Creating a Map of the Underground Heritage in the Mediterranean Area: A Visual Representation for a Comprehensive Research

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Abstract Interest in man-made (or artificial) cavities in the countries of the Mediterranean Basin led the Commission of the Italian Speleological Society to study and catalogue some of the most common troglodyte types in the region. Since 2000, the Commission has drawn up a study of the geographical distribution of rock-cut structures through a project initially developed by Mario Mainetti and Erica Besana in 1994. This geographical catalogue has been realised through integrating the information available in the international bibliography with the scientific research carried out by the Commission and the research groups affiliated therewith. The result of this work is a list of 1948 rupestrian sites distributed throughout 31 countries and represented on a general map. In this chapter, a general overview of the project is presented, along with a description of some case studies from different countries, including Tunisia, Libya, Turkey and Italy.

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1 Introduction

Artificial caves are human creations of historical, archaeological, anthropological and geological significance which are spread throughout the world and different in respect of their typology, construction period, and techniques. During the last 30 years, several interdisciplinary studies and research works have been conducted to create a homogeneous body of knowledge and compare experiences deriving from different areas. The most significant among them is the catalogue of the rupestrian sites of the Mediterranean area, an ongoing project—initially developed by Mario Mainetti and Erica Besana in 1994—in which 1948 rupestrian sites (Table 1), distributed throughout 31 countries, have been listed, analysed and visually represented. This investigation originated from the idea of creating a set of maps and datasheets to describe the distribution of underground architecture and the typological facets of the basic units. Subterranean heritage consists, in fact, of a diverse spectrum of architectural types, including dwellings, churches, mosques, minor places of worship, oil mills, dovecotes, and defensive structures. The majority of these examples are part of a vernacular language designed to respond to local needs, which perfectly exemplifies the interrelationships among cultural aspects, environmental control, and source sharing. The analysis and the adaptation of these ideas to contemporary represent an opportunity to develop new directions in sustainable techniques, and to promote diverse cultural and historical identities. In this chapter, different architectural types existing in some specific regions of Italy, Libya, Tunisia and Turkey are considered, with the aim of providing a broad overview of the different existing forms. References to historical events and geological features that determined settlements' distribution

Table 1 The number of settlements in the countries studied

Country		Country		Country		Country	
Albania	5	Macedonia	7	Malta	3	Serbia	15
Algeria	15	Georgia (eastern part)	4	Morocco	19	Montenegro	3
Armenia (western part)	1	Jordan	9	Moldova (southern part)	3	Syria	13
Bosnia and Herzegovina	2	Greece	157	Palestine	31	Spain	326
Bulgaria	9	Israel	9	Portugal	6	Switzerland	13
Cyprus	5	Italy	678	Gibraltar (UK)	1	Tunisia	161
Egypt (northern part)	4	Lebanon	18	Romania	10	Turkey	191
France (southern part and Corsica)	156	Libya	63	San Marino	1	Ukraine (Crimea)	10
Total							1948

and architectural features will also be included. Finally, a description of research methods and future directions will be identified, with the aim of increasing awareness of the heritage through data dissemination.

2 Research Method and Initial Results

The main idea of realising a map—and the related inventory—of the rock-cut sites in the Mediterranean area has been driven by the desire to create a compendium of all the information collected by different research groups and scholars in the field at different times.

In particular, the map has been originally created including the data available in scientific literature and those deriving from architectural surveys conducted by the National Commission of Artificial Cavities of the Italian Speleological Society (SSI). Contributions of other institutions and scholars have been included at a later stage to increase the level of awareness of rupestrian sites in countries not adequately investigated previously.

As mentioned previously, the project commenced in 2000 as a continuation of the experience of Mainetti and Besana, with the aim of providing a visual representation of a phenomenon which, with different forms, covers all of the Mediterranean Basin. Countries that do not border the Mediterranean Sea, such as Switzerland, Ukraine and Georgia, have been, however, included in this research to establish a cultural continuity among them and the bordering nations.

The visual material produced in this project has been realised while following a hierarchical structure. The first cartographical representation of the rock-cut sites of the Mediterranean Basin is a grey-scale index map in Mercator Projection (Fig. 1).

