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LOST CONSTANTINOPLE: SUBTERRANEAN WATER STRUCTURES- APPLICATION OF SPEOLOGY TECHNIQUES IN THE ARCHAEOLOGICAL RESEARCH

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Abstract

An Archaeological survey has being realized about the water distribution system of ancient Constantinople directed by Dr. Çiğdem Özkan Aygün on behalf of Istanbul Technical University since 2005. The researches sofar covers the cisterns, wells, water distribution channels/galleries and other water structures in the area of today's Hagia Sophia Museum, Topkapı Palace Museum, Istanbul Archaeological Museums and Hippodrome. This zone refers to the acropole of the ancient settlement and first hill of East Roman city. Besides the existence of researches related to the supply system arriving to the city, a comprehensive archaeological research does not exist related to the historic triangle. The main objective of this project, is to explain the functioning of this water supply and distribution system, the connection between themselves and their connection to the historical upper structure. This is the reason why we have preferred to start our survey from the last point that those distribution lines arrive. This is the area which has kept its importance through all cultures as the religious and administrative nucleus of the historical city.

Besides a group of archaeologists, architects, civil engineers and art historians from Istanbul Technical University, this project has been realized with a group of professionals from ASPEG (Anatolian Speleology Group) . Also photographers and divers have contributed to the survey. We have utilized underwater and terranean ROV (Remote Operating Vehicles) for the inaccessible areas.

While following the water distribution channels, some unexpected structures have been also found and examined. The most important ones are under Hagia Sophia like a hypogeum under the northern garden.

This project has been pioneer for the cooperation of archaeology and speleology in Turkey and been followed with many other projects with a crutial contribution of speleologists. Information about the publications can be found under www.hagiasophiasubterranean.itu.edu.tr

Keywords: water supply system, galleries, wells, cisterns, water towers, archaeology, speleology, subterranean cities

Objectives of the Research

The main objective of this project, is to detect the unknown parts and explain the functioning of the Byzantine and Ottoman water supply and distribution sytem under the historical peninsula of ancient Istanbul/Constantinople. Although we know that in the past the water supply lines were conntected like a web, it is a difficult job to detect their connections under the totally changed over structure of the modern city. Those subterranean remainings together with the cisterns are the most neglected and distructed structures of the historical peninsula. The second step of our mission has been to find the connection of this substructure with the historical upperstructure which is non existant or mostly changed today.

We have prefered to start our survey from the last point that those distribution lines arrive which is named as the I.Hill of the East Roman city. This is the area which has kept its importance

through all cultures as the religious and administrative nucleus of the historical city. The biggest difficulty was the fact that this area was all covered with the museums like Hagia Sophia Museum, Topkapı Palace Museum and Istanbul Archaeological Museums buildings. The permissions which are needed to work under this area has been the most problematic part of our mission.

Research Members and Methodology

The survey was spread on a vast area which was unaccessable to the public. As well as archaeologists, architects, civil engineers and art historians from Istanbul Technical University, a group of about 20 professionals consisted of ASPEG (Anatolian Speleology Group) members , photographers and divers have contributed to the survey. Because of the high architectural vulnerability factor, we had to utilize nondestructive methods and penetration to the conduits even only 40 cm high would could be possible only with our collaborators from ASPEG.

Those conduits, wells or cisterns which were still full of water, had to be entered through squba techniques and even hookah system was utilised for the wells which are too narrow to enter with squba equipments. We have utilized underwater and terranean ROV (Remote Operating Vehicles) for the inaccessable areas and for detecting the dangerous objects in some part of the research area . Those ROV's were produced specially for that survey by our research member Engin Aygün who also shot the underwater documentery.

Our Contributions to the Public Archaeology

Although most of the subterranenan cisterns and related conduits have already been destructed there is a vast number of those structres still needed to be discovered. The inhabitants of the city are the real owners and should be the ones to preserve it instead of destructing them. Also we need their consciouness and collaboration to get reports for the remainings unknown to us.
To receive the public support and to share the results of our findings, we have been shooting documentaries and showing them on tv channels like İZtv documentary channel (**https://www.youtube.com/watch?v=qDm29b05src**) and TRT (Turkish Radio and Television). We have also organized conferences open to public to raise the awareness. As a result of our efforts, we must say that there is a high interest in the public towards the subterranean city.

Our survey also generated a poisitive affect for the collaboration of archaeology and speleology. Other projects have been conducted especially about the water supply lines in different archaeological areas with the help of speleologists since then.

Unfortunately we must declare that our efforts to give information including only the scientific results of our survey through serious and reliable media has not been appreciated by the official authorities and also has been used as a reason for not giving permission to proceed our researches. As a contradiction to their strict behaviour towards the scientific researches, the same authorities has been tolerant towards the nonscientific, opportunist and fictitious declarations in the mass media regarding our subject area especially about Hagia Sophia recent years.

