

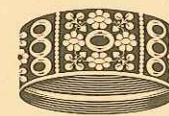
ESTRATTO

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ÇİĞDEM ÖZKAN AYGÜN

## New Findings on Hagia Sophia Subterranean and its Surroundings

This article is covering the findings of our researches at the subterranean of Hagia Sophia in 2005<sup>1</sup> and 2009. The Topkapı Palace Museum and Istanbul Archaeology Museum areas were also included in our research in 2009. We will be commenting on the results of the ongoing research concerning this area, in an upcoming article because of the vast amount of findings deserves a more detailed explanation.

This article is the product of a research (Fig. 1) which was performed only in 9 days in total due to the severe time restrictions put by the museum management. The lack of available time puts us into difficulty to comment on the huge number of findings but we still wanted to share them as completely as possible. We have discovered and drawn the plans of 1km. of the subterranean channels and three related chambers in Hagia Sophia in the above mentioned period. The chambers and most of the channels were totally new for the literature. Additionally, eight wells were discovered under the building and in the courtyards through using the methods of diving and caving. New findings about the hypogeum in the north courtyard have been recorded despite the structure was filled with sewage. In the Topkapı Palace area we discovered 1250m. of channels under the Second Courtyard and Harem section. One unknown room

<sup>1</sup> Ç. ÖZKAN AYGÜN, *The Wells, Subterranean Channels and Water Systems of Hagia Sophia in Istanbul*, in *FeRA 1 (Frankfurter elektronische Rundschau zur Altertumskunde)* (2006), pp. 35-40, [www.fera-journal.eu](http://www.fera-journal.eu); Ç. ÖZKAN AYGÜN, *Istanbul Ayasofyası'nın Döşeme Altı Dehliz, Kuyu ve Su Sistemleri* in *28. Uluslararası Kazı, Araştırma ve Arkeometri Sempozyumu*, 24. Araştırma Sonuçları Toplantısı, vol. I (2007), pp. 467-480.



related to the channels was found under Harem. We dived into the huge wells called Dolap Ocağı (Water Wheel) and discovered the channel which had been used to combine those two wells and another one going towards the cisterns and substructures in the Mangane region which completes the data about the water supply system arriving to the area. Two other huge wells in the courtyard of Ottoman Mint similar to the Dolap Ocağı system were discovered. We also dived in some of the known cisterns of Topkapı Palace in order to record their relationship with the water supply system. The director of the research would like to thank to ASPEG (Anatolian Speleology Group) for their professional help in discovering and measuring the subterranean channels and related structures through caving and engineering methods. Thanks are due to the directorates of the Topkapı Palace Museum and Istanbul Archaeology Museum for their precious help and support in our work and especially Prof. İlber Ortaylı for letting us to announce our findings to the public via a conference in Topkapı Palace in February 23th, 2010. Also we thank to Ass. Prof. Hülya Tezcan, Prof. Filiz Özer (Istanbul Technical University), Prof. Okan Tüysüz (ITU), Prof. Atilla Bir (ITU), Nimet Engin Baki, Nick Theocharis (University of Bern) and Jan Kosteneč (Charles University) for sharing their knowledge and Engin Aygün for designing and producing the robot cameras which are utilized in this research.

The area which is concerned through our research is the last point that the ancient water supply lines arrives. As it is also proved by the latest works of Crow et al.<sup>2</sup> it had been claimed by Professor Kazım Çeçen that the line coming from the long distance sources of Stranja Mountains in Tracia has to be the 'Longest Roman Water Supply Line' which amounts together with the findings of Crow et al. to at least 592 km. Çeçen suggested that the source of the water arriving to the acropole area is the Belgrade Forest which had been utilized to feed the lower districts of the city. The supply lines, cisterns and reservoirs had been continued to be used during the Byzantine and Ottoman periods with continuous new additions. The exact line that those water supplies have been following in the city is not known but the earlier works have been depending on an educated guess with the help of the topographical maps and placing the open-air reservoirs, the fountains, aqueducts and

<sup>2</sup> J. CROW, J. BARDILL, R. BAYLISS, *The Water Supply of Byzantine Constantinople*, London, 2008, p. 1.

water-towers on those maps. Our research follows a different method of direct survey in the channels and cisterns. Our findings have proved that there exists a web of subterranean supply lines which are in connection with the wells and cisterns which means that the whole system is connected in itself. Some 43 cisterns have been signed only in the courtyards of Topkapı Palace by Tezcan<sup>3</sup>. The Schneider's excavation in the atrium of Hagia Sophia indicated that the foundations of the church were not destroyed but simply covered over in Justinian's building campaign of 532-37 and probably lie more or less intact under the present church. However, with the exception of the fragments found in the atrium and the skeuophylakion, the lines of these foundations remain unknown. Our research, besides discovering the water supply system of the area, creates the chance to arrive those subterranean remainings through non-destructive methods and without any excavation. This research also gives answer to the legends of a large subterranean cistern and secret channels under the *Megale Ekklesia*. Legend has it that of them even talking about boats can connect to the sea via this huge cistern and channels.

