientific support of the Polytechnic of Bari, Department of Architecture, Construction, and Design, through a study agreement.
In the Apulian-Lucanian Murgia region (southern Italy), there are a large number of sacred sites associated with rock settlements. These sites contain numerous frescoes dating from the 6th to the 15th century, representing an artistic and cultural heritage of medieval European art that must be preserved.
Since these sites are often located in natural settings, such as the vertical walls of ravines or the underground beneath farms and/or churches, and are dug inside the calcarenite banks, they are subject to biological attack by mold, bacteria, algae, and small vegetation. The physical properties of calcarenite, such as porosity and hygroscopicity, combined with concomitant environmental, temporal, biological, chemical, physical, and anthropogenic factors, lead to irreversible multiple degradation.
The intensity and speed of deterioration of the frescoes is strictly dependent on external factors such as environmental conditions. The S.H.I.E.L.D. project aims to establish predictive diagnostic protocols for risk conditions through the application of targeted indirect investigations (multispectral images and environmental information) that can guide conservation programming and project.
These investigations provide precise information on the health of the investigated elements and enables predictive identification of the specific causes of active degradation, minimizing direct investigations involving the removal and destruction of original material.
The detection principle we are testing exploits the physical property of objects to emit or reflect radiation at different wavelengths, in addition to visible light, with intensity depending on their chemical and physical characteristics. Based on this, using a specific and innovative algorithmic model, we aim to identify a correlation between the output of multispectral frames taken on frescoed walls and the presence of one or more causes of degradation. Specifically, the project aims to develop a new predictive technological system that, based on appropriate sampling, can help identify the main causes of degradation, such as water infiltration into the walls and the presence of chlorophyll-rich microalgae. Based on the same principle of reflectance, we will attempt to associate the formation of calcareous concretions or large salt crystals, or the presence of bacteria via their metabolites and catabolites, in the texture of the frescoes and the underlying substrate.
At its current stage, the project has selected two characteristic sites for which it has developed a sampling of analyses to determine the diagnostic approach to be tested on a significant number of rock sites located in the Puglia and Basilicata regions. This will validate the methodology on different types of supports, environmental conditions, and exposures.
The study presented here begins with specialized instrumental surveys of the two sites, which have very different environmental conditions, followed by visual interpretation of the conservation data and preliminary scientific diagnostics.

Keywords: Apulian-Lucanian Murgia Rock Heritage, Biological attack on Frescoes, Degradation causes on frescoes painted on calcarenite structures, Predictive diagnostics through instrumental analisis, Multispectral imaging

Introduction

Here are some initial, still experimental, results from the ongoing S.H.I.E.L.D. (Saving Heritage through Imaging and Environmental Long-term Diagnostics) project (2025-2027), implemented by the private business group Tecnosoft S.r.l., e.RATIO S.r.l., and Geoatlas S.r.l., the latter with the scientific support of the Polytechnic University of Bari, Department of Architecture, Construction, and Design, through a study agreement.

In the Murgia Apulia-Lucana region (southern Italy), there are a large number of places of worship associated with rock settlements. These sites contain numerous frescoes dating from the 6th to the 15th century, representing an artistic and cultural heritage of medieval European art that must be preserved.

Since these sites are often located in natural settings, such as the vertical walls of ravines or the underground passages beneath farms and/or churches, and are built within calcarenite banks, they are subject to biological attack by mold, bacteria, algae, and small vegetation. The physical properties of calcarenite, such as porosity and hygroscopicity, combined with concomitant environmental, temporal, biological, chemical, physical, and anthropogenic factors, lead to irreversible multiple degradation. The intensity and speed of deterioration of the frescoes is strictly dependent on external factors such as environmental conditions.

The S.H.I.E.L.D. project The aim of the project is to establish predictive diagnostic protocols for risk conditions through the application of targeted indirect investigations (multispectral images and environmental information) that can guide conservation processes. These investigations provide precise information on the health status of the elements being investigated, with the particularity of being able to predictively detect the specific causes of active degradation, minimizing direct investigations involving the removal and destruction of original material.

Biological degradation of surfaces: ecological succession and mechanisms of biodeterioration in underground structures

Under particular conditions of high humidity, various biotic forms can develop on the surfaces of underground structures, drawing their sustenance from photosynthesis. These are primarily photosynthetic bacteria (prokaryotes), including cyanobacteria (which engage in oxygenic photosynthesis, releasing oxygen into the environment) and anoxybenic bacteria (which do not produce O_2). More complex forms include unicellular and multicellular algae (eukaryotes).

The biological degradation affecting stone and painted surfaces in underground environments represents one of the most complex and damaging phenomena for the conservation of frescoes in underground spaces.

Microbial colonization follows a natural ecological succession that begins with pioneer microorganisms (cyanobacteria) and evolves into increasingly complex communities.

Pioneer phase: Cyanobacteria are therefore the first biological community to establish themselves on underground stone surfaces. Obviously, in the presence of light sources, on surfaces bathed in external light. These prokaryotic microorganisms, despite their historically inappropriate name of *"blue-green algae,"* are true bacteria capable of oxygenic photosynthesis. Their pioneer function is determined by unique physiological characteristics: they are obligate photoautotrophs that require only light, even in minimal quantities, and carbon dioxide to synthesize organic matter.

The ability to colonize underground environments, characterized by low or no light, is enabled by the presence of accessory pigments called phycobilins. These pigments allow cyanobacteria to capture wavelengths of light up to 650 nm, making them efficient even in extremely low luminance conditions. Once established, cyanobacteria form a mucilaginous biofilm on the surface of the rock, consisting of extracellular polymeric substances that retain moisture and create a microenvironment favorable to the settlement of other organisms. This biofilm represents the first layer of organic matter available to subsequent heterotrophic organisms.

Intermediate stage: After the cyanobacterial biofilm has established itself, green algae (Chlorophyta) and diatoms (Chrysophyta) establish themselves. Epilithic green algae form visible patinas on the rock surface, while diatoms, characterized by a siliceous shell, grow primarily in areas with stagnant water and high porosity. These communities typically concentrate in the capillary rising damp zones, in basements and wall bases, where moisture is more widespread and persistent.

The presence of algae and diatoms significantly increases the amount of organic matter in the biofilm, creating the conditions for the development of more complex heterotrophic organisms. Algae characteristically form patinas on surfaces, often dark green or blackish in color, and contribute to modifying the physical and chemical properties of the stone's surface layer.

Late stage: As the organic matter produced by primary photosynthetic communities increases, fungi, molds, and yeasts multiply. Ascomycetes and actinomycetes (especially Streptomycetes) are the most common fungal communities in underground environments. Unlike cyanobacteria and algae, these organisms are heterotrophic and feed on the organic matter produced by previous stages of succession.

Fungi develop hyphae that penetrate deeply into the stone material, reaching the underlying layers of plaster

and paint. By secreting organic acids, fungi accelerate the chemical degradation processes of the stone, solubilizing the mineral components and creating microfractures that facilitate further penetration.

Biological colonization in underground environments is strongly influenced by the specific microclimatic conditions of these enclosed spaces. High relative humidity is the most critical factor for the development of algae, mold, and fungi. Artificial lighting, introduced to allow visits to underground cult sites, activates photosynthetic processes and promotes the growth of algae and cyanobacteria in exposed areas.

Carbon dioxide, which in enclosed underground spaces can reach concentrations of up to 1,500 ppm, reacts with water to form carbonic acid, which solubilizes the calcium carbonate present in the plaster and stone. Poor ventilation favors the accumulation of humidity and CO_2, while water infiltration and capillary rise create saturation zones that accelerate biodeterioration processes.

The influx of visitors represents an additional stress factor: studies conducted on underground environments have shown that the bacterial and fungal population can double within three days of opening to the public, due to the influx of microorganisms, humidity, and heat.

(edited by L. Calia[(2)], V.Basile[(2)], F.Lomurno[(2)], D. Lorusso[(2)], G. Martines[(1)])

Decay problems on the painted surfaces of underground cult sites

The first visible effect of biological degradation is pigment alteration on painted surfaces. Cyanobacteria and algae form green or blackish patinas that completely cover the underlying paint, making it illegible. Fungi and mold produce irregularly shaped dark spots, while the crystallization of salts (gypsum, nitrates, chlorides) generates white efflorescence that settles on the surface. The combined action of light and organic substances produced by microorganisms causes pigment discoloration through photochemical processes and the corrosive action of organic acids.

Structural damage is the most serious consequence of biodeterioration. Carbonic acid, formed by the reaction between CO_2 and water, dissolves the calcium carbonate that forms the matrix of plaster and stone, weakening the cohesion of the paint layers. Fungal hyphae mechanically penetrate the paint layer to the stone substrate, creating microchannels that facilitate the penetration of water and salts.

The crystallization and recrystallization cycles of salts within the pores of stone generate mechanical stresses that cause flaking, scaling, and detachment of the paint from the substrate. This phenomenon is particularly devastating for mural paintings on plaster, which are naturally more fragile than stone.

Microboring is a specific process of cyanobacteria, algae, and microfungi that penetrate the crystalline structure of the stone through the secretion of acids and the mechanical action of their hyphae. This process creates a network of microfractures that weaken the cohesion of the material. The gelatinous patinas produced by the algae cause the paint layers to lift, facilitating detachment.

Biodeterioration in religious hypogea, rich in wall decorations created using various techniques, including fresco, the most common, presents particularly dangerous characteristics that require sophisticated conservation approaches. The paintings are applied to plaster, a substrate that suffers irreversible damage as soon as microorganisms reach the underlying layers. The use of biocides to control microorganisms is problematic, as it can eliminate less dangerous species, allowing the development of more harmful ones, altering the ecological balance of the microbial community.

This is even more evident in low-protection contexts, where routine ongoing maintenance cannot prevent the onset of potentially incremental deterioration.

The effectiveness of disinfection and disinfestation treatments varies significantly depending on the microbial association present, necessitating a thorough preliminary diagnosis. Preventive conservation is the most effective approach, based on rigorous control of relative humidity, CO_2 concentration, lighting, and visitor traffic. It is essential to prevent sudden and repeated changes in humidity and temperature that alter the environmental balance and trigger biodeterioration processes.

The concept of preventive diagnostics in cultural heritage conservation is based on the principle that in-depth knowledge of the artifact must precede any operational decision. This approach, consolidated in the theoretical foundations of contemporary restoration, takes on particular importance in this case with regard to mural paintings in underground environments, where the complexity of the degradation mechanisms and the fragility of the materials make any intervention potentially irreversible.

Rock-hewn and underground churches present unique microclimatic and geological conditions: nearly constant temperatures, but often associated with very high relative humidity, poor natural ventilation, the presence of seepage water, biological growth, and, not infrequently, saline efflorescences of various kinds. The parent rock, which simultaneously serves as a structural support and a pictorial substrate, introduces additional variables related to the local lithology (tuff, limestone, basalt, sandstone), its porosity, and its hygrothermometric response.

First, we must analyze some specific degradation factors of underground environments. These include humidity, the primary cause of deterioration. In this case, there are multiple sources: capillary rising damp from the rock or soil; condensation, favored by the temperature differential between the cold stone mass and the warmer air introduced from outside or by visitors; and weather infiltration through fractures and discontinuities in the vault or walls.

Water, in liquid or vapor form, dissolves the salts present in the rock and plaster, transporting them to the painted surface where, through evaporation, they crystallize, generating efflorescence and sub-efflorescence. These crystallization and dissolution processes produce mechanical stresses that progressively disintegrate the paint film and the preparatory layers.

Secondly, there are biological factors: the confined, humid environment favors the development of complex microbial communities, as described in more detail above. However, it is important to highlight how salt migration and deposition/crystallization on painted surfaces are merely an incremental factor in the development of surface biofilm. These organisms colonize the painted surface, producing organic acids that attack the substrate's carbonates and pigments that alter the surface's color. It should be recognized that in some cases, biofilm can play an unexpected protective role, but in the majority of underground contexts, it represents an active factor in degradation.

It should be noted, although beyond the scope of this analysis, that a complete assessment cannot ignore mechanical and structural degradation. These include the discontinuity between the plaster and the rock, the stratifications between successive layers of plaster, the concretions and encrustations caused by runoff water, perhaps rich in exogenous elements brought in by infiltrations from the surface. Finally, unfortunately, the frequent, inadequate previous *"conservative"* interventions cannot be ignored: Many rock frescoes have undergone undocumented restoration over the centuries, performed with incompatible materials. Over time, these materials cause new degradation, often more severe than the original.

(edited by G. Martines[1].)

Preventive Diagnostic Protocol through Multispectral Investigation

The principle of multispectral surveying being tested exploits the physical property of organic matter to absorb part of the light it is exposed to, in a spectrum that includes UV-visible light, and reflect the remainder at specific wavelengths based on its chemical-physical characteristics. Based on this, using a specific and innovative algorithmic model, we aim to identify a correlation between the output of multispectral frames taken on frescoed walls and the presence of one or more causes of degradation. Specifically, the project aims to develop a new predictive technological system that, based on appropriate sampling, can help identify the main causes of degradation, such as water infiltration into the walls, the presence of microalgae with photosensitive pigments, and bacteria producing certain metabolic catabolites.

Based on the principle of reflectance, we will attempt to associate the formation of typical degradation, such as the formation of calcareous concretions or large salt crystals, with the presence, in the texture of the frescoes and the underlying substrate, of their main causes: the microclimatic conditions of the underground cave and the associated microbial flora.

At its current stage, the project has selected two characteristic sites for which it has developed a sampling of analyses to determine the diagnostic approach to be tested on a significant number of rock art sites located in the regions of Puglia and Basilicata. This will validate the methodology on different types of substrates, environmental conditions, and exposures.

The study we intend to present begins with specialized instrumental surveys of the two sites, which experience very different environmental conditions, followed by visual interpretation of the conservation data and a preliminary scientific diagnosis.

(edited by L. Calia[2], D. Lorusso[2].)

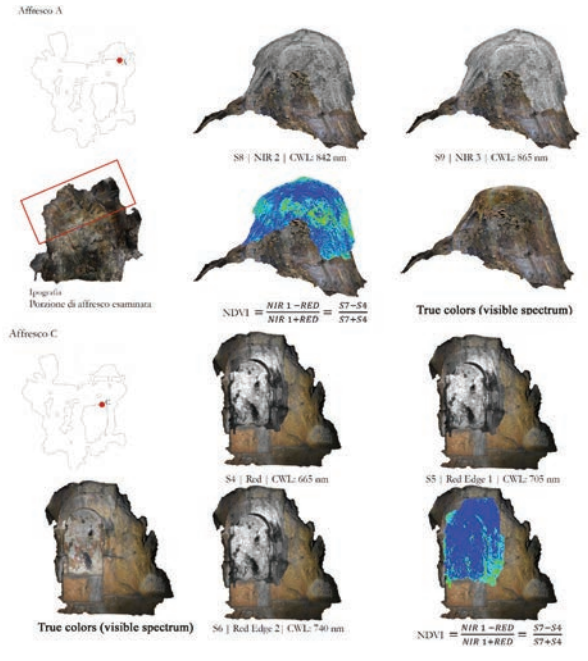

Fig. 1. Multispectral mapping of frescoes «A» and «C» of the underground church of Sant'Angelo in Santeramo: The mapping with NDVI algorithm shows evident areas with photosynthesis activity

The S.H.I.E.L.D. project for the diagnosis of frescoed surfaces in hypogea in the Puglia region (Southern Italy)

The proposed project identified around ten sites for experimental diagnostics. Specifically, two areas have been investigated at this stage: the churches of Sant'Angelo in Santeramo (Bari). This underground church was built inside an active karst cave, with strong water flow, active stalictism and stalagmite phenomena, and a particularly complex environment.

Inside the church, there are three frescoes: one in a natural semi-vault in the entrance area, one in an architectural niche surrounded by semi-columns, and one in a lateral niche.

The second case study examined is the underground church of San Michele in Altamura (Bari). This site is located within the urban fabric and has already undergone several interventions in 2008, 2015, and 2020, with substantial waterproofing of the limestone boulder's extrados to protect the interior from water infiltration from the street level. This choice, however, required extensive conservation work on the decorative surfaces, which, following the hygroscopic changes, showed signs of (predictably) significant acceleration in deterioration.

Inside this structure, there are several frescoes, both above the altars and on the pillars. Many have already undergone previous conservation work.

In both cases, the S.H.I.E.L.D. project planned the following investigation plan:

Optical microscopy: a technique that allows observation of microscopic samples taken from frescoes, such as pigments, binders, preparatory layers, or surface deposits. It uses visible light and lenses to magnify the image, allowing analysis of the stratigraphic structure and composition of the materials.

For the purposes of: Identification of pigments: allows identification of the original materials used by the artist; Study of the state of conservation: conditions of disintegration, alterations, saline efflorescence, or biological attack are observed; Stratigraphic analysis: the various layers of paint, preparatory layers, and any restorations are distinguished; this is performed by taking a microsample (often less than a millimeter) from the fresco. The sample is embedded in resin and cut to obtain a thin section, then observed under an optical microscope in reflected or transmitted light, sometimes with polarization to highlight crystals and pigments. One of the advantages of the test, although direct (and therefore microdestructive), is the minimal amount of material actually required.

Soluble salt analysis (such as nitrates, sulfates, and chlorides): these are among the main causes of fresco deterioration. They form or migrate due to humidity and can crystallize beneath the surface (subflorescence), causing detachments. They form visible efflorescence, altering the aesthetics and coherence of the subsurface layers. They compromise the cohesion of the paint film. Even in this case, the sample required is minimal; often, it is taken from already deteriorated surfaces.

Fig. 2. Multispectral analysis process of the fresco «A» of the hypogeal church of San Michele in Altamura: The processing highlights the areas in which no correspondences are identified between the chromatic party and the response to the stimuli in the corresponding wave frequencies

Microenvironmental monitoring: since frescoes are immovable works, often exposed to climatic variations and atmospheric agents, environmental monitoring is used to control temperature and relative humidity (sudden changes can cause mechanical and chemical stress), detect the presence of condensation or infiltrations, and prevent the formation of soluble salts and biological colonies.

Microbiological analysis to study the microorganisms that colonize painted surfaces. These organisms can degrade pigments and plaster, form biofilms, and promote the crystallization of salts or the formation of black crusts.

But be careful: some microorganisms can also be used for restoration, in innovative techniques such as biocleaning and bioconsolidation.

SEM (Scanning Electron Microscope) is used to observe the morphology and composition of materials at a microscopic level. In the field of frescoes, it is used to analyze painted surfaces and plaster, identify microcracks, patinas of alteration, and aggregates, and assess the degree of degradation or the quality of restoration materials. The test can be performed on slides made for optical microscopy to reduce the number of samples required on site.

(edited by G. Martines[(1),] L. Calia[(2)], V.Basile[(2)], F.Lomurno[(2)], D. Lorusso[(2)], M. Cinelli, R. Pavone, C.Spinelli.)

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Knowledge as the Foundation of the Restoration Project: The San Marco Ravine in Massafra (Southern Italy)

Valentina Santoro

Assistant Professor (Tenure Track) of Architectural Restoration, Department ArCoD, Polytechnic University of Bari, Bari, Italy, valentina.santoro@poliba.it

Giuseppe Martino

Architect; Postgraduate Student at the School of Specialization in Architectural and Landscape Heritage, Department ArCoD, Polytechnic University of Bari, Bari, Italy, g.martino8@studenti.poliba.it

Abstract

Rock-cut heritage has traditionally been investigated through the historical, archaeological and architectural analysis of individual monuments, while conservation has often remained focused on the protection of their material fabric. This paper proposes a broader interpretative framework by considering the San Marco Ravine in Massafra (Apulia, Southern Italy) as a cultural landscape in which architecture, geomorphology, settlement dynamics, intangible values and community memory constitute an integrated territorial system.

The research is grounded in a multiscalar methodology combining historical and archival investigation, architectural survey, UAV and terrestrial photogrammetry, three-dimensional modelling, conservation assessment and GIS-based data management. Rather than treating documentation as a preliminary phase of restoration, the study interprets knowledge as a continuous process supporting conservation, long-term monitoring and future decision-making.

The integrated documentation produced through the research constitutes the initial core of a dynamic knowledge infrastructure currently being developed through institutional agreements between the Department of Architecture (ArCoD, Polytechnic University of Bari), the Municipalities of Massafra and Mottola, and the Diocese of Castellaneta. The platform is intended to support preventive conservation, planned maintenance and the integrated management of the wider rock-cut heritage of the Ionian-Tarantine area.

The Massafra case study demonstrates that restoration should move beyond the conservation of individual monuments towards the management of cultural landscapes, where the preservation of historical relationships between architecture, territory and local communities becomes an essential component of conservation practice. In this perspective, knowledge is no longer simply the prerequisite for restoration but its permanent foundation, transforming the restoration project into a strategic instrument for the long-term governance of cultural heritage, in accordance with the principles promoted by UNESCO, ICCROM and the Council of Europe.

Keywords: Hypogeal heritage, conservation, restoration, natural landscape, accessibility

Author contributions. The first and second sections were written by V. Santoro; the third section by G. Martino; the final section was jointly written by both authors.

Rock-cut heritage and cultural landscape: towards an integrated approach to Conservation

Rock-cut architecture represents one of the most significant expressions of the long-standing relationship between human communities and the natural environment throughout the Mediterranean basin. It reflects complex settlement patterns shaped by closely interconnected artistic, economic, social, and religious processes.

Developed through the gradual adaptation and excavation of the bedrock, rock-cut settlements document complex settlement dynamics in which architecture and land morphology are intrinsically intertwined. Rock-cut churches, domestic spaces, productive areas, and agricultural structures testify to the complexity of these cultural landscapes (Fonseca, 1970; Dell'Aquila & Messina, 1998; Bertelli, 2004).

In Southern Italy, and particularly in the Apulia region, rock-cut architecture is of exceptional significance because of the continuity of human occupation, the extensive territorial distribution of settlements, and the remarkable historical, architectural, artistic, and so-

Fig. 1. Massafra, San Marco ravine: ancient rock-cut dwellings and churches carved into the limestone are visible along the sides of the ravine (Photo: V. Santoro)

cio-cultural value of its heritage. Within this context, the ravines (*gravine*) of the Ionian-Tarantine area constitute one of the clearest examples of the interaction between natural and anthropogenic processes. These deep karst incisions have profoundly influenced settlement development, the organization of productive activities, and the location of places of worship, giving rise to cultural landscapes in which the boundary between the natural environment and the historic built fabric is often difficult to define (Fonseca, 1979; Jacovelli, Caprara & Fonseca, 1966; Poli, 2013).

The systemic nature of these contexts requires moving beyond the traditional interpretation of individual monuments towards a multiscalar and interdisciplinary approach, in which the understanding of historical, geomorphological, settlement, and functional relationships becomes the essential prerequisite for effective strategies of protection, conservation, and enhancement of rock- cut heritage (Brandi, 1963; Carbonara, 1996).

Beginning with the pioneering studies of Cosimo Damiano Fonseca (Fonseca, 1970; Fonseca, 1979), which established the historical and archaeological foundations for the study of Southern Italy's rock- cut civilization, research has progressively expanded to include historical-artistic, architectural, and settlement-related perspectives[1]. Only during the last few decades has scholarly attention increasingly shifted towards issues of conservation, management, and heritage enhancement, in parallel with the development of the cultural landscape concept and the international principles promoted by the Council of Europe, UNESCO, and ICOMOS (Council of Europe, 2005; UNESCO, 2011; ICOMOS, 2014).

Within this framework, ICCROM has likewise emphasized that heritage conservation should be grounded in the continuous production, updating, and sharing of knowledge, recognizing systematic documentation and long-term monitoring as essential components of conservation processes (ICCROM, 2015; ICCROM, 2021).

1 The research was developed within the activities of the Ancient Architecture Research Group of the Department of Architecture, Construction and Design (ArCoD), Polytechnic University of Bari, focusing on the rock-cut heritage of the Ionian-Tarantine area. The study integrates historical and archival research, multiscale architectural survey, terrestrial and UAV photogrammetry, three-dimensional modelling, vector mapping, and conservation assessment. The resulting documentation constitutes the initial core of a GIS-based knowledge platform currently being implemented through institutional agreements with the Municipalities of Massafra and Mottola and the Diocese of Castellaneta. The platform is intended to support long-term monitoring, preventive maintenance, and the integrated management of the regional rock- cut heritage.

Despite these significant developments in the international debate, much of the literature devoted to rock-cut heritage still focuses primarily on the analysis of individual monuments and their historical or artistic features. Comparatively fewer studies investigate these sites as complex territorial systems, in which architecture, landscape, local communities, material conservation, and social identity constitute inseparable components[2]. Consequently, and consistently with the principles established by the 2005 Faro Convention, there is an increasing need to move beyond a concept of restoration centred exclusively on the conservation of individual monuments and their material authenticity towards broader strategies capable of integrating knowledge production, cultural values, and collective memory into conservation practice (Jokilehto, 1999; Council of Europe, 2005). Against this background, the San Marco Ravine in Massafra (Fig. 1), including the rock-cut churches of San Marco and Santa Maria della Candelora, is presented here as a case study to investigate the extent to which a restoration project can be grounded in the knowledge of the territory and the intangible values embodied by local communities, within the broader perspective of the integrated management of cultural landscapes.

