

Plus de quatre mille ans d'aménagements souterrains en Cappadoce (Turquie)

More than four thousands years of underground solutions in Cappadocia (Turkey)

Eric GILLI, Université Paris 8, Saint Denis, France

Ali YAMAC, Obruk, Istanbul, Turkey

Résumé

En Cappadoce (Turquie) les éruptions du Mont Argée ont déversé d'importantes quantités d'ignimbrites dont l'altération fournit des terres fertiles favorisant l'implantation humaine.

Ces formations trop friables pour être utilisées comme matériaux de construction ont des propriétés mécaniques qui permettent le creusement d'ouvrages souterrains durables. Une civilisation troglodytique s'est donc développée depuis quatre mille ans. Nos études montrent la diversité des usages. Dans l'Antiquité, de nombreux problèmes d'aménagement ont trouvé des solutions souterraines telles que des villes à plusieurs niveaux, des dérivations de fleuve, des aqueducs de plusieurs kilomètres, des citernes, des tunnels de dérivation des eaux pluviales.

Les premiers exemples de structures souterraines sont des sites hittites. On rencontre ensuite des tombeaux hellénistiques ou romains qui ont été transformés en églises, monastères et cimetières à l'époque byzantine, puis en simples habitations, greniers et pigeonniers, aux époques ottomane puis moderne. Certains de ces ouvrages sont encore en usage, mais la plupart sont tombés dans l'oubli et sont fortement dégradés. Parfois découverts fortuitement, lors de grands travaux, ils posent le double problème de la sécurité des constructions modernes et de la préservation du patrimoine.

On assiste aujourd'hui à un regain d'intérêt pour le monde souterrain de Cappadoce et des sites anciens sont valorisés par des aménagements touristiques. A cela s'ajoutent des réalisations actuelles, telles que des hôtels troglodytiques, des musées souterrains ou des silos de grande taille pour la conservation des agrumes. Ces ouvrages utilisent encore des techniques traditionnelles, souvent conjuguées à la mécanisation qui permet un creusement rapide.

Abstract

Cappadocia (Turkey) is a volcanic province where the eruptions of Mount Erciyes spread important amounts of ignimbrites whose alteration provides fertile land that favoured human settlements. These formations are too brittle to be used as building materials. However, they have mechanical properties that allow the digging and the stability of underground structures. A troglodyte civilization developed there, over four thousand years. Our studies show the diversity of these uses. During the Antiquity, many development problems found solutions such as underground cities, river diversions, several kilometres long aqueducts, cisterns, or rainwater collection galleries.

The first examples of underground structures are probably Hittites sites. Then Hellenistic or Roman graves were rock cut. They were transformed in churches, monasteries and cemeteries in the Byzantine times, then in simple homes, attics and dovecotes, during the Ottoman and modern periods. Some ancient works are still in use but most have fallen into oblivion and are highly degraded. Sometimes they are discovered incidentally during building operations which poses the twin problems of security for modern buildings and patrimony preservation.

Today there is a renewed interest in the underground world of Cappadocia but also of other Turkish provinces. The most interesting sites are valued by tourism developments. Added to this, are the current achievements such as cave-hotels, underground museums or large silos for the conservation of citrus. These works are sometimes still using traditional techniques, but the mechanization makes it possible a quick digging that favours the expansion of these underground solutions.

More than four thousands years of underground solutions in Cappadocia (Turkey)

Eric GILLI, *Paris 8 university, Saint Denis, France*

Ali YAMAC, *Obruk group, Istanbul, Turkey*

1 Introduction

1.1 Geology

Cappadocia is a volcanic region of central Turkey) where the thickness of ignimbrites, which spread to a surface of about 25 000 km² have reached a height of 400 m in various areas. They are the result of eruptions from both Ercyies and Hasan volcanoes mainly during the Upper Miocene and Pliocene periods but drawing in Çatal Höyük old city (Mellaart,1967) suggests that volcanism was still active 10,000 years ago. Such an ignimbrite formation is vulnerable to erosion and was rapidly carved by rivers flowing on the surface which formed deep and narrow valleys in this plateau region.