Although archeological surveys have been carried on the water supply lines reaching to Constantinople, there is no systematic research for the supply lines in the city. Most of the evidence which have been recorded beforehand unfortunately does not exist anymore because of the ongoing construction activities in modern İstanbul without considering the historical heritage. Furthermore the subterranean cisterns are the most vulnerable heritages since they are hidden from the view.

In our research, the most important support was the research by Prof. Dr. Kazım Çeçen through 1980's and 1990's. Çeçen mentioned about a water distribution centre (Ayasofya Maksemi) in the vicinity to the Basilica Cistern<sup>4</sup>. During the excavations which aimed to provide an exit for visitors during the restoration of Basilica Cistern in 1980's, parts of the covered channel of the Hagia Sophia Water Distribution Centre were uncovered. According to Çeçen, it is evident that water flowed to the Basilica Cistern from this distribution centre and it is a part of the city distribution network of the supply line coming from the Belgrade Forest

<sup>3</sup> H. TEZCAN, *Topkapı Sarayı ve Çevresinin Bizans Devri Arkeolojisi*, İstanbul, 1989 (Türkiye Turing ve Otomobil Kurumu), pp. 196-240.

<sup>4</sup> K. ÇEÇEN, C. KOLAY, *Topkapı Sarayına Su Sağlayan Isale Hatları*, İstanbul, 1997, p. 64.



(northwest of the city). The water coming from Belgrade Forest could be elevated up to 34-35 m. As the altitude of acropole was around 38m, this elevation was enough to feed the cisterns and distribution centers in the area. The higher parts of the city must have been fed through the Valens Aqueduct which has an altitude of 61-62m from the sea and carries the water coming from Strandja Mountains.

#### METHOD OF SURVEY

Our group of researchers is consisted of academicians and professionals from disciplines of archaeology, architecture and engineering who also are experienced in caving and scuba. With the help of their technical skills, the researchers achieved to go by subterranean conduits even only 40 cm high and they have recorded the dimensions, the slope and the construction material all the while a trained photographer and cameraman have followed them and documented the research material. The wells and cisterns full of water were documented through the scuba techniques and the hookah system when the entrance is too narrow to enter with scuba.

Some of the wells and cisterns which had not been entered before might have contained dangerous materials such as sharp objects. In order to avoid the risk, we have sent the robot cameras first to see the conditions of the research area (Fig. 2). The robot cameras also had been utilized for the channels where there had been danger of poisonous gases (Fig. 3).

#### *The Findings:*

The reference points for the location of the findings are indicated on Fig. 1.

#### THE VAULTED STRUCTURE UNDER THE INNER NARTHEX AND THE RELATED CHANNELS (Fig. 4)

(Location is indicated by Point E1 and Point E2 on Fig. 1)

The structure running parallel to the esonarthex has double line of cross vaults (1.3m. of height) supported by 23 piers (Fig. 5). The structure is

made out of brick except the three layers of stone (with dimensions of 42cm long and 27 cm thick) at the feet of the piers. It has 47.2 m. of length and 3.90-4.25m. of width. The piers with dimensions of 58-62cm on one side are made out of brick (28-29.5cm long and 3-3.5 cm thick) with 4.5 cm of mortar in between and rising over the stone as it is mentioned. Such small bricks can be compared with Constantinian phase of Hippodrom<sup>5</sup> and the dimensions recorded from the wall on the eastern limit of hypogeum<sup>6</sup>

The distances between the piers are not regular, varying between 118cm to 168cm. The piers, walls, vaults and floor are all covered with hydraulic cement. The black stain which is visible all over the floor and walls can be the sign of the big fires in 5th and 6th centuries. This stain is peeled at most parts together with the thin layer of hydraulic cement with fine aggregate and makes it visible a thicker layer of cement with coarse aggregate.