The objective is therefore not simply to interpret the site through a historical and architectural analysis of its principal rock-cut monuments–although such specialist investigation remains indispensable and requires continuous updating–but rather to understand the relationships linking architecture to its contemporary territorial and social context. Geomorphology, settlement dynamics, and collective memory are thus considered the fundamental components of a restoration project primarily aimed at preserving the continuity of knowledge. From this perspective, restoration cannot be limited to the conservation of the physical monument alone; rather, it must be based upon a comprehensive understanding of the territorial relationships that generated these places and continue to define their cultural significance today (V.S.).[3]

The Rock-Cut Landscape of Massafra: Territorial Structure and Settlement Dynamics

Massafra developed within the ravine system of the Ionian-Tarantine arc (Fig. 2), a geomorphological setting that profoundly shaped the evolution of its rock-cut settlements. The defining feature of this landscape is the network of *gravine*–deep erosional ravines characteristic of the Murge plateau– within which human communities established settlements and places of worship from antiquity onwards. The town preserves numerous rock-cut complexes carved into the limestone bedrock, many of which are now incorporated into the modern urban fabric, including the settlements of San Leonardo and Sant'Antonio.

These karstic ravines constitute the fundamental structural element of the city, whose historical development followed settlement patterns characteristic of the local environment (Fonseca, 1970, pp. 15–28). Originally, the inhabited area was largely confined to the ravine itself rather than extending across the present-day urban area, giving rise to a distinctive territorial identity that continues to define the city today. The choice of these locations was determined by their intrinsic advantages: the permanent availability of water supplied by the stream flowing along the ravine floor and the natural defensive conditions provided by the steep slopes (Cazzato, pp. 31–47).[4]

The modern town still maintains a close relationship with these territorial components, as its consolidated urban fabric is bounded to the west by the Madonna della Scala ravine and to the south by the San Marco ravine.

The Madonna della Scala ravine plays a fundamental role not only from a landscape perspective but also as the city's principal religious landmark. The Madonna della Scala is venerated, together with Saint Michael the Archangel, as the patron saint of Massafra. The sanctuary originally consisted of a small rock-cut chapel excavated into the cliff, where an important cycle of medieval frescoes remains in a good state of preservation. The original church was arranged in three naves but underwent substantial alterations following the construction of the present sanctuary and, above all, the

2 The progressive shift from a monument-centred approach to heritage protection towards a systemic understanding of cultural heritage is reflected in the principal international documents concerning cultural landscapes and integrated heritage management. Among the most influential are the *European Landscape Convention* (Council of Europe, Florence, 2000), the *Framework Convention on the Value of Cultural Heritage for Society* (Faro Convention; Council of Europe, 2005), the *UNESCO Recommendation on the Historic Urban Landscape* (2011), and the more recent guidelines developed by ICOMOS and ICCROM concerning heritage documentation and preventive conservation.

3 Most of the scholarly literature devoted to the rock-cut heritage of Southern Italy has traditionally focused on the historical, archaeological, art-historical, and iconographic analysis of individual monuments and architectural complexes. In addition to the pioneering contributions of Cosimo Damiano Fonseca, significant studies include those by Jacovelli, Caprara, Dell'Aquila and Messina, and Abatangelo, as well as more recent research on the rock-cut systems of Apulia and Basilicata. By contrast, comparatively few studies have interpreted rock-cut landscapes as complex territorial systems and as a unified subject for conservation planning.

4 On the relationship between urban development and the persistence of rock-cut settlements in southern Italy, see also Poli, G., 2013, pp. 85–93.

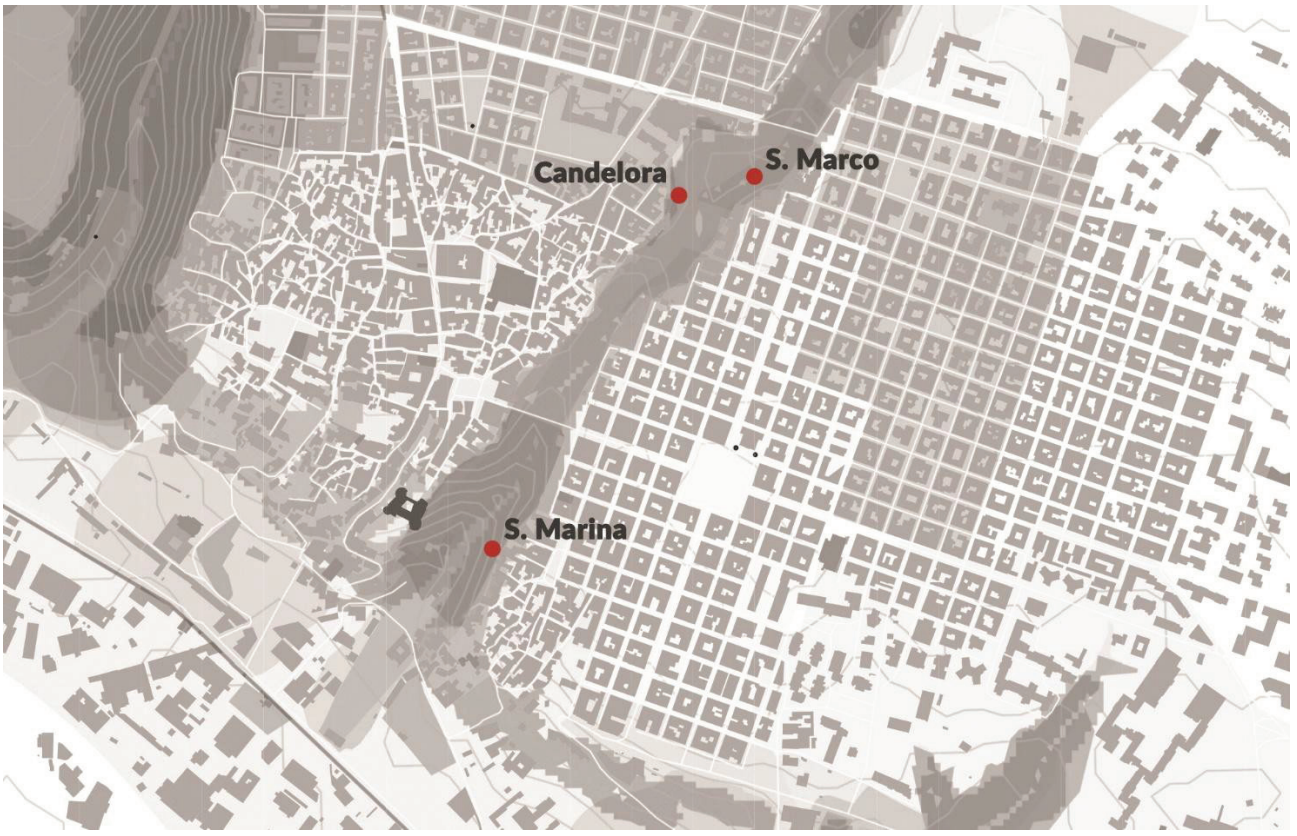

Fig. 2. Massafra, San Marco ravine showing the location of the rock-cut churches of San Marco and Santa Maria della Candelora to the north, and the Santa Marina rock-cut settlement and the Castle to the south (Drawing: A. Santoruvo, S. Vallario, M. Ventrella).

monumental staircase built directly above the hypogeal space (Jacovelli, 1998, pp. 29–34). This monumental staircase connects the sanctuary with the upper plateau overlooking the ravine (Fig. 3). Both the staircase and the current sanctuary date to the eighteenth century, when a replica of the ancient Byzantine icon, still preserved within the rock-cut chapel, became the object of popular devotion. This access route establishes not only a physical connection between the town and the sanctuary but also a spiritual and landscape relationship that remains deeply embedded in the collective identity of the local community.

The sanctuary complex therefore exemplifies what Salvatore Settis has defined as a "community of life" (*comunità di vita*) (Settis, 2019, pp. 78–79), in which conservation extends beyond the protection of individual heritage assets to encompass the network of relationships linking people, places, and collective memory. From this perspective, the landscape is not merely the setting in which the rock- cut monuments are located but becomes itself a heritage asset whose preservation depends on safeguarding the historical, perceptual, and functional relationships that define it. Within the ravine system of Massafra, the San Marco ravine represents the context in which the relationships between the natural environment, historical settlement, and sacred spaces remain most clearly legible, providing the basis for an integrated interpretation of this cultural landscape.

Within the ravine, the southernmost rock-cut settlement of Santa Marina is accompanied by two places of worship situated closer to the historic town centre: the Church of San Marco, from which the ravine takes its name, and the small chapel known as the Candelora. This urban evolution reflects the continuity between successive settlement phases which, although visually interconnected, exhibit only limited physical interaction. The San Marco ravine, now located within the centre of the modern town, was known until the seventeenth century as the "Paradise of Massafra" (Crescenzi, 2012, p. 64). Until 1860, the two sides of the town were connected only by the Liscia Bridge; this was subsequently complemented by the San Marco Bridge (Fig. 4), located near the homonymous rock- cut church, and later by the Ponte Nuovo, constructed in response to the town's urban expansion (Crescenzi, 2012, p. 62).

The ravine preserves Mediterranean vegetation of remarkable ecological value, which significantly contributes to the landscape quality of the site.[5]

At its southern entrance, the ravine is dominated by the town castle, today preserved in its sixteenth- century

5 Among the most characteristic species are the Trojan oak (*Quercus trojana*), the holm oak (*Quercus ilex*), and the olive tree (*Olea europaea*); rarer species include *Campanula versicolor* and *Carum multiflorum*, alongside widely distributed species such as the pri-

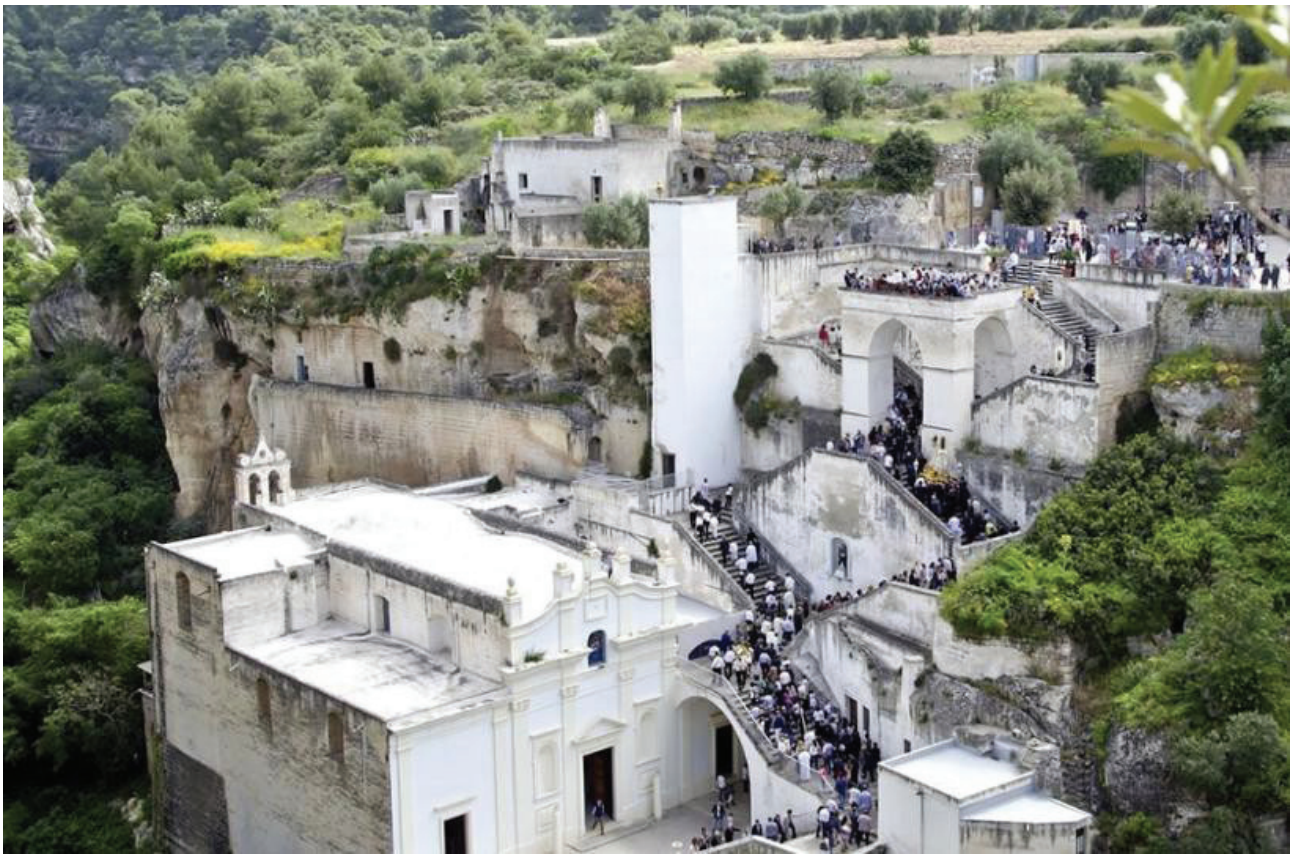

Fig. 3. Massafra, the monumental complex of Santa Maria della Scala during the traditional Buona Nuova procession (Source: La Gazzetta del Mezzogiorno, 23 June 2017)

configuration, which forms a monumental architectural backdrop overlooking the natural valley below. Along the upper edge, the ravine is bordered by a predominantly residential urban frontage that directly overlooks the natural landscape, enhancing the perception of its depth. On the western side, a nucleus of historic buildings documents the earliest expansion of the settlement beyond the original rock-cut environment.

The ravine should therefore be understood not merely as the physical support for human occupation but as a territorial structure that has guided settlement patterns, land use, and the construction of local identity over the centuries.

The principal archaeological and architectural complexes distributed throughout the ravine illustrate the evolution of settlement forms and religious practices, offering a diachronic interpretation of the transformations that have shaped this rock-cut landscape.

Beginning from the southern end, the first major complex is the rock-cut village of Santa Marina, located on the eastern slope of the ravine opposite the historic centre of Massafra. The settlement comprises an articulated system of dwellings, productive spaces, and religious buildings excavated directly into the calcarenite bedrock. Owing to the geological characteristics of this highly porous substrate, the church from which the village derives its name collapsed following a flood that occurred in the early seventeenth century (Caprara, 2015). This event highlights two key issues: first, the collapse of rock-cut monuments represents a recurring rather than exceptional phenomenon;[6]second, it underlines the urgent need for conservation strategies capable of preserving these sites, which are now increasingly recognised as fundamental components of the historical identity of local communities (Scalzo & Tioli, 2019, pp. 1011–1018).

Immediately in front of the church entrance, a natural rock terrace provides access to the wide entrance of the building. Despite the progressive deterioration of the settlement, the village has continued to play an important role in the cultural life of the community (Fig. 5), serving since the 1960s as the setting for the annual Living Nativity representation (V.S.).

ckly pear cactus (*Opuntia ficus-indica*). See *Parco Naturale Regionale Terra delle Gravine*, “Vegetation of the Park”, https://www.parcoterradellegravine.it/vegetazione/ (last accessed: 12 June 2026).

6 Similar deterioration phenomena have also been documented in the Chapel of the Candelora and in the nearby rock-cut church of San Leonardo, both located in Massafra, confirming the inherent vulnerability of settlements excavated into calcarenite.

Fig. 4. Aerial view of the eastern slope of the San Marco ravine (Photo: G. Martino).

Documentation as a Knowledge Infrastructure: Digital Survey, Conservation Analysis, and the Vulnerability of Rock-Cut Heritage

On the same eastern side of the ravine, slightly north of the village of Santa Marina, stands the rock- cut church of San Marco (Fig. 6). Its almost central position along the longitudinal development of the ravine made it, over the centuries, one of the principal sacred sites of the town, to the extent that it gave its name to the entire karstic incision (Caprara, 1979). Located on one of the ravine's natural terraces, the church occupies a position that is easily accessible and, at the same time, strategic for territorial control. This setting encouraged the development of religious and productive activities around the complex and made it a stopping point along the so-called "ridge routes", followed by pilgrims travelling towards other rock-cut centres in the area.[7]

The church was built in the sixth century AD, during the Byzantine period, in a phase marked by considerable political and military instability. Its original layout consisted of a basilican plan with a single terminal apse and a narthex intended to house *arcosolium* tombs, an element that testifies to the articulation of the liturgical space and to the importance of the building (Jacovelli, Caprara & Fonseca, 1966). In the following centuries, particularly between the seventh and ninth centuries, the complex continued to be frequented, as demonstrated by the Greek and Latin inscriptions still preserved today, clear evidence of the presence of pilgrims belonging to different rites and of the strategic importance of the site. From the end of the tenth century onwards, following the Byzantine reconquest and the incorporation of Massafra into the County of Lecce, the building underwent significant architectural transformations, including the addition of a second apsed nave on the southern side, the alteration of the narthex, and the opening of a window intended to illuminate the *pastophorion* (Nuzzo, 2022, pp. 483–495).[8]

The Chapel of the Candelora (Fig. 7) is located on the western side of the ravine, opposite the church of San Marco (see Fig. 2). The settlement appears to be chronologically later than San Marco and is generally dated to around the twelfth century. Neither the façade nor the entrance of the building is preserved today, probably because they were demolished during the enlargement of a private garden. This circumstance may have led to the removal of the front portion, later the subject of a reconstruction hypothesis proposed by the architect Caprara (Caprara, 1988). However, as in the case of the church of Santa Marina, it cannot be excluded that a flood event, although more recent and datable to the late twentieth century, also contributed to the collapse of the front part of the building. Also set on a broad natural terrace, the Candelora dominates the

7 The main rock-cut centres of the area include Mottola, Palagianello, Palagiano, and Laterza, historically connected through ridge and valley-floor routes.

8 For further discussion of the historical context of the Byzantine reconquest of the Terra d'Otranto, see Nuzzo, 2022, pp. 483–495.

Fig. 5. Massafra, San Marco ravine: visitors at the Living Nativity scene in the Santa Marina rock- cut settlement (Source: Pro Loco Massafra, https://www.prolocomassafra.it/presepe-vivente-a- massafra)

ravine slope and preserves a rich pictorial cycle, among which the depiction of the "Presentation of Jesus at the Temple" is particularly significant. A few metres north of the crypt there is a small chapel, accessible directly from the outside, probably intended for funerary use and most likely reserved for the founders or benefactors of the complex.

A comparative reading of the different complexes shows that each building forms part of a unified system, in which the understanding of reciprocal relationships is essential for guiding subsequent cognitive and conservation analyses. In contemporary restoration projects, survey represents the primary tool for constructing knowledge and constitutes the indispensable basis for all subsequent design choices (Brandi, 1963; Docci & Maestri, 2009; Letellier, 2007). The San Marco ravine was documented through an integrated survey based on UAV photogrammetry, terrestrial photogrammetric survey, and three-dimensional modelling, aimed at understanding the relationships between the rock-cut architectures, the geomorphological context, and the urban fabric. The digital models and vector drawings made it possible to analyse the spatial organisation of the complexes, reconstruct their main evolutionary phases through stratigraphic analysis, and establish the cognitive basis for the subsequent restoration project.[9]

In the case of the church of San Marco (see Fig. 6), the study enabled an in-depth understanding of its different spaces–naves, presbytery, apses, and narthex–both from a symbolic perspective and in relation to their respective liturgical functions. Although excavated into the rock, the building documents a remarkable variety of structural systems, including arches and vaults, which define the internal volume and are supported by pillars that articulate the entire spatial configuration of the complex.[10]

The survey operations also made it possible to develop a stratigraphic analysis, allowing the different construc-

9 The survey operations were carried out by S. Matera, I. Moramarco, C. Moretto, and E.P. Russino for the Chapel of the Candelora, and by A. Santoruvo, S. Vallario, and M. Ventrella for the church of San Marco, as part of a teaching exercise conducted under the guidance of the architects C. Chiumarulo, A. Iacovelli, G. Martino, G. Ranieri, and S. Todisco, tutors of the Architectural Restoration Studio C, coordinated by Prof. Santoro.

10 Among the principal studies dedicated to the monument, see Caprara, R., *La chiesa rupestre di San Marco a Massafra*, Florence, 1979.

Fig. 6. Massafra, the rock-cut church of San Marco: plan and section (Drawing: A. Santoruvo, S. Vallario, M. Ventrella)

tion phases to be understood through the interpretation of the limited stratigraphic evidence that can be recognised in an architecture created by the subtraction of matter, as is typical of rock-cut construction.

Despite their fragmentary state of preservation, the painted surfaces display stylistic features attributable to the figurative production of the Byzantine world, although with significant local variations. The partial survival of the paintings makes it possible to recognise only the figures of the Holy Physicians and Saint Mark the Evangelist (Fig. 8), executed in fresco directly on the calcarenite support. Saint Mark is depicted in the act of blessing, holding a volume–probably a Gospel book– against a dark monochrome background bordered by a red frame. In addition to widespread surface deterioration, the complete loss of the saint's face can be observed.[11]

A particularly significant feature was recorded in the apsidal conch of the main nave. It is devoid of pictorial decoration and, at the same time, characterised by the presence of engraved crosses[12] and, above all, by three horizontal rows of holes, each consisting of twelve cavities probably used to fix a wooden wall decoration or painted stucco panels.[13]

The survey of the Chapel of the Candelora revealed an even more complex constructive and decorative system than that of the church of San Marco. Of particular interest are the different roof configurations of the various bays, characterised by two- and four-pitched vaults and, in particular, by the south-western bay, covered by a lenticular dome supported by pendentives on which cherubs are depicted, appearing to symbolically sustain the vault itself (Abatangelo, 1966, p. 163).

A further element revealed by the survey concerns the lowering of the original floor level of the hypogeal space, clearly visible in the sections and attributable to the removal of three superimposed quarry courses, probably carried out to obtain building material for

11 The removal of the faces of sacred figures is documented in numerous rock-cut contexts in southern Italy and is traditionally associated with the popular belief that treasures were hidden behind the frescoes.

12 The engraved crosses may be related either to rituals for the consecration of the building or to devotional practices that developed during the long period of use of the complex.

13 These recesses have a diameter of approximately 1.5 cm, with a horizontal spacing of about 13 cm and a vertical spacing of about 27 cm. Their metric and distributive regularity suggests that they were intended to house pins or clamps for anchoring a wooden wall decoration or stucco panels. The same type of hole is also present near the arch of the iconostasis, suggesting an analogous function.

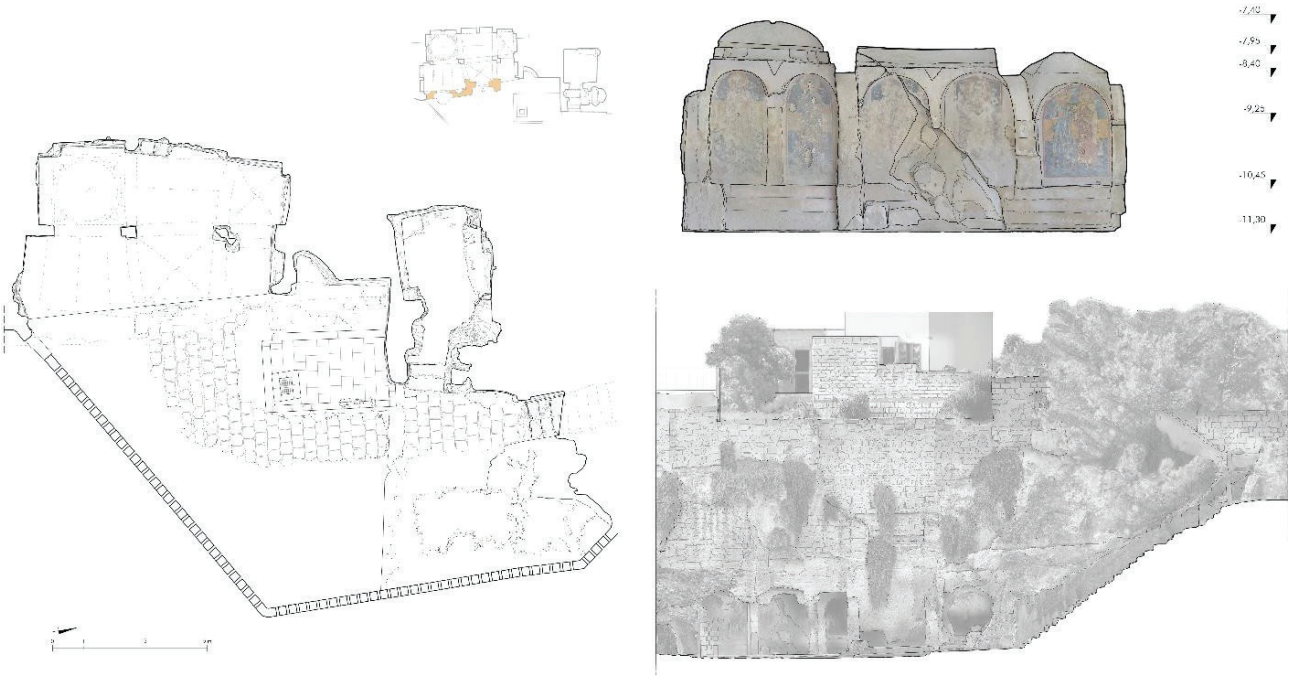

Fig. 7. Massafra, the rock-cut church of Santa Maria della Candelora: surveyed plans and sections. The missing portions of the façade are highlighted in orange (Drawing: S. Matera, I. Moramarco, C. Moretto, E.P. Russino)

more recent constructions.[14] This lowering profoundly altered the original spatial perception of the interior, which must originally have had a maximum height of approximately 3.30 m, compared with the almost 5 m perceived today.

The iconographic programme of the church of the Candelora (Fig. 7), despite the building's more serious conservation problems, is better preserved than that of the church of San Marco. Among the main depictions, the "Presentation of Jesus at the Temple" stands out: the Child, wrapped in swaddling clothes and held by the Virgin, is presented to the elderly Simeon. The richness of the details and the presence of the halo around Christ's head recall the catechetical function typical of medieval painting.