The Water Structures under the First Hill of ancient Constantinople/İstanbul

Galleries and Cisterns

It is well known that the water supply has been a great challenge for the city of Istanbul. The historical peninsula did not have enough fresh water sources but it was chosen as a settlement area because of its strategic importance. The most ancient water structures in this area has been the wells and small cisterns. It is known that the first Roman supply line to channel water to the city was built by Emperor Hadrian (117-138). Emperor Valens (364-378) supplies water for the city from Thracia

which is 64m. high from the sea level and constructs Valens Aqueduct to pass the supply line over. Byzatines add many closed and open cisterns which are generally related with the supply lines but also can function autonomously. The cisterns are critical for a medieval city where the supply lines arriving from outside of the city walls could be difficult to maintain under the frequent sieges.

The supply lines although very difficult to trace the exact line, basicly comes from two different height. The above mentioned Thracian waters consists the high level sources where the Belgrade Forest waters being closer to the city consists the low level sources (35m. high from the sea level). They serve to supply both of the high and low points in this hilly city.

The Ottomans maintain the Byzantine supply lines and add new sources but the line known as Kırkçeşme higly correlates with the Byzantine line arriving from Belgrade Forest. The supply lines under the First Hill is basicly the Byzantine galleries. Those galleries are generally above the level of the main rock and the dimentions changes from 40cm to 90cm of width and 40 cm to 180 cm height[1].

Wells

Unlike the cisterns, the wells are fed by the subterranean water sources. Before the construction of big cisterns like Basilica cistern, L-shaped cistern in the southern courtyard of Hagia Eirene or Euxippos cistern in the west of Hippodrome which are dated to Vth-VIth centuries, the acropole area was fed through the wells and small cisterns. First Hill area of the east Roman city which consists also the acropole of the ancient city, is the center for the religious and administrative structures from pagan, christian and islamic era and containts the most ancient wells in the city.

Water Towers

Water arriving to the city from far away sources through the supply lines is taken into a distribution reservoir (castellum) and from there it is delivered to the quarters of the city which are located at different heights from the sea level. The water towers have the function of leveling the pressure of the water to be distributed so we see those water towers in İstanbul at app. each 10m. of difference in altitute. Some also have the distribution chests on their top.

Water Distribution Chests

They had a dimension of app. 1mx1m. They had the functions of precipitation and regulating the distribution of water to the fountains and houses of the high ranked people according to the need of those points. We have information how they have functioned and measurement techniques applied in Ottoman time which had functioned based on the same principles probably also during the Byzantine era.

[1] for detailed information on the galleries under Hagia Sophia see AYGÜN ÖZKAN, 2011, pp. 62-64; AYGÜN ÖZKAN, 2007 a , pp. 469-470; AYGÜN ÖZKAN, 2007 b , pp. 57-60; AYGÜN ÖZKAN, 2006a, pp. 99-110; AYGÜN ÖZKAN, 2006b, pp. 35-40.

The Findings Reached Through Our Survey

Hagia Sophia Subterranean (Fig. 1)

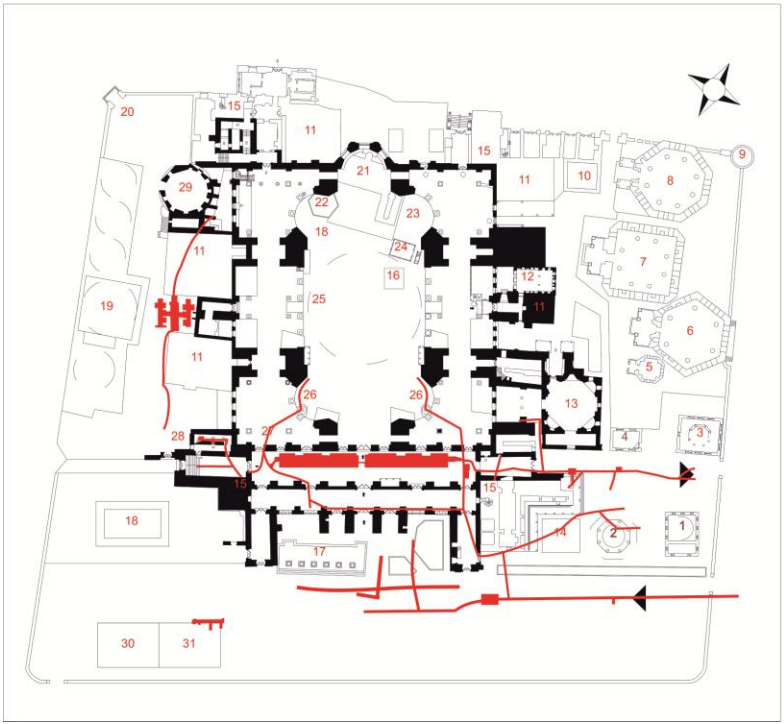


Figure 1 Findings of the project related to the subterranean of Hagia Sophia (redrawn from drawing of Murat Eğrikavuk by Kaçar, M., Bir, A. for Aygün, Ç. Ö. ,2011