The eastern corridor is wider (2m in average) than the western corridor (1.62m in average). The brick constructions which are not covered with the hydraulic cement are added to the piers at their eastern side at a later date (Fig. 6) and they don't reach up till the level of the vault. Although they look like buttresses, there is no pressure falling over them from the upper structure or sideways. They are made out of square bricks with the dimensions of 28.3x28.3x3.2 cm. Considering that they all have the same height, we can assume that they could function as supports to carry the lead water-pipe that we have seen on its floor. The same lead pipe was elevated from the floor with the help of the iron nails that are hammered to the walls in the channels. The iron nails are 17 cm long and are square in their section. The head of the nails have 3x3 cm dimension whereas the body is 1.5x1.5 cm (Fig. 7).

The structure is divided into two parts at the middle with a wall made out of reused marble pieces and mortar at a later date. It is visible that a water conduit which is close to the level of the vault is passing in this wall at the vertical direction to the narthex and continuing under the naos.

The sinter level at 40cm and 50 cm shows that there had not been a high level of water accumulation in this structure in the past. But it is also

<sup>5</sup> J. BARDILL, *Brickstamps of Constantinople*, I, Oxford, 2004, p. 105.

<sup>6</sup> K. DARK, J. KOSTENEC, *The Hagia Sophia Project, Istanbul, 2004-8*, in *Bulletin of British Byzantine Studies*, XXXV (2009), pp. 56-68, in part. 65.



recorded by the ex-managers Alpaslan Koyunlu in 1981 and Erdem Yücel in 1996 that the western part of the building became extremely humid and the floor got wet. Those are the only occasions that the structure under the narthex became full of water and it was emptied through the help of the pumps.

It seems that this structure was not utilized as a cistern but as a part of the drainage system and because of the damages in the drainage system occasionally it gets clogged. The only original constructional connection between that structure and the channels is with the channel G6-G7. This channel is as high as 1.7m. and there doesn't exist any traces of the pipeline in that channel. The channel continues till under the modern wall of the courtyard and is closed artificially. The other connections of the structure with the channels G1-G3 in the north and G2-G4 in the south is created through breaking holes at the junction points. To sum up, we can say that it is possible that this structure together with the G6-G7 channel can be dated to former buildings and the later built channels were incorporated to it. Furthermore the channel G6-G7 has arms going under towards SW porch, SW ramp, baptistery, baptistery porch and the horologion (or Antechamber as it is named by Dark and Kosteneć). Those can indicate that G6-G7 channel to be actually a tunnel which was connecting the subterranean structure with other parts of the building and maintain a passage from this structure towards augusteion.

#### THE CHANNELS

The vaulted structure is connected with channels at its northern and southern extremities. Our research ended up with the measurement of more than 1 km of total length. Although those channels show a very complicated architectural stratification, we can make a general classification according to some common characteristics.

We can say that the height of the channels passing under the building and the northern courtyard are much lower (60-80cm.) than the channels under the western and southern courtyard (1.7 – 2m.) as a general tendency. Only the G4-G5 channel at the SW is low that is supporting the theory about existence of other additional buildings probably belonging to Patriarchite Palace at that area in the past. This general characteristic may be depending on the level of the natural rock which is getting lower towards west and south. Also we can say that the channels under the building are covered with hydraulic mortar in order to prevent the humidity. Those are mostly just beneath the floor of the building but it is

not possible to follow the topography on their ground as it is elevated artificially at many points because of the debris (probably the debris of Schneider's excavation) or the in situ remainings of the former buildings (Figs. 8, 9). Generally they are visible the marble floor slabs of superstructure on the top of the channels and occasionally they are made out of spolia from the former building.

The channel which is coming from the direction of Ottoman urn (G2) is passing through a layer app. 1 m higher than the G6-G7 channel. The two marble urns (G1,G2) are known to be placed during Sultan Murad III's (1574 – 1595) reign and used to keep water for purification ritual of the muslims. Those channels coming from the direction of the urns were used to drain the water spilled from them and they were also carrying the leaden pipe which was supplying the fresh water to fill them. It is probable that there existed Byzantine basins in place of those urns like the one being exhibited in the exonarthex (inv. 311) of Hagia Sophia museum in our day. The openings for conduits which can be seen in the bowl and at the bottom of this basin is an evidence for its function<sup>7</sup>.