This scene is accompanied by the figures of Saint Nicholas the Pilgrim and Saint Stephen, which testify to the strong relationship between these places of worship, pilgrimage routes, and the surrounding territory.[15]

The documentation produced therefore assumes the value of a true knowledge infrastructure, one that can be continuously implemented and is intended to support the complex phases of design and management. The main critical issues identified in the church of San Marco are linked to the high porosity of the calcarenite and to the thermo-hygrometric conditions typical of hypogeal environments, worsened by inadequate rainwater management and the prolonged disuse of the site. These conditions have favoured moisture-related phenomena, salt efflorescence, biological colonisation, and widespread processes of surface deterioration, to which anthropogenic alterations must be added, such as the removal of portions of the pictorial decoration. The Chapel of the Candelora presents, in addition to material decay, significant structural problems caused by the collapse of the façade and the consequent loss of part of the load-bearing system. Its state of conservation also shows phenomena of calcarenite disaggregation and localised losses along the masonry, despite previous consolidation works.

Taken as a whole, the critical issues identified confirm that the vulnerability of rock-cut heritage does not depend solely on the material condition of the architecture, but on the interaction between geomorphological, environmental, anthropic, and management-related factors. Understanding these factors is therefore the essential prerequisite for guiding conservation interventions based on the principles of prevention, minimum intervention, and integrated heritage management (G.M.).

14 Similar traces are also visible at the sanctuary of the Madonna della Scala, where the modern building was created by exploiting the same calcarenite bench.

15 Saint Nicholas the Pilgrim, who arrived in Puglia from Greece and died in Trani, where he is still venerated today, represents a significant element of connection between the iconographies and the broader Mediterranean historical and cultural context. For further discussion of the figure of Saint Nicholas the Pilgrim, see Albino, 2024.

Fig. 8. Massafra, the rock-cut church of San Marco: digital restoration of the fresco depicting Saint Mark the Evangelist (Drawing: A. Santoruvo, S. Vallario, M. Ventrella)

From Knowledge to the Project: Principles for the Conservation of Rock-Cut Heritage

The research conducted in the San Marco ravine confirms that rock-cut heritage cannot be understood solely through the conservation of individual monuments. Instead, it requires an integrated interpretation in which architecture, geomorphology, settlement dynamics, intangible values, and local communities are recognised as interrelated components of a single cultural landscape (Council of Europe, 2005; UNESCO, 2011). From this perspective, the restoration project extends beyond the scale of the individual intervention to become a tool for understanding, managing, and enhancing the wider territorial heritage (Carbonara, 1996; Carbonara, 2007).

The methodological approach developed in this research–combining historical and archival investigation, architectural survey, terrestrial and UAV photogrammetry, three-dimensional modelling, conservation assessment, and digital data management–demonstrates that knowledge should not be regarded merely as a preliminary phase of the restoration process, but rather as a continuous and evolving process accompanying the entire life cycle of the heritage asset (Jokilehto, 1999; Bianchini, 2014). Within this framework, the GIS platform currently under development constitutes a dynamic knowledge infrastructure, designed to support long-term monitoring, preventive conservation, planned maintenance, and future decision-making processes (Letellier, 2007; ICCROM, 2015; ICCROM, 2021).

The Massafra case study also demonstrates that the conservation of rock-cut heritage should be grounded in preventive conservation strategies, the re-establishment of historical and functional relationships between the urban settlement and the ravine landscape, and the active involvement of local communities in the recognition and enhancement of their cultural identity. Conservation therefore extends beyond the safeguarding of historic fabric to include the protection of the cultural processes, social practices, and historical relationships that give meaning to heritage places (Council of Europe, 2005; UNESCO, 2011).

Although developed from a specific case study, the proposed methodology is transferable to other rock-cut landscapes across the Mediterranean, where comparable geomorphological conditions, settlement patterns, and conservation challenges require integrated knowledge systems and interdisciplinary management approaches. Consistent with the principles established by the Venice Charter (ICOMOS, 1964), the international framework on cultural landscapes (UNESCO, 2011; ICOMOS, 2014), and the most recent strategies for integrated heritage management promoted by ICCROM (2021), the restoration project evolves from a practice focused on the conservation of individual monuments into a strategic instrument for governing the cultural landscape. In this perspective, restoration becomes a multidisciplinary process capable of integrating scientific research, digital documentation, territorial planning, and community participation within a coherent, long-term framework for the conservation and sustainable management of cultural heritage (V.S., G.M.).

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Losing the Past: *Maps and Inventories of Cappadocia (Turkey)*

Ali Yamaç
OBRUK Cave Research Group
ayamac@gmail.com

Abstract

Cappadocia, undoubtedly one of Turkey's most important cultural and historical treasures, is gradually vanishing and, regrettably, is going to continue in its deterioration over time. Two primary factors contribute to this extinction, or more accurately, two significant enemies of Cappadocia exist. The first of these natural forces. Erosion and rock disintegration are gradually deteriorating several stone-cut structures in Cappadocia. The degradation of nature, while potentially unavoidable, occurs gradually over an extended timeframe. In contrast, the devastation inflicted by Cappadocia's alternative enemy is far more intense and occurs at an expedited rate. This second enemy is humanity. The uncontrolled acceleration of touristic investments and mass tourism in the region over the last 20-30 years is undermining both the ecosystem and the structure of Cappadocia. This destruction is causing irreparable damage to the region's cultural legacy, as various structures, including those that are some centuries old, are progressively disappearing. The principal objective for dealing with this extinction, which is unlikely to be wholly averted despite the possibility of managing its advancement, is to properly transmit all these historical values to future generations before it is too late. Nevertheless, this undertaking, feasible only with a comprehensive inventory and precise mapping of all of Cappadocia, remains unfulfilled. In this presentation, many different examples of natural and anthropogenic destruction will be presented, and inadequate mapping will be demonstrated, emphasizing the importance of detailed mapping and inventory.

Keywords: Cappadocia, rock-cut structure, rock-cut church, inventory, database

Introduction

There are two major enemies of Cappadocia (Fig. 1). The first is nature, which also created it. Erosion, which has spent millions of years wearing away the soft volcanic rock to form valleys and fairy chimneys, continues to wear away this rock over time, ultimately destructing all the structures carved into it.

The facade of a rock-cut structure depicted in a 1839 engraving by Texier does not exist today (Fig. 2). The powerful monumentality expressed by Texier's facade seems to manifest capabilities beyond the grasp of Cappadocia's carvers. Various aspects of its design and decoration, however, strongly resemble features found in a combination of other surviving facades in Cappadocia. The drawing, therefore, probably documented an actual structure that by now has disappeared. Texier's elusive facade may well belong to the Bezirhane courtyard complex at Avcılar, near Ürgüp in eastern Cappadocia. The original courtyard facade of this complex has collapsed, so that the interior wall of the hall that rested directly behind it is visible as the complex's exterior. Much like Texier's facade, this surviving wall at Bezirhane exhibits three equally spaced bays framed by engaged piers and horizontal mouldings. In addition, the three horseshoe arches at Bezirhane are articulated in the same manner as those on Texier's facade (Texier 1839; Kalas 2004).

Aqueduct remains excavated in valleys and lost their function over time due to erosion are another example (Gilli & Yamaç 2015). In Güvercinlik Valley there are several water tunnels portions, dug in the valley at different times, can be seen together. Despite many processes of maintenance and restoration, it is certain that ignimbrites are sensitive to erosion, thus the tunnels become unusable after a period of time (Bicchi et al. 1995). On the north part of the valley, another water tunnel is located on the opposite wall of main water tunnel. Remainings of that other tunnel which can be observed in places, have almost been vanishing completely because of erosion. A small part of it, which is older than the main tunnel and where there are subsidiaries of previous water tunnel located also on the east wall, has been explored and surveyed. South of this area, it is mostly certain that the holes observed on the completely eroded east walls of the valley belong to another water tunnel (Fig. 3). Similar eroded holes also exist in Meskendir Valley (Castellani 2002).

Similarly, in 1950, a large part of the 60-meter-high front wall of Çavuşin collapsed and only a few photographs remain of this wall in its original state (Pekin 2014) (Fig. 4).

Fig. 1. Location map showing the Cappadocia region (after Google Maps - elaboration A. Yamaç)

Because no previous research has been conducted in Çavuşin, we have no information about the formation of this wall settlement before its collapse. On the other hand, it is incredible that a survey covering the entire wall has not yet been done.

A few months ago, two major collapses occurred in Göreme and Ürgüp, destroying dozens of dwellings that had not yet been explored or surveyed (Fig. 5).

There are countless examples of this kind; the erosion that created Cappadocia is also destroying it. Rockfalls and erosion are one of Cappadocia's most serious problems, and there have been countless studies and articles written on this subject. While it is impossible to prevent this, researches are being conducted to at least delay it.

The deterioration of nature, although it may be inevitable, takes place over an extended period. Conversely, the destruction caused by Cappadocia's other enemy is notably more severe and occurs at an accelerated pace. This enemy is humanity.

In 1985, UNESCO designated the distinctive region of Göreme-Cappadocia as a cultural and natural World Heritage Site. In recent decades, urbanization and mass tourism have significantly altered Cappadocia's ecosystem. The region, which had sustained a subsistence-based traditional agricultural economy for centuries, saw tremendous transformations. The expansion of tourism and contemporary innovations has prompted many young individuals to abandon the arduous traditional lifestyle in favor of a future grounded in modern infrastructure and the burgeoning tourism sector. In 1983, Göreme had approximately three pensions, in stark contrast to nearly eighty today, resulting in significant transformations in the village's traditional lifestyle and extensive unregulated construction operations.

When we compare old photographs of Cappadocia with those of today, this destruction is clearly visible (Fig. 6).

The authorities seem to favor the short-term economic gains of mass tourism over the long-term cultural advantages linked to historic preservation. The building of roads, car parks, hotels, balloon areas, all-terrain vehicle activities, motocross, and horseback riding, is significantly harming this fragile nature.

Currently, it is exceedingly difficult to locate a traditional cave housing that has not been converted into a guesthouse or renovated residence. Most of these newly constructed dwellings scarcely adhere to the traditional traits of local architecture. Architectural styles, which varied from village to village in Cappadocia, are now supplanted by uniform structure and decorative components, lacking any sub-regional distinction.

Despite protection from UNESCO and the Turkish Ministry of Culture and Tourism, no sustainable master plan has been established that addresses the needs and requirements of the region and its local populace. Disorganized construction efforts related to tourism and urbanization resulting from overall development are largely untenable for the region's sustainable future. Moreover, even structurally sound cave dwellings have

Fig. 2. Engraving by Texier showing the facade of a rock-cut structure (Texier 1839)

Fig. 3. Remains of an eroded water tunnel on the east wall of Güvercinlik Valley (photo E. Gilli)

been demolished by local municipalities using bulldozers. To date, there are no regular meetings convened by the official protection board, which is primarily tasked with granting building and restoration permits. The official local decision-making bodies lack training in recognizing the significance of details and the complexities of the rapidly evolving region, rendering them incapable of providing sound recommendations. The various working groups in the Cappadocia region lack collaboration and intercommunication, hindering the formation of effective professional teams.

In Cappadocia, where such natural and human destruction took place, we believe that the most important task should be to ensure that the existing historical and cultural values be fully transferred to the future. The two important elements in this approach are mapping and inventory, which have been the most neglected aspects of Cappadocia research thus far.

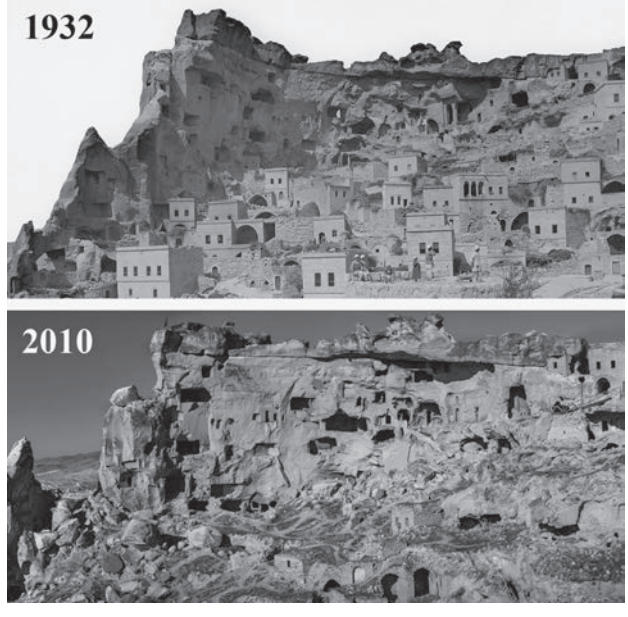

Fig. 4. Çavuşin (up Jerphanion 1932; below A. Yamaç 2010)

Maps

There are hundreds of articles and books about the region, and countless new ones are published every year. Academics debate the frescoes of that Byzantine rock-cut church, or the architectural similarities between this church and another. Detailed plans and surveys of most of these churches are also being drawn up. However, just as we saw in Texier's engraving above, when they are destroyed by erosion or rock falls, we can only guess where they were located because, with a few exceptions, detailed maps of almost none of the areas have been prepared. Most researchers continue to use maps that were prepared years ago and are only sketches.

Quoting Robert G. Ousterhout:

"The open-air museum is the most visited area of the region, but it has never been properly mapped, we still rely on a simplified and incorrect map drawn half a century ago" (Ousterhout 2024).

He was referring to Luciano Giovannini's work 'Arts of Cappadocia', and indeed, the Göreme map in his book, which is only a sketch, has been copied and used in many works since that day (Giovannini 1971) (Fig. 7). Indeed, it is tragic that Göreme National Park, the most important attraction point in all of Cappadocia, visited by hundreds of thousands of tourists every year, still lacks a detailed and up-to-date map.

Similarly, numerous experts, from Michel and Nicole Thierry to Yıldız Ötüken, from Hild and Restle to Veronica Kalas have been working in the rock-cut churches of the Peristrema Valley for 62 years (Thierry & Thierry 1963; Hild & Restle 1981; Ötüken 1989; Kalas 2000) and, just like Giovannini's Göreme National Park sketch, Thierry's 62 years old rough sketch of Peristrema Valley is still used as the basic map of this valley in all publications (Fig. 8).

Fig. 5. Göreme, collapse of a fairy chimney at Sept. 20, 2025 (photo Anadolu Ajansı)

These examples can be multiplied; in the Yeşilhisar – Erdemli Valley 16 rock-cut churches, studied to date. The first survey on these churches is an article written by Nicole Thierry (Thierry 1989). The article had the plans for eight churches and a monastery structure. Subsequently, the results of Nilay Karakaya's research, which began in the Erdemli Valley in 2002 and continued until 2010, were presented in five symposiums and three articles. In all of Karakaya's works, the sketch map found in Nicole Thierry's 1989 article was used (Fig. 9). Although this unscaled sketch was sufficient to a certain extent for determining the locations of the first eight churches Thierry researched, it is extremely inadequate for subsequent studies. Nilay Karakaya's article, in which she discovered and researched seven more churches in the valley, does not include a map showing the locations of these churches, and today the locations of Church No. 1, Church No. 2, Church No. 3, Church No. 4, Haralam Monastery Church, Bezirhane 1 Church, Bezirhane Monastery Church mentioned in this article are unclear (Karakaya 2003; Karakaya 2004; Karakaya 2005; Karakaya 2006).

Another problem caused by the lack of detailed maps is that, since their exact locations are unknown, some of the structures in Thierry's sketches may be the same structures later researched by Karakaya and given different names.

The most tragicomic example of this matter is the continued use of the map drawn by Jerphanion one hundred years ago in all publications and brochures depicting Soğanlı Valley, as no additional research has been conducted (Fig. 10) (Jerphanion 1925–1942).

In finalizing, we think it's useful to demonstrate the need of documenting and preservation with a tragic example. The front facade of the Yüksek Kilise (High Church) in Ürgüp, researched by Sacit Pekak in 2014, completely collapsed in 2021. Therefore, Pekak's article is the only source of information about this church, which no longer exists. This article has only a plan of the church without any measurements and does not include any photographs (Pekak 2014). On the other hand, the measurements we took and the plans we drew of the parts of the church which are still standing today are very different from the sketch plan published in Pekak's article (Yamaç et al. 2025) (Fig. 11). Therefore, we can assume that the part of the same plan that has now been destroyed is also quite incomplete and inaccurate. This situation is yet another proof of how important it is to be meticulous in the work carried out on these structures, which are vulnerable to all kinds of damage.

We stated that mapping and inventory are the two most important tools for ensuring that structures of historical and cultural value facing the threat of disappearance can be passed on to the future. As indicated by the examples above, with the exception of a few areas such as Çanlı Kilise and its surroundings, or Güzelöz and Mavrucan valleys, almost none of the important parts of Cappadocia have been mapped in detail.

Inventories

A similar situation applies to the inventories. We know it's hard to believe, but there is still no detailed inventory of the artificial cavities found in Cappadocia. Even

the number of rock-cut churches is still controversial since there are different numbers listed in many different references. For instance, there are only 118 rock-cut churches in Guillaume de Jerphanion's comprehensive work (Jerphanion 1925–1942). Considering the churches around Peristrema, which are not included in Jerphanion's book, and all the other rock-cut churches that have been discovered and published in the region over the past 100 years, the total number of churches could be as high as 300.

For example, Lyn Rodley wrote that "My estimate of the number of churches, based on published lists and field observation, used to be around 300" (Rodley 1985).

Indeed, according to the TAY-Türkiye Arkeolojik Yerleşmeleri (Archaeological Settlements of Turkey, www.tayproject.org), which is one of the most comprehensive inventories ever made on this subject, there are 359 rock-cut churches in Cappadocia (Akyürek et al. 2015).

Finally, the results of the inventory conducted by us in recent years, which involved scanning all known sources, are also around this number (Bixio et al. 2021; Yamaç et al. 2024). Even if we acknowledge that there may be some deficiencies in all these inventories, we suppose that the number of the rock-cut churches in the territory will not exceed the foregoing number much.

On the other hand, Prof. Yıldız Ötüken's 'Kappadokya Bölgesi Bizans Mimarisi Araştırmaları' (Research on Byzantine Architecture in the Cappadocia Region), a 373-page unpublished associate professor thesis lists 687 Byzantine churches in Cappadocia (Ötüken 1981).

Similarly; Jolivet-Levy and Ousterhout wrote in their works, respectively, that in Cappadocia there are 600 and 700 religious structures carved into the rocks (Jolivet-Lévy 1997; Ousterhout 2010).

Seven years later, in his last book Ousterhout wrote;

"Cappadocia preserves an abundance of physical remains: at least a thousand rock-cut churches or chapels, of which more than one-third retain significant elements of their painted decoration" (Ousterhout 2017).

About a century before these two researchers, Josef Strzygowski gave the same number, but he also brought a logical explanation.

"Das Tal Göreme bei Ürgüb, von dem die Berichte melden, dass es ursprünglich eine Statte des Todes, spater von christlichen Mönchen besiedelt worden sei. Die Zahl der Kirchen wird mit 'bin' (tausend) geschätzt, was in der Sprache des Orients 'binbir', tausend und eins, d. h. viel, unzählig" heissen will" (Strzygowski 1903).

(The Göreme Valley near Ürgüb, which reports say was originally a place of death, later settled by Christian monks. The number of churches is estimated at 'bin' (a thousand), which in the language of the Orient means 'binbir', (a thousand and one), i.e., "many, innumerable").

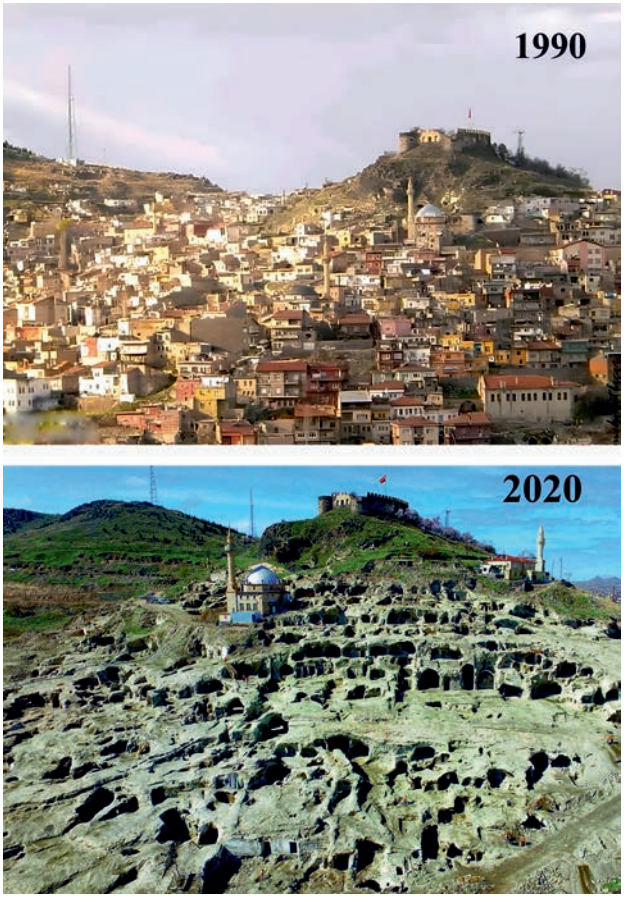

Fig. 6. A few years ago, the Nevşehir Municipality, without authorization, demolished all the structures around Nevşehir Castle, resulting in this scene (up anonymous postcard 1990; below photo M. Gülyaz 2020)

Jolivet-Levy and Ousterhout did not provide any sources for the numbers 600, 700, and 1000. On the other hand, Prof. Yıldız Ötüken's thesis is likely the most comprehensive inventory prepared to date and is based on extensive source research. There are basically three reasons why the number of churches in this inventory is much more, a total of 687, than in the other inventories mentioned above. First of all, Ötüken's inventory includes provinces outside Cappadocia, such as Elazığ, Malatya, and Erzincan. Secondly, it also includes churches mentioned in old travelogues that no longer exist today and finally, there are several masonry churches in the list. With all these additions, it is natural that the number of churches of Cappadocia, which is around 300 in other inventories, is 687 in Ötüken's inventory.

Given the extensive inadequacies in Cappadocia's church inventories, expecting a comprehensive database of other rock-cut structures in the region to be compiled is a dream. However, the region boasts hundreds of rock-cut structures, from shelters and apiaries to hydric tunnels and dwellings, the vast majority of which date to the Byzantine period.