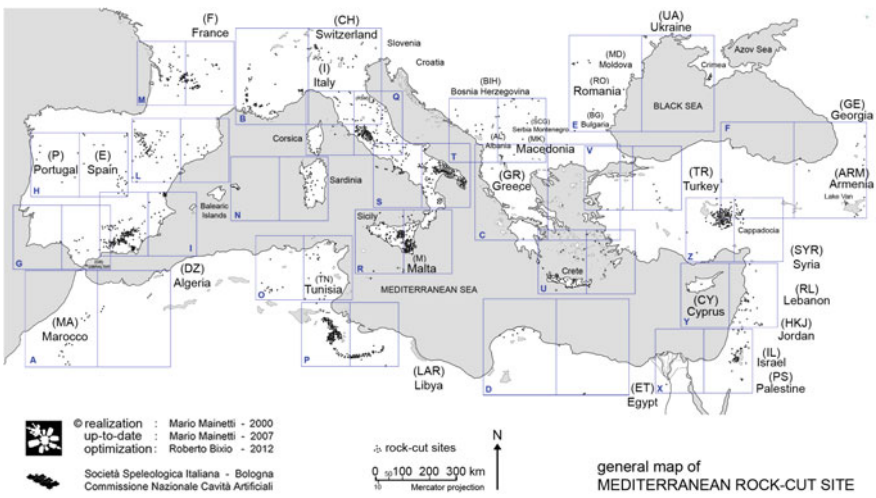

Fig. 1 General index map of the rock-cut sites in the Mediterranean area

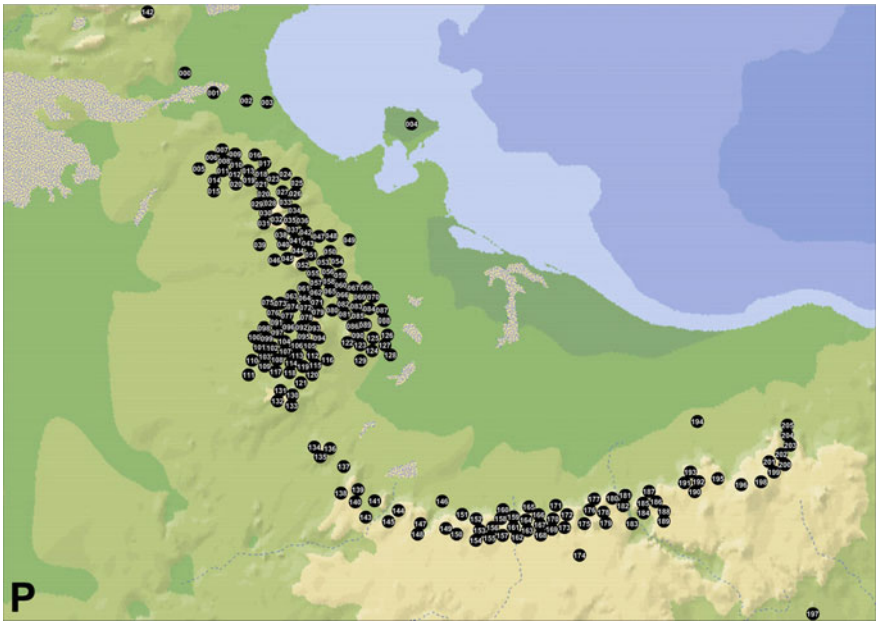

Fig. 2 Example of the map indicated with the letter "P", including Libya and Tunisia

This chart represents the distribution of the sites and provides an index of the relevant map sheets covering their regions of interest. The areas covered by the project amount to 23, with each one defined by a specific letter and represented through physical maps. In these drawings, colours are used to show changes in elevation and a set of black dots with numbers indicate the underground sites (Fig. 2). Each site has been associated with a set datasheet consisting of various information, such as geographical coordinates, typology, and the relevant bibliography if existing.

Besides the necessary information to pinpoint and classify the structures, the datasheets can also include information on the archaeological features of each cave, including transformations, extensions, and changes in use. Each datasheet is identified by an alphanumeric code, from which it is possible to know its location and typology immediately. Although the Commission on Artificial Cavities of the International Union of Speleology (UIS) has created a standardised classification system consisting of seven underground types [29], in this catalogue only four categories have been considered:

- Underground and semi-underground dwellings;
- Places of worship (sanctuaries of different types, including reused natural caves);
- Temporary shelters and underground defensive systems;
- Underground structures with utilitarian functions (barns, baths, animal shelters).