In many places, the erosion has also created thousands of fairy chimneys which is an essential component of the peculiar landscape of Cappadocia. In that area, the lack of building stone was counterbalanced by the possibility of digging cave dwellings in the flanks of the valleys or in the fairy chimneys. That is the second particularity of Cappadocia which is now part of the Unesco World heritage (Fig. 1). Hundreds of underground settlements have been inventoried (Bixio, 2012).



Figure 1. Fairy chimneys and cave dwellings in Göreme

1.2 Occidental discovery

First occidental reports were done by Paul Lucas in 1717, then Charles Texier, who in was in charge of searching archeological stuff for the Louvre museum, described several places of Cappadocia in 1838. During 1842 W.J. Hamilton had an extensive survey of the area.

The French priest G. Jerphanion was amongst the first people to present the underground world of Cappadocia but his work focused on Byzantine churches (Jerphanion, 1912 & 1925-1942). Then Cappadocia left unknown till the sixties. But at that time and even now people were more interested in Christian religious architecture than in the underground world itself. Therefore new explorations (Bixio et al, 2002, Bixio, 2012) reveal the extension of this underground world and show that its usage was much older and concerned various aspects of the life in the far Antiquity. They are unfortunately poorly studied but these discoveries show the capacity of these people to dig large underground structures that remained stable for centuries.

2 Use of the underground space

2.1 Age of cave dwellings

It is possible that flint tools were used since the Palaeolithic to dig shelters. However the digging of large volumes in the ignimbrites is only possible with metal tools thus the underground civilisation could only be possible since the Brass ages (Düring, 2011). Thus we assume that the tradition of digging underground could start at the Hittites period.

2.2 Antiques religious places

Discoveries in Hattusas, the Hittite capital, show that people had dug tunnels for probable military purpose, or for water supply. South to Hattusas, the underground city of Gökçetoprak (antique name was Sivasa), explored by Triolet (1996) and Bixio et al (2012) could be a Hittites' temple. Indeed, their religion accorded a great importance to springs, groundwater and underground places. Unfortunately, in spite of the presence of nearby Hittites' petroglyphs, there are neither underground archeological findings nor architectural features that can definitely prove it.

2.3 Graves

The first really proven use of rock cut places concerns Hellenistic and Roman periods during which underground graves are very common. Inhumation and cremation were both used, depending on the periods and the locations. If cremation was used (mainly for poor but non indigent people), ashes were placed in coffins or urns in niches carved in the grave walls. The smallest urns could be placed in small holes square or triangular featured that totally covered the wall in placed called columbarium.

To prevent fires and epidemics, it was forbidden to burn the bodies and to bury them in the cities or the villages and funeral places were always outside the living places. They were installed along a main road which gave to travellers, an indication on the wealth of the place and its inhabitants

The richest family had important places to bury their members. Some graves were like houses with several rooms. People and families had to pay for burial services that involved several kinds of workers like, musicians, wood and food providers, transporters, coffins makers, architects and rock cutters and one can suppose that funeral was an important source of income. More over, as families had to honour their ancestors at least annually, incomes were assured for decades, which made it possible to have perennial funeral companies.

The important size of Hellenistic or Roman rock cut graves in several places of Turkey, like Dalyan (Kaunos) or Demre (Myra), shows that people had tools and techniques for underground working in as hard rock as limestone. In Cappadocia the presence of similar Hellenistic and Roman graves (III to I century BC) is attested in numerous places like, Üçhisar, Mazıköyü (Fig. 2), Marcan or Akbin valley (Thierry, 1977; Gilli, 2017a; Yamaç, 2017) where necropolis are present. Work was easier as the main local rocks are ignimbrites that are softer than limestone. But, on the other hand, they are more sensitive to erosion and, except for rare places; the original features were not preserved. However the study of tools marks sometimes makes it possible to precise the age of some underground places (Lamesa, 2016).

One important unsolved question is the presence or not, of underground catacombs at the same period. Indeed, in numerous places, sometimes close to the graves, deep and underground tunnels, with side chambers, are observed (Fig. 3). There is no doubt that they were used as shelters for people or food until the 19th century but their age and the initial purpose of their digging remain unknown.