The findings related to the subterranean of Hagia Sophia including 1km of galleries, pipelines (Fig. 2), subterranean rooms, wells, spolia especially from second phase of Hagia Sophia (Vth century) , hypogeum and the substructure under the nartex (Fig. 3) have been found through this research and published lastly in *Bizantinistica Anno XII-2010* (AYGÜN ÖZKAN, 2011). As those findings have been already published, we will not go into details for every subtopic but we will give information about the hypogeum in the north garden which is the less known and neglected structure in the Hagia Sophia complex. Hypogeum and the substructure under the Inner Narthex are the structures which had not been built as water structures but converted in a later time and connected to the supply line system. Those were the most enigmatic structures between the findings under Hagia Sophia.

One of the most interesting findings of our research has been two wells still full of water under the naos just below the pavement slabs. Our dives into those wells one full with 10m. and other with 6,5m. of water has been like a voyage to the pagan times of the structure through a water tunnel. The one to the south of the northwest pier of the dome had been mentioned by two researches before (ANTONIADES, 1907 and EMERSON & VAN NICE, 1943) but the others were found or researched for the first time. In total, 8 wells has been found at Hagia Sophia and its courtyards.

There were various number of spolia generally belonging to the Theodosius' Hagia Sophia. The Justinian's Hagia Sophia was known to be a rush job and we have observed in the subterranean channels that even very fine material belonging to previous building has been used as an ordinery stone to build those channels. Some unique marble slabs has been a great surprise for us.

As the area of Hagia Sophia had several historical layers from pagan and Christian era (IVth, Vth and VI centuries) it had a complicated system of water supply / drainage lines and galleries intersected with each other. The supply lines reached to 3 different layers on top of each other under the western garden. The supply line which was in connection to the main supply line of the city was also passing from under the western garden and continuing towards Hagia Eirene and later towards Harem section of the Topkapı Palace. Especially the gallery which is connected with the Horologion and being used as a store room for the museum today, was high and large enough to be a passage between the church and probably the Great Palace and Hippodrome. The nonexistence of the pipelines in that gallery has supported our thesis.

Some of our findings proved and some of them denied the legends created especially by the travelers who have visited this marvelous building in the history. For instance, there was not any trace belonging to the legendary cistern (DE CLAVIJO, 1406; GRELOT, 1680; VAN DER VIN, 1980; MORENO, 1789) but it is probable that we have found the well so called sacred Samaritan well which is accessable not from inside but outside of the building which stand at the point described by different sources which is at the south-east of the church (ANTONIADES, 1907; BONFIGLIOLI, 1974; LETHABY & SWAINSON,1894).

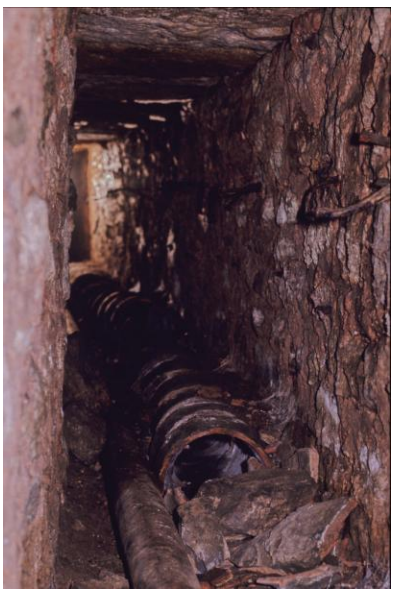


Figure 2 The gallery with terracotta and iron pipelines (by Metin Albukrek)
Figure 3 The substructure under the inner nartex (by Çiğdem Özkan Aygün)

Hypogeum under the Northern- 'Vezir's Courtyard of Hagia Sophia

There is a totally neglected hypogea under the northern courtyard which is also known as the Vezir's Courtyard. Although it is one of the most interesting structures under the courtyards of Hagia Sophia and it is full of rubbish and sewage today. This structure is located between the NW and NE buttresses. Hagia Sophia had to be supported by outer buttresses which were built various

dates including the Ottoman era. We have entered into the hypogeum through a hole in front of the NE buttress.

