

# Updating the typology classification of artificial cavities

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## Abstract

After the adoption in 2013 at the international level of the typological classification of artificial cavities, originally proposed by the National Commission of Artificial Cavities of the Italian Speleological Society, new researches and studies from different parts of the world highlighted the need for updating it, and possibly adding new entries in the classification. Many of these studies derived from activities of the members of the Commission on Artificial Cavities of the International Union of Speleology, and have been presented in the four Congresses Hypogea, organized since 2015. The advancements in research on artificial cavities brought at the Italian level to discuss new possible additions to the classification, and to present in this contribution the revised classification, that has been already defined and accepted by the Italian Commission. The classification is illustrated through some text, and the two tables included in this article.

## 1. Introduction

Studies on artificial cavities go back to many years ago, with a variety of researches and surveys that have been published in many different sources, since the issue of artificial cavities cover a wide range of disciplines, from history to archaeology, from geology to architecture, from biology to hydraulics, and so on. Starting from some of the main references on the issue, these were essentially classical works, such as the underground drainageways in southern Etruria and northern Latium by JUDSON & KAHANE (1963), that on archaeology of water by TÖLLE-KASTENBEIN (1993), or monographies on the most interesting areas in the world, as the rupestrian environment of Cappadocia, in Turkey (BIXIO & CASTELLANI, 1995; RODLEY, 2006; BIXIO, 2012), or shelters in China (GOLANY, 1992).

Then, a wide literature is available as regards especially the hydraulic structures, including the ancient underground aqueducts and all the related works for water tapping, collection, transport and distribution (CASTELLANI & DRAGONI, 1991; CASTELLANI, 1995, 2000; LAUREANO, 2001; MAYS, 2010; PARISE, 2009, 2012; SEMSAR YAZDI & LABBAF KHANEIKI, 2010; PARISE et al., 2015b; ANGELAKIS et al., 2016; BIXIO et al., 2017; VALIPOUR et al., 2020).

Hydraulic works were, however, not the only underground works object of studies: many other underground structures and works were in the meantime the focus of specific studies, from defensive works in underground shelters (BIXIO & DE PASCALE, 2015) and other war works (TRIOLET & TRIOLET, 2011), to rupestrian settlements and dwellings in the Mediterranean area (CRESCENZI & CAPRARA, 2012; POLIMENO et al., 2019), to worship and cult sites (GALEAZZI et al., 2016), and to dovecots (GERMANIDOU, 2015; BIXIO et al., 2023).

Italy was among the most active country in studies about artificial cavities, and Italian scholars among the leading researchers, both as concerns speleological explorations and scientific studies. It was therefore not surprising that the first efforts to classify the high number of typologies came from Italy. This contribution summarizes the story of the classification, and the main international activities coming out of it, before presenting a proposal of its revision, that follows that recently published in *Opera Ipogea* journal by GALEAZZI & GERMANI (2023), following works within the dedicated Commission on Artificial Cavities of the Italian Speleological Society.

## 2. The typological classification of artificial cavities

The typological classification of artificial cavities was issued by the National Commission of Artificial Cavities of the Italian Speleological Society in the 1980s, and proposed to the international community at the III Symposium on underground quarries, held in Naples in 1991.

It was only many years later, however, and precisely at the 15th International Congress of Speleology, held in Kerrville (Texas, USA), on 19-26 July 2009, that this topic became matter of wider interest, also thanks to the activity of the renewed Commission on Artificial Cavities of the International Union of Speleology (UIS). The UIS Commission restarted its work after the congress at Kerrville, in the attempt to raise again the attention on the issue of artificial cavities. At this goal, it was again in Italy, namely in Turin, that the classification of artificial cavities was the object of a specific workshop, organized in May 2012, with its proceedings published in a special issue of the journal *Opera Ipogea*

(PARISE, 2013). On that occasion, starting from the Italian classification (GALEAZZI, 2013), some adjustments were produced, both in the typological tree structure and in the terminology.

The further inclusion of new typologies of cavities led to the revised classification, that was presented at the 16th International Congress of Speleology, held in Brno (Czech Republic) in 2013 (PARISE et al., 2013), and since then adopted also at the international level.

Thereafter, the renewed enthusiasm of the UIS Commission on Artificial Cavities brought to the idea of organizing an international congress, specifically dedicated to Speleology in Artificial Cavities. The congress was entitled "Hypogea", and the first one was organized in Rome, Italy, in 2015, producing a ponderous volume of proceedings (PARISE et al., 2015a), that was distributed to participants at the time of the congress. The success obtained at Rome made Hypogea the main activity in the

years to come for the UIS Commission on Artificial Cavities.