During the Byzantine period, the former necropolis areas were transformed in religious places by first Christians. A huge number of churches, cemeteries, cave dwellings and underground shelters were dug either in these previously used areas or in new places. Among them, Göreme valley is famous for its density of rock cut Christian churches.

Some examples like in Sofular, Akbin or Mazi tend to indicate that people used the pre-existing graves for new purpose, by enlarging them or digging side rooms and passage ways. Each new inhabitant more or less destroyed the traces of the previous ones, which is the main difficulty in the study of these cave dwellings.



Figure 2. Underground Hellenistic graves and modern storage place in Maziköy

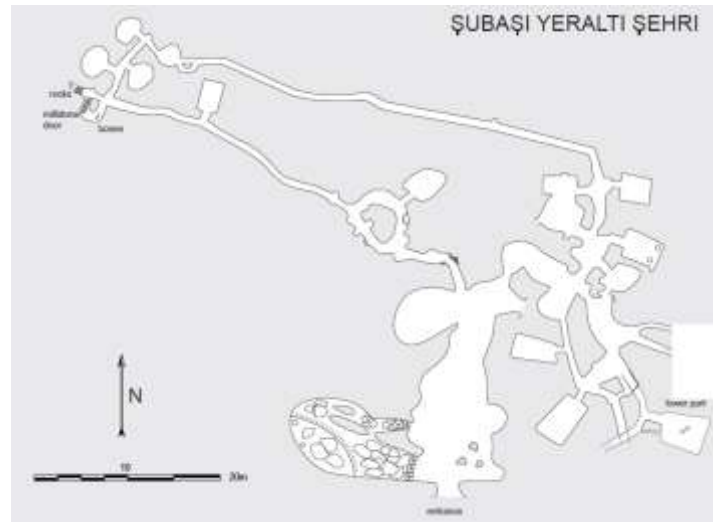


Figure 3. Possible catacombs in Subasi

2.4 Granaries and underground shelters

Some underground places recently explored are formed by several rooms in which large silos are present. They look similar to the collective *igudar* of North Africa (Asmhri & Ramo, 2013), where people, since the Antiquity, stored their agriculture production, either to protect it against robberies or to keep enough food in case of poor harvest.

In addition to the protection of the crop, people had also to protect themselves from invasions. The exploration of cave dwellings shows that most of the places had underground shelters. They are made with an access tunnel that includes an efficient closure system made of a stone cut wheel, similar to a millstone (Fig.4). Once closed, it was impossible to open it or to destroy it from outside. Some of these shelters were large enough to receive, people and cattle.

2.5 Underground cities

In plateau areas, below the largest villages the cave dwellings are real mazes. The most visited place is the underground city of Derinkuyu. It is an incredible network of underground stair ways, small and large chambers, monasteries and churches that extend below the Derinkuyu village. It extends to a depth of 45 m, with at least seven levels. Only a small part of the place is open for tourism (Fig.5).



