WATER TUNNEL OF GUVERCINLIK VALLEY (CAPPADOCIA – TURKEY)

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Abstract

The region, known as Cappadocia and located in the borders of four provinces of Turkey today, has witnessed continuous settlement up to now. Tuffaceous rocks spewing out of the active volcanos in the late Pliocene and Pleistocene period in the region were used for many different purposes such as houses, barns, churches, burrowing by the locals. There are also underground cities for shelter and hiding. Water and irrigation requirement of the local people has also been solved by troglodyte methods. Because of the fact that there is not enough water on the plains of Cappadocia, only dry agriculture can be carried out. Water exists only in the valleys and the main agriculture lands are inside those valleys. In ancient times, the need of water for irrigation was provided by the tunnels within tuffaceous rocks in those valleys. At first sight, it may seem illogical to take the water flowing on the surface into a long tunnel on the wall of a valley which needs a tremendous effort to dig. But; apart from having a continuous and controlled irrigation of those agricultural lands, those tunnels should also have been excavated to decrease the surface water flow in order to widen the efficient agricultural lands in the valleys which are already narrow and also to protect the valleys from floods.

Today, there are one or more than one water tunnels in all the valleys of Cappadocia and only three of them have been extensively explored up to now. The water tunnel system, located in Guvercinlik (Pigeon) Valley in Uchisar is probably the last of two (or possibly three) different water tunnels excavated in different dates in this valley besides being the longest one known. With a total length of 1.840 meters, 14 separate surface connections and several side tunnels, that main water channel is a marvelous example of hydraulic engineering of Middle Ages.

Keywords: Cappadocia; hydraulic tunnel; water tunnel; underground channels

Introduction

In Cappadocia region of Turkey (Fig.1), the thickness of ignimbrite, which spread to a surface of about 25.000 km^2 as a result of eruptions active during Upper Miocene and Pliocene periods, have reached to a height of 400 m in various areas. The compressibility of these ignimbrites, which were already low, has been more and more decreased by rainwater due to microporosity (TOPAL & DOYURAN, 1998). After all, these rocks have created thousands of fairy chimneys through rapid erosion together with thermo clastic effects beside hydraulic effects. Such a formation which is vulnerable to erosion was rapidly rented by rivers flowing on the surface and formed deep and narrow valleys in the region. Those deep and branched valleys, formed among broad planes and plateaus, subject to same rapid erosion even today. There are long water tunnels dug on the valley walls at least in three of such valleys in Cappadocia. Because of the fact

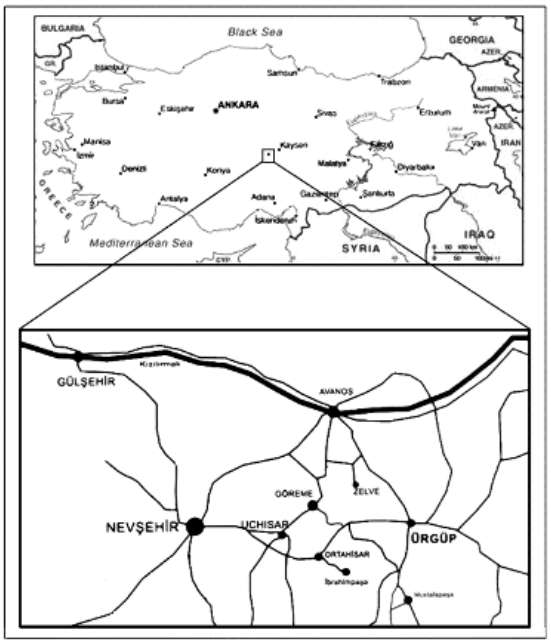


Fig.1- Location map of Cappadocia (A. Yamac)
Fig.1- Cartina di Cappadocia (A. Yamac)

that there is not enough amount of water available on the planes over the valleys, only dry agriculture can be carried out. Furthermore, the volcanic based soil fed by alluviums in the depth of valleys is a complete arable land and there are rivers ~~on all of~~ the valleys. At first sight, it may seem illogical to take the water flowing on the surface into a tunnel by digging long and ~~operose~~ water tunnels on the wall of a valley where there was already a river inside. However, there are important reasons for such an effort:

- To decrease the surface water flow in order to widen the efficient agricultural lands in the valleys ~~which are already narrow,~~
- Continuous and controlled irrigation of those agricultural lands,
- To avoid erosion of the valley slopes and to protect crops in the valleys due to fast discharge of meteoric waters,
- To use the residual water in the settlements at the end of the valleys.