The structure is made of three chambers. The subterranean marble doorjambs of the portal still exists which is located on the eastern extremity of the main chamber (Fig. 4).
The main chamber is 1.4m. wide and 7.61 m. long with 2.3m. height. All chambers are covered with barrel vault.
The cubicula located on the north and south of the main chamber contain arcosolia and 10 *kline* which still exist (Fig. 5). Southern chamber is destructed with the northwest buttress from its western end which could contain two more kline at that side.
The *kline* chambers are broken up by a wall of greenstone at their western extremity breaking down the *kline* at that part (fig. 43). This wall may be the foundation of the byzantine buttress at the northwest.

The main chamber is connected with two water conduits occasionally from its western and eastern ends in a later date and all of the structure is covered with hydraulic cement transforming it to a cistern. M. Kouppas describes hydraulic cement made of " coarse lime (titanos) slaked by water into powder, sifted and laid in layers with cotton shreds. This was thoroughly mixed, and then olive oil was poured in and the whole gradually brought to a homogeneous mass" (LETHABY& SWAINSON, 1894).

The conduit to west is all brick and today carries sewage into the hypogeum. The conduit at the east comes from the direction of the skeuophylakion. This conduit can be connected to the channel which can be seen inside the niche in the interior of the skeuophylakion in the same direction. The pipe continues to north towards the big L shape cistern in the south courtyard of Hagia Eirene. Recalling Socrates' statement that Hagia Sophia and Hagia Irene were 'enclosed by a single wall and served by the same clergy', it is possible that the L shape cistern were being utilized by both edifices. Fresh water still runs from skeuophylakion. The *kline* which are placed in the niches and made out of marble with 5cm.thickness do not t have regular dimensions in every niche. The general dimensions are 150-160cm.x 80-90cm. Whereas the *kline* at the eastern extremity of the southern chamber is 140x140 cm.

The vaults of both the southern and the northern chambers have been broken at the center and earthenware pipes are visible at those points. The pipes have a 18 cm of diameter and covered with glaze from inside. Also, a piece of white marble slab can be seen from the broken points to allow the passage of the pipes. Those pipes were seemed to be used for pouring water in rather than carrying water out. It probably was drinkable water as the pipes are glazed. The piece of white marble slab is in accordance with the records from previous explorations in north courtyard. As the marble is irregularly broken to let the earthenware pipe pass through, we may think that it belongs to the marble revetment of a upper structure dating back to the original hypogeum building and it can be taken in the same context with skeuophylakion from the fifth or fourth centuries suggested by the dimensions of the brick (35cm. length and 4cm thickness in hypogeum and 34.5-37 cm length and 4.5 cm thickness in original phase of the Skeuophylakion) The later usage of hypogeum as a cistern can be related to a probably Justinianic structure – Great Baptistery? that is taken in the same context with the brick and greenstone pier which is visible on the west of the northwest outer buttress.

This funerary structure is unique with its depth, size and plan when it is compared with very few examples found in and around Constantinople. It is sure that it belongs to a prior date than Justinianic Hagia Sophia and can be dated to 4^{th} or beginning of 5^{th} century. Being all covered with hydraulic mortar including the vaults, there must had been a structure related with it after it had been coverted into a cistern.

Fig. 4 (left) The marble doorjambs of the portal (by Engin Aygün)

Fig. 5 (right) The arcosolium in the cubiculum of Hypogeum under the northern courtyard of Hagia Sophia (by Engin Aygün)

Hippodrome

The water supply line following the west side of Hippodrome ; the cistern beneath Sphendone; the 16th century Ottoman fountain related with the supply line; the water distribution chest in Sphendone and the terra cotta and iron pipelines have been researched and documented through our research of Hippodrome of Constantinople.

We have found out that the Byzantine supply line which is also utilised in the Ottoman time (Fig.6). The distribution chest and the Ottoman inscription over the fountain built on southwest of Hippodrome show that it has been an important distribution point in16th-17th centuries with water flow of 9lt/min and being raised to 18 lt./min.

Hippodrome lies on the axis of northeast-southwest. South-western apsidal termination of Hippodrome is called Sphendone. This part of the Hippodrome is built over the I. Hill of Constantinople which is descending towards the Marmara Sea. The level difference is tolerated with a 12m. high substructure under the Sphendone. The inner buttresses of this substructure creates 25 rooms covered with barrel vaults. Some of them are utilized as arcosolium type tombs. Although the construction material is brick (31cm.x5cm.) and mortar, the walls are covered with hydraulic cement.
Those rooms are surrounded with a corridor as large as 4,5m.. Inner buttresses are also added into those corridors probably after the earthquake of 551AD. (Fig. 7)

Figure 6 The water supply line following the west side of Hippodrome (by Engin Aygün)

Figure 7 Inner buttresses of Sphendone (by Metin Albukrek)

The Cistern under Sphendone of Hippodrome

The Substructure under Sphendone has level differences also in itself. The west end is 6m. higher than the east end. The lower eastern part is transformed into a cistern with 12m. height (Fig. 8). The cistern is also fed with a pipeline which is connected with the main supply line passing underneath the *Mese* which was the main street of Constantinople. This cistern was one of the biggest cisterns in the city with its neighbours Philoxenos Cistern and Basilica Cistern and it was supplying water for the Great Byzantine Palace. It must be the cistern Psykhra Kinsterna which was mentioned in *Patria*.