Figure 4. Millstone door used to close a passageway in Derinkuyu

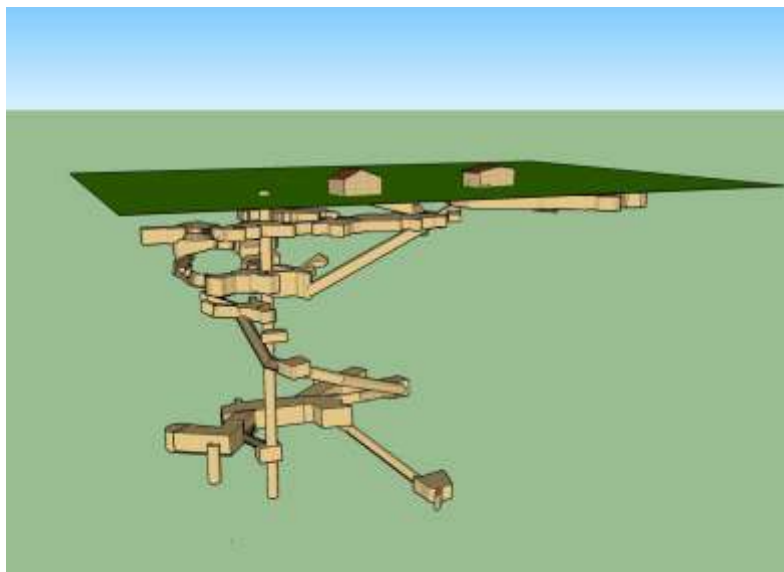


Figure 5. 3D view of the tourist part of Derinkuyu underground city. Depth is 45 m

Several places are blocked by millstone doors. The deepest part of the city is organised in a helix shape, around a vertical shaft that was certainly used during the digging, for extracting the cuttings. The presence of churches at the lower part suggests that people had to hide there, to practice their faith in safety and security, free of persecution.

It is generally assumed that these places were underground cities, but the absence of sanitation, water supply and waste deposit systems, does not support the idea of a long time residence for people. It is more probable that they were mainly used for storage, religious activities and underground shelters; only for a few days during invasion periods. Indeed, invaders had to immediately find food whose absence would oblige them to leave the place. Thus, being able to subtract food and cattle, from the surface to the underground world, was an effective way to protect local people from invasions.

2.6 Hydraulic works

2.6.1 Irrigation tunnels

There are long underground water tunnels in several valleys in Cappadocia. They collect surface springs, groundwater or rainwater. The underground solution reduces evaporation during the dry season. Due to the continuous erosion, new tunnels were required to be dug because of the corruption of the previous tunnels through the ages. The most upstream part of these tunnels could feed underground cisterns and fountains in troglodytes' settlements (Bicchi et al, 1995).

The longest explored one in Cappadocia is in Güvercinlik valley (Üçhisar). The total surveyed length is 3.5 km but parts remain unexplored (Gilli & Yamaç, 2015). It ends below Üçhisar village where underground cisterns are present (Fig. 6). The work was realized by 50 m-long portions connected to the surface by an inclined or horizontal gallery. In each portion the workers dug upstream and downstream to reach the nearby portions. Sometimes the connection between two nearby portions is poor, which shows the limits of the positioning and surveying methods.

In addition to these aqueducts, draining tunnels were also dug in the bottom of the valleys to prevent the erosion of crop areas (Castellani, 2002). These large tunnels were also used as underground quarries that produced blocks used to built terraces for artificial culture areas in the bottom of the valleys or their attributes (Gilli, 2017b). The smallest cuttings were probably used to fill in the artificial crop areas. Indeed, once fragmented, ignimbrites alter quickly and form a very fertile soil. These works that are well preserved in Ibrahim Pasa valley show that people had a global approach of their environment and used underground solutions for all the aspects of their life (Fig. 7).