After Rome 2015, following the will by the UIS Commission on Artificial Cavities to keep organizing Hypogea every two years, other three congresses have been organized, allowing continuous exchange of experiences and researches about artificial cavities from different parts of the world. All of this was realized notwithstanding the worldwide difficulties related to the Covid pandemic, and to political problems in some countries.

In 2017, Hypogea was organized in the magnificent scenario of Cappadocia, Turkey (PARISE et al., 2017); the lower number of participants, with respect to the first edition in Rome, allowed to give more space to field trips, and to visit many different situations of artificial cavities. In May 2019, it was the turn of Dobrich, Bulgaria, where the third Hypogea congress was held, as usual with the production of an interesting volume of proceedings (ZHALOV et al., 2019).

Then, in 2020 the Covid pandemic stopped the activities of the UIS Commission on Artificial Cavities, as well as those of the entire world. However, once passed this very difficult time, we started again thinking about Hypogea, and came back to Italy, this time in its north-western sector. In Genoa, at the turn between September and October 2023, the fourth edition of Hypogea was successfully organized, giving new, and very much needed, breadth to the UIS Commission on Artificial Cavities. The congress proceedings (SAJ et al., 2023) were as always distributed

at the Congress, a habit of which the Hypogea organizers have always been proud. At the time we write, the fifth Hypogea congress is planned to be held in Georgia in 2026; the decision to postpone one year the next congress was taken by the UIS Commission in order not to overlap this meeting with the 19<sup>th</sup> International Congress of Speleology in Belo Horizonte (Brasil).

All the four Hypogea so far organized have allowed a comparison among the countless studies carried out worldwide, at the same time highlighting the need for a further revision of the classification, updating it through the inclusion of new typologies. In this case, too, the journal Opera Ipogea has played a fundamental role, hosting tens of contributions discussing different typologies of artificial cavities, and the related acquisition methods (see, among the many valid contributions so far published, BIXIO & DE PASCALE, 2013; KLONER & ZISSU, 2013; TRIOLET & TRIOLET, 2013; GILLI et al., 2014; ZISSU & KLONER, 2014; YAMAÇ, 2019, 2021; BIXIO et al., 2021). To all of the above, the works about potential instability problems related to artificial cavities, with the opening of anthropogenic sinkholes at the surface (GUTIERREZ et al., 2014; PARISE, 2019, 2022) has to be added: in some countries, and particularly in Italy (VENNARI & PARISE, 2022), this subject has been the focus of many studies, of high interest also for civil protection issues, aimed at ensuring the private and public safety.

### 3. Revising the classification of artificial cavities1

The aim of the present contribution, deriving from the work by the Commission on Artificial Cavities of the Italian Speleological Society, is to propose a revision of the classification, updating denominations and introducing sub-classes for better detailing some typologies. Figure 1 shows the revised version of the classification, as accepted by the Italian Commission. At the same time, it was decided not to change the original numbering, as this would distort the previous documentation, possibly creating some misunderstandings in the future.

The new classification proposal, therefore, obeys to the following

scheme: 1) all the main typologies, labeled by capital letters ranging from A to G, remain unchanged; 2) all the sub-typologies, indicated by numbers after the main label, e.g. A1, remain unchanged, too; 3) a new level is introduced by adding a lowercase letter after the main label and the number, e.g. A.1a; this is aimed at better specifying the function those structures had at the time of their construction, and also in the sub-sequent phases of re-use. The following tables illustrate the revised classification.

**Table 1:** Revision and updating of the typological classification of artificial cavities (by the Commission on Artificial Cavities of the Italian Speleological Society) (continues).

<b>A ANCIENT UNDERGROUND HYDRAULIC WORKS</b>	A.1 – Water regulation and land reclamation works	A.1a – conduits for regulating the level of lakes and basins without natural outlets
		A.1b – conduits for the reclamation of marsh land; galleries for the regulation of streams in order to obtain land to be used for agricultural purposes, or to reduce water pressure (defence from flooding, protection from erosive effects)
		A.1c – channels created by covering water courses, to gain new spaces in urban areas (construction of roads, buildings, etc.)
	A.2 – Water tapping works	A.2a – tapping/collection channels to feed underground reservoirs (A.4a) or directly the aqueducts (A.3a)
		A.2b – tapping/collection channels to feed fountains, tanks or external channels, even free-flowing
	A.3 – Underground transport water works: aqueduct	A.3a – aqueduct
		A.3b – galleries carrying non drinkable water (white waters)
		A.3c – conduits to transport water producing power
		A.3d – qanāt, qanaq, karez, kārīz, foggara, rhattara
		A.3e – by-pass
	A.4 – Water storage works	A.4a – reservoirs
		A.4b – cisterns
		A.4c – tunnel cisterns
		A.4d – rock-cut cisterns
		A.4e – underground tanks
		A.4f – silos for liquids
	A.5 – Hydraulic wells	A.4g – small cavities to trap the wind, or other underground structures for the condensation of moisture to produce water
		A.5a – groundwater wells or cistern wells, artesian wells
		A.5b – withdrawing wells (from aqueduct or cisterns)