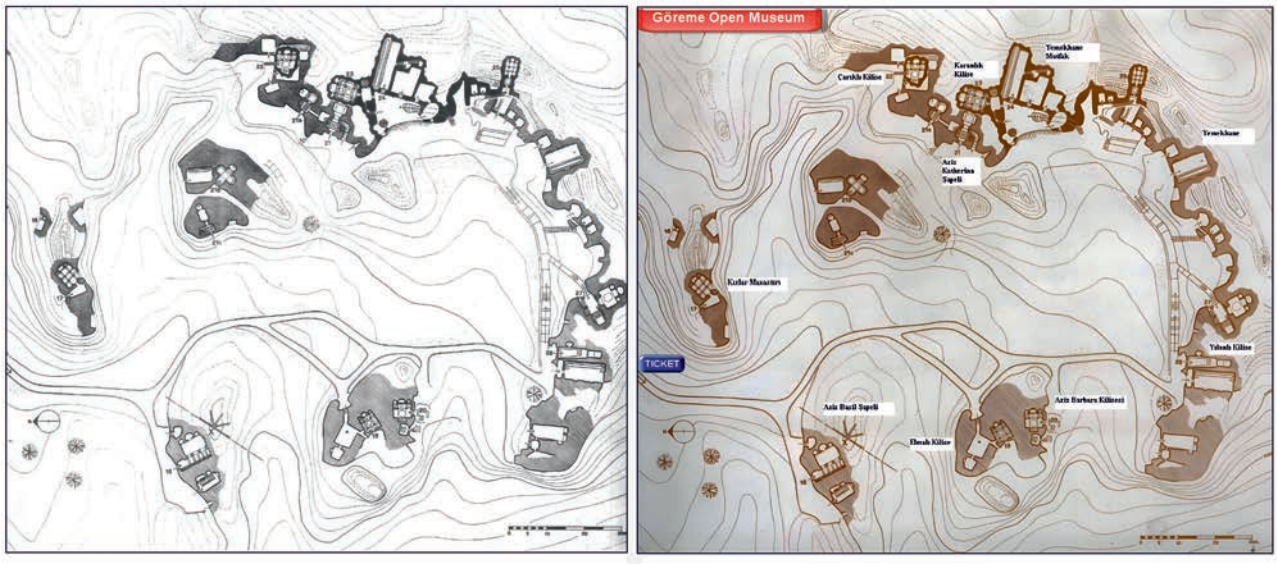

Fig. 7. Göreme National Park plans; left Giovannini, right brochure of Ministry of Culture and Tourism (Giovannini 1971)

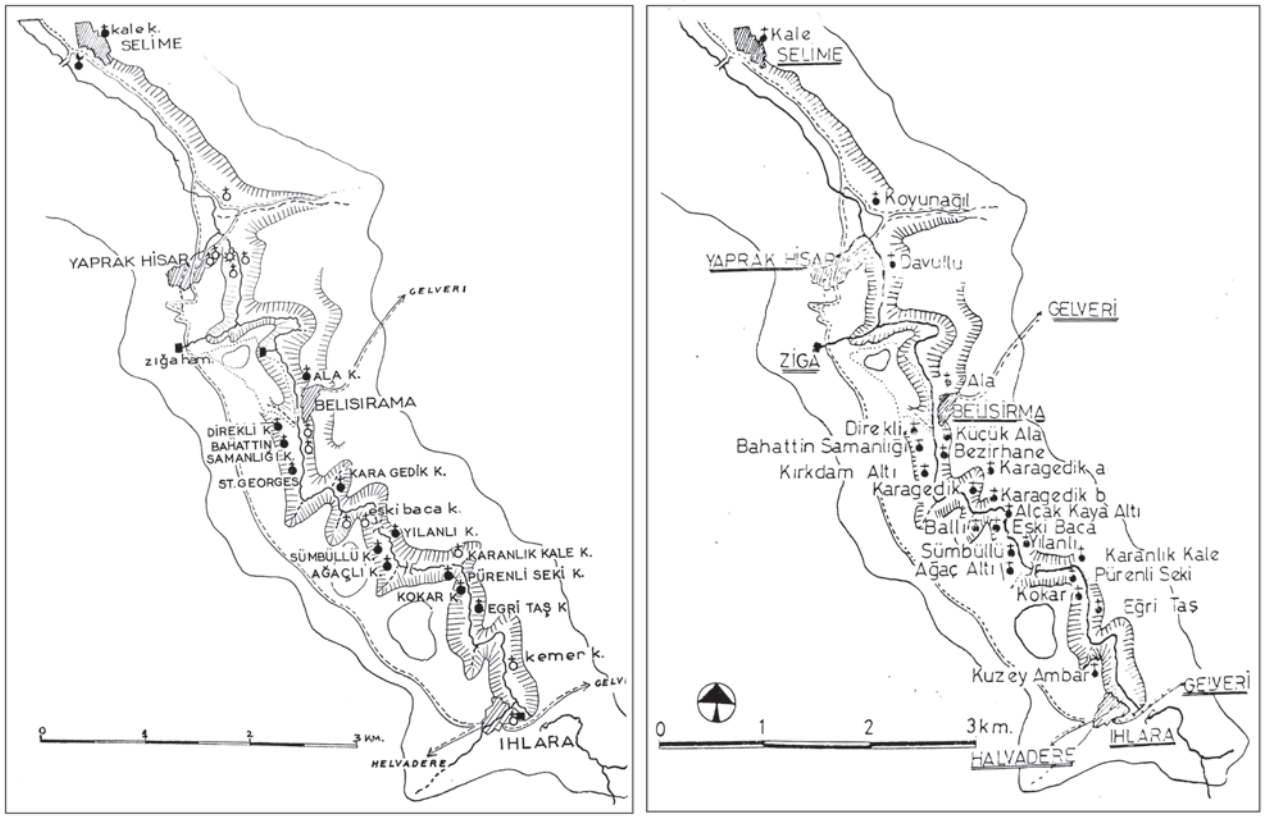

Fig. 8. Peristrema Valley plans (left Thierry & Thierry 1963; right Ötüken 1989)

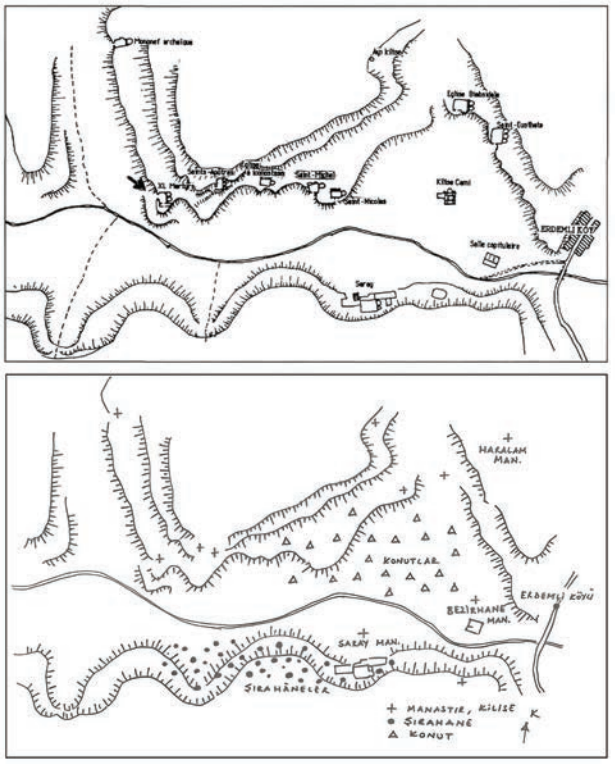

Fig. 9. Erdemli Valley plans (up Thierry 1989; below Karakaya 2003 and 2004)

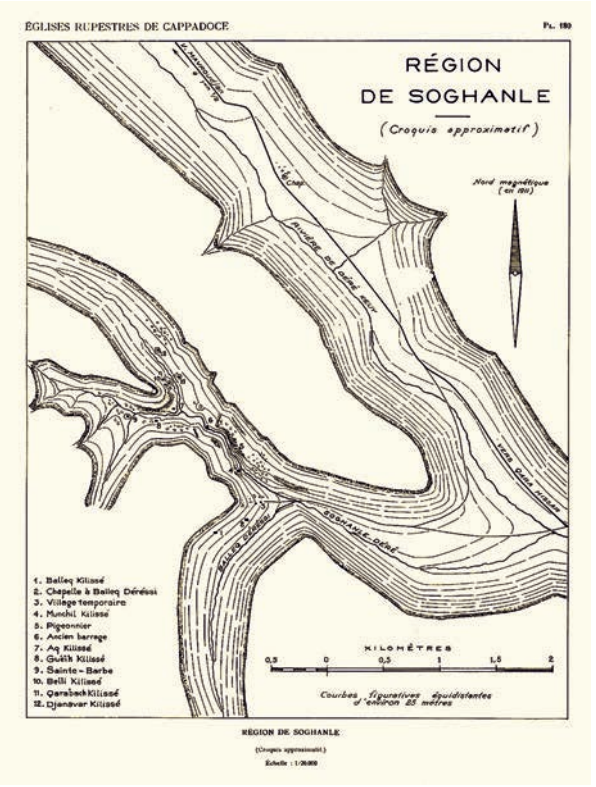

Fig. 10. Plan of Soğanlı Valley (Jerphanion 1932)

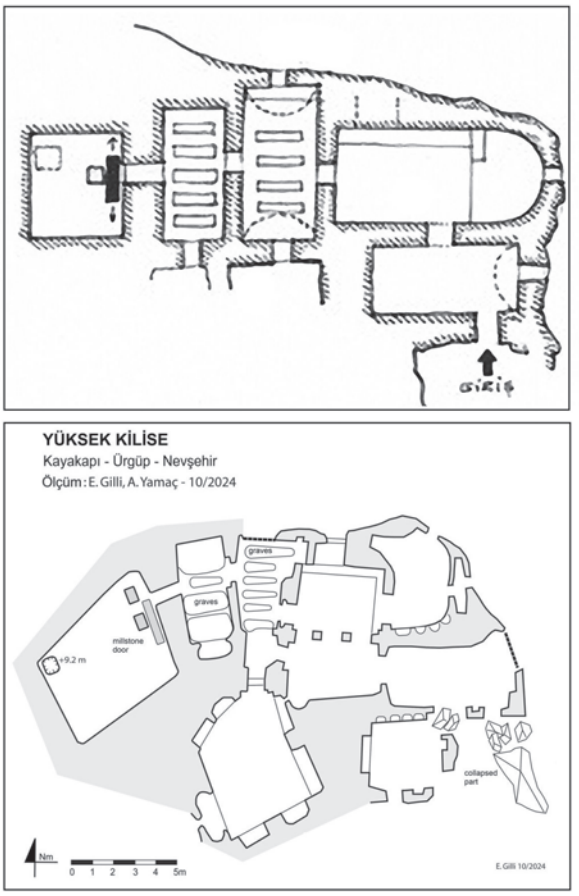

Fig. 11. Yüksek Kilise plans; up Pekak (Pekak 2014), below E. Gilli and A. Yamaç (Yamaç et al. 2025)

Conclusion

Even today, Cappadocia still lacks detailed surveyed maps or a comprehensive database. Meanwhile, scholars are occupied composing articles on a detail in a specific church fresco. However, if that church collapses by a rockfall tomorrow, its position will become unknown. Just as we don't know the whereabouts of the churches mentioned by ancient travelers in Ötüken's inventory, now lost.

How can a structure be preserved without a map, plan, or even an inventory? How will Cappadocia be passed on to the future? Or, with the title of Ousterhout's article; *"What kind of Cappadocian future do we imagine?"*

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CATEGORIES AND TYPES OF ARTIFICIAL CAVITIES: UPDATES

HYPOGEA
TBILISI•2026

History, Architecture and Socio-Economical Features of Artificial Cavities in the Southern Apennines Hydrographic District (Italy)

Maria Assunta Fabozzi[1], Francesca Lagna[2], Isabella Serena Liso[2], Sandro Muscillo[2], Mario Parise[2], Piernicola Lollino[2], Luca Comegna[1], Emilia Damiano[1], Maria Petriccione[3], Giuseppina Mello[1], Gennaro Capasso[4], Vera Corbelli[4], Daniela Ruberti[1*]

[1] Engineering Department, University of Campania "Luigi Vanvitelli", Aversa, Italy; mariaassunta.fabozzi@unicampania.it; luca.comegna@unicampania.it; emilia.damiano@unicampania.it; giuseppina.mello@unicampania.it; daniela.ruberti@unicampania.it
[2] Earth and Environmental Sciences Department, University of Bari Aldo Moro, Bari, Italy; franc.lagna@gmail.com; serenaliso.uniba@gmail.com; sandromuscillo@libero.it; mario.parise@uniba.it; piernicola.lollino@uniba.it
[3] Department of Historical, Geographical Sciences and the Ancient World, University of Padova, Italy; maria.petriccione@unipd.it
[4] Autorità di Bacino Distrettuale dell'Appennino Meridionale, Caserta, Italy; vera.corbelli@distrettoappenninomeridionale.it; g.capasso@distrettoappenninomeridionale.it
[*] Corresponding author: daniela.ruberti@unicampania.it

Abstract
The hydrographic district of the Southern Apennines, managed by the Autorità di Bacino Distrettuale dell'Appennino Meridionale (AdB-DAM) in southern Italy, encompasses an area of approximately 67,500 km^2 where the subsoil hosts a remarkable variety of artificial cavities. These underground spaces, excavated through different historical phases into lithologically heterogeneous substrates, present a dual condition: an active geological hazard, since the deterioration of pillars and vaults may trigger sinkholes propagating to the ground surface, and a cultural heritage of considerable value for territorial regeneration. A scientific cooperation agreement between the AdB-DAM, the Department of Earth and Environmental Sciences of the University of Bari and the Engineering Department of the University of Campania Luigi Vanvitelli has supported a three-year project addressing the recognition and management of these cavities at District scale. The work has produced a relational GIS database, a typological classification consistent with the UIS standard and a tiered hazard assessment procedure that integrates geometrical and geomechanical parameters with the chronology of historical sinkhole events. The results indicate the convergence of two long-standing research lines, geological hazard evaluation and historical-architectural documentation, within an operational framework suitable for risk mitigation policies and heritage valorisation strategies at the regional level.

Keywords: underground quarries, subsoil instability, sinkhole hazard, GIS database, cultural heritage

Introduction

Artificial cavities are a widespread component of the Italian subsoil and document a long history of human adaptation to the geological substrate (Parise et al. 2013; Vigliotti et al. 2023). In southern Italy their distribution is particularly dense, in response to litho-stratigraphic conditions that favoured the extraction of building materials and the excavation of stable underground spaces. Tuffaceous rocks of the Campanian volcanic districts, the Calcarenite di Gravina Formation along the Bradanic foredeep and various calcarenitic-tuffaceous units of the Apulian and Lucanian territory, among others, share workability and self-supporting capacity, properties that have been exploited since at least the Roman age (Andriani and Walsh 2002; Bonomo et al. 2019).

The progressive expansion of urban fabrics during the last two centuries has often sealed the surface evidence of these cavities, transferring them to the realm of forgotten heritage. The result is a twofold condition. On the one hand, abandoned and undocumented underground spaces represent a geological hazard, since the deterioration of pillars and vaults may evolve into sinkholes (Gutierrez et al. 2014; Parise 2019, 2022) that propagate to the ground surface (Parise and Lollino 2011; Liso et al. 2023; Ruberti et al. 2025). On the other, the same spaces preserve material evidence of past extractive techniques, water supply infrastructures and worship practices that may sustain cultural and touristic regeneration of marginal urban areas (Garofano and Govoni 2012; Margiotta and Sansò 2017; Varriale 2021; Ruberti et al. 2024; Damiano et al. 2024).

Within a three-year project funded by the Southern Apennines River Basin District Authority (Autorità di Bacino Distrettuale dell'Appennino Meridionale, AdB-DAM), a multidisciplinary research effort has been un-

dertaken to provide a unified framework for the recognition, characterization and risk assessment of artificial cavities across the District. The present contribution synthesises the methodological structure of the project and discusses the architectural variability, the hazard implications and the heritage value of the surveyed sites, with reference to representative case studies.

The Southern Apennines hydrographic district

The Southern Apennines Hydrographic District (DAM), established by Legislative Decree 152/2006 implementing the EU Water Framework Directive, covers approximately 67,500 km² and includes seven regions: Abruzzo (partially), Basilicata, Calabria, Campania, Lazio (partially), Molise (partially) and Puglia. The territory hosts about 13 million inhabitants, 25 provinces and more than 1,600 municipalities. The hydrographic network extends for around 31,000 km and the coastline reaches 2,500 km along both the Tyrrhenian and the Adriatic-Ionian sides, making the DAM the most extensive coastal district in Italy (Fig. 1). Major river basins include Liri-Garigliano, Volturno, Sele, Bradano, Sinni-Noce, Fortore and Biferno.

The geological framework is heterogeneous and reflects the tectonic evolution of the Apennine system and its interaction with the adjacent foreland domains (Fig. 2). The territory includes mountainous sectors, hilly landscapes and extensive alluvial and intermontane plains.

The dominant morpho-structural element of the District is represented by the Apennine chain, which develops along a NW–SE direction and acts as the main watershed between the Tyrrhenian and Adriatic drainage systems. The geological framework is mainly composed of Mesozoic carbonate successions associated with flysch deposits and marly–arenaceous–clayey units, while crystalline rocks of metamorphic and igneous origin crop out locally within the Calabrian sector, particularly in the Sila and Aspromonte massifs (Vezzani et al. 2010; Bucci et al. 2021). The structural evolution of the Apennine chain generated a complex arrangement of tectonic and stratigraphic units, leading to pronounced heterogeneity in lithological properties and permeability conditions. Such variability exerts a primary control on groundwater circulation patterns and on the development of hydrogeological systems at both local and regional scales. Moreover, the predominance of clay-rich and marly deposits in several sectors of the District frequently promotes slope instability and landslide phenomena (Loche et al. 2022). From the perspective of artificial cavity occurrence and distribution, some lithological domains are particularly significant. Extensive volcanic deposits in northern Campania, generated by the Roccamonfina, Somma–Vesuvius and Phlegraean Fields volcanic districts, include thick successions of pyroclastic and volcaniclastic materials, such as Campanian Ignimbrite and Neapolitan Yellow Tuff, which have historically represented highly workable geological materials suitable for underground excavations (De Vivo et al. 2019; Vigliotti et al. 2023; Ruberti et al. 2024). A further volcanic contribution is represented by the Mt. Vulture district in northern Basilicata (Schiattarella et al. 2005).

Other geological settings particularly favourable to hypogeal excavation include the Plio–Pleistocene calcarenitic formations of the Bradanic foredeep and the carbonate platforms of the Apulian foreland, where lithological characteristics facilitated both quarrying activities and the development of underground spaces (Andriani and Walsh 2002; Di Giacomo et al. 2018; Fiore et al. 2018; Bonomo et al. 2019). In these contexts, the interaction between natural geological features and anthropogenic excavation processes has contributed to the widespread development of underground systems with considerable variability in geometry, function and stability conditions. Overall, the geological complexity of the District, combined with the contrasting geomechanical behaviour of the different lithologies, strongly influences the spatial distribution and evolution of artificial cavities and represents a key factor for understanding both their hazard implications and their cultural and territorial significance (Parise and Lollino 2011; Fabozzi et al. 2023).

Multidisciplinary approach and database structure

The project adopts a multidisciplinary protocol that integrates geological, geotechnical, archaeological and architectural data. The protocol, designed for application across the entire District, has been calibrated on a sequence of case studies in the Campania and Apulia regions, the two areas with the most extensive knowledge bases in the District, which served as methodological benchmarks and as repositories of typological information (Di Giacomo et al. 2018; Fiore et al. 2018; Vigliotti et al. 2020; Ruberti et al. 2020; Damiano et al. 2023). The protocol foresees three operational phases.

The first phase consists of archival and bibliographic research. Historical cadastral maps, technical reports of local administrations and civil engineering archives are systematically searched in order to retrieve memory traces of underground spaces. This phase is particularly relevant for cavities located beneath religious buildings, where ecclesiastical archives often preserve information about ossuaries, crypts and burial chambers that have been subsequently sealed (Damiano et al. 2023; Ruberti et al. 2024).

The second phase combines topographic survey, photogrammetric documentation and geotechnical char-

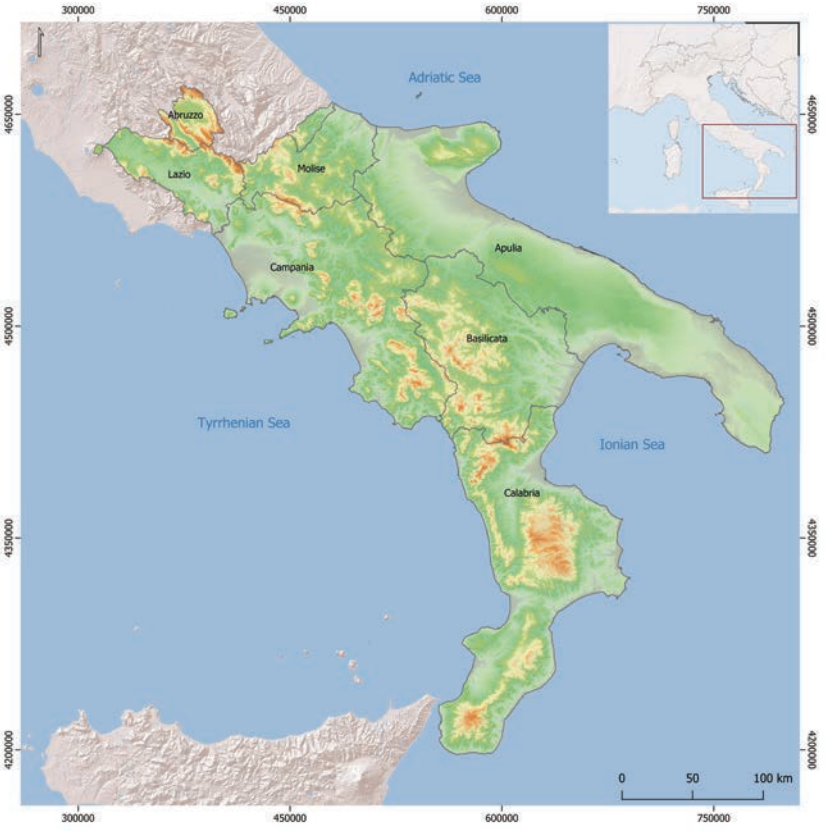

Fig. 1. Study area. Metric coordinate system in EPSG:32633 (WGS 84 / UTM zone 33N)

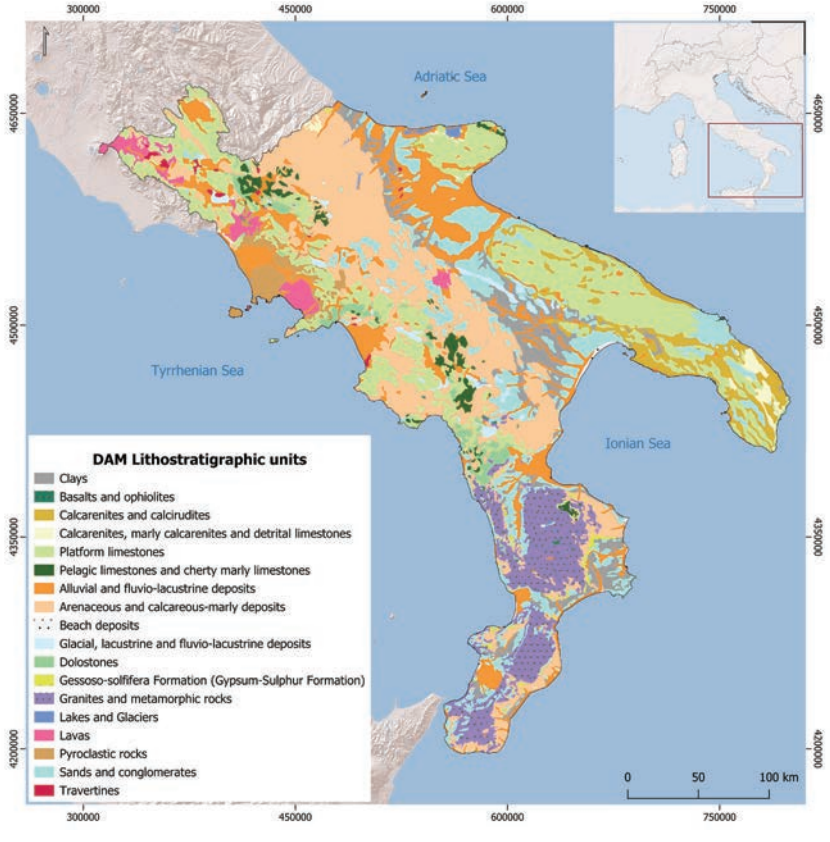

Fig. 2. DAM Lithostratigraphic map. Metric coordinate system in EPSG:32633 (WGS 84 / UTM zone 33N)

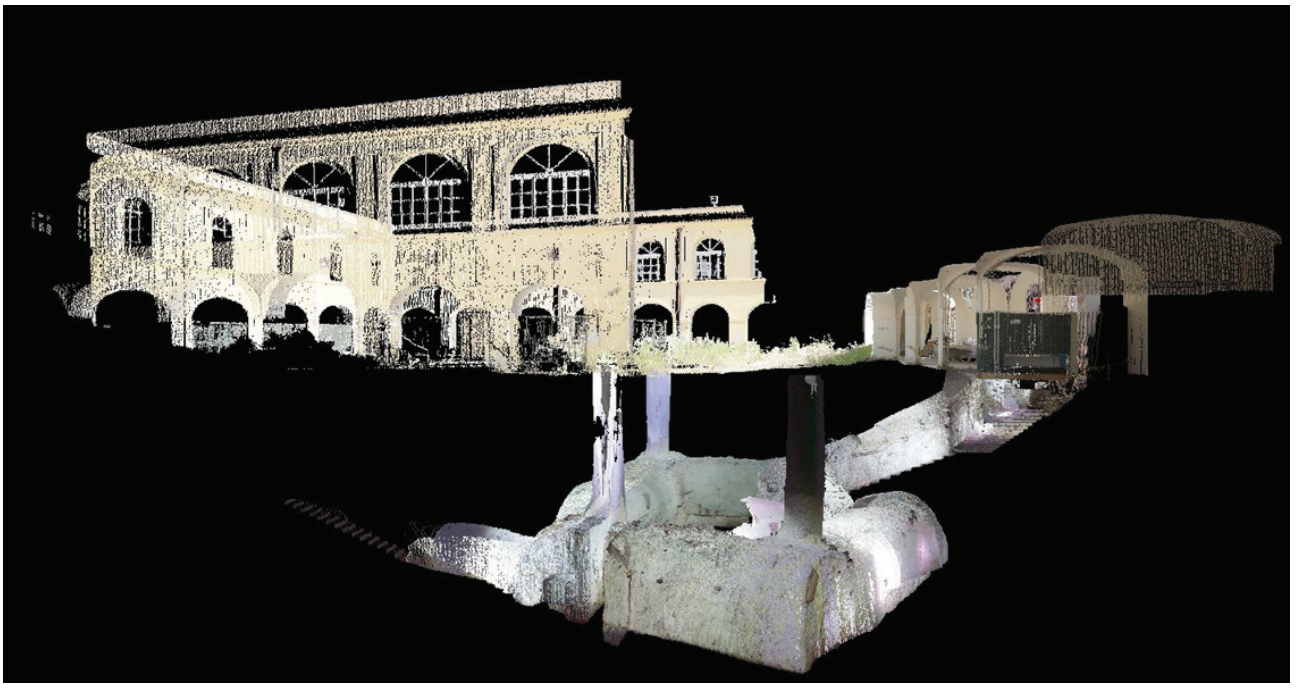

Fig. 3. Processing of the laser scanner survey of the cavities located beneath the Cloister of the Sant'Agostino complex (Caserta)

acterization of the cavity. Three-dimensional models of the cavity geometry are generated through Structure-from-Motion procedures or terrestrial laser scanning, depending on accessibility and lighting conditions (Fig. 3). Geomechanical surveys of the rock mass include the assessment of discontinuity patterns, the evaluation of weathering processes and the identification of structural anomalies that may compromise stability (Margottini et al. 2016; Di Giacomo et al. 2018).

The third phase consists of the integration of the collected data within a Geographic Information System. The District-wide database, developed within the project, organises spatial layers of cavity location, lithological context, urban land use and historical sinkhole occurrences (Vigliotti et al. 2020; Liso et al. 2023) (Fig. 4). This relational structure allows the cross-referencing of geological, architectural and historical attributes and supports the production of hazard zonation maps consistent with the planning needs of the AdB-DAM (Fabozzi et al. 2023; Ruberti et al. 2025).