Underground structures such as burials, hydraulic works, mining works, transit routes as well as underground masonry works have been excluded from the present research.

Availability of the current data had a strong influence on the distribution of sites on the map. Differences in the number of sites for each country are not always dependent on the real quantity of real artificial caves or settlements, but they are somewhat related to the availability of such data. Accessibility of some of the geographical areas investigated is another essential element influencing the data distribution. Examples of this disproportion are represented by countries such as Armenia and Georgia, which are particularly abundant in artificial cavities, but rarely displayed on the map due to a lack of systematic studies.

The definition of "site" has been another crucial element which has influenced the distribution of underground settlements throughout the area. In fact, each site has been identified as a group (or a set of groups) of cavities on a specific piece of land. For example, Sassi of Matera has been reported as one site, even if the settlement consists of thousands of small dwellings dug in the tuff, subdivided into various groups and units. At the same time, other examples of sites can correspond to a single group of cave structures isolated on the territory.

In the next chapters, some models of the subterranean heritage of Italy, Turkey, Tunisia and Libya will be presented. These regions are representative of the varieties of cultural landscapes of the Mediterranean and are an expression of the extensive and robust relationship existing between peoples and their natural environments.

3 Case Studies

The case studies of the next paragraphs exemplify the diversity regarding the scale, geological features and climate of the regions analysed during this research. Different cultural, social and religious aspects will be described as determinants of traditional habitats and settlements.

3.1 Italy: Medieval Rupestrian Sites in Apulia

The Middle Age rupestrian phenomenon in Apulia represents the primary expression of a civilisation which has characterised for many centuries the history of the region. Apulia, an NW–SE elongated peninsula, which is surrounded by the seas and representing a natural bridge between the Italian Apennines and the other side of the Adriatic Sea, presents a peculiar morphology which significantly influenced the birth and development of the rupestrian civilisation.

At the same time, organisation of the human settlements developed according to the strategic, religious and political needs of the different ethnic groups.

Scientific interest in the rupestrian sites was initially focused on the caves of the most significant artistic and architectonic values, generally worship places such as rock-cut churches [7, 14]. It commenced during the last decades of the 1800s, and was dominated by the "pan-monastic" theory, according to which all Byzantine art in Southern Italy had to be considered the work of Greek monks, who arrived in Italy after the Arab invasions and the related iconoclastic oppressions. In this very general view, all cavities and hypogean settings were exclusively classified as Basilian settlements and hermit crypts.

With time, during the 20th century, a less closed vision started to develop. This new approach considered a "rupestrian culture" not limited only to the hermit and monk dimension, but essentially dedicated to "living in caves", in an attempt to understand this culture within the natural context offered by the local karst landscape. This latter, geologically characterised by carbonate rocks affected by karst processes, resulted in paucity of water at the surface (a serious problem for settlers), but, at the same time, offered many sites on which to carve and dig artificial cavities, thanks to the presence of soft rocks such as calcarenites [10]. These rock masses could be worked easily, simultaneously providing excellent mechanical properties to sustain the excavations, thus guaranteeing stable conditions for a variety of purposes [29]. Moreover, deep karst valleys and gorges, locally called gravine [28], offered along their steep flanks good sites on which to create settlements, which were hidden in respect of the view from the surface and, therefore, successfully protected from enemies' attacks.

Studies and researches on the rupestrian culture came to define a comprehensive chronology for the "life in caves", covering a long timespan, from prehistory to the Early Middle Ages. However, it was in the first two centuries of the second millennium that a real rupestrian culture could be identified, and represented a valid alternative to the classically built settlement. The rupestrian architecture was, in fact, linked to the masonry buildings, for both plans and volumes of construction, and the architectural elements, to recreate the illusion of a built-up setting [6]. In particular, rock-cut churches show many characters and schemes very similar to those of the built churches of the same age [25]. From the purest forms, consisting of a quadrangular room, an apse and niches on the walls, and adding to these further elements, the architecture of rock-cut churches reaches very complex planimetric shapes. A typical fan-shaped plan characterises the most complex and monumental architectural church types [7].