Figure 8 The Cistern under Sphendone of Hippodrome (by Metin Albukrek)

The Water Supply Line and The Water Distribution Chest under Sphendone

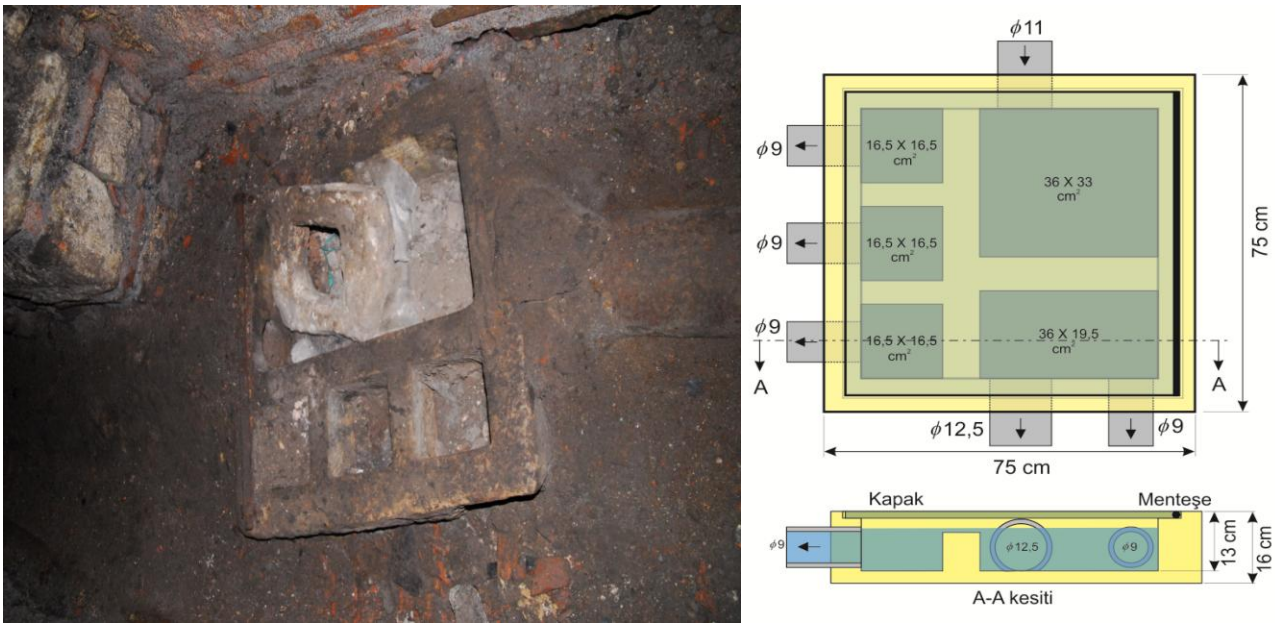
We have found a water distribution chest at the beginning of the supply line under Sphendone (Fig.9 & 10). After the measurements and drawings of the chest has been finished we have understood that the water distribution was regulated towards three different directions from the

supply line (AYGÜN ÖZKAN & KAÇAN & BİR, 2014) . The gallery at its entrance is 70 cm high then it arrives to 160cm. height. The material of the wall is rubble, mortar and brick.

There are two types of pipe lines passing in the gallery which gives information for the water capacity and production era. The earlier pipelines are terracotta. The inner perimeter of the terracotta pipeline which follows all through the gallery is 18cm. which shows us that it was a major arm of the supply line. We have also found evidences belonging to a siphon probably related with the supply line coming from Philoxenos cistern.

It seems that there are terra cotta pipes from Byzantine and 16th century Ottoman phases and there exists the iron pipe which runs parallel to the more ancient terra cotta pipe. This iron pipe probably belongs to the phase of the restoration of the pipelines during era of Mahmut I. in 18th century. The same iron pipe lines have been found in the galleries under Hagia Sophia when Mahmut I. orders also building of a new *Şadırvan* (fountain) for Hagia Sophia. This is a new technology which is resistant to the water pressure.