Architectural variability of the cavities

The architectural variability of the catalogued cavities is organised according to the typological tree of the UIS Commission on Artificial Cavities (Parise et al. 2013), which provides a hierarchical reference for the classification of underground spaces by original function. Within this framework the District inventory is mostly dominated by four branches, namely underground quarries, cavities beneath places of worship, hydraulic works and refuge or defensive spaces. Each typology reflects the original function and the lithological context (Vigliotti et al. 2023; Fabozzi et al. 2023). The geometry of the cavities is described through a set of recurrent descriptors that support both the typological reading and the stability assessment, namely the plan pattern of the excavation, the characteristic span of the rooms, the width and spacing of the pillars and the thickness of the overburden that separates the void from the ground surface (Parise and Lollino 2011). The ratio between room span and pillar width, together with the overburden thickness, governs the redistribution of stresses around the void and therefore the propensity to instability, a relation that links the architectural reading of each typology to its hazard implications (Parise and Lollino 2011; Fabozzi et al. 2023).

Underground quarries represent the dominant category in the Campanian volcanic district. The tuff was extracted from the subsoil through galleries with pillars-and-rooms geometry, exploiting the workability of the rock while preserving the surface for agricultural or urban use. Pillar widths in the Campanian volcanic district typically range between 2 and 5 m, with room spans up to 10 m and overburden occasionally below 5 m. In the Bradanic and Apulian context the extractive cavities are carved into the Calcarenite di Gravina Formation and locally generate stratified rupestrian landscapes, where the quarry and the dwelling functions are difficult to separate stratigraphically (Di Giacomo et al. 2018; Bonomo et al. 2019).

Cavities beneath places of worship constitute a thematic subset that has been the focus of dedicated investigations (Damiano et al. 2023; Ruberti et al. 2024). Crypts,

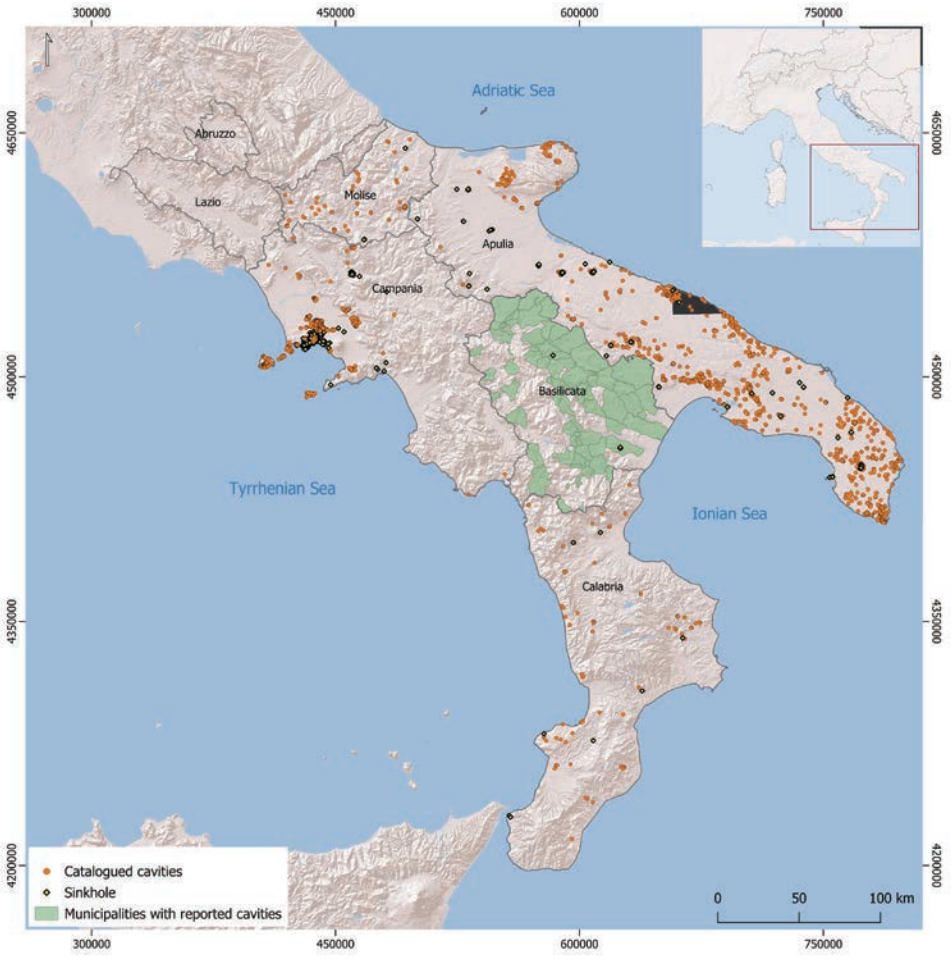

Fig. 4. Catalogued cavities and sinkhole. Metric coordinate system in EPSG:32633 (WGS 84 / UTM zone 33N)

ossuaries and burial chambers were excavated immediately below the church floor and often reused pre-existing extractive voids. The historical development of the monumental complex of San Francesco le Moniche in Aversa documents the sequence of overlapping functions, from monastic cellar to liturgical hypogeum to forgotten infrastructure (Ruberti et al. 2024). The case of Sant'Agostino in Caserta extends the same interpretative scheme to a cloister context, where the artificial cavity acted both as a storage facility and as a hydraulic node of the convent (Damiano et al. 2024).

Hydraulic cavities form a third category, including wells, cisterns, distribution galleries and drainage channels.

Refuge and defensive cavities, finally, are documented in several inland sectors of the District and include shelters carved during conflict periods, in particular during the Second World War. Their morphology is irregular and adapts to existing fractures or pre-existing voids, with limited engineering investment.

Cultural heritage and territorial valorisation

Beyond the hazard dimension, the catalogued cavities constitute a heritage corpus of considerable value for the cultural and socio-economic profile of the District. The artificial cavities preserve material evidence of past extractive technologies, of liturgical practices and of water management strategies that are no longer visible at the surface. The integration of geological and cultural perspectives, proposed in the framework of geoheritage and geotourism, allows the reinterpretation of the cavities as nodes of a wider territorial narrative (Ruberti et al. 2024).

The valorisation strategies adopted in selected case studies suggest a viable path. The same documentation acquired for hazard assessment may be redirected towards heritage interpretation, with limited additional effort and significant cultural return, as the Campanian case studies of San Francesco le Moniche in Aversa and

the cloister of Sant'Agostino in Caserta demonstrate (Ruberti et al. 2024; Damiano et al. 2024).

The economic implications of this approach are particularly relevant for the inland and minor urban centres of the District, where the demographic decline and the limited industrial development require alternative development trajectories. The activation of itineraries based on the underground heritage may sustain local employment in the conservation, restoration and tourism sectors, contributing to the resilience of communities that often coincide with the areas of highest geological hazard.

Conclusions

The work carried out within the project funded by the Southern Apennines River Basin District Authority has produced a District-wide framework for the recognition, characterization and management of artificial cavities. The framework rests on a multidisciplinary protocol, on a relational GIS database and on a tiered hazard assessment procedure that integrates geometrical, geomechanical and historical information.

The architectural variability of the catalogued cavities reflects the lithological heterogeneity of the seven regions of the District and the long temporal range of underground occupation, from the Roman age to the twentieth century. The classification in main typologies, including underground quarries, cavities beneath places of worship, hydraulic infrastructures and refuge spaces, provides an operational reference for further cataloguing activities and for cross-regional comparison.

The dual nature of the artificial cavities, as geological hazard and as cultural heritage, emerges as a defining feature of the District. Hazard mitigation and heritage valorisation share the same documentation basis and benefit from a coordinated approach. Future research will extend the database to under-investigated sectors of the District, including inland Calabria and the Molise foothills, and will deepen the analysis of climate change effects on the long-term stability of weak-rock cavities.

Acknowledgements

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The Sculpture Cave of Dénezé-sous-Doué (Maine-et-Loire / France): First Analysis of Sculptures Detached from the Walls

Luc Stevens

Avenue des bergeronnettes, 17
1420 Braine l'Alleud, Belgium
E-mail: troglo21@yahoo.fr

Abstract

In the heart of Anjou, the commune of Dénezé-sous-Doué contains a veritable jewel of popular art. In the center of the village, the wall of an artificial cave are carved with more than 300 sculptures, probably dating from the second half of the 16th century.
The panels depicts scenes of life such as maternity and childbirth, but also more obscene scenes. In the middle of this "crowd of characters", we also note the presence of musicians, strange Indians wearing their feather headdresses, some phantasmagorical animals, or even a strange Pieta that seems to address a criticism against the ruling power.
Despite numérous researches since the rediscovery of this site in the years 1970, nobody has ever studied in details the sculptures that were not attached to the wall of the cave and that were stored in the reserve of the local musuem without any inventory after the excavation works.
After a general introduction on the cave and on the scene represented on its wall and on thee history and hypothsis regarding this use of the cave, the paper will present for the first time the main sculptures that were rediscovered in the reserve of the museum and will draw some preliminary lessons these newly studied sculptures can bring to the history of this cave.
The paper will also present a methodology currently being developed in the region that uses scanning electron microscopy coupled with X-ray fluorescence to distinguish different types of tufa. This enables the identification of calcite, saltpetre and gypsum, either alone or in combination, depending on the samples. This non-destructive technique involves taking a few milligrams from the surface and could eventually enable a comparative study of the chemical composition of the cave's pillars and walls and the detached sculptures. If successful, this methodology could help identify which panels the detached sculptures were originally attached to.
Unfortunately, 70 years after its rediscovery, this unique work in Europe is in danger of disappearing. The sculptures are cracking, disintegrating; others are eaten away by humidity which attacks the stone from the inside. The paper will also present the most recent works done in order to save the sculptures.

Keywords: Carved cave, sculpture, tuffa, XVIth century, inventory

Introduction

The Loire Valley, inscribed on the UNESCO World Heritage List in 2000, constitutes a major cultural landscape combining castles, historic urban centres, and cultivated land shaped by long-term interactions between human activity and the natural environment. On the south bank of the Loire, the village of Dénezé-sous-Doué is home to a cave unique in Europe. Its walls are covered with more than 300 sculptures, arranged in a dense and continuous figurative programme, generally attributed to the late Renaissance.

This article forms part of a broader research project on the Sculpture Cave of Dénezé-sous-Doué. Its objectives are, first, to consolidate the available knowledge concerning the site and, second, to document the need for enhanced safeguarding of a monument currently threatened by alterations (crystallizations, salt efflorescence, algae, etc.) which progressively damage the sculpted surfaces.

1. Geographical and Geological Context

The village of Dénezé-sous-Doué is located about fifteen kilometres west of Saumur. The presence in the subsoil of tufa (soft Upper Cretaceous chalk), which is easy to excavate, encouraged the digg ing–both in the village and throughout the region – of numerous troglodyte dwellings, underground quarries, and other anthropogenic underground developments.

2. Rediscovery of the Site

At the time of its rediscovery in 1956, the cave was almost entirely collapsed. Guided by the writings of the local archivist Célestin Port (1876), Jeanne and Camille Fraysse identified several sculptures in a shaft that had largely been backfilled. Their discovery was followed, in the 1970s, by major clearance operations that revealed several hundred high-relief sculptures carved into the tufa walls of the cavity.

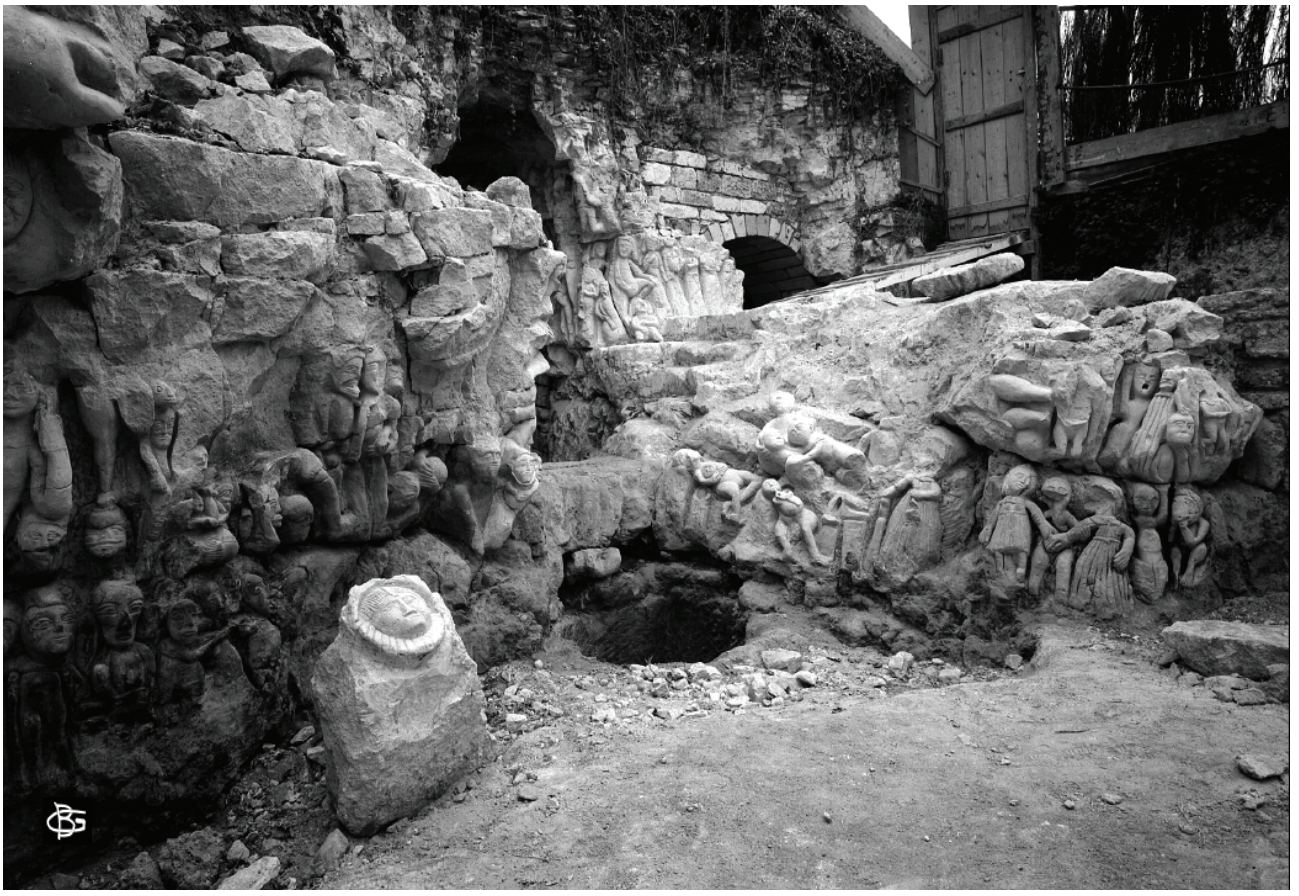

Fig. 1. Works during the rediscovery of the site in the 1970s (photo B. Gacogne)

Of these roughly 400 sculptures, approximately three quarters are still present in the cave and /or connected to the tufa bed, adorning the rocky walls of the cave. The remaining quarter consists of pieces that detached from the walls during the collapse of the cave. Most of these fragments were stored in crates and set aside, receiving only limited attention from scholars.

The sculpted area covers an approximately 20-metre by 9-metre space. Its collapsed vault was replaced in 1982 by a concrete slab supported by several pillars. This sculpted area adjoins an underground quarry in which two ovens are also found: one for baking bread and the other for drying fruit (Fig. 1).

3.Themes Depicted

Carved in the round, the figures in the Sculpture Cave intertwine and nestle into every nook and cranny to form a dense figurative ensemble carved into the tufa. The sculptures are conventionally grouped into nine panels (A to I) on the different walls of the cave. Rather than attempting an exhaustive presentation of each panels[1], this section presents the main thematic groupings that can be observed within the cave. Such thematic organisation necessarily involves interpretation, but it provides a synthetic overview of the cave. Questions of dating and broader interpretation are addressed in the following sections (Fig. 2).

3.1. The cycle of life

Several scenes may be interpreted as referring to the cycle of life. One scene evokes a kind of **wedding** and shows a man holding by the arms two figures who are holding hands. A second scene alludes to the **consummation of the marriage**, with two reclining embracing figures accompanied by a third figure who seems to bring their heads closer together. Further on, a naked female figure with a large belly evokes a **pregnant woman**, while another scene–with a woman lying down and nude, holding in her arms a child dressed in a long pleated robe–evokes **childbirth** and **baptism**. On the opposite panel, a couple in which the **woman breastfeeds a child** completes this sequence of motifs associated with the cycle of life (Fig. 3).

1 For a more detailed description of the sculptures and panels, see Stevens 2023.

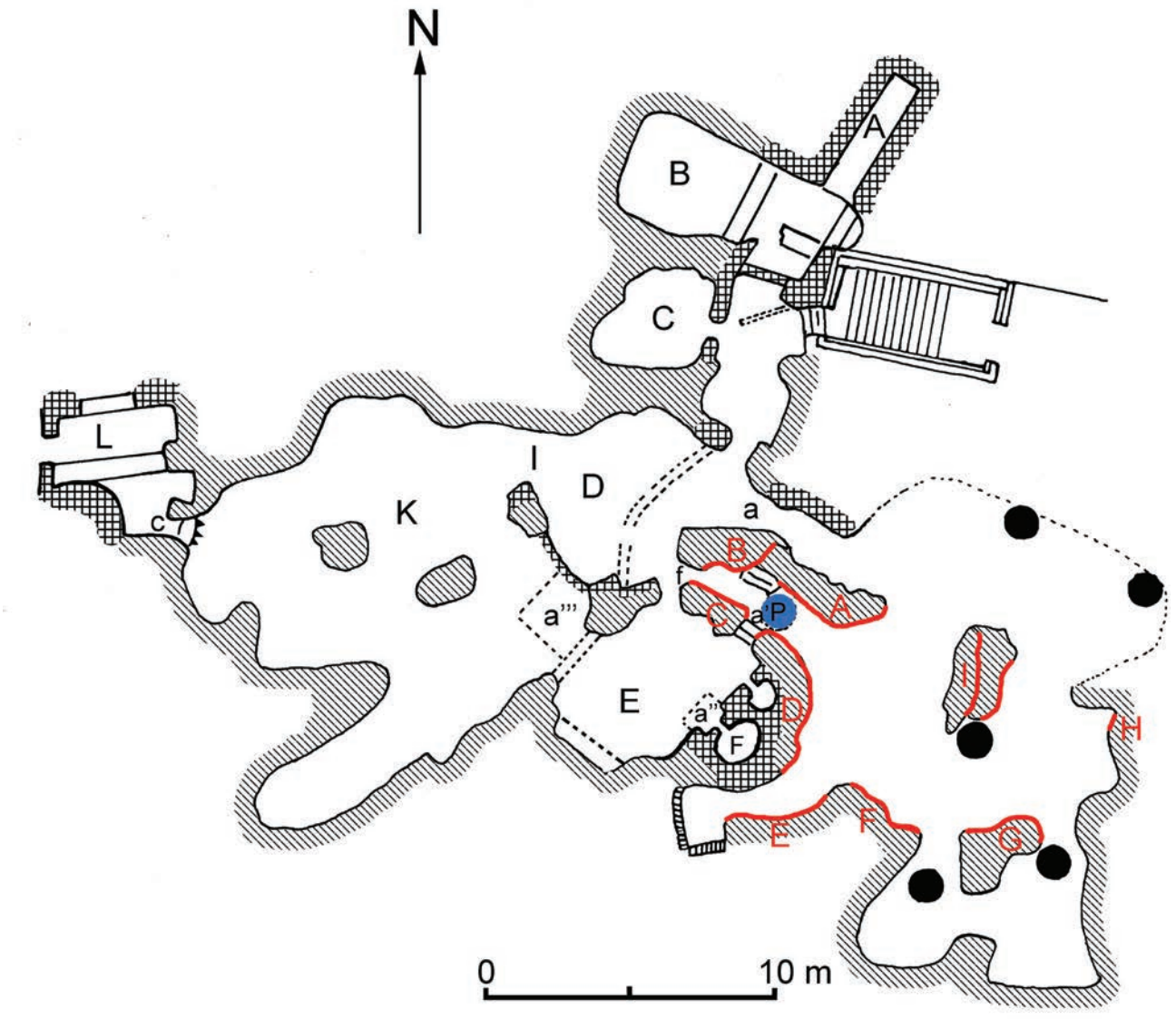

Fig. 2. General plan of the Sculpture Cave. The sculpted panels are shown in red (plan L. Stevens, after Mauny and Brethon)

3.2. Musicians and dance scenes

Several musicians are represented on the cave walls, with three principal instrument types identifiable in the corpus: the bagpipe, the mandore, and the oboe. Two dance scenes may be considered in relation to these musical representations and suggest the role of festive or performative motifs within the iconographic programme.

3.3. Fantastic animals

Although the vast majority of sculptures represent human figures, a smaller group depicts hybrid or anthropomorphic creatures. These include two serpent heads with human features, a monkey-like figure with human facial traits wearing a pleated garment, and a creature combining an animal body with a human head.

3.4. Sexual scenes

Many figures are represented nude, and several scenes include gestures that may be interpreted as sexually explicit, notably figures touching their own lower abdomen or that of an adjacent figure. Garments leaving the breasts uncovered are also present. It should be noted, however, that male and female genitalia are only rarely rendered in an explicit manner. Within this corpus, the sexual dimension appears to derive primarily from gesture and some bodily interaction rather than from nudity alone.

3.5. Typical figures

Several typical figures can be identified. Several figures wearing feather headdresses recall **Native Americans**. Figures wearing crosses, rosaries, or long, loose

Fig. 3. View of the "wedding" on Panel A of the cave (photo L. Stevens)

garments may indicate the presence of **ecclesiastical figures**. In addition, also includes more singular motifs, such as a **recumbent figure**, a possible **cephalophore** (i.e., a beheaded saint carrying his own head), a **pipe smoker**, a **gagged** figure, etc.

3.6. Figures with characteristic clothing

Many figures wear distinctive garments that may reflect either social differentiation or contemporary fashion at the time when the sculptures were produced. These garments, whether smooth or pleated and sometimes furnished with buttoning or collars, include long and short robes, occasionally tied at the waist with a cord or belt whose ends are sometimes clearly represented. Some figures wear a cape or cloak, while others display a necktie or jabot. As the feet are rarely represented, footwear is almost absent, with the exception of one male figure wearing boots. The presence of the ruff, a pleated collar surrounding the neck, indicates the representation of dress forms associated with elite social groups. Other garments are more unusual, notably short-legged breeches (*haut-de-chausses*) leaving the lower legs visible and apparently worn by some female figures. Likewise, several garments expose the breasts. Finally, some female figures wear a ribbon falling vertically over the forehead. Taken together, these clothing elements constitute important indicators for the chronological assessment of the ensemble (see section 4. Dating) (Fig. 4).

3.7. A strange *Pietà*

Panel C comprises approximately thirty figures organised around a central scene with four larger figures, a composition that has often been compared to a *Pietà*.

At the centre of the panel, two main figures sit side by side: a bearded man and a woman with bare legs holding a reclining figure on her knees. She wears a headdress with a vertical ribbon hanging down over her forehead (a widow's ribbon). To the left of this couple, a seated child also supports the lying figure. To the right, a large standing figure, whose torso and head have disappeared, holds a large axe in his right hand and gives his left hand to a child.

Since the discovery of this panel in 1963 by Dr Gruet, researchers have drawn comparisons with representations of the *Pietà*, although several features depart from canonical iconography: the cross is replaced by an axe; the recumbent figure is not clearly dead, since he grasps the woman's arm; and the female figure displays bare legs. A. Brethon has proposed that the panel may constitute a political caricature in which the woman represents Catherine de' Medici, the seated man the Duke of Guise, and the reclining figure the dying king Fran-

Fig. 4. Woman wearing "*haut-de-chausses*" that also reveals her breasts (photo L. Stevens)

cis II. This interpretation is based on a sixteenth-century polemical text, *Le réveille-matin des Français et de leurs voisins* (The Wake-up Call for the French and their Neighbours), which recounts an episode dated to 1560, during the brief reign of Francis II (1559–1560). Following the Conspiracy of Amboise (aimed at kidnapping King François II), led by Protestants and foiled by the Guise, the repression of Protestants was severe. Pope Pius IV, a Medici, pleased with this good example set by France, sent a work by Michelangelo to his niece, Catherine de' Medici, as thanks. It was the preliminary drawing for the famous *Pietà*. However, the original drawing of the *Pietà* was altered on its way to the French court. According to the text consulted at the Bibliothèque nationale de France: "*The Cardinal of Lorraine [Cardinal de Guise], the Queen (his niece), the Queen Mother and the Duchess of Guise were depicted in the nude, with their arms around each other's necks and their legs intertwined*." Whilst the panel does indeed allude to Michelangelo's *Pietà*, the painting presented at Blois seems to differ from it in several respects: the axe in place of the cross is not mentioned; the Duchess of Guise is not depicted at Dénezé... Nevertheless, the political caricature and the tenor of the message against those in power appear identical in both cases (Fig. 5).

Fig. 5. Panel of the strange *Pietà* (photo L. Stevens)

4. Dating

No written source referring unambiguously to the sculptures of the Dénezé cave is currently known before the nineteenth century. Historical texts mention the Mousseaux caves on several occasions, but in the absence of any explicit reference to sculpture this designation remains too imprecise, especially given the long-standing presence of numerous caves and troglodyte sites in Dénezé. Because the presbytery constituted one of the accesses to the Sculpture Cave, this building is of particular importance for tracing earlier references to the site. Several seventeenth-century archival mentions of a cave near the presbytery have been identified, but they do not provide sufficient detail to establish with certainty that the Sculpture Cave is meant rather than another cave in the village. A twelfth-century papal bull refers to the *capella de Caverno* at Dénezé (Lécuyer 2018), but, again, the absence of any clear reference to sculpture prevents secure identification with the present site.