<b>A</b> <b>ANCIENT UNDERGROUND HYDRAULIC WORKS</b>	A.6 – Distribution works	A.6a – castellum aquae A.6b – distributors
	A.7 – Sewers	
	A.8 – Navigable underground canals	
	A.9 – Ice houses, snow houses	
	A.10 – Hydraulic underground tunnels or ducts with unknown function	
<b>B</b> <b>UNDERGROUND AND ROCK-CUT CIVILIAN SETTLEMENTS</b>	B.1 – Permanent dwellings	B.1a – underground structures to mitigate adverse meteoric phenomena (ventiducts, sirocco rooms, wind towers)
	B.2 – Temporary dwellings	B.2a – seasonal or extemporary settlements B.2b – false caves and nymphaea
	B.3 – Underground factories	B.3a – underground oil mills to produce oil
		B.3b – underground grape-treading basins for wine production
		B.3c – other underground workplaces (not dedicated to oil and wine production)
		B.3d – ovens to cook the limestone rocks and produce quicklime
	B.3e – underground conduits to draw outer air to be directed into furnaces in order to feed the flames	
	B.4 – Underground or rock-cut warehouses, storages, cellars	
	B.5 – Underground silos, grain pits	
	B.6 – Underground or rock-cut stables for animals	
B.7 – Underground or rock-cut structures for breeding and housing pigeons, bees and fishes	B.7a (former B.7) – rock-cut pigeon houses, dovecotes	
	B.7b (former B.8) – rock-cut apiaries	
	B.7c – fish tanks	
B.8 – Any other kind of underground civilian settlements		
<b>C</b> <b>UNDERGROUND WORKS DEDICATED TO WORSHIP AND BURIALS</b>	C.1 – Underground places sacred to celebrate cults	C.1a – underground or rock-cut buildings dedicated to sacred ceremonies and rituals, temples of any religion, mithraea and artificial cavities dedicated to cults
		C.1b – hypogea for hermitic, cenobitic and monastic life
		C.1c – underground places for carrying out esoteric cults and initiatory rites
	C.2 – Underground places for burials	C.2a – catacombs
		C.2b – rock-cut necropolises
		C.2c – isolated underground burials
C.2d – crypts		
	C.2e – funerary columbaria	
	C.2f – putridarium	
<b>D</b> <b>UNDERGROUND OFFENSIVE AND DEFENSIVE WAR WORKS</b>	D.1 – Defensive works	D.1a – underground traps
		D.1b – trenches (covered or open air)
		D.1c – bastion fortifications
		D.1d – stone fortifications
		D.1e – forts
		D.1f – cave fortifications
	D.2 – Galleries and connecting passages	D.2a – tunnels for transit or movement of weapons and armed men
		D.2b – connecting tunnels inside the bastions and the fortifications
	D.3 – Mine and countermine	D.3a – mine tunnels
		D.3b – countermine tunnels
		D.3c – mine chamber and mine shaft
	D.4 – Underground firing points	
	D.5 – Underground military deposits, including those for chemicals, bacteriological substances, garbage, hazardous materials	
	D.6 – Underground shelters for soldiers	D.6a – military anti-aircraft shelters
		D.6b – military anti-atomic bunkers
D.6c – military shelters and/with trenches, including underground hospitals		
D.7 – Underground shelters for civilians	D.7a – shelters	
	D.7b – anti-aircraft shelters	
	D.7c – anti N.B.C. (Nuclear – Bacteriological – Chemical) bunkers	
D.8 – ICBM Silo for inter-continental rockets (attack facility)		
D.9 – Defensive and offensive complexes	D.9a – defensive complex of first class	
	D.9b – defensive complex of second class	
	D.9c – “water-earth” complex	
<b>E</b> <b>MINING WORKS</b>	E.1 – Quarries	
	E.2 – Underground mines	
	E.3 – Suspended typology (before, non metalliferous mines)	
	E.4 – Mineral exploration	
	E.5 – Underground farming (e.g. mushroom patch)	
	E.6 – mine shaft (if isolated)	
	E.7 – mine descending way (if isolated)	
	E.8 – deposito of explosives (if isolated)	
	E.9 – gallery to carry out waters (if isolated)	

F UNDERGROUND TRAN- SIT WAYS	F.1 - Abandoned tunnels
	F.2 - Underground tunnels for pedestrians
	F.3 - Railway tunnels, tramways or funicular
	F.4 - Non-hydraulic (technical) wells, shafts
G OTHER WORKS	



Figure 1: The revised typological classification of artificial cavities, as approved by the Commission on Artificial Cavities of the Italian Speleological Society (drawing by R. Bixio).

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