M3-M4 line is the deepest channel of all (top of its vault is app.5m. below the Justinianic atrium) and passes under the Theodosian pavement excavated by Schneider to the west of the propyleum. This channel provides the higher flow rate than the other channels and most probably was dug in natural rock. It was not possible to reach its floor because it is full of mud up to 40cm remaining to its vault. It was possible to grovel till point M5. There was a terracotta pipe which is glazed from inside entering into the channel perpendicularly which reminds the possibility for its feeding the famous Kantharus which had been recorded to be existing in the atrium<sup>8</sup>. This channel was most probably from the former buildings.

Although all of the channels are blocked artificially or destructed because of the downfall caused by the modern interventions like in the case of tourist toilets on the NW or debris of the excavation in the west courtyard, we could manage to follow G6-G7 channel and H2-H4 channel on south direction till the modern gate of the courtyard (also they were destructed at that point of the ISKI - General Directorate of Istanbul Water and Sewerage Administration excavations carried for the modern

<sup>7</sup> A. TADDEI, *Monuments and Epigraphic Evidence from the City and Suburbs*, in *The Sculptures of the Ayasofya Müzesi in Istanbul*, Istanbul, 2010, pp. 45,46.

<sup>8</sup> A. M. SCHNEIDER, *Die Grabung im Westhof der Sophienkirche zu Istanbul*, Berlin, 1941, pp. 29-30; G. BONFIGLIOLI, *S. Sophia di Costantinopoli, L'Architettura*, Bologna, 1974, p. 77.



water distribution channels at that point). Although they had different architectural features, G6-G7 is covered by the pavement slabs of the SW porch at its beginning but follows as an all brick construction. The construction technique of H2-H4 channel differs for its part on the north of Room D (H3-H4) and on the south of Room D. (H2-D), is covered with barrel vault and its walls are covered with ordinary stone masonry. It is visible that this channel is straitened by the stone wall (Fig. 10) on its both sides. H3-H4 channel has marble slabs on the top (Fig. 11) None of the channels are covered with hydraulic cement.

G4-G5 is as low as 60 cm. It is directed towards the actual Turkish Şadırvan (fountain). This channel shows the same architectural features as H1-G8. They are covered with hydraulic mortar on their sides and brick barrel vault on the top.

L1-L2 and H3-H4 are also similar to each other by their brick barrel vault and stone walls. Occasionally, the natural rock is visible amalgamated in the walls (fig. 12).

H2-D, L1-L2 (2m ) and G6-G7 (1.7m) channels are the highest channels. L1-L2 is also the widest channel with 1.5m. width. Furthermore, H2-H4, L1-L2 and H5-H6 are the channels which carry the 22cm. diameter terracotta pipe line and the iron Ottoman pipe which will be mentioned under the next title in details. H1-G8 channel is connected to H2-H4 channel at the point of H1 with a sharp decline of 1.5 m. height.

A1-A2 and A3-A4 channels were incorporated with the hypogeum after that structure had been converted into a cistern which creates a *terminus post quem* for those channels. Actually there is still water coming from those channels into the hypogeum. Unfortunately, in the actual situation, A1-A2 carries sewage into the construction whereas A3-A4 has still clear water. Those two channels display different features from each other which may indicate different construction dates. A3-A4 is all covered with hydraulic cement and its top is straight (Fig. 13) while in A1-A2 only the sides are covered and it is covered with a brick vault (Fig. 14).

#### THE PIPELINES IN THE CHANNELS

It is recorded that in spite of 150 lead fistulae surviving from ancient Rome, only one stamped fistula is known in Constantinople<sup>9</sup> This

<sup>9</sup> CROW, BARDILL, BAYLISS, *The Water Supply of Byzantine Constantinople* cit. (note 2), p. 142.

information makes our findings of lead and terracotta pipes in the channels, one of the most important results of our research. They are also exhibited in the courtyard of Hagia Sophia Museum, the marble pipes coming from the supply lines of the city. Although we did not record any marble water pipes in the channels under the courtyard of Hagia Sophia, the terracotta and lead pipes that we have found can be classified under two groups according to their dimensions. The lead pipes with 7.2 cm. inner diameter are observed in the channels corresponding under the building which were mentioned under the previous title and they were ending up at the bottom of the marble urns. This pipeline was most probably Byzantine production and was utilized also through the Ottoman period (Fig. 15).