Since the first mention of the cave in 1876 and its rediscovery in the twentieth century, various chronological hypotheses have been proposed. The study conducted by A. Brethon (1996), based on costumes, musical instruments, and figure types, has provided the principal argument for dating the sculptures to the second half of the sixteenth century. This dating is currently regarded by many specialists as the most plausible. The **three main types of instruments** (bagpipes, mandore, and oboe) may reflect the diffusion of Italian Renaissance influences in France after the Italian Wars. **Certain clothing elements** are also characteristic of this period:

"Valois-style bosom-baring" known as "Venetian style", consisting of a neckline that left the breasts bare, was a fashion that appeared at the court of Charles IX from 1561 and was notably adopted by Diane de Poitiers.

"The ruff", a collar made of pleats placed around the

Fig. 6. Figure wearing a ruff and the widow's ribbon

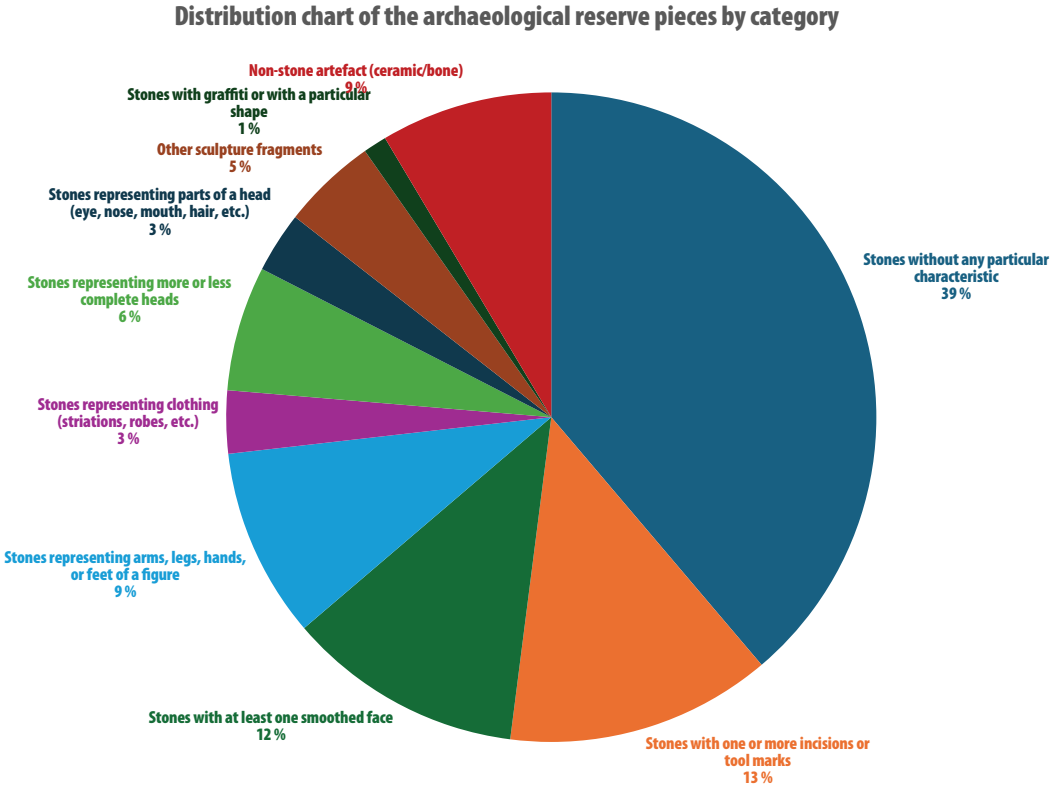

Fig. 7. Distribution chart of the archaeological reserve pieces by category

Fig. 8. Figure with prominent facial features (R393) (photo L. Stevens)

Fig. 9. Graffiti still awaiting decipherment (R1371) (photo L. Stevens)

neck, spread after the return from the Italian Wars and remained fashionable until the seventeenth century.

Vertugadins (farthingales) are rounded frameworks, or padding, worn in the sixteenth and seventeenth centuries around the waist to puff out the skirt.

Women's drawers, modelled on men's *haut-de-chausses* and fitted with straps, are an invention of Venetian origin that was introduced in France by Catherine de' Medici.

The widow's ribbon was worn by Catherine de' Medici from 1560 onward in order to distinguish herself from her rival Diane de Poitiers, mistress of the late king, who ostentatiously displayed mourning.

Pleated *haut-de-chausses*, tightened at the knees, were worn in the time of Francis I, Charles V, Henry II, and Charles IX.

Native Americans depicted with feathers were introduced in France, notably during festivities in Nantes (1548) and Rouen (1552). The first Native American known in Anjou was Essoméric, brought back from Brazil in 1505 by Blinot Le Paulnier de Gonneville. The **pipe smoker** also provides a chronological marker, since the introduction of tobacco in Europe dates to the end of the fifteenth century with the discovery of America in 1492.

Finally, the panel compared above with a *Pietà*, insofar as it may allude to Michelangelo's *Pietà*, can also be considered a possible chronological indicator.

Although Brethon's hypothesis remains the most persuasive at present, it cannot be regarded as definitive. The site-clearance works led to the discovery of several engraved stones indicating dates from the first half of the seventeenth century (1633, 1634), as well as a coat of arms dated 1648 on one of the cave walls (fig. 6).

5. Who excavated the Sculpture Cave, and why?

Neither the textual record nor the sculpted corpus currently provides a precise indication of the makers of this ensemble or of the intentions underlying its creation. In the absence of direct evidence, authors who have studied the cave since its rediscovery have proposed a range of hypotheses. Some are only weakly substantiated, whereas others draw on literary sources, symbolic interpretations, or the history of confraternities and religious dissent. None can presently be considered conclusive. The principal hypotheses are summarised below.

- A **pagan temple**: On the basis of panels interpreted as the cycle of life, Héron (1976) evoked, that the cave may have functioned as a pagan sanctuary centred on fertility and associated with the well.
- A **marginal confraternity or secret society**: Annie Brethon (1996) suggested that the cave may have been created by a marginal confraternity of stonemasons. This hypothesis is linked to the political and religious tensions of the second half of the sixteenth century. The Wars of Religion opposed Catholics and Protestants in a series of conflicts between 1562 and 1598 that strongly affected the Dénezé region, while the ordinance of Villers-Cotterêts (1539) prohibited confraternities of tradespeople and collective worker associations. In this context, Brethon proposed that the stonemasons of Dénezé may have formed an ecumenical and socially marginal group compelled to meet underground, where the sculpted programme would have been created.
- **Ribald peasant fantasy: Raymond Mauny wonders to what extent the cave might correspond**

Fig. 10. Animal head with clearly depicted nostrils and whiskers (R713) (photo L. Stevens)

Fig. 11. Head that has undergone restoration (R714) (photo L. Stevens)

to a *"whimsical fantasy of a mischievous, irreverent quarryman-winemaker from the late Middle Ages or the Renaissance ?"* (Mauny 1967).

- **A representation of the Diableries of Doué**: In 1975, P. Piboule drew a parallel between the representations in the Sculpture Cave of Dénezé and the Diableries of Doué (popular theatrical performances). F. Rabelais mentions on several occasions the Diableries of Doué and those of other nearby towns or surrounding regions. Rabelais judged the Doué's Diableries to be among the most "confused" in the region, notably because of the presence of many unruly students. These diableries were part of mystery plays, the most frequent of which were Passion plays[2]. Because Dénezé lies only about five kilometres from Doué, such performances may also have been known locally. In this context, the *Pietà* panel could be read as a parody of a Passion scene; hybrid creatures might correspond to theatrical costumes; and the numerous musicians would fit a performative context. Rabelais also refers to sexual excesses associated with certain diableries in the region. This hypothesis is suggestive, but it remains inferential.

6. Inventories

6.1. Objectives

The inventory programme was conducted in two phases. **The first phase** consisted of updating the detailed inventory of all sculptures still preserved in the cave. A detailed inventory had previously been prepared in 1999 by the Actions Caverne association and served here as a baseline. We revised this inventory in two ways. First, using earlier documentation, largely dating from the period of rediscovery, we added sculptures that had disappeared before 1999. Second, we supplemented the photographic corpus assembled in 1999 with new photographs taken in 2022 and with older images dating from the initial exploration of the site. This photographic documentation is essential both for recording the state of preservation of the sculptures and for assessing the progression of deterioration over time.

The **second phase** focused on the stones and sculptural fragments detached from the walls during the site clearance and subsequently stored for many years in small wooden crates. These crates were initially kept in one corner of the cave and, since 1999, in the attic of a village house now used as a heritage centre and museum associated with the cave. This is the first detailed inventory of these materials since the cave's rediscovery. Its purpose is to provide a more comprehensive view of the sculptural corpus formerly present in the cave and thereby to refine our understanding of the site.

2 In the Middle Ages, the mystery play was a dramatic genre that depicted religious subjects such as the Nativity, the Passion, the Resurrection, scenes from the Old and New Testaments, or the lives of the saints (CNRTL dictionary). These performances frequently featured devils, and the scenes in which they appeared were known as diableries. During the diablerie parades, which took place before the mystery plays, the actors playing the roles of devils would parade through the streets.

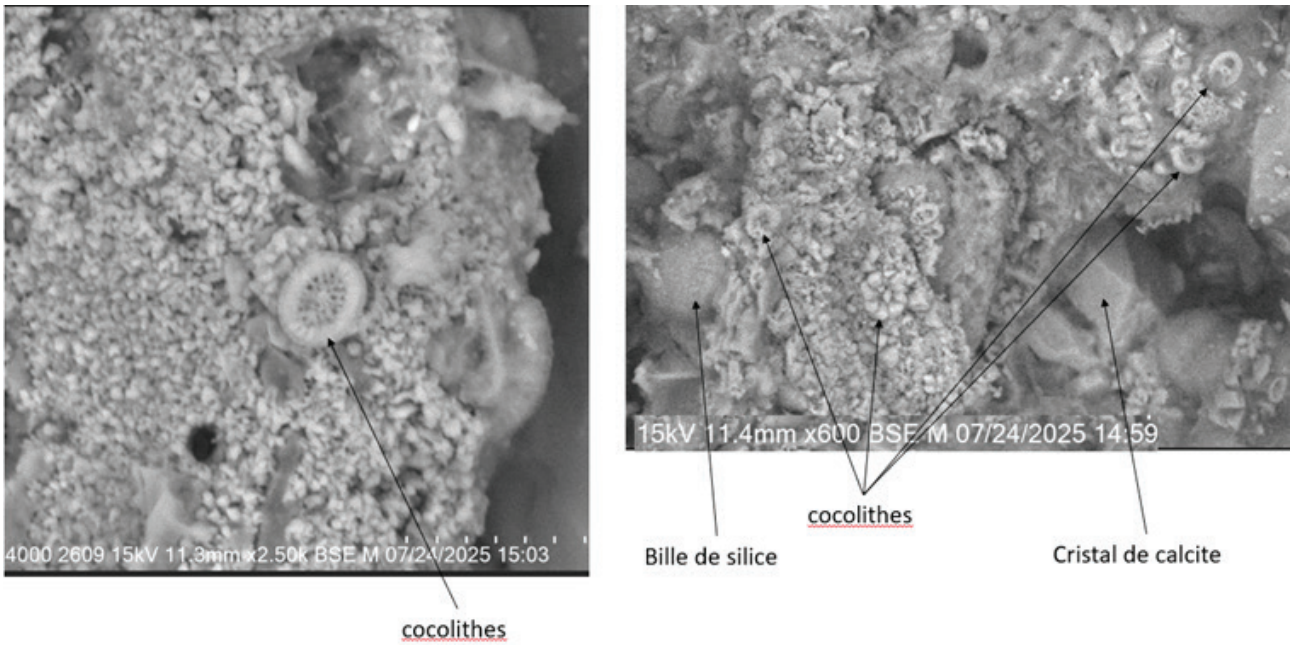

Fig. 12. Different types of coccoliths present in the cellar (photo D. Bellenot)

6.2. Methodology

For **the first inventory**, concerning sculptures still *in situ*, we retained the numbering system established by the Actions Caverne association, which uses continuous numbering within the cave and prefixes each figure number with a panel letter (for example, D68 for figure 68 in panel D). When earlier texts or illustrations justified the addition of a figure absent from the pre-existing inventory, the number of the nearest figure was retained and the suffix ".1" added (for example, D68.1). For each sculpture, we then sought older photographs dating from the period of rediscovery in order to create a comparison across three chronological points. These images were obtained from the site's discoverers, early researchers, and the archives of the SFES. This work has already been published (Stevens 2023) and is used by archaeologists, conservators, and other specialists interested in the sculpture corpus and its state of preservation.

The inventory of fragments held in the museum reserve collections had not previously been undertaken in detail. The only pre-existing record consisted of a crate inventory listing the number of pieces contained in each box. A new inventory protocol therefore had to be established. Each crate was assigned a new identifier, and each individual piece received a number prefixed by R for "Reserve". Because the original crates were in an advanced state of deterioration, the contents of each were transferred into new crates. The integrity of each crate assemblage was strictly maintained and no mixing of contents between crates was permitted. Every piece, regardless of its perceived interpretive value, was photographed at least once and generally on both faces. Fragments considered archaeologically informative were additionally photographed from several angles and under varied lighting conditions in order to document sculptural detail. Each piece was photographed at least once alongside a scale bar so that its dimensions could be recorded. Photographic files were renamed according to the inventory number followed by an index (for example, R652_3.jpg for the third photograph of item R652). A brief descriptive record was then entered for each piece in an Excel database. An inventory of the crates, together with a concordance between old and new crate numbers, was also produced. In crates containing numerous very similar pieces of limited archaeological value, grouped lots were created.

6.3. Main statistical results

The results presented here are new and provide a first view of the richness of the collections held outside the cave.

In total, 111 crates containing 1,884 pieces were inventoried[3]. These pieces are distributed across 1,372 lots. Of these 1,372 lots, 1,271 contain only a single piece or object, and the remaining 101 contain between 2 and 27 pieces, with a mean of 6 pieces per lot.

The reserve collections consist predominantly of stones originating from the cave (91%). The remaining material comprises archaeological objects, mainly ceramics and bones, recovered during works in or around the cave.

3 There are also 9 items not in a box as they are too large to fit inside one.

- The stones were categorized into nine main categories:
- Stones without any particular characteristic;
- Stones with one or more incisions or tool marks;
- Stones with at least one smoothed face;
- Stones representing arms, legs, hands, or feet of a figure;
- Stones representing clothing (striations, robes, etc.);
- Stones representing more or less complete heads;
- Stones representing parts of a head (eye, nose, mouth, hair, etc.);
- Other sculpture fragments;
- Stones with graffiti or with a particular shape (Fig. 7).

More than half of the stones are of limited archaeological value. This group consists mainly of stones without distinctive features and of stones bearing a small number of tool marks but no clearly identifiable sculptural form.

The remaining stones appear more directly related to sculptures, although their identification is not always precise. Thus, 12% of the stones have at least one smoothed face, without allowing the represented part of a figure to be determined. A further 12% correspond to body parts, 3% to clothing elements, and 5% to other sculptural fragments that cannot currently be characterised more precisely. Particularly informative are the 6% of pieces consisting of heads that are complete or nearly complete, representing 117 items. Although preservation varies considerably, these heads substantially expand the corpus available for the study of the Sculpture Cave.

In addition, 128 stones (6.8% of all pieces) bear a modern annotation, likely dating from the period when the site was rediscovered. These annotations are not always legible today, but in some cases they make it possible to link stones to their original panel, which is essential information for trying to understand the overall organization of the sculptures and the relationships between the figures.

6.4. Some notable pieces

Within the corpus, 223 pieces were selected as especially informative, either because of their state of preservation, the quality of their execution, or their potential contribution to understanding the cave. All 117 heads are included in this subset. Owing to space constraints, only a small number of these fragments, published here for the first time, are presented below.

These selected fragments are mainly pieces of figures–especially faces–but also pieces of clothing or sculpted fragments other than faces whose size is remarkable. One should also note the presence of graffiti that is difficult to read (Fig. 8-11).

7. Future research directions

Several avenues for future research can be identified. Recent technological developments and scientific analytical methods may contribute substantially to a better understanding of the site. If successfully applied, these approaches could facilitate the partial reconstruction of certain sculptures and help compensate, at least in part, for the absence of a detailed excavation report from the clearance operations conducted in the 1970s.

7.1. Promote the reserve collections and improve understanding of earlier inventories

One of the first objectives is to align the results of our inventory of pieces outside the cave with the inventories previously produced. As far as possible, we would like to associate each crate in our inventory with the cave panel where the sculptures were originally located.

This work will involve, on the one hand, analysing the documents deposited in the departmental archives and, on the other hand, contacting certain people and associations who contributed to those earlier inventories.

In addition, in order to improve access to these collections, which remain difficult to consult, the complete inventory will be published together with photographic documentation of the most informative pieces.

7.2. Trying to match the pieces of the puzzle

As observed during the inventory, several sculptural fragments preserved in the reserve collections have already undergone partial reassembly. Although the complete reconstruction of all sculptures by joining fragments is unrealistic, a targeted selection of representative pieces could be documented by photogrammetry or 3D scanning. Computational approaches could then be used to test possible joins between fragments belonging to the same sculpture. In addition, digital reconstruction methods may help model missing volumes in broken works. Comparable approaches are already being applied in archaeology for the reconstruction of ceramics and other artefacts (Terouinard 2023).

7.3. Determining which panels the various sculpture fragments were associated with

The methodology proposed by Denis Bellenot is based on the chemical analysis of the cave walls and detached sculptural fragments. The different walls and pillars of the cave display observable heterogeneity in colour, surface texture, and block regularity. The first stage

of the study therefore consists in characterising this heterogeneity through analyses carried out at different points within the cave:

- Elemental chemical profile (Fe, Ba, Ca/Si, Na, K, etc.);
- Microfossil profiles: types and distribution;
- Study of the distribution of opal microbead diameters.

If this first stage produces sufficiently discriminating results, the second stage will consist in applying the same characterisation protocol to isolated tufa fragments in order to test hypotheses regarding their original position within the cave. Such a method could contribute to a more comprehensive reconstruction of the carved panels (Fig. 12).

Conclusions

The inventory of sculptures and detached fragments from the Dénezé-sous-Doué Sculpture Cave, preserved both in the cellar and in the museum's reserve collections, contributes to a more complete understanding of the site. It also documents ongoing stone deterioration affecting the corpus and is intended to provide a reference framework for future conservation measures. In addition, approaches such as 3D documentation of reserve fragments and geochemical analysis of the tufa may make it possible to reconstruct, at least in part, the original organisation of the cave before its collapse.

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Susceptibility to Sinkholes Caused by Artificial Cavities in Continental Southern Italy

Isabella Serena Liso[1], Francesca Lagna[1], Sandro Muscillo[1], Cosimo Cagnazzo[1], Piernicola Lollino[1], Maria Assunta Fabozzi[2], Luca Comegna[2], Emilia Damiano[2], Maria Petriccione[3], Gennaro Capasso[4], Vera Corbelli[4], Daniela Ruberti[2], Mario Parise[1*]

[1]Earth and Environmental Department, University Aldo Moro, Bari, Italy
franc.lagna@gmail.com; serenaliso.uniba@gmail.com; sandromuscillo@libero.it; piernicola.lollino@uniba.it
[2]Engineering Department, University degli Studi della Campania "Luigi Vanvitelli", Aversa, Italy; mariaassunta.fabozzi@unicampania.it; luca.comegna@unicampania.it; emilia.damiano@unicampania.it; daniela.ruberti@unicampania.it
[3]Department of Historical, Geographical and Ancient Sciences, University of Padova, Italy
maria.petriccione@unipd.it
[4]Autorità di Bacino Distrettuale dell'Appennino Meridionale, Caserta, Italy; vera.corbelli@distrettoappenninomeridionale.it; g.capasso@distrettoappenninomeridionale.it

*Corresponding author email: mario.parise@uniba.it

Abstract
This contribution addresses sinkholes related to the presence of artificial cavities and their evolution through time. The study area covers the largest hydrographic district in Europe, the Hydrographic District of the Southern Apennines in Italy; it includes five entire regions (Apulia, Calabria, Campania, Basilicata and Molise) and sectors of the Latium and Abruzzo regions, encompassing highly diverse geological settings, from volcanic areas and karst terrains to mountain ridges such as the Southern Apennines and the Serre and Aspromonte massifs in Calabria. Within this geologically and morphologically varied territory, artificial cavities (defined as underground voids excavated by humans) are widespread, reflecting the long historical and cultural development of Italy. At some locations, the use of the underground has been so extensive that, in the historical centres of several towns, it is very difficult to find areas without subterranean voids. These cavities belong to most of the categories listed in the recently updated classification by the International Union of Speleology, with numerous examples in category E, mining (E1 and E2), category B, civilian settlements (B1 to B7), category C, worship (mostly C1 places of cult), and category A, hydraulic works (A1 to A7).
In this context, the abandonment of underground sites in recent times has often led to degradation and weathering, which may evolve into local failures and instabilities. Where artificial cavities occur at shallow depth, these instabilities may propagate upward until they reach the ground surface as sinkholes. Sinkholes related to artificial cavities therefore represent a common hazard in many towns and villages of southern Italy and, in recent decades, have caused significant problems and damage to society.
Starting from an updated chronology of past sinkhole phenomena, organized in a dedicated catalogue linked to the original function and use of the artificial cavities, this contribution analyses the distribution of both cavities and sinkhole events. The aim is to define the areas most susceptible to this type of hazard and, at the same time, to identify the categories of artificial cavities that may be most dangerous in this respect. This effort is a crucial step toward increasing societal resilience to geological hazards related to the presence of underground voids produced by human activity.

Keywords: artificial cavities, sinkholes, damage, susceptibility, hazard

1. Introduction

Artificial cavities are underground works created by humans in different historical periods and for a variety of purposes. Since the earliest civilizations, human beings have used the underground environment to protect themselves from harsh weather, animals or enemies. Initially, this was generally achieved by adapting existing caves to their needs; over time, however, humans began to modify natural sites or to excavate entirely new voids, wherever the rock mass allowed this (Palmer 2007; Del Prete and Parise 2013). Consequently, many areas of the world host a large number of artificial cavities, in some cases forming actual subterranean towns, such as those of Cappadocia, Turkey (Triolet and Triolet 1993; Bixio et al. 2002; Rodley 2010; Bixio et al. 2021); similarly, the examples documented in Armenia and Georgia (King et al. 2003) are particularly remarkable.

In other countries characterized by millennia of civili-

Fig. 1. Sinkhole in rural area at Barletta (Apulia, S Italy)

Fig. 2. Artificial cavities in several levels, actually below part of the modern town of Massafra (province of Taranto, Apulia, S Italy)

zation, these underground features are also significantly represented, as documented by numerous works and books on rock-cut civilization (Laureano 2010; Bixio et al. 2012; Mainetti 2013; Polimeni et al. 2019; Varriale et al. 2022). Depending on the main geometrical features of the cavity (depth, width, thickness and lithology of the overburden), the type of cavity and its duration of use, many artificial cavities, once abandoned, soon became affected by degradation (water infiltration and weathering; Calcaterra and Parise 2010), with the host rock mass involved in decay processes that may lead to a decrease in the physical properties of the rocks (Canakci 2007; Castellanza et al. 2018). Over time, this process may lead to progressive instability, typically starting underground with rock failures and detachments and then propagating toward the surface, where a sinkhole (Gutierrez et al. 2014; Parise 2019; Parise 2022) can eventually be produced (Fraldi and Guarracino 2009; Lollino et al. 2013). Since they originate in underground settings, sinkholes are a subtle geological hazard (Fig. 1) that generally develops without visible evidence until the final, catastrophic collapse phase is reached (Parise and Gunn 2007; Parise and Lollino 2011; Parise 2015); the lack of precursory signs results in a high risk to society.

In past epochs, humans began to excavate soft materials, such as volcanic rocks, calcarenites and tufa, to create artificial cavities (Fig. 2). The variety of these features is well represented in the Classification of Artificial Cavities, initially proposed by Italian scholars (Galeazzi 2013) and later adopted internationally by the dedicated Commission of the International Union of Speleology (UIS; Parise et al. 2013). In this classification, each category is designated by a capital letter, to which a number is added to further specify the purpose for which the original cavity was excavated. This system allows each artificial cavity to be assigned to a category, although the frequent possibility of changes in use throughout history must be taken into account. The classification was recently updated (Galeazzi et al. 2025) through the introduction of an additional level, consisting of a lowercase letter after the main label and number, e.g. A.1.a. This update was intended to better specify the function of these structures at the time of construction, as well as during successive phases of reuse. For further details, please refer to Galeazzi et al. (2025). From the perspective of land management and planning, however, the exact location of underground voids and their present conditions are particularly important. Indeed, knowledge of these features is the first step toward mitigating the risk related to the potential collapse of artificial cavities.