The existence of a fountain related with the exterior wall of the sphendone which is related with the water chest, gives us a *terminus ante quem* for the water chest and the gallery. We understand fro the legend of the fountain that it was built in 16th century by the reign of Sultan Suleiman the Magnificient.



Figures 9 & 10 The Water Distribution Chest under Sphendone and its Drawing (by Çiğdem Aygün – Drawing by Atilla Bir and Mustafa Kaçan)

Water Structures in the area of Topkapı Palace

The waters arriving to the Topkapı Palace area comes from two different sources hence from two different heights. There exists 3 Ottoman maps showing the supply line so called *Beylik Supply Line* which arrives to the Palace from approximate heights of 62m and from the province of Thracia (Maps of 1584, 1607 and 1748) but there is no map showing arrival of the *Kırkçeşme Supply Line* which comes from Belgrade Forest (northern forests of Istanbul) to the Topkapı Palace.

Although those were the supply lines utilised during the Ottoman era with names in Turkish, they were mostly restorated from Byzantine water supply lines. The line coming from the Belgrade

Forest maintains water structures with an altitute of 30-35m. like Hagia Sophia and Basilica Cistern. Our research has maintained the evidances for the distribution of water from Kırkçeşme line in the Topkapı Palace area. It is also found out that the two huge interconnected wells which are known as *Dolap Ocağı* (Wells with pump wheel) which are fed with Kırkçeşme line. Water distribution to the *Harem* was also unknown. The distribution and drainage channels beneath Harem area have been found out through our research. The main water supply line arriving to Hagia Sophia that we have observed passing from the west of Hagia Sophia could be also arriving to the Harem area.

Cisterns at the Area of Topkapı Palace

There has been recorded 43 cisterns in the area of Topkapı Palace courtyards , Istanbul Archaeology Museum courtyards and *Gülhane Park* (TEZCAN, 1989).
This is the historical area where the pagan temples of Greek colony Byzantion, Roman Byzantium and churches of Byzantian city of Constantinople rests. Water was the most important need for those religious structures.
As they are forgotten and neglected today, it was very difficult to find their entrances. Even some of the entrances were lost under the modern pavements of the courtyards including the biggest cistern under the courtyards of Topkapı Palace .
In our research of this project we strongly used Speleology techniques to have the data from very norrow and dark sides even inside the water by using cave dive techniques.
It is impossible to write about all of those cisterns in this article but the biggest ones are chosen. Some of them are researched through diving methods as they were full of water. We have utilised underwater ROV before dving in such cisterns as a precaution against the possible dangerous objects in them.

L Shaped Cistern under the South Courtyard of Hagia Eirene

This cistern is dated to VIth century (Fig.11 & 12). It has 48 columns. It is the second biggest cistern under the courtyards of Topkapı Palace. First build church in Constantinople which was named as "Ecclesia Antiqua" then was Hagia Eirene even before first Hagia Sophia or "Megale Ecclesia" of 360 AD which was built to the south of Hg. Eirene. They were sharing the same peribolos and the same clergy. As a result of this fact, the L-shaped cistern should be serving both for Hagia Sophia and Hagia Eirene. We have found the supply line going to the direction of Basilica Cistern through our research so this L-shaped cistern and Basilica Cistern must also be connected with each other through supply lines. It has 3 meters of water in it and full of rubish today.

Figures 11 & 12 L Shaped Cistern under the South Courtyard of Hagia Eirene (by A. E. Keskin)

The Cistern under the Courtyard of Old Chemistry Lab belonging to Istanbul Archaeology Museums

Another cistern was searched by using vertical cave techniques. The entrance is closed so we penetrated from the narrow entrance of the drainage water(that been used as a sewer).4 We made a descent to 8 meters where basement was full of poisonous water including cyanide and mud .

This cistern must be the substructure of a IX-Xth century Greek Cross planned church which does not exist today. It has 4 corridors with a total dimension of 22m.x13m. It has ionic impost capitals (Fig. 13).

Figure 13 The Cistern under the Courtyard of Old Chemistery Lab (by Metin Albukrek)

The Cistern under "Gözdeler Taşlığı" Section of Harem

This cistern is dated to IV-Vth centuries. It is covered with barrel vault. The capitals are half-finished corinthian type which are specially produced for this cistern. We can understand from the water mark that it was full of water till the top of the capitals (Fig. 14).

Figure 14 The Cistern under "Gözdeler Taşlığı" Section of Harem (by Ali Ethem Keskin)

The Cistern under the III. Courtyard of Topkapı Palace

This cistern has dimensions of 33m.x25m. Reused capitals are mostly ionic impost with simple cross in relief **(Fig. 15 & 16)** .Today, it is full of municipal water and being used as a water reservoir. It was interesting to see the huge sized inscription of "Allah" on the wall. It was covered with Ottoman hydraulic mortar as a sign that it was used as a cistern also in the Ottoman era.