Figure 6. Underground cistern in the 3.5 km-long aqueduct of Güvercinlik

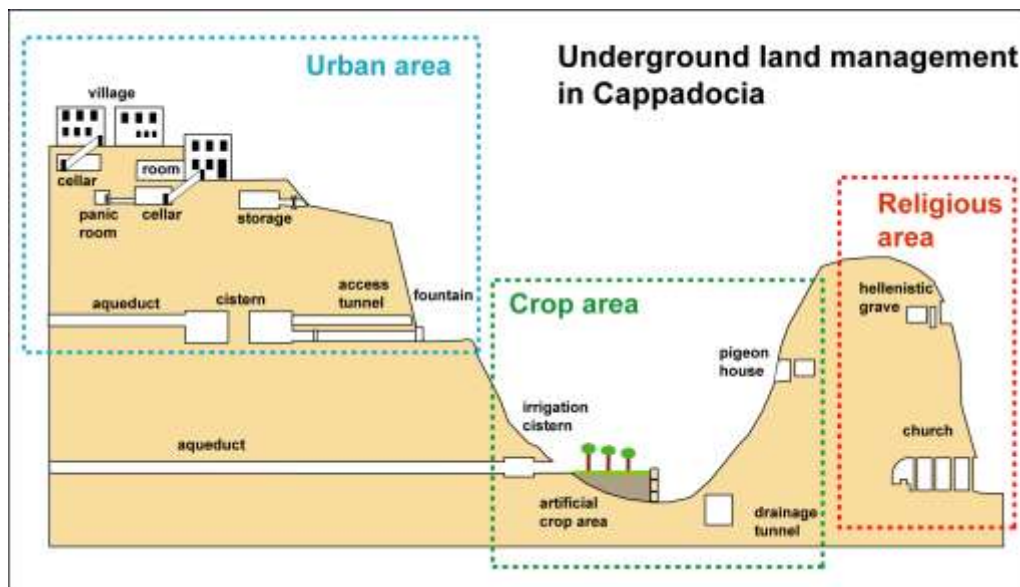


Figure 7. Summary sketch of the underground management in Cappadocia

2.6.2 River deviation tunnel

Hydraulic works can be amazing. One of the most interesting underground artificial caves is the Halys tunnel, which is supposed to have been used to divert Kızılırmak River (antique name Halys) (Fig. 8). It is located in Sarıhidir Village, near Avanos. The aim of digging the tunnel should have been building a ford or a bridge in order to cross the main stream of Halys. The age of the tunnel is unknown but a text from Herodotus reports the use of a deviation of Halys by Croesus' army in 550 BC to attack the

city of Pteria, in the Persian kingdom of Cyrus. The conception is attributed to the mathematician Thales. It could be that tunnel; however no dating supports this hypothesis (Gilli, 2013, Gilli et al., 2014).

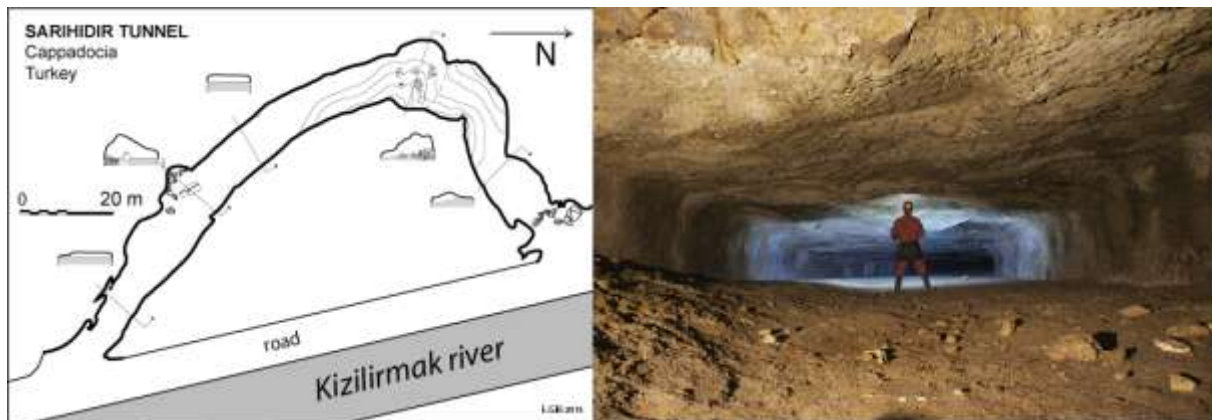


Figure 8. Halys derivation tunnel dug to divert the Kızılırmak river

2.7 Modern uses

Cave dwellings were still used until the beginning of 20th century. They were then deserted along with the development of modern constructions that are more comfortable. Meanwhile, since a few decades the use of the underground space is active again with both traditional and modern ways of digging. Most of the hotels in tourist places, like Göreme or Ürgüp, actually dig or restore underground chambers, using the same techniques and tools that in past times. For small projects, the workers from the Kavak village are reputed for their traditional know-how, but modern cutter heads, on mobile excavators, are nowadays used to dig important underground storage places for citrus fruits or potatoes. They are present in most agricultural places of Cappadocia. An interesting example is also the underground pottery museum in Avanos (Fig.9).