The Hydrographic District of the Southern Apennines (hereafter ADAM, from its Italian acronym) includes five entire regions (Apulia, Calabria, Campania, Basilicata and Molise) of peninsular Italy, as well as portions of Latium and Abruzzo. It is an inter-regional authority responsible, among other functions, for the management of geo-hydrological hazards through the definition of related regulations. Within the framework of a project dedicated to artificial cavities in the ADAM territory, this contribution presents a methodology for assessing susceptibility to sinkholes linked to artificial cavities in the ADAM Hydrographic District. The methodology is based on a detailed review of available material from multiple sources, integrated with direct knowledge acquired through previous studies by the authors and, where appropriate, taking advantage of the chronological database of sinkholes in Italy. This database has been populated over several years through a joint project between the Institute of Research for Geo-Hydrological Protection of the National Research Council of Italy and the Department of Earth and Environmental Sciences at Aldo Moro University in Bari (Parise and Vennari 2013; Vennari 2017; Vennari and Parise 2022). The present article represents a follow-up to the two contributions presented at Hypogea 2023 in Genoa, Italy (Fabozzi et al. 2023; Liso et al. 2023).

2. Geological setting

The boundaries of the territory of the Southern Apennines District Authority in Italy are defined by Art. 64 of Legislative Decree No. 152/2006 (implementing Directive 2000/60/EC). The District comprises 25 provinces (six of them partially), 1,632 municipalities, 100 mountain communities, 44 reclamation consortia and 978 protected natural areas, with a resident population of almost 14 million inhabitants (about 23% of the Italian population). The landscapes of the ADAM territory display heterogeneous morphology, ranging from mountains to hills and including wide alluvial and inter-mountain plains. The Southern Apennines mountain chain represents the Tyrrhenian-Adriatic divide; it is mainly formed by Mesozoic carbonate rocks and marly, arenaceous and clayey soils. In Calabria, in its southernmost sectors, the Sila and Aspromonte chains are made up of metamorphic and igneous granitic rocks (Calamita et al. 2009; Beltrando et al. 2010; Vezzani et al. 2010; Bucci et al. 2021). In Campania, the presence of three volcanic districts (Roccamonfina, Somma-Vesuvius and Phlegrean Fields) has produced a wide distribution of lava and volcaniclastic deposits, both at the surface and in the subsoil (De Vivo et al. 2019). An inactive volcanic district (Mt. Vulture) is also present in northern Basilicata (Schiattarella et al. 2005).

Due to the complex geological history of the Apennine chain, the considerable variability in the lithological and permeability features of the rock masses controls the distribution and geometry of the hydrogeological structures and the pattern of groundwater circulation.

3. Sinkhole predisposition and evolution

The susceptibility to sinkholes is controlled by a variety of elements that, as for all other types of ground instabilities, may be grouped into three categories: predisposing, preparatory and triggering factors (Berti et al. 2025). As recently defined in the Vertical Spoke *"Ground Instabilities"*, within the framework of the PNRR Project RETURN *(multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate)*, predisposing factors include all geological-structural and geo-mechanical characteristics that define the tendency of a given area or material to undergo a certain process, before climatic aspects or anthropogenic pressure are considered. Preparatory processes add to this predisposition, develop over time and represent the macro-category that links instability to climatic actions and anthropogenic activities (e.g., rainfall intensity, multi-year cycles, etc.). Finally, triggering factors are intense actions (earthquakes, rainstorms or anthropogenic activities) that determine the onset of the geological hazard.

The distinction between predisposing, preparatory and triggering factors/processes is therefore essentially tem-

Fig. 3. Wide-open crack on the vault of a worship site

Fig. 4. View of an old quarry at Canosa di Puglia, with trapezoidal shape. The artificial cavity has been later re-used for other purposes, thanks to the good state of conservation

poral: predisposing factors are considered invariable at the observation scale, whereas preparatory factors show changes or cyclical trends over the same period. A trigger, in contrast, is considered a process that acts over a very short and well-defined time interval.

Large- and medium-scale geological structures (i.e., faults, bedding planes, etc.) are critical predisposing factors for sinkholes in carbonate rocks. They serve as potential zones of weakness within the rock mass, allowing medium-sized to large rock volumes to detach (Klimchouk and Andrejchuk 2002; Parise and Lollino 2011). In some cases, they can also act as conduits or barriers for groundwater flow, thereby increasing pore pressure along potential failure surfaces.

Moreover, carbonate rocks are often stratified, and the occurrence of weak layers within hard rocks significantly predisposes the rock masses to failure, particularly where composite successions are present and layers show strong vertical variations in hardness (Bird 1976; Emery and Kuhn 1982; Blanco Chao et al. 2003). Weak layers in carbonate rocks are often clay-rich and characterized by low shear strength, a combination that typically increases the potential for rock failures (Fig. 3).

Undercutting by tidal and wave action, together with the formation of deep tidal notches (Antonioli et al. 2015), destabilizes coastal cliffs by removing basal support, shifting the centre of gravity outward and increasing tensile and shear stresses, particularly in stratified rocks with intervening weaker layers (Griggs et al. 2019). When karst caves or artificial cavities are located near the coastline, this process may result in sinkhole formation, with the possibility that the remaining arch is later destroyed by further sea storms.

Among the many preparatory factors, wetting and drying cycles, related for instance to salt crystallization and sea spray, can be mentioned in coastal settings (Kanyaya and Trenhaile 2005; Andriani and Walsh 2007; Lawrence et al. 2013). In addition, the action of sea waves must be considered, as it can be particularly significant during intense sea storms or when cyclic wave action affects rocky coasts (Sunamura 1977; Adams et al. 2005; Hall et al. 2008).

In recent decades, climate change has been widely considered a primary element that may contribute to defining new boundary conditions for the development of failures and for the increase in the number of ground instabilities (Zhang et al. 2004; Stive 2004; Trenhaile 2014; Gariano and Guzzetti 2016). Global warming, ice melting and the expected consequent sea-level rise, together with changes in the pluviometric regime, from rainfall distributed throughout the year to strongly concentrated rainstorms and sea storms, create new conditions that may prepare future failures with much higher frequency than in the past (Hammar-Klose and Thieler 2001; Himmelstoss et al. 2009; Liso et al. 2023).

Sinkholes documented in the past in the ADAM district (Fiore and Parise 2013; Vennari and Parise 2022; Liso et al. 2023) encompass most of the different typologies of artificial cavities, according to the UIS classification (Galeazzi et al. 2025). This is due to the widespread presence of cavities in southern Italy, which testifies to the rich cultural heritage from past civilizations, during which the underground environment was used for a variety of purposes, from worship and burial sites to civilian dwellings, workplaces, etc. However, when the history of sinkholes is considered, Category E (mines) clearly appears to be linked to the highest number of events (Parise 2010; Parise 2012). The abandonment of underground mine and quarry sites, together with their closure at the surface, typically leads to the loss of memory of these subterranean sites while favouring the onset of weathering and degradation processes, mainly linked to the lack of ventilation and air circulation in underground rooms (Fig. 4). Over time, this promotes deterioration of the physical properties of the rock mass (Lollino and Parise 2023b), which becomes more prone to failure, as repeatedly demonstrated by several cases, especially in Campania (Guarino and Nisio 2012; Guarino et al. 2018; Tufano et al. 2022) and Apulia (Pepe et al. 2013; Fiore et al. 2018; Vennari et al. 2022; Fig. 5).

At the surface, the loss of memory of underground sites has led to the expansion of built-up areas toward sectors where quarrying activities had previously been

Fig. 5. Pillar in bad instability conditions in a calcarenite quarry

carried out, thereby creating conditions for possible future collapse events. In the case of subterranean quarries and mines, the situation is even more complex (Swedzicki 2001; Hutchinson et al. 2002; Ferrero et al. 2010), owing to the spatial configuration of closely spaced galleries, which form a very dense network of underground spaces.

The above issues indicate the need to consider a wide range of historical, geological and technical elements in order to carry out a reliable sinkhole hazard assessment. Following the procedure outlined in previous works (Parise 2015), the collection of all relevant features that can be identified in artificial cavities is essential. Of course, this delicate phase of work must be carried out only under safe conditions, whenever the physical stability conditions allow it, and by expert cavers.

Conclusions

The availability of a robust body of information on artificial cavities, from their excavation/construction techniques (Bixio et al. 2023) to their main geometrical features and current instability conditions (Parise 2017), is crucial for a preliminary evaluation of sinkhole susceptibility and for the implementation of preliminary stability analyses using dedicated charts or numerical models (Fazio et al. 2017; Perrotti et al. 2018; Lollino and Parise 2023a). The integration of historical sources, field surveys, speleological observations and geotechnical data makes it possible to move from a simple inventory of underground voids to a more operational assessment of susceptibility-prone areas. In this perspective, the ADAM catalogue represents an essential tool for supporting land-use planning, prioritizing investigations and defining mitigation strategies in urban and peri-urban contexts affected by abandoned artificial cavities. Future work should therefore focus on the systematic updating of the database, the refinement of susceptibility criteria for different cavity categories and the transfer of this knowledge into practical guidelines for risk reduction and societal resilience.

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Artificial Cavities in the Late Oligocene - Miocene Deposits of NW Romania. First Update

Tudor Tămaş[1,2], Codruța Valea[1,2], Mădălin Erhan[2], Eusebiu Szekely[2]

1. Department of Geology, Babeş-Bolyai University, Cluj-Napoca, Romania
2. Montana Caving Club, Baia Mare, Romania
* Corresponding author: tudor.tamas@ubbcluj.ro

Abstract

This paper presents the preliminary results of an investigation of the artificial cavities from NW Romania, covering areas in Sălaj county and some locations in Bistrița-Năsăud county, and which in time may be extended and lead to interesting research perspectives. So far 17 cavities were investigated. The surveys were done with modified DistoX2 rangefinders using the PocketTopo software, complemented by 3D scans with iPhones 15/16 pro. The data obtained in the field, the results of analyses in the laboratory and additional data from various reference sources are added to dedicated record sheets. Most of the cavities were dug in late Oligocene - middle Miocene siliciclastic deposits. They represent: mining adits (7); rupestrian church/habitat (2); crypt (1); storage areas (4) and underground quarries (1), while for two of them the purpose is unclear yet. Their estimated ages vary from the Middle Ages to the communist period, but for some of them, proper references regarding exact age and/or purpose were not published or are generally difficult to retrieve.

Keywords: artificial cavities, survey, documentation, Oligocene - Miocene rocks, NW Romania

Introduction

There is generally little information regarding the number of artificial cavities documented in NW Romania. A comprehensive review was published in 2000 by Boroneanț, indexing underground objects with archaeological significance. Areas of interest with a large number of rock hewn dwellings, are known in SE Romania: the northern part of Buzău County (3 in Fig. 1a), or Murfatlar (4 in Fig. 1a) which were the subject of detailed studies. Since then, particular sites have been subject to thorough investigations. At Roșia Montană (2 in Fig. 1a), extensive archaeological investigations in the frame of a National research program and large scientific projects have resulted in the mapping of 35 km of galleries out of an estimated total of 140 km (Cauuet 2014; Lazăr et al. 2014), with over 7 km of Roman works, dating from at least the 2nd century AD (Cauuet et al. 2003; Cauuet 2014). The Roșia Montană Mining Landscape was added to the World Heritage List in 2021. In the Baia Mare area (1 in Fig. 1a), mining works are documented since at least the 14th century, and they have been investigated for the better part of 30 years (Ișteban and Minghiraş 2004; Mureşan et al. 2022). After the last active mines were closed, work has been done in order to promote the establishment of a UNESCO geopark (e.g. Kovacs and Fülöp 2009; Kovacs et al. 2025). Our initial search for artificial cavities in the counties of Sălaj and Bistrița-Năsăud in NW Romania gave only a few results, presented below. Aside from the volume of Boroneanț (2000), the catalogues of a few local caving organisations, and possibly official documentation which may be difficult to access (at least on mining), there is no database where such underground voids are recorded, except for sites of specific archaeological interest.

We investigated 17 cavities so far, 14 of them in Sălaj county, and 3 in Bistrita - Năsăud county (Fig. 1b). The cavities were either identified directly in the field, or from various documentation sources (geological maps, newspapers, internet resources, scientific papers etc). For any basic investigation we collected location and survey data, as well as additional samples of interest for lithology, mineralogy and palaeontology. Surveys were done with modified DistoX2 rangefinders using the PocketTopo software, complemented by 3D scans with iPhones 15/16 pro. The data obtained in the field, the results of analyses in the laboratory and/or additional data from various reference sources are added to dedicated record sheets. This is a cavers' work in progress, adding up surveys, data and references when found, and as such it may contain a certain amount of guesswork wherever references or local information were not available.

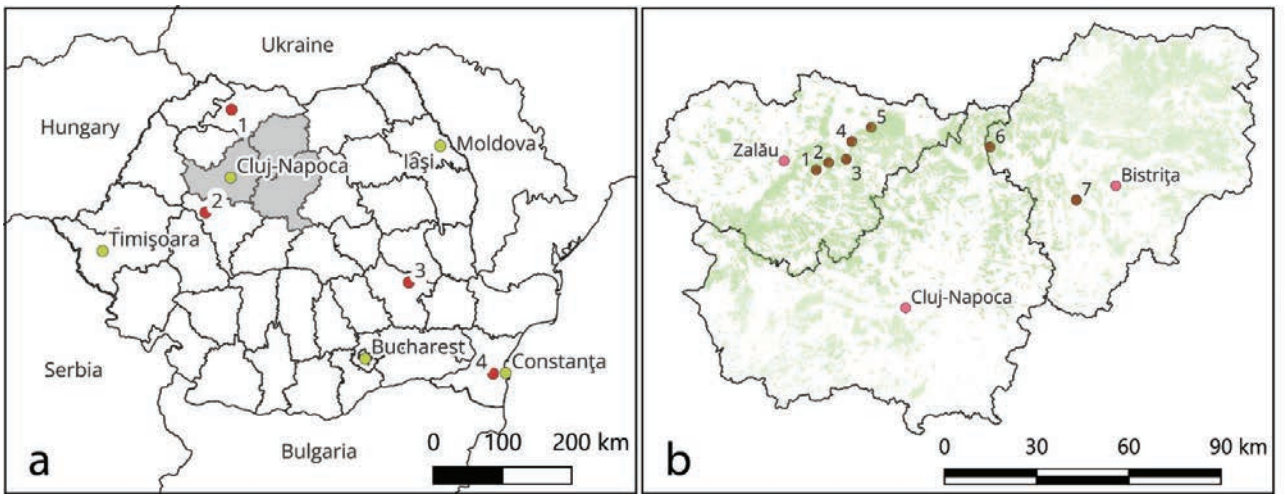

Fig. 1. a. Map of Romania indicating the sites mentioned in the introduction: 1. Baia Mare mining area; 2. Roșia Montană; 3. Rupestrian dwellings in the Northern Buzău county; 4. Rock hewn dwellings in the Murfatlar area, Constanța county. b. Grey area of Fig. 1a enlarged, showing the locations of cavities presented in this paper: 1 Jac, 2. Lupoaia; 3. Gâlgău Almașului; 4. Surduc; 5. Cliț; 6. Ciceu-Corabia; 7. Chiraleș

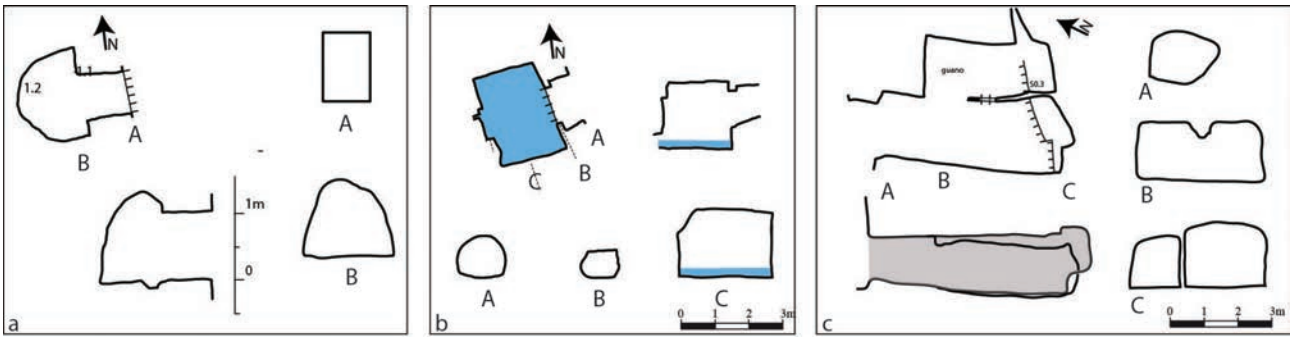

Fig. 2. Surveys of artificial cavities from Jac. a. storage in the Piatra Lată Roman quarry; b the cavity from Cămnin hill; 3. Pemnița Monului rupestrian church (cartography by T. Tămas and C. Valea)

Results - description of the cavities

Archaeological objectives in Sălaj county

Boroneanț (2000) mentions only two small artificial cavities in Sălaj county, both of which were related to larger archaeological contexts. One of them is located in the Piatra Lată Roman quarry in the village of Jac (1 in Fig. 1b), while the second one we have not identified yet. The cavity from Piatra Lată opens at 7 m from the ground in a wall of sandstones with intercalated conglomerate levels and has to be reached by means of a rope. It is only 1.6 m long, 1.3 m high and has a rectangular entrance (1 x 0.7 m) facing eastwards. It probably had the role of a tool shed (Boroneanț 2000; Ilieș et al. 2026). At 1 km SE from the quarry, a second cavity we surveyed was investigated during more recent archaeological campaigns on top of the Cămnin hill (Bejinariu et al. 2016). It is 3 m long and consists of a rectangular chamber (2.8 x 2 m, 2 m high) accessed via a nearly circular entrance facing east, 1.4 m in diameter. Another cavity in the vicinity of Jac is Pemnița Monului, a rupestrian church/dwelling located SW from the village, on the northern side of a forested ridge, and was already investigated by Ilieș et al. (2024). It consists of two rectangular shaped rooms oriented NNW-SSE, connected by a doorway and a small window. Both rooms end in a NE-SW oriented fracture parallel to the cliff face at the entrance (Fig. 2c). It is attributed to the medieval age (sec. XI - XIV or possibly earlier).

Coal mines and other excavations in Sălaj county

In an area that presently covers parts of the Cluj and Sălaj counties (Fig. 1), coal mining started east to west and owing to the large number of coal seams located at various stratigraphic levels (between 14 and 23 different layers) but also due to their limited relative extent, a large number of mine galleries and pits were opened since the 1850's. The first mines were dug between 1896 - 1904 in the area we focused on (Papp 1915; Petrescu et al. 1987), while the last one was started in 1987. Some of these mines were operational well into the late 20th century, until 2000-2001 when the last mining operations in the area were ceased (Varga 2010). The coal seams of interest are located in Oligocene - Early Miocene formations. At Lupoaia (2 in Fig. 1b), coal seams are located in the Zimbor formation (Chattian, late Oligocene), while in the other localities with artificial cavities surveyed (Gâlgău Almașului, Surduc,

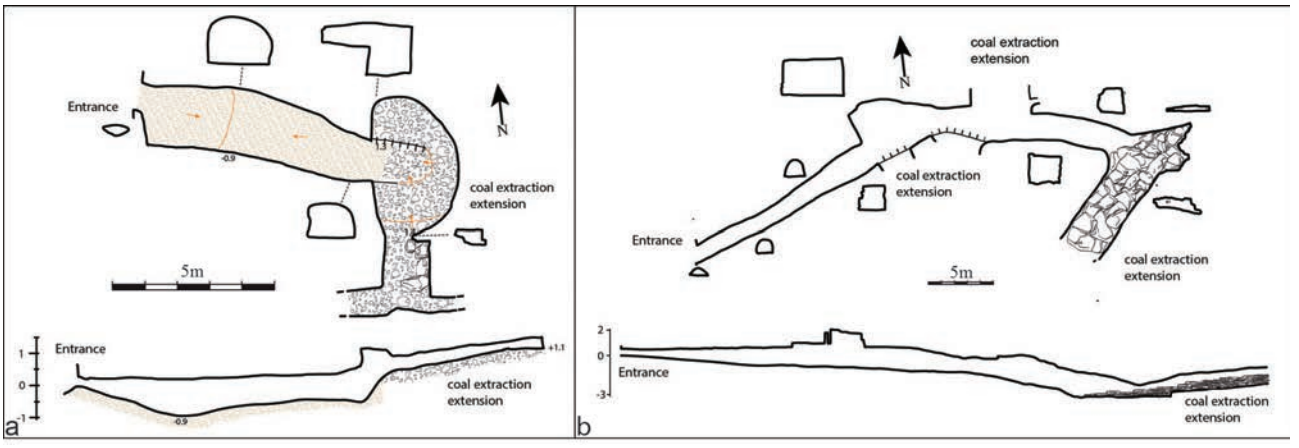

Fig. 3. Coal mines surveyed at Lupoaia (cartography by T. Tămaș)

and Clit), they are intercalated in the Valea Almașului formation (late Oligocene - early Miocene). The Zimbor formation consists of two distinct horizons, reddish silty clays with sandstone and microconglomerate intercalations, and sandstones with coal intercalations, reaching over 220 m at its type locality (Rusu et al. 1978). The Valea Almașului formation is a thick comprehensive formation (ca. 600m) including quartzitic - kaolinitic sandstones, silty clays and microconglomerates, with 12 coal layers (Petrescu et al. 1987).

Lupoaia

Coal extraction at Lupoaia started in 1904 - 1905 and mining activity was continuous until 1932, then briefly during and after the 2nd world war (1940 - 1944 and 1945 - 1948) (Papp 1915; Petrescu et al. 1987). Four coal layers were identified in the Zimbor formation, out of which only one, 75 cm - 1 m thick, was exploited at the beginning of the 20th century (Papp 1915). We have located two coal mines in the vicinity of an old tailings dump just outside the village, surveyed whilst using a CO_2 detector to monitor air quality. The first mine (Fig. 3a) is 13 m long and consists of a gallery with arched ceiling connecting to a 30 cm coal layer after 8 m. The coal layer was extracted over a further 5m and is limited at the top by a conglomerate bed. Two small crawls at its southern end were abandoned during the survey when the CO_2 measurements passed 4500 ppm, but the chances of finding further passage were not great, due to their extremely small size.

The second mine surveyed at Lupoaia is presently 49 m long and still ongoing along two coal extraction extensions (Fig. 3b). It starts as a small *rathole mine*, the entrance gallery consisting of a 15 m crawl until the coal seam was reached at the ceiling level and the gallery was enlarged to standing - size dimensions (cross section 4 m wide and 3 m high). Shortly after reaching the larger passage, there are two coal extraction extensions not yet surveyed to the left and right (N and S), whereas the main gallery descends eastwards for 25 m and reaches another extension where the coal was extracted, ending in a conglomerate breakdown to the east, and continuing 7 more m SW under a dangerous ceiling

Fig. 4. a. The directional gallery in the mine from Grădina Zmeilor reserve, looking NW towards the third lateral gallery; two thin coal layers are visible next to the ceiling; b. Entrance to the mine gallery from Str. Peșterii (photos by T. Tămaș)

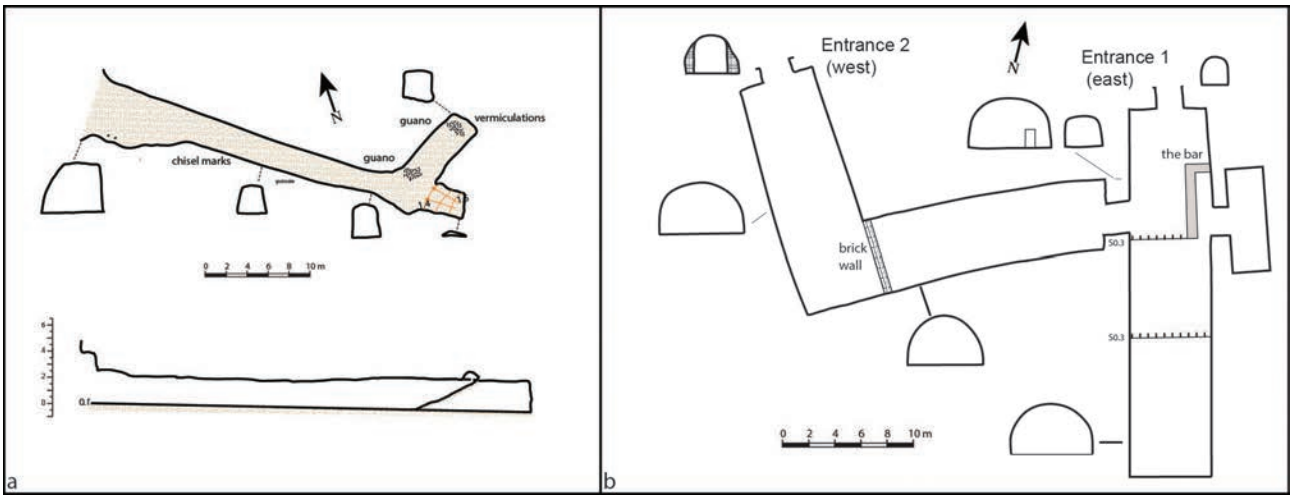

Fig. 5. a. The mine gallery SW from Surduc; b. The cavity from Str. Poduri (cartography T. Tămaș)

consisting of loose conglomerate slabs. This final sector is almost 4 m wide and 1.3 m high, thus comparable in size with the coal layer mentioned by Papp (1915). CO_2 measurements taken during the survey have shown a linear increase along the descending gallery, reaching 2300 ppm at its minimum point. The investigations in this mine are ongoing, including surveying the extraction areas and sampling for mineralogy.