As aforementioned, the entire rock-cut village is strongly dependent upon the natural morphology of the site: the steep to vertical rock wall allowed excavating cavities, often dislocated in different stories and connecting one to the others through external stairs carved in the rock, or using internal links. Furthermore, road systems within the settlements allowed reaching the closest communication routes of greater importance. Water resources were provided through complex networks of surface channels to collect and transport the rainfall, and to store water in underground cisterns and tanks [24, 27, 30]. Some villages were also provided with defensive systems consisting of controlled accesses and sighting sites. In addition to civil dwellings and working places, many villages also hosted worship sites, located in particular areas of the settlements. Churches were situated on the outskirts of the

Fig. 3 Examples of crypts from Apulia: on the left, the crypt of S. Angelo at Otranto (Lecce province); on the right, a view from within a crypt in the Lama d'Antico site, at Fasano (Brindisi province)

town, since they were realised in a second moment, following excavation of the civilian dwellings, or merely to ensure the sacrality of the site. On the other hand, with regard to the settlements in the gravine, the crypt is typically located at the top, on the high plain or in the central terrace but without any other cavity above, so as to maintain and respect a specific hierarchy of values. The house of the priest or the custodian was often nearby, while tombs were typical in the area in front of the crypt.

The diversity of the forms and solutions to be found in this subterranean environment of Apulia represents a practical and efficient expression of a state of necessity, characterised by significant values. Its cultural, social and institutional aspects are surely comparable to those of the built-up villages (Fig. 3).

3.2 Italy: Rock-Cut Sites of Latium

In Latium, the rupestrian phenomenon is mainly concentrated in the volcanic formation areas of Volsino, Cimino-Vicano, Sabatino, and Vulcano Laziale (Alban Hills). This specific geological composition, consisting of tuffs, has fostered the development of different rock-cut structures.

In the area of Viterbo, after VII–VI AD, the Etruscan and Faliscan dug into volcanic tuff, creating vast necropolises. Among these tomb monuments, the necropolis of San Giuliano, located on a tuff cliff and already inhabited during the Bronze Age, is the best example of the variety of cave types (Fig. 4). Other underground sites in the Etruscan Latium include Blera, Castel d'Asso, Norchia, San Giovenale, Sutri, Tarquinia, Tuscania, Vetralla, and Vulci.

The fall of the Roman Empire and the subsequent barbarian invasion generated a progressive depopulation of the rural areas of Latium, although small rupestrian settlements connected to agro-pasture arose in the High Middle Ages. Reuse of old subterranean Etruscan or Roman structures was frequent during this period: the settlement of Castelnuovo di Porto in Belmonte [17, 36], the one called fosso Formicola in the area of Marcigliana and the structures found in the Alban Hills are all examples of such practice [8]. During IX–X centuries AD, many hermitages and

Fig. 4 The Necropolis of San Giuliano, Barbarano Romano (picture by C. Germani)

monasteries, often decorated with rupestrian paintings, were dug into the tuff and limestone, in the areas of Viterbo and the Apennines respectively (Valley of the Aniene River; [12]). In 2009, Tuscia University [1] carried out a research project comparing the historical heritage of Cappadocia and Latium. These two geographical areas present many similarities regarding architectural types such as churches, stores, cisterns and dovecotes, although subterranean hydraulic and drainage works—widespread in Cappadocia—are much less present in Latium.

Other significant studies, mainly focused on the sepulchral architecture of Etruscan Latium, have been conducted by Raspi Serra [33] and a group of speleologists who carefully analysed all of the sanctuaries in the region [13]. Further studies have been carried out on almost unknown sites such as Belmonte [17] and San Lorenzo Vecchio [16].

Finally, additional experiences in the analysis of medieval underground structures have been carried out during the previous decade [8] in some specific parts of the region. Dovecotes and pigeonholes, widespread throughout the region, are part of this diverse rupestrian heritage. These structures have been probably used since Etruscan times to collect both the guano and potassium nitrate to be used as natural fertiliser in agriculture [32].

Dwellings realised through adding new rooms in existing cavities have prolonged the rupestrian phenomenon to the 20th century, generating a series of structures in which new and old structures are part of the same system.

3.3 Tunisia and Libya: Berber Underground Settlements

Southern Tunisia and Western Tripolitania are the areas of North Africa characterised by significant examples of traditional architecture encouraged by the

combination of Ibadism, Nafusi Berber culture and the peculiar topography of this territory. These types arose from the adaptation to climatic conditions and in response to the collective needs of the communities who have inhabited this area for centuries which encouraged a highly distinctive identity. This uniqueness is evident in landscape transformations, architectural solutions and the urban "organisms" which are entirely representative of the social aspects and perfectly adapted to the environment [31].