Those ancient water tunnels generally collect the water from the springs and/or reservoirs from the beginning of the valley and due to the continuous erosions, new tunnels were required to be dug because of the corruption of the previous tunnels through the ages (Fig. 2).

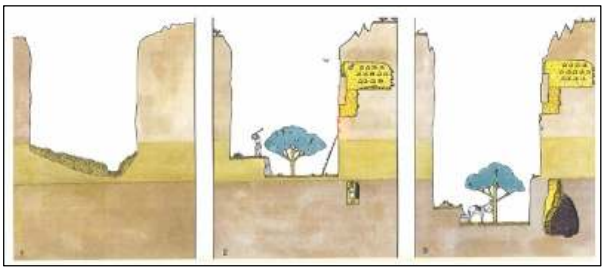


Fig.2- Evolution of valleys in Cappadocia (Castellani 2002)
Fig.2- Evoluzione delle valli di Cappadocia (Castellani 2002)

As the time passed, several new water tunnels were dug in the same valley. Today, ~~through~~ looking at the ~~residuals~~ from the surface, it is impossible to detect how many times this process was repeated. Similarly, to date ~~the remainings~~ of these tunnels is also nearly impossible.
In this article, we describe the results of our exploration and survey of water tunnels in Guvercinlik (Pigeon) Valley of Cappadocia, near the town of Uchisar. This tunnel system that was discovered and partially explored in 1984 (GILLI, 1984) shows great similarity with water tunnels in two other valleys ~~near this valley~~. Researches were executed in Meskendir Valley (CASTELLANI, 2002; BURRI & PETITTA, 2005) and Zemi Valley (BUKARENKO et al., 2011). When compared with ~~those~~ two other tunnels in other valleys, Guvercinlik (Pigeon) Valley Water Tunnel System catches the attention not only by being the longest, but also by having two and even three different tunnels dug in different periods in the same valley.

Guvercinlik (Pigeon) Valley Water Tunnels

Guvercinlik (Pigeon) Valley starts ~~on~~ a point near ~~to~~ the main road at 2.5 km south of Uchisar Village. At that ~~beginning point~~ two valleys made a fork; ~~west one is~~ Güvercinlik Valley and ~~towards the east~~ Zemi Valley ~~begins from the same point. Guvercinlik (Pigeon) Valley has its~~ name from the dovecotes on ~~the~~ both walls of the valley at the northernmost part, near

Uchisar. All ~~of~~ the old houses of Uchisar Village, located at the end of the valley, were built on the ~~walls of this valley~~. The valley begins with a mild slope in the south ~~and the~~ depth ~~is~~ about 6-10 meters whereas the depth near Uchisar Village reaches to 40 meters.

The main water tunnel~~,~~ starts from the intersection point of Zemi Valley in the south end where Guvercinlik (Pigeon) Valley starts, takes its water from the two underground reservoirs very close to the main road. The tunnel continues for 1.840 meters through the western wall of the valley (Fig. 3). This length makes ~~this water tunnel~~, not only in Cappadocia but in Turkey, one of the longest ancient water