Gâlgau Almășului

Two mine galleries were surveyed in Gâlgău Almașului (3 in Fig. 1b), the longest being the one from the Grădina Zmeilor nature reserve (Fig. 4a). This 423 m long mine adit has two lateral galleries dug at 50 m from the entrance, and a third one (17 m) at 75 m. All three are following the coal seam along the dip of the strata. Aside from it being the longest cavity we investigated so far, it also contains a multitude of secondary mineral occurrences, mainly iron oxi-hydroxides and sulfates resulting from the oxidation of pyrite in the host rocks (Valea et al. 2026). Based on differences in the shape and relative size of its cross sections, the mine seems to have been dug in two different periods (early 20th century and the communist era), but we found no bibliographic data so far to support this. At 1.8 km east from the Grădina Zmeilor reserve, at the end of the creatively called *"Str. Peșterii"* (*Cave street*), we surveyed another gallery, 26 m long, probably dug during the communist era (Fig. 4b). The gallery has trapezoidal, almost rectangular cross-sections and no coal occurrences inside, but some secondary mineral crusts (gypsum and iron sulfates) were identified.

Fig. 6. a. Plan view of the 111m mine gallery from Cliț. b. Entrance to the 4th cavity from Cliț, with the inscription visible top right

Surduc

Five km north from Gâlgău Almașului, three cavities were surveyed in Surduc (4 in Fig. 1b), all situated along the National road 1H. The first one, situated ca. 200 m SW from the village, is a large mine adit (3 x 3.6 m in cross sections) dug in sandstones, with the entrance area enlarged by surface processes and with chisel marks visible in some sections of the walls. The gallery is 47 m long, oriented NW-SE and ends in massive breakdown. It contains 2 bat guano accumulations, a sector with well preserved vermiculations, as well as a few occurrences of secondary sulfates (gypsum, epsomite, hexahydrite, thenardite and natrojarosite) (Fig. 5a). The second cavity, at ca. 50m NE from the first one, is only 6 m long at present, and has the ceiling dug along an apparent bedding plane in a conglomerate bed. Due to the extent of the surface processes, a

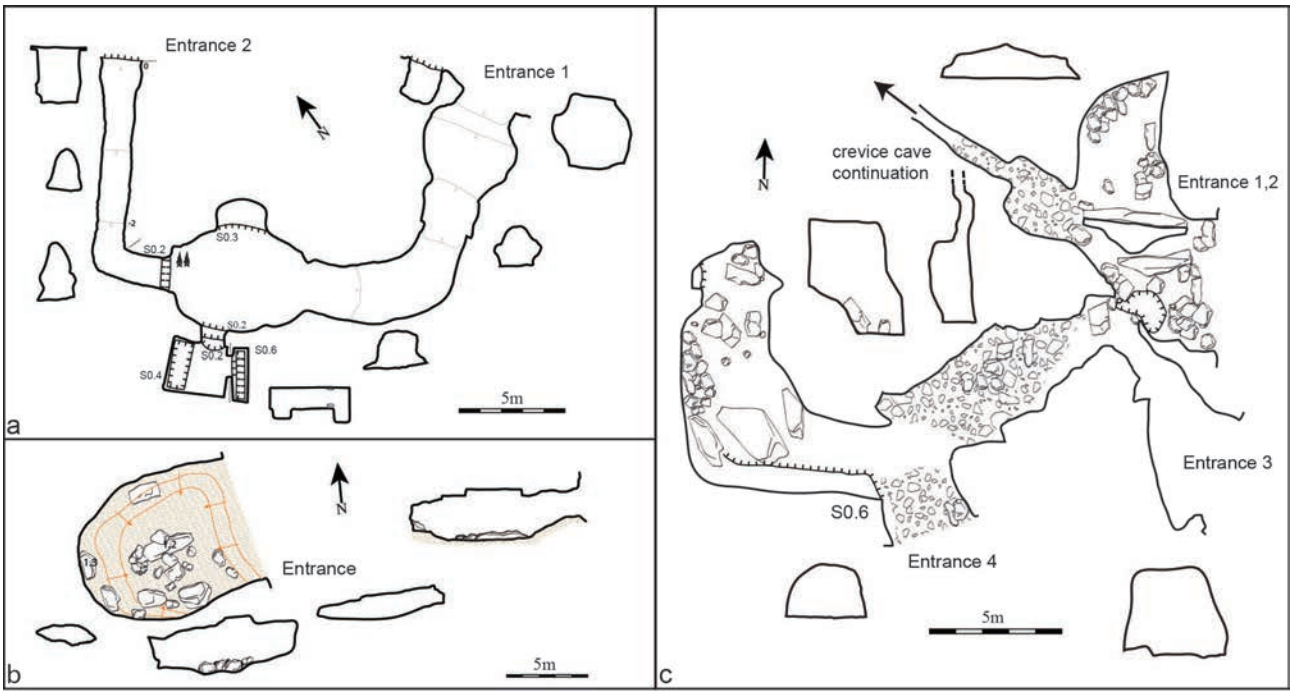

Fig. 7. Artificial cavities in Bistrita - Năsăud county: a. Lajos Bethlen's crypt (simplified from Tămaș et al. 2023); b. Second cavity from Chiraleș (survey by T. Tămaș and C. Valea); c. Cave from Cetatea Ciceului, horizontal sector (modified from Tămaș et al. 2000)

large portion of the cliff has recently fallen in front of its entrance while the slope above the entrance hasn't stabilised yet, making it quite dangerous to visit.

The third, most imposing cavity from Surduc is located 450 m south of the centre of the village, on the right side of Str. Poduri. It is 64 m long, has two entrances facing NNW, and very large cross sections (5 m wide and 3.2 m high). It consists of two large tunnels oriented NNW-SSE, 24 m and 16 m long respectively, interconnected by another tunnel sector (17 m long) at an almost 90 degree angle (Fig. 5b). A smaller, 6 m long side tunnel was dug parallel to the eastern one. The entrances to the cavity are 1.9 x 1.9 m (entrance 1) and 2.2 x 2 m, but entrance 2 was reduced in size by lateral brick walls of a recent construction. The tunnel accessed from the western entrance has a sandy floor, while the rest of the complex, separated by a brick wall, has a concrete floor set in the early 1990's when the last known use of the cavity was as a club with quite a reputation, according to the local press. Considering its large size and location next to the main road and not far from the train station, we assume at this point that it was probably used as a coal storage facility at the beginning of the 20th century, but the references to support this are yet to be found.

Cliț

In the neighbouring village of Cliț, situated 9 km NE from Surduc (5 in Fig. 1b), four other cavities were surveyed along the county road 109E. The first three are located in a long sector of sandstone cliffs, 3 km west of the village, while the fourth is located about 500 m W of the village centre. The longest one (Fig. 6a) is a 111 m long mine adit oriented NNW-SSE, starting from the side of the road. The directional gallery is 85 m long, ascending by a 2°slope, and intersects at 34 m from the entrance a 0.5 m layer of grey clay with organic matter that can be followed for ca. 30 m. At 41 m from the entrance, an opening to the left leads to a steep (60°), 22 m long, ascending blind shaft with square cross sections (1.5 m) which opens a few thin coal layers. Secondary mineral deposits associated with the clay layer opened by the gallery contain some jarosite and gypsum crusts.

The second cavity, 250 m east from the first one, is a short spectacular *"oxbow"* of the road, sometimes called *"the grotto"*, 18 m long, oriented W-E, which may have a natural origin, but also could have been used as a road tunnel. The third one, 250 m further east, is a 4m niche probably used for tool storage. Finally, the 4th cavity in Cliț is located 750 m SE from the village centre. It may have been used both as a dwelling or storage (Fig. 6b) and consists of an arched entrance sector, 1.6 m high and 1.6 m long, leading to a larger chamber, 5 m wide, 6.6 m long and 2.6 m high, dug manually. A partial inscription in the sandstone wall next to the entrance may possibly mark the date of digging for this cavity as 1873.

Cavities in Bistrița-Năsăud county

The best documented among the artificial cavities investigated in Bistrița-Năsăud county is Lajos Bethlen's crypt from Chirales (Fig. 7a), 40m long, with two entrances that connect to a central chamber (Tămaș et al. 2023). The crypt was dug between 1815 and 1818, then desecrated and emptied before World war 1 (Makkai

1941). It is dug in late Sarmatian (middle Miocene) weakly cemented sands, sandy clays and silty clay sediments deposited in a delta channel facies. 50 m SW from the crypt, the second cavity surveyed opens in a little clearance along the same county road, in a continuation of the cliff face hosting Lajos Bethlen's crypt. It consists of a single elliptic chamber, 11 m long and 9 m wide (Fig. 7b) and according to local information, it was used for storage. There is no mention of it in Kádár (1901), where ample mention is made of its more famous neighbour.

Reassessing the Cave from Cetatea Ciceului

Another well known objective from the Bistrița-Năsăud county, the Cave from Cetatea Ciceului, is located in the vicinity of Ciceu Corabia village, at 750 m asl (6 in Fig. 1b). The hill in which the cave is located is part of a 5 km long volcanic structure, consisting of alternances of pyroclastic flow material (rhyolitic - rhyodacitic) and fallout tuffs deposited in a marine environment during the Lower Badenian (middle Miocene) (Seghedi and Szakács 1991). The cave, 272.6 m long (Giurgiu et al. 1983), can be accessed by four entrances and consists of two morphologically distinct sectors. The descending sector is a crevice cave with a vertical extent of 53 m (Tămaș et al. 2000). However, of importance to our present study is the horizontal sector, with a total length of 52.4 m, comprising two short passages with archway cross-sections (2 to 5 m high, generally 2 - 4 m wide) oriented N20°W, which connect a passage oriented SW-NE (Fig. 7c). In some locations along the sector there are well preserved chisel marks on the walls and in our opinion, it was created as a quarry for the extraction of the volcanic rocks for millstones. Millstone quarrying in the hillside around the cave area is mentioned since at least 1552, while by 1781 the best millstones in all of Transylvania were reportedly cut here (Kádár 1900; Rusu 2005).

Conclusions

This study presents our first results on the survey of artificial cavities dug in Late Oligocene - Miocene rocks from Sălaj and Bistrița-Năsăud counties in NW Romania. A number of 17 cavities were surveyed until now, ranging from 1.6 to 423 m in length and mostly dug in siliciclastic deposits (sands, sandy clays, sandstones, conglomerates). Their ages range from the Roman period to the Middle ages and from the 19th century to the communist era (post 1945). The main cavity typologies recognised so far reveal a wide architectural and functional spectrum, with five categories represented: mining adits (and storage adits probably related to mining), underground quarries, rupestrian church/habitats, storage adits and crypts. At the time of our study, only a few of them were already thoroughly investigated as parts of larger archaeological contexts, such as the cavities at Jac and Lajos Bethlen's crypt; however for the majority, the surveys and the additional information gathered may serve as the basis for a developing inventory, highlighting the need for more detailed documentation and geological investigation.

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IN MEMORIAM

Twenty Years Without Vittorio Castellani (1937-2006), One of the Fathers of Speleology in Artificial Cavities in Italy and the World

Carla Galeazzi[1,2]*, Roberto Bixio[1,3], Vittoria Caloi[1,2], Carlo Germani[1,2], Mario Parise[1,4]

1. Italian Speleological Society - National Commission of Speleology on Artificial Cavities
2. Egeria Centro Ricerche Sotterranee, Rome
3. Centro Studi Sotterranei, Genoa
4. Earth and Environmental Sciences Department, University Aldo Moro, Bari, Italy
(Reference author: carla.galeazzi123@gmail.com)*

Abstract
Vittorio Castellani was an enthusiastic researcher and scholar. He investigated the truths of the underground world with the same scientific rigor that had earned him prestigious and coveted awards in the university and academic spheres. He combined a great culture and great intelligence: these qualities, together with his habit of scientific research, allowed him to isolate the significant aspects that appeared during an investigation: whether speleological, archaeological, or astronomical. For this reason, his opinion has always been authoritative and enlightening.
He played a decisive role in the development of post-war Italian astrophysics, both as a scientist in the field of stellar astrophysics and as a reference figure in the organization of research. Full Professor of Astrophysics at the University La Sapienza of Rome and later of Stellar Physics at the University of Pisa. Director of the Space Astrophysics Laboratory of Frascati (Rome), member of the Council for Astronomical Research, director of the Institute of Physics at the University of Pisa and of the Astronomical Observatory of Teramo. President of the Italian Astronomical Society, member of the Accademia Nazionale dei Lincei and Linceo Prize for Astronomy in 2000. He has represented Italy in the ESO Council and at the International Astronomic Union, has collaborated with the Institute of Astronomy (Cambridge, UK), the Astronomy Centre (Sussex, UK), the Instituto de Astrofísica de Canarias (Spagna), the European Southern Observatory and the Observatoire de Meudon (Francia). He participated in two missions of the Italian Antarctic Program (1993 and 1995) that aims to develop and support scientific research and to contribute to the governance and protection of Antarctica in the spirit of the Antarctic Treaty.
Despite his countless professional commitments, he dedicated himself with equal passion to Speleology. He took part in numerous archaeological and speleological missions in Italy and abroad (Spain, Greece, Turkey, Morocco, China, Oman, Turkmenistan, and Uzbekistan). He was a forerunner in many fields of Speleology, being among the first, in Italy and in the world, to deal with artificial cavities and focusing his interests on research on the technological development of the ancient and prehistoric world, regarding ancient hydraulic works. Author of countless publications and articles in the sector, he has been a member of the National Commission for Artificial Cavities of the Italian Speleological Society since its establishment, promoter and scientific director of the journal *Opera Ipogea* (see Digital resources).

Keywords: Vittorio Castellani, scientific research on speleology archaeology and astrophysics, ancient hydraulic works, rock-cut settlements, Lincei Academy, *Opera Ipogea*

Speleology as a pioneering vision

Castellani began his speleological activity in the late 1950s, when speleology was largely a scientific domain pursued by researchers affiliated mainly with the Italian Speleological Society (SSI), which he joined in 1960, remaining member of SSI until his dead. Speleological groups in Italy were very few, and equipment - especially for those who could not rely on support from research institutions - was complex and expensive. Clothing, too, was still functionally inadequate. It was often necessary to test gear that was not always fit for purpose, with an inherent potential risk. Looking back today at the progression in underground karst environments while wearing garments made heavier by water and mud, on slippery ladders secured with hemp ropes, and at dives carried out without a wetsuit, we can understand that the protagonists of those explorations were driven - or at least sustained - by the sacred fire of curiosity and a great passion for discovery.

Re-reading the accounts published posthumously last May (Castellani 2026) and the technical reports that are largely set in the same places we have the confirms that necessity often stimulates ingenuity, but that without curiosity speleological activity would not exist.

Fig. 1. Vittorio Castellani in the 2000 while acquiring data in one of the ancient aqueducts of Latium (Italy). Photo Tullio Dobosz, Archive Centro Ricerche Sotterranee Egeria

Fig. 2. Vittorio Castellani during one of the study campaigns of the ancient caravan capital of Sijilmāsa (Moroccan Sahara). Photo Archive Castellani's family

In Castellani's accounts, it senses an authentic passion for discovery, coupled with an ability to synthesize multiple disciplines while looking toward the future. Thus, the techniques learned for exploring karst underground environments were applied by Castellani to research in archaeological areas - sometimes submerged - and later to artificial cavities in various parts of the world: his speleology was without geographical or intellectual boundaries.

Studies conducted in artificial cavities in Italy and around the world

In 1959, he was part of the group that explored the Grotta dell'Orso in Sarteano (Grosseto – Tuscany, Italy), which would later yield a remarkable assemblage of archaeological finds.

From 1960 to 1963, in agreement with the competent Superintendence, he organized a topographic survey campaign of the extensive proto-historic necropolis located near Grotte di Castro (Viterbo – Latium, Italy), during which abundant ceramic material was recovered. The adoption of speleological techniques enabled the access to hypogea whose entrances opened on steep tuff cliffs and the exploration of a significant system of tunnels.

In the following years, he conducted a similar campaign near Cerveteri (Rome), again in agreement with the competent Superintendence (Castellani 1974).

In 1963, he took part in an expedition to Sardinia and in the exploration of Grotta di Su Bentu. He participated in the underwater archaeology campaign carried out in Southern Italy by a mission of the *American Underwater Archaeological Society*, recovering significant materials, and he was among the group that, for the first time, identified the pile-dwelling site of Gran Carro in Bolsena Lake (Viterbo – Latium, Italy).

In 1966–1967 he devoted himself mainly to underwater speleological activity, which had begun in 1959 with an attempt to pass the Imele sump and led him to overcome the sumps of the Pastena Cave; he joined the Speleological Section of the Italian Alpine Rescue Corps. In 1971 he led the Italian delegation in the international speleological expedition "80 km Bajo Tierra" at Ojo Guareña, Spain (Bernacchi et al. 1974).

From 1971 to 1982 he headed the Department for Prospections and Comparative Research in Archaeology and Ethnology at the L. Keimer Foundation (Basel, Switzerland), for which he carried out five missions in the Moroccan Sahara (Castellani 1973; Castellani et al. 1974; Castellani 1976; Caloi & Castellani 1981; Castellani 1990), collaborating in the excavation of the ancient caravan capital of Sijilmāsa (Fig. 2) and exploring and surveying a series of necropolises and prehistoric tumuli, at times associated with significant rock engravings.

In 1978, with Arrigo Cigna, he studied possible speleogenesis in extraterrestrial environments (Castellani & Cigna 1978; Castellani & Cigna 2009a; Castellani & Cigna 2009b).

He developed an aerial photograph system using weather balloons, which was tested both in Italy (Necropolis of Montelibretti, Rome) and in Morocco. He explored and surveyed the tunnel system of Fontana Nova at Tarquinia (Viterbo – Latium, Italy). He explored and surveyed the Roman emissary of Lake Albano (Rome), followed by an intense and prolonged phase of research and exploration of ancient underground conduits in Central Italy (Isernia, Palestrina, Gabii, Nemi, etc.) (Castellani & Dragoni 1991; Caloi & Castellani 1994; Castellani & Dragoni 1997; Castellani & Dragoni 1998).

In collaboration with the University of L'Aquila, he completed a structural analysis of the Claudian Emissary of the Fucino (L'Aquila – Abruzzo, Italy), aimed at reconstructing the methods and techniques used in

Fig. 3. In 1997 Vittorio Castellani (second from right) took part in the mission to study the water-supply system (karez) of the Turpan oasis, in the Xinjiang region (China), in collaboration with the University of Urumqi

its excavation.

In 1993 he carried out a mission to Samos (Greece) to study the ancient water work of Eupalinos (according to Herodotus) (Castellani 2000b).

From 1993 to 2000 he participated in the multi-year missions in Cappadocia (Central Anatolia, Turkey) authorized by the Turkish Ministry of Culture, with the Centro Studi Sotterranei of Genoa and a team of National Commission for Artificial Cavities of the Italian Speleological Society, dedicated to the identification, exploration, and survey of ancient Byzantine underground settlements and their related hypogeal water systems for land reclamation (Castellani 1994; Castellani 1995; Bixio & Castellani 1995a; Bixio & Castellani 1995b; Bixio & Castellani 1996).

In 1995 he took part in the mission to Boeotia (Central Greece) to study the land-reclamation works of the Copais basin (Castellani 2000b).

From 1996 to 1998 he was a member of the Scientific Committee of the "International Campaign for Research, Study and Enhancement of the Sidin Area", under the UNESCO patronage, actively participating in exploration, documentation, and survey campaigns of the underground aqueduct of Gravina in Puglia conducted by the Centro Studi Sotterranei of Genoa (Bixio et al. 2000).

In 1997 he took part in the mission to study the water-supply system (*karez*) of the Turpan oasis, in the Xinjiang region (China), in collaboration with the University of Urumqi (Fig. 3) (Bixio et al. 1999).

In 1999 he was in Pantelleria (Sicily, Italy) to study the ancient Punic cistern system, conducted in collaboration with the University of Bologna (Castellani & Mantellini 2003).

In 2000, with the University of Pisa, he flew to Oman (Castellani 2000a) to study the settlement of Khor Rori (Dhofar). In the same year, in collaboration with the Centro Ricerche Sotterranee Egeria of Rome, he conducted the study of the aqueduct of ancient Praeneste (Fig. 4).

Fig. 4. Vittorio Castellani and Carla Galeazzi during the study of aqueducts of ancient Praeneste (Palestrina, Rome, Italy). Photo Tullio Dobosz, Archive Centro Ricerche Sotterranee Egeria

In 2001 he was engaged in Turkmenistan and Uzbekistan to study irrigation systems fed by the Murghab and Zeravshan rivers.

In 2003 he examined various prehistoric evidence in Sardinia, which led him to write one of his most distinctive books (Castellani 2005), in which he theorizes a likely location for Atlantis (Castellani 2004). In the same year, in collaboration with the Centro Ricerche Sotterranee Egeria of Rome, he conducted new studies of artificial drainage outlet system of the Nemi Lake (Rome) (Castellani et al. 2003) (Fig. 5).

His last mission outside Italy took place in 2004, on the Turkish Armenian border, organized by the Centro Studi Sotterranei of Genoa in collaboration with Hacettepe Üniversitesi (Ankara, Turkey), for the research, exploration, and documentation of underground environments at the archaeological site of the medieval city of Ani, capital of Armenia around the year 1000. At the same time, the authors of this contribution launched with Vittorio Castellani an important census project of

Fig. 5. Vittorio Castellani and Carla Galeazzi during the study of ancient outlet drainage system of Nemi Lake (Vallericcia well, Rome, Italy). Photo Tullio Dobosz, Archive Centro Ricerche Sotterranee Egeria

Fig. 6. Vittorio Castellani in 2004 in the Ponte Terra canyon (San Vittorino, Rome, Italy), while checks the mapping of the area carried out in collaboration with the Centro Ricerche Sotterranee Egeria. Photo Carlo Germani, Archive Centro Ricerche Sotterranee Egeria

the ancient Italian underground aqueducts, published after his death (see *Opera Ipogea* in Digital resources), and still in progressive updating of the data (Parise et al. 2009; Parise et al. 2015).

A clear vision for the speleology of the future

Castellani was also a tireless advocate of speleological organization. After a cave accident from which he managed to extricate himself almost on his own (Castellani 2026), he understood the need to establish a Speleological Rescue team (today CNSAS) also in Central Italy. From 1971 he took on the role of head of the 5th Group, which at the time covered a very large area; he held it until 1975 (Castellani et al. 1975), when he moved to England for professional reasons.

He joined the board of the Italian Speleological Society (SSI) in the 1976–1978 three-year term, and from 1979 to 1987 he served as its president. He interpreted this role with active engagement and a strong sense of responsibility, as summarized by his statement: "*This speleological community is something beautiful, great, and serious*".

In his first editorial (1977), he noted how speleology was progressively becoming more structured, also thanks to the emergence of the first forms of coordination among neighboring groups and to shared projects. He promoted the establishment of a Commission dedicated to Speleological Education and proposed the production of manuals to be distributed in schools. He advocated the widest possible dissemination of speleology; the scientific coordination of research; the protection of caves and karst areas; and free access to speleological literature (the "Franco Anelli" Documentation Center in Bologna - today one of the most important thematic libraries in the world -would be established a few years later). He also called for the definition of a national standard for drafting topographic surveys and for greater attention to bat conservation. Fifty years have passed, yet these issues remain strikingly relevant.

In 1978, immediately after being elected SSI president, Castellani returned to the need to create a new national speleological newsletter, helping to formalize the birth of the journal *Speleologia*. In the same year, he reaffirmed the value of using a clear and shared speleological language - capable of describing the underground world with precision - avoiding emphasis and terms borrowed from other disciplines.

In 1980, he clearly recognized the need to support Schools of Speleology, both through basic services and through dedicated teaching materials. This insight would be implemented several years later in the form of the "Notebooks".

The 1982 editorials, which marked the conclusion of his first term, shifted attention decisively to the protection and conservation of the entire karst territory, rather than "only" caves. In parallel, they outlined an increasingly ambitious editorial program, including *Speleologia*, *Grotte d'Italia*, the *International Journal of Speleology*, and a renewed focus on handouts/ "notebooks". The themes of international expeditions, regionalization and relations with the Italian Alpine Club (Club Alpino Italiano) also emerged.

The year 1983 opened with a growing awareness of the impact on cave environments produced by adaptation works carried out for tourism purposes.

In 1985, under his leadership, the Italian Speleological Society reached broad representativeness, with more than one thousand individual members and about 200 groups. Discussion resumed on the National Cave Cadaster and a dedicated Commission was established; however, it struggled to embrace the practical possibility of sharing data on a national scale: an opportunity partly missed and never fully recovered. Meanwhile,

instead, the National Commission for Artificial Cavities worked on defining a cadaster sheet for anthropogenic works of historical-archaeological interest, demonstrating that data integration is feasible and productive, despite the greater complexity arising from the wide variety of cavity types.

Conclusions

This work is part of the speleological celebrations conducted in Italy in 2026 in memory of Vittorio Castellani, which include a conference on speleology in artificial cavities, the posthumous publication of his unpublished stories, and the reprint of two of his works of particular interest. Twenty years after his death, the profile of Vittorio Castellani (Fig. 6) stands out as that of a scientist able to combine rigor, curiosity, and vision. His speleological work, particularly on artificial cavities, showed how different disciplines (from archaeology to ancient hydraulics), paved the way for a modern approach to the study of artificial cavities, grounded in careful documentation, international exchange, and the safeguarding of underground heritage.

Revisiting today his explorations and his organizational commitment also means recognizing how the agenda he outlined remains active: training, shared standards, data accessibility, protection of karst environments and hypogeal works, and clear scientific communication. Nurturing this legacy is not only a tribute to his memory, but a concrete responsibility: to keep "building synthesis" among different skills and communities, to understand and enhance the underground world with care and accountability.

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