Fortified granaries and cave dwellings are the most remarkable examples of this landscape transformation which are spread throughout a semicircular mountain chain which extends from the Matmata region near Gabes, Tunisia, to the city of Gharyan in Tripolitania. The western part of this mountain chain, oriented along a north–south axis and bisecting the south of Tunisia, is called Djabal Dahar, with the eastern part crossing Tripolitania instead being called Djabal Nafusa.

The origin of the underground settlements, in both regions, is dated between the VII and XII centuries AD [19], between the first and second Arab invasions. However, the migratory process following the Hilalian invasion in the 12th century has finally defined the structure and configuration of the settlements located on both the northern and the southern parts of the mountain border.

Many scholars have tried to classify the caves of this vast region into different types. In this chapter we will use the classification proposed by Jean Despois [11], one of the earliest scholars who studied and analysed the underground structures, identifying four main types according to their historical evolution.

The first type, probably the oldest, is characterised by one or two horizontal rooms and can be found throughout the Djabal Nafusa (Fig. 5) and in the adjoining regions of Tunisia around Tatawin. Houses are excavated along the mountain slopes with horizontal bedding of alternately hard and soft layers.

Rooms are excavated in sequence, creating a system in which an area, generally used as a living room, is followed by an area used for sleeping.

Fig. 5 The construction of a single room in Kabaw, Libya (Picture by B. Polimeni 2011)

Some of these habitations were transformed with external spaces in front of the entrance in order to form a specific urban configuration that in the Tunisian towns of Douiret, Chenini and Ghomrassen is called Kalaa.

The main design feature is a central rectangular or squared courtyard surrounded by rooms that are long and narrow. Golany [19] reports that in 1972, in the city of Matmata, there were 600 underground houses, 60 of which were abandoned, connected by a system of pathways on the surface.

The third type of habitation is the "pit-in-depth", a cruder construction dug deeply into harder rock or earth. These are frequently found under modern houses and are used as cellars or for storing grain. Their original purpose was undoubtedly that of habitation. In the region of Kabaw, Libya, such pits are often used as olive presses.

Finally, the fourth type combines a cave dwelling with some other form of habitation, as can be seen in the Arab village of Tigrinna in the Djabal Nafusa. The plan is similar to the grand court type, but the patio contains only two or three caves, covered by a facade of stone walls which, in some cases, are connected to external rooms.

3.4 Turkey: Artificial Cavities in Asia Minor

In the Mediterranean Basin, Turkey is the country with the highest and most varied number of locations wherein rock-cut structures are present. One hundred and ninety-one, distributed throughout the country, have been included on the map, although the real consistency of existing artificial caves is undoubtedly much higher [4]. It should also be taken into consideration that, in some cases, significantly large areas are listed as a whole: in the region of Cappadocia, for instance, only the rock-cut churches comprise more than 600 [21].

The Anatolian region, enclosed with the provinces of Nevşehir, Kayseri, Kırşehir, Aksaray and Niğde, has the highest concentration of underground sites and has represented, for its geographical position, a cultural bridge linking the East and West since ancient times.

The presence of different cultures and religions is testified by the presence of some of the most significant archaeological, architectural and artistic heritage of the world. Among these, evidence related to the use of the underground for carving structures is not minor.

In this particular geological environment, often consisting of volcanic tuff, it is possible to identify evidence and strategies in respect of the lives of different populations. From Hittites to Urartu, Phrygians and Lycians; from Greeks to Romans; from Armenians to Byzantines; from the Mongols to Turkish ethnic groups, including Seljuks and Ottomans, many civilisations have succeeded and overlapped in Asia Minor.

Several Hittite terms, present in the oldest sources, allude to places or buildings excavated in the rocks [26]. Among these, the most significant example is probably

the sacred spring cave called ^{D}KASKAL.KUR, which is located on the ancient site of Troy and mentioned in a treaty of 1280 BC.

The innermost part of the hypogeum was entirely artificially excavated using the well-known technique of opposing fronts, although this sector is probably more recent [15, 23] and personal communication, January 1, 2005. Realistically, it was needed to create a "tunnel-cistern" connected to the city overhead with supplying wells inside of the walls [5].