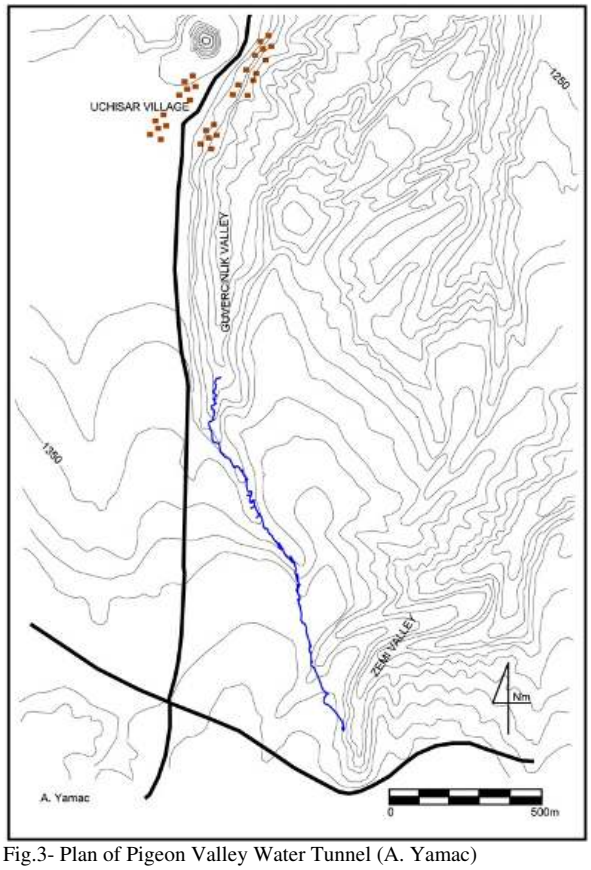


Fig.3- Plan of Pigeon Valley Water Tunnel (A. Yamac)
Fig.3- Cartina di tunnel acquea di Valle di Piccione (A. Yamac)

tunnels explored and surveyed till now. The main line of the tunnel is continuously 1.40-1.80 m high and its width varies 50-80 cm (Fig. 4). The terracotta pipes observed on the basement in the first sections of the tunnel disappear after 350 meters. Those terracotta pipes, probably, should have been installed in order to use

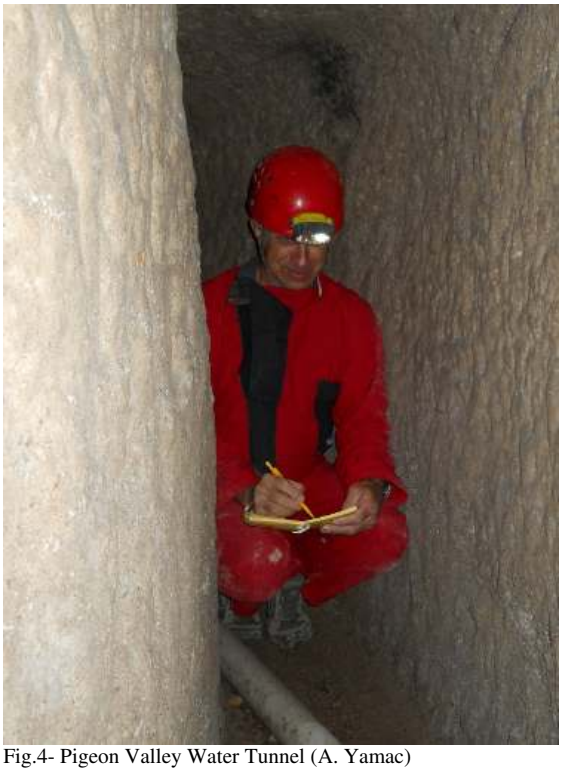


Fig.4- Pigeon Valley Water Tunnel (A. Yamac)
Fig.4- Tunnel acquea di Valle di Piccione (A. Yamac)

at least some amount of water, in the beginning of the 20th century when the tunnel was no longer benefitted efficiently. There are totally 14 surface connections and 22 branches in the tunnel. It is obvious that those surface connections were possibly dug for the maintenance of the tunnel and the branches for increasing the amount of water in the tunnel by spring waters from various directions. More interestingly, there are four different cisterns inside the tunnel. On those points the tunnel is blocked by a wall with a height of half of the total height of tunnel to provide a water accumulation. Those structures should have been thought as a solution to ~~decrease of~~ water ~~experienced~~ in summer times. Another importance of Guvercinlik (Pigeon) Valley is that the water tunnels, digged in the valley at different times, can be seen together and from very close points. 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.