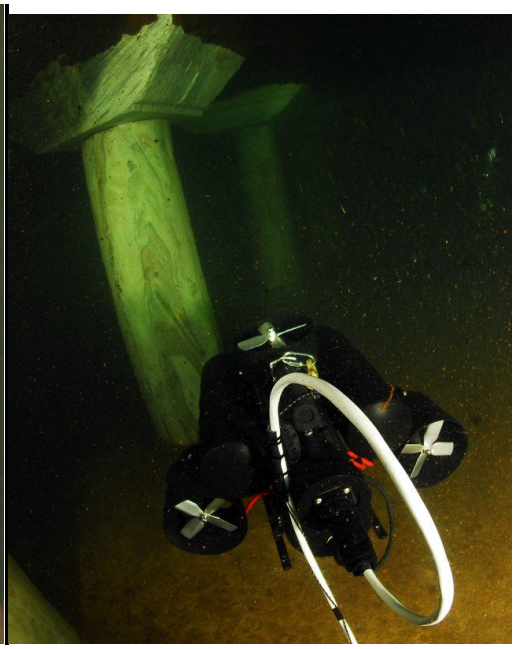
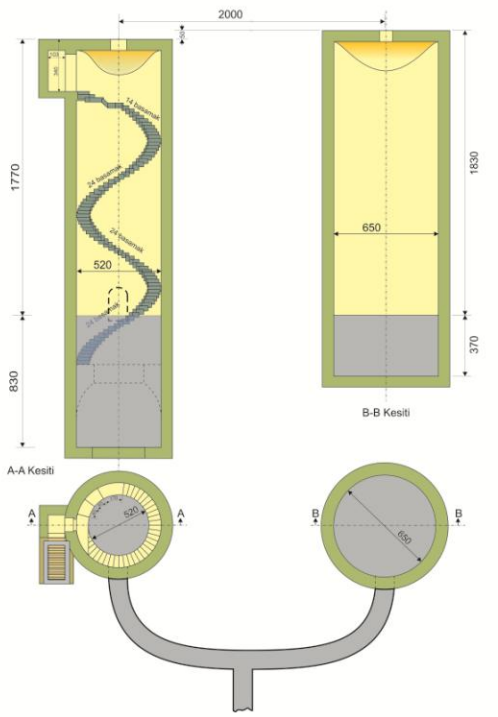



Figure 15 (left) The Cistern under the III. Courtyard of Topkapı Palace (by Ali Ethem Keskin)
Figure 16 (right) Inspection with ROV (by Ali Ethem Keskin)

Dolap Ocağı – Wells with Pump Wheel

There exists two huge wells which are connected to each other in the I. Courtyard of the Topkapı Palace.
Those interconnected wells were also connected with the Kırkçeşme supply line which arrived to the area at 18m. depth (Fig. 17 & 18). The pump wheel to take the water up had been run by the oxes. So called "Küçük-Small Dolap" well has a diameter of 5,2m and depth of 26m. which had 8m. of water when we have dived and it was connected with a gallery to the "Büyük-Big Dolap" well which has a diameter of 6,5 m. and depth of 22m (Fig. 19 & Fig. 20).
Although this system was built in Byzantine era, it was lost by the time when Ottomans had conquested the city. It had been refound by Great Architect Sinan in 16th century and totally renovated as a Ottoman architectural structure[2]. According to the 1715 dated notes of Architect Sinan, 247.5 lt/min. of water is delivered to those wells through the supply line.
We have detected also the supply line descending towards the direction of Marmara Sea from those wells towards the Byzantine Mangana quarter which housed an imperial palace, arsenal and several churches.

[2] For detailed information about Architect Sinan's restorations on Byzantine water supply system see **ÇEÇEN,**1996



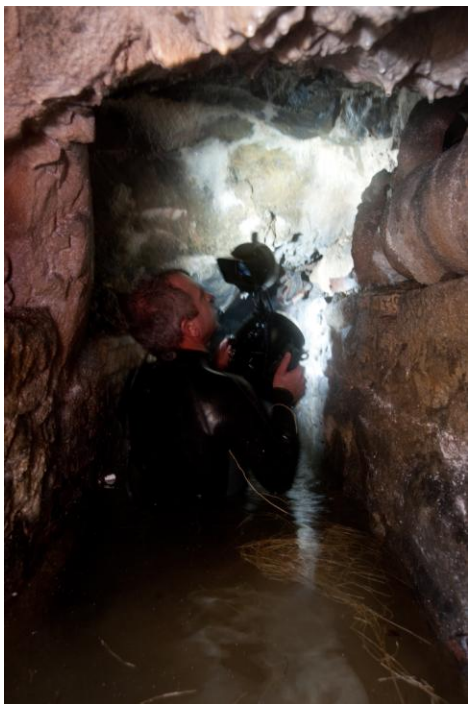


Figure 17 (left) Wells with Pump Wheel **(**Drawing by Atilla Bir and Mustafa Kaçan)
Figure 18 (right) The terracotta pipeline in the channel connecting the wells (by A.E. Keskin)