Other references to waterworks can be found in Herodotus [20] (Herodotus, I-75), which in the 5th century AD describes a bypass made by Thales of Miletus on behalf of Croesus in a war against Cyrus, king of the Persians, to divert the Halys River, today Kızılırmak. It is likely that this work corresponds to a tunnel excavated in the rock, located in the middle course near Sarıhıdır, and used to create a ford for caravans and commercial purposes [18].

The oldest historical sources mentioning underground structures used as residences date back to the 4th century BC and refer to an area not precisely identified in today's Eastern Turkey (Senofonte, L.IV, V, 25–28) [35].

The Middle Ages is probably the historical period in which most of the rock-cut architecture has been realised in various Anatolian regions.

Several examples show the massive diffusion of artificial cavities during this period: from the hundreds of cavities explored in the underground of Ani, in the Kars district [2], to those investigated at Ahlat, shared by Urartians, Armenians, Seljuks and Mongols [9].

Studying and cataloguing these examples has allowed the authors to understand the historical evolution of different rock-cut types, their state of conservation and distribution throughout the land. From this point of view, Cappadocia preserves the most remarkable repertoire of architectural forms. This area comprises thousands of churches, monasteries, tombs, dwellings, dovecotes and apiaries present, along with war shelters and water systems, excavated in the tufaceous cliffs and subsoil between the 4th and 13th centuries AD [3, 22, 34].

The first systematic study on this vast hypogeal heritage dates back to the beginning of the 20th century, conducted by an archaeologist, epigrapher and Byzantine scholar, the French Jesuit Guillaume De Jerphanion (1925–1942). At that time the structures had long since been abandoned (although some cavities are still inhabited today, or used as warehouses or workshops) and strongly compromised due to natural degradation, which has resulted in the disappearance of large volumes of rock and the loss of spaces excavated therein.

Since then, many scholars (art historians, archaeologists, architects, geologists, geographers and, in particular, speleologists, through their specific research and topographic survey methods) have been working to locate, explore and document this type of heritage, producing a remarkable body of literature. However, much remains to be done: the growing knowledge of rock-cut sites has indeed increased the awareness that the structures investigated thus far represent only the tip of a "stone iceberg" which has yet to emerge.

Fig. 6 Cave church of El Nazar in the Zemi Valley. On the left a picture of S. Saj, 1991; on the right the same church after the restoration in 2013 (Picture by R. Bixio)

At the same time, it is evident that the scientific community should implement the research into this topic, as it is exposed to the risk of rapid and widespread decay, until its inevitable disappearance.

The reasons for this threat are twofold: firstly, the persisting degradation is produced by natural agents on rock formations: erosion, rock falls, freeze-thaw cycles, flooding, etc. On the other hand, decay is a consequence of the increased impact of human factors (outside: the building of dams, roads, car parks, hotels, balloon areas, etc.; inside: non-archaeological sediment discharge, lowering of ancient tunnels, construction of masonry walls, gates and lighting systems for the ever-increasing number of tourists, the drainage of sewers to quickly solve the problems of local urban services, etc.). Such alterations are evidently due to the low sensitivity and knowledge of the same communities that today still exploit the economic potential of some of these anthropic cavities inherited from antiquity, thus having a substantial cultural and historical value, while others are subject to total carelessness.

Recent interventions of consolidation of the most important monuments (Fig. 6), thanks also to UNESCO patronage, are nothing but a drop in the ocean in respect of the rock-cut evidence of these places and, although necessary and commendable, still constitute an alteration of the original morphology of the sites, further complicating their historical understanding.

4 Conclusions

In this chapter the richness of the underground landscape of the Mediterranean regions has been described using four case studies, along with methods and strategies used thus far, to document and share knowledge acquired. This reference frame, created by mapping some specific aspects of the landscape, has delineated a substantial coincidence between the geographical space and the cultural environment. The rupestrian culture of this large geographical area testifies, in fact, to the birth, growth and development of several ancient civilisations, in which modalities of settling in the natural environment have left a significant mark in many countries of the region.

Although compiling a comprehensive and detailed inventory of the underground heritage appears to be complicated due to the multitude of sites, logistics and political difficulties, this first contribution can represent a solid base for further investigations which, in the future, might involve other scholars and institutions. To do so, an open-source geographic information system (GIS) accessible online, and including information deriving from different scientific fields, is the next step of this research.

The goal is to make this information freely accessible to a large community of people involved in the process of understanding and preserving cultural heritage, providing them with a powerful tool with which to foster the exchange of methodologies, case studies and best practices.

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