Figure 9. Güray Müze, the underground pottery museum of Avanos

3 Geotechnique

As ignimbrite density is low (1.4), it is easy to excavate for creating underground spaces. The main problem is not the rock itself but the presence of anomalies like basalt elements, cracks and faults. In some places it is obvious that the planned works had to be stopped or transformed due to the presence of such anomalies, but in most area the density of cracks was low enough to make it possible the digging of large underground volumes up to 10 m wide.

Except for the Üçhisar cisterns where large central pillars prove the use of a room-and-pillars method to support the overlying ignimbrites, most of the underground features poorly took into account the mechanical properties of the rock to create specific shapes for the cave dwellings.

The underground Hellenistic and Roman graves or the Byzantine churches are simple copies of the outside equivalent buildings. Vaults and pillars are mainly used for decorative purpose and several features like rock cut beams and joists are totally useless.

Workers were more interested in using the properties of the ignimbrites to copy pre-existing architectural forms that they were used to offer to their customers.

For non religious places the shape was mainly directed by the future usage and the ceilings were horizontal, even for large underground works like Sarihidir tunnel whose section is 10 m wide (Fig.8). Vaults are rare but the workers had a good knowledge of the behaviour of the ignimbrites, thus collapses due to inappropriate digging techniques seem to have been rare. Meanwhile, active erosion, slope decompression and probable earthquakes have caused many collapses that mainly affect the outermost parts of the cave dwellings and make it possible to see the inner parts of the dwellings.

4 Tourism and patrimony conservation versus city extensions

After the tourist success of Derinkuyu "underground city", most of the villages where extended cave dwellings were encountered, tried to organize tourist attractions which led to new surveys and explorations by Turkish or foreign caving groups. Even if all these attempts are not always successful, the idea that the underground world is part of the Turkish heritage is widely accepted and municipalities like Nevşehir, Kayseri and Gaziantep, or associations like CEKUL Foundation, now ask for systematic surveys. Important work was done by OBRUK group in those regions.

The need of a better knowledge of the underground world is also driven by the spatial extension of the modern cities that now extend on places where cave dwellings or underground quarries are present, which poses both problems of safety for buildings and preservation of the patrimony. For instance since several years there were continuous cave collapses in Gaziantep, related to the presence of an abandoned and forgotten underground limestone quarry. In 2012, a 35 m in diameter sinkhole occurred below the new cemetery (Fig. 10). The municipality decided then to inventory and survey its underground world which revealed a total extension close to 90.000 m² for the cave network below the cemetery (Yamaç, 2012).



Figure 10. Collapse of the new cemetery in Gaziantep (phot. A. Yamaç)

5 Conclusion

The peculiar natural and human environment of Cappadocia drove local people to develop a very active underground culture since the oldest times. Due to the lack of dating, no one is able to tell the age of the beginning, but as ignimbrites are soft formations, This underground civilization evolved over time with the apparition of new tools (brass, iron, steel), the growth of insecurity, and the succession of

different cultures and religions. Recently, the development of new activities like tourism or intensive agriculture was followed by new underground realizations. These examples show that the underground tradition is preserved even as it evolves. They make Cappadocia a unique place for studying, preserving and promoting an underground style of life.