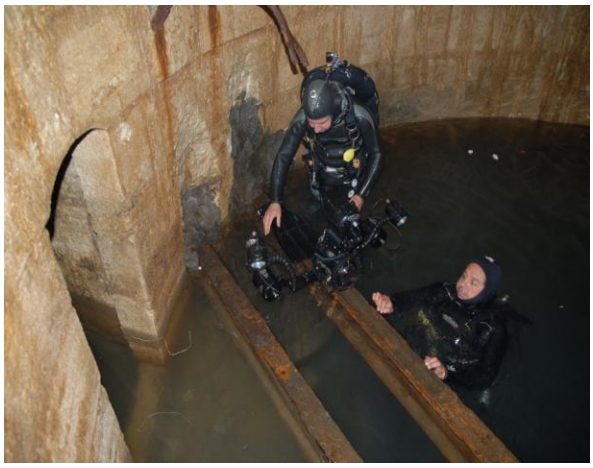



Figure 19 (left) The channel connecting two wells (by Metin Albukrek)
Figure 20 (right) Diving to the Small Well (by A.E. Keskin)

Non-Destructive/Non-Invasive Methods Utilised for the Survey

Surveys with Non-destructive/non invasive methods are helpfull for economy of time and money especially before the excavations in a vast area or for underwater explorations. Non invasive methods are also needed for preservation in situ . They are sometimes vital for the sites where the excavation permissions are almost impossible or for the sites to be rescued in a limited time.
As our survey area consisted very problematic sites for the permissions; we needed to utilize a combination of different methods for our survey in the limited time given.

Underwater ROV (Remote Operated Vehicle)

It is designed and produced by Engin Aygün for the deep wells, cisterns, galleries dark and full of water and used for pioneer inspection for dangerous materials and where there is no possibility for penetration of human (Fig. 21 & Fig. 22).

It is neutrally buoyant and moves in every direction. It can arrive till 150 m. depth and carries 2x400 lumen led lamps and a nickel–metal hydride battery. It can be commanded from surface and takes audio visual record and photograph.

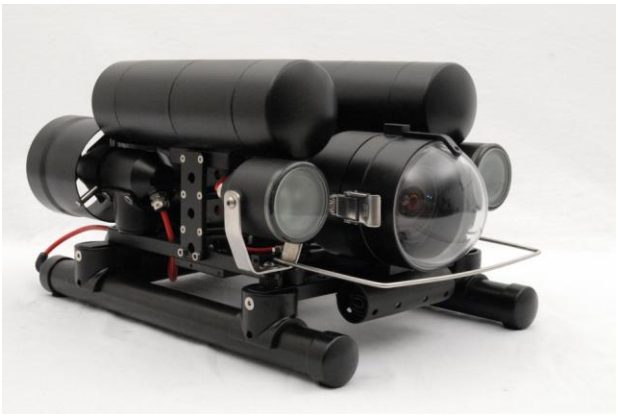


Figure 21 & Figure 22 Underwater ROV produced for our survey (by Engin Aygün)

Subterranean ROV

The subterranean ROV has been designed and produced by Engin Aygün specially for our survey. It can move across on rough and muddy ground in every direction and can be checked with a coloured monitor on its commander (Fig. 23).

It has rubber tracks and a water-proof compartment for camera. It can be controlled with a 30 m. cable. It has 2x400 lumen led illumination property.

Figure 23 The Subterranean ROV produced for our survey (by Engin Aygün)

The Current Situation and Dangers Agains the Archaeological Remanings

The galleries under Hagia Sophia are not utilized only for the passing of pipes for water supply but also functions for the drainage. The blocked and damaged galleries causes the problem of humidity. One of the consequences of humidity is the falling dawn of the mosaics.
Hypogeum (which had been converted to a cistern) under the north garden of Hagia Sophia and some galleries are full of sewage.
The subterranean substructures and galleries get damaged in occasion of new upper structures.
Denial of the existence and ignorance of those galleries, makes those areas available for some illegal actions (e.g. Many wallets and passports have been found in the galleries of Hagia Sophia which were thrown down from the narrow splits between the marble pavement slabs).

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