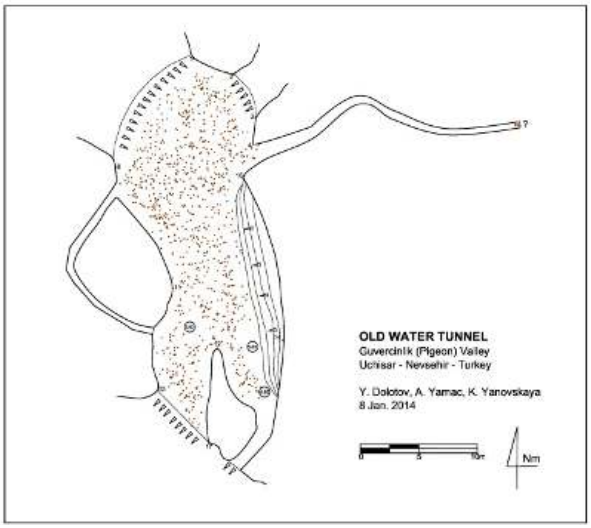


Fig.5- Plan of Old Water Tunnel (A. Yamac)
Fig.5- Cartina di Vecchio Tunnel Acqua (A. Yamac)

For instance~~;~~ on the north part of the valley, another water tunnel on the opposite wall of main water tunnel ~~locates~~. Remainings of that other tunnel which can be observed in places, has almost been ~~vanishing~~ completely because of erosion. A small part of it, which is certain to be 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 (Fig. 5). ~~In the south~~ of this area, it is certain that the small holes observed on the completely eroded east walls of the valley belong to another water tunnel (Fig. 6). ~~Such similar~~ eroded holes also exist in Meskendir Valley (CASTELLANI, 2002; BURRI & PETITTA, 2005).

~~Yet;~~ it is unclear if those water tunnels, which are located on the east walls of Guvercinlik (Pigeon) Valley and which are completely eroded, are follow ups of the old tunnel~~, which is~~ partially mapped in Fig. 5, or a third water tunnel ~~which is older than that~~.

We have no argument to date both the main water tunnel and the older ones. Some studies (BURRI & PETITTA, 2005) suggest the water tunnels in the valleys



Fig.6- Eroded holes on the east wall of Guvercinlik Valley, possibly remnants of an old water tunnel (A. Yamac)
Fig.6- Eroso fori sulla parete est del Valle di Piccione, forse i resti di un vecchio tunnel di acqua (A. Yamac)

were excavated between 7th to 13th centuries, but the human settlement in the region dates back to millennia ago. Thus older ages could be possible. Dating is difficult as no architectural peculiarity ~~nor~~ artefact are present to characterize a period time. Furthermore, such underground structures have been continuously used, repaired and rehabilitated for centuries. The oil lamps used to dig and check the tunnel deposited soot. Thus, carbone dating could be envisaged in some places.

~~Technics~~

Local people had developed a troglodytes civilization and used to live and work underground. Lighting was provided by oil lamps whose homes are visible in the tunnel. Bigger niches allowed hosting of oil jars (Fig~~ure~~ 7-A).

Digging such an underground structure poses no particular problem because the ignimbrites are easy to excavate and have good geotechnical properties. The two main problems are the cuttings removal, and especially the positioning. Indeed, digging an underground structure whose main axis is more than 1.600 meters requires a considerable precision for calculating the directions and slopes.