6 Reference

- Asmhri E. M. et Ramou H., 2013, Réflexions sur l'origine des Igoudar.in Ait Hamza M; et Popp H., Les igoudar un patrimoine culturel, Centre Etude Hist. et Envir., Série coll.et séminaire, Institut royal de la culture, Rabat, n° 30, pp 23-56
- Bicchi A. R., Burri E., Castellani M., Castellani V., Pensabene G., 1995, Evidences for hydrogeological planning in ancient Cappadocia, in Bertucci G., Bixio R., Traverso M. (Eds.) "Le città sotterranee della Cappadocia", Erga, Genova, pp. 78-86.
- Bixio R. (Ed.), 2012, "Cappadocia. Records of the underground sites", British Archaeological Reports - International Series 2413, Oxford.
- Bixio R., Castellani V., 2002, Dispositivi di difesa nei sotterranei cappadoci, in Bixio R., Castellani V., Succhiarelli C. (eds.), Cappadocia. Le Città Sotterranee, Roma, pp. 265-278.
- Bixio R, Castellani V and Succhiarelli C., 2002, Cappadocia - Le città sotterranee, Istituto Poligrafico e Zeca dello Stato, Roma, 319 p.
- Castellani V., 2002, I condotti idrici della valle di Meskendir, in Bixio R., Castellani V., Succhiarelli C. (Eds), "Cappadocia. Le città sotterranee", Istituto Poligrafico e Zecca dello Stato, Roma, pp. 279-290.
- Düring B.S., 2011, "The prehistory of Asia Minor. From Complex Huneter-Gatherers to Early Urban Societies", Cambridge University Press, New York.
- Gilli E., 2013, Le tunnel de dérivation de l'Halys à Sarıhıdır, Turquie (550 avant JC). Une réponse troglodytique à un problème hydrologique, AFTES Edit, Tunnels et Espace Souterrain, 237, pp. 276-282.
- Gilli E., 2017a, From columbaria to dovecotes: two thousand years of use of cave dwellings in Agirnas (Kayseri, Turkey), in Parise M., Galeazzi C., Bixio R., Germani C., Yamaç A. (Eds.) "Proceedings of the Intern. Congress in Artificial Cavities. Cappadocia, March 6-10, 2015", Istanbul, ISBN 978-605-9680-37-0, pp.446-453.
- Gilli E., 2017b, Underground hydraulic works related to artificial crop areas in Cappadocia, in Parise M., Galeazzi C., Bixio R., Germani C., Yamaç A. (Eds.) "Proceedings of the Intern. Congress in Artificial Cavities. Cappadocia, March 6-10, 2015", Istanbul, ISBN 978-605-9680-37-0, pp.228-233.
- Gilli E., Yamaç A. and Tok E., 2014, Halys deviation tunnel and cliff dwellings of Sarıhıdır (Cappadocia – Turkey), Opera Ipogea, 2/2014, Società Speleologica Italiana, Bologna, pp. 29-36.
- Gilli E., Yamaç A., 2015, Water tunnels of Güvercinlik Valley (Cappadocia – Turkey), in Parise M., Galeazzi C., Bixio R., Germani C. (Eds.) "Proceedings of the Intern. Congress in Artificial Cavities. Rome, March 11-17, 2015", ISBN 978-88-89731-79-6, 202-207.
- Jerphanion G. de, 1912, Les églises de Cappadoce. In: C. R. des séances de l'Acad. des Inscriptions et Belles-Lettres, 56-5, pp 320-326. DOI : 10.3406/crai.1912.73046
- Jerphanion G. de, 1925-1942, Une nouvelle province de l'art Byzantin : les églises rupestres de Cappadoce, Geuthner, Paris, 5 vol.
- Jolivet-Levy c., 2015, la Cappadoce. Un siècle après G. de Jerphanion (tome 1 & 2),. Geuthner edit., Paris, 382 p.
- Lamesa A., 2016, « D'une Cappadoce à l'autre (V^{ème} av. J.-C -X^{ème} apr. J.-C.) : problèmes historiques, géographiques et archéologiques. » thèse doctorat d'archéologie, Université paris Sorbonne
- Mellaart J., 1967, Çatal Höyük: A Neolithic in Anatolia, Thames and Hudson, London, p. 142
- Triolet J., Triolet L., 1996, Deux conceptions du grand souterrain-refuge villageois, Hiermont (Picardie - France) et Sivasa (Cappadoce - Turquie), in Subterranea, n°97, éd. S.F.E.S., Artenay.
- Thierry N., 1977, Un problème de continuité ou de rupture. La Cappadoce entre Rome, Byzance et les Arabes, C. R. des séances de l'Acad. des Inscriptions et Belles-Lettres, 121- 1., pp 98-145
- Yamaç A., 2017, Underground Settlements and Cave Dwellings of Agirnas Village, Kayseri (Southeast Turkey), HYPOGEA 2017 Congress, Cappadocia – Turkey, March 2017.
- Yamaç A., 2012, Gaziantep Çalışmaları Raporu (unpublished).