Engineers have solved both problems by constructing the tunnel by successive portions, a hundred meters long (Fig. 7-B). Based on a precise surface topography, inclined conduits were dug from the

bottom of the valley till the desired depth, then the aqueduct was dug upstream and downstream, to reach the next portion. In most cases, the connection was perfect, but some junctions have been problematic, with vertical or horizontal positioning errors. The workers then had to dig vertical passages or horizontal meanders to reach the neighboring portion

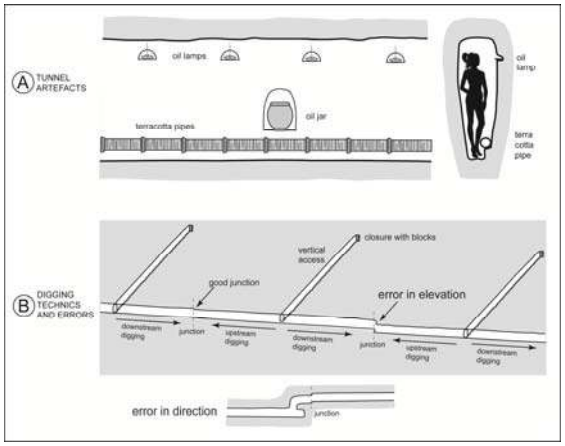


Fig.7 - A) Tunnel artefacts like oil lamp niches and terracotta pipes. B) Digging technics and some errors at the junctions (drawing E. Gilli).
Fig.7- A) Manufatti tunnel, come nicchie lampada olio e tubi in terracotta.B) Scavando tecniche e alcuni errori a livello delle giunzioni (disegno E. Gilli).

Geology

Cappadocian Volcanic Province (CVP) is one of the major volcanic provinces of Turkey. The CVP, terminated and partly transacted by major fault zones, extends for about 300 km southwest-northeast and is surrounded by tectonic basins and massifs of the central part of the Anatolian block (TOPRAK et al., 1994). There were numerous eruptions during Upper Miocene and Pliocene in the area and the rocks observed around Guvercinlik (Pigeon) Valley belong to pyroclastic flow mostly called ~~as~~ Akdag - Zelve Ignimbrite ~~which has an~~ estimated eruption date around 7.6 mio years. Fallout thickness, size and amount of lithic clasts, depositional facies and flow directions of the deposits shows that the source area of this pyroclastic flow is about 6 km north-northeast of Kaymakli Village and covers a total area of 1.200 km^2 (SCHUMACHER & MUES-SCHUMACHER, 1997; INNOCENTI et al., 1975). Besides, tectonic movements intensively seen in the region cause transposition of precipitated basaltic and andesitic lavas and later ignimbritic deposits. Those tectonic movements are the major reasons for the continuous stratigraphical changes of the adjoining areas.

Conclusion

Guvercinlik Valley water tunnel gives valuable information on the difficulties people had for managing water and on the solutions they had developed. Some works are still used ~~now~~ but the lack of maintenance and the absence of integration in local development plans endangers this heritage and restricts the knowledge local people and tourists should have concerning the habits of people living in the region in ancient times towards nature and water use. The diversity of Cappadocian underground water works~~:~~ spring catchments, wells, aqueducts, cisterns should be inventoried and classified. Unfortunately, the water usage ~~technics~~ of people in Cappadocia, whose history has been evaluated by thousands of years, have not been investigated comprehensively up to now. There are hardly ~~no~~ scientific researches available other than few limited resources about the subject. They need comprehensive scientific surveys and should be protected and carried into future as far as possible. Indeed, in addition to their historical interest, they have an environmental and ~~an~~ economical interest by making it possible the preservation of a local agriculture which is an important factor for the environment protection that could benefit to the touristic ~~place~~ Cappadocia ~~is~~.

In our point of view, these hydrological underground structures of Cappadocia like which bear utmost importance as for showing. Further studies on Guverginlik tunnel could focus on a more accurate survey of the valley right wall to determine the exact number of old tunnels and to determine their relative chronology.

Dating is also an important objective but this will remain very difficult.

Acknowledgement
We have to express our thankfulness to Mr. Yuri Dolotov and his teammates for their extraordinary efforts for the survey of this long and exhausting water tunnel during the harsh winter conditions. Without their efforts that exploration and article ~~wouldn't be~~ possible.

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