The terracotta pipes with 22cm of inner diameter are observed in the channels H2-H4 and L1-L2 which are situated under the western courtyard, parallel to the building. Flow rate for 22cm. (40 *digit*) diameter pipe is 68.4 m<sup>3</sup>/hour with 0.5 m/second velocity taken as an average value<sup>10</sup>. It is also visible an iron pipe parallel to this terracotta pipeline (Fig. 16). It is probable that after the damage of Byzantine terracotta pipeline, this Ottoman iron pipeline had been paved. The iron pipes are resistant to the pressure and although it is much more thinner than the terracotta pipes for its diameter, it could carry the same amount of water. It is noticeable the existence of the iron nails hammered on those channels. They were the same kind of nail which were utilized to carry the lead pipe but there was no lead pipe in those channels. The reason can be that the lead is a precious material and those pipes could be taken away when they are ceased to be utilized.

The quantity of water to be delivered is calculated in terms of the inner diameter of the supply pipe. According to ancient sources which give information about the water supply to the buildings in the city, there existed a hierarchy of water privileges. A high rank owner could receive water for his house with 15 *digit* pipe (app.7.2 cm / 3 inch pipe<sup>11</sup>). We can say that the 22cm pipeline is the main supply line while 7.2 cm. lead pipeline with 7.3 m<sup>3</sup>/hour flow rate is used for minor purposes like feeding a fountain.

Another type of pipe line is the group of pipes that we have recorded in the northern courtyard running towards east which is layed out parallel

<sup>10</sup> J. G. LANDELS, *Engineering in the Ancient World*, London, 1978.

<sup>11</sup> Ibid.



to the western wall of the building. Those terracotta pipes have 12 cm of diameter through its inside (Fig. 17). There were lots of those pipes visible scattered on the ground during our 2005 survey. We have seen that they did not exist any more in our 2009 campaign. We have learned that the northern courtyard was cleaned up and obviously they had been considered as waste. The same pipes are recorded in the channel under the exonarthex (point G3 on the Fig. 1) coming in from the western direction (Fig. 18) and at the remains belong to now lost Samson's hospice, which according to written sources connected Hag. Eirene and Hag. Sophia<sup>12</sup>

#### THE SPOLIA IN THE SUBTERRANEAN CHANNELS

The *in situ* upright piece of marble ornamented with moldings is found in situ on the way to the G3 point which could be belonging to a door jamb of the earlier basilica (Fig 19).

In the channels, there has been found fragments of ornamented architectural elements which can be attributed to the 5th century building. One of those is the fragment of *simā* (Fig. 20) originally standing upon the epistyle of the Theodosian atrium. This fragment was ornamented with a sequence of palmettes enclosed within arched frames<sup>13</sup>. Another example of this classical motif of schematically reproduced palmette can be seen in the courtyard of Hagia Sophia Museum on an impost block (inv. 139) which comes from 5th century Rotunda near the church of the Myraleion and it is considered to be a widespread motif in the Constantinopolitan area during the first half of the 5th century<sup>14</sup>

A reused marble frieze is found during our research on the top of the tunnel at G4-G8 channel which is decorated with a repeated vegetal pattern (Fig. 21). This motif is a unique one which can be dated to early 5th century together with the other spolia material found in the channels.

The fragment of a marble architectural element with the well-drilled leaves on a meandering branch forming a border frieze around an octagonal

<sup>12</sup> U. PESHLOW, *Die Irenenkirche in Istanbul: Untersuchungen zur Architektur*, Tübingen, 1977, pp. 140-205; J. BARDILL, *The Palace of Lausus and Nearby Monuments in Constantinople: A Topographical Study*, in *American Journal of Archaeology*, CI,1 (1997), pp. 67-95.

<sup>13</sup> E. RUSSO, *Evidence from the Theodosian Saint Sophia*, in *The Sculptures of the Ayasofya Müzesi in Istanbul*, İstanbul, 2010, p. 27.

<sup>14</sup> C. BARSANTI, A. GUIGLIA, *Late Roman and Early Byzantine Capitals*, in *The Sculptures of the Ayasofya Müzesi in Istanbul*, İstanbul, 2010, p. 90.

medallion which seems to have been decorated either in its center which is totally damaged (Fig. 22). The other half of this fragment is photographed by Schneider<sup>15</sup> in his excavation catalogue. This piece is found on top of the tunnel passing under the SW porch of the building and the reverse side is reused as floor slab of the porch.

Other than those skillfully patterned and produced fragments, there has been found many examples of simply molded marble slabs, even columns and capitals which are utilized on the top of the channels (Figs. 23, 24, 25, 26).

#### THE WELLS

The examination of the wells in an around the building was another way to get information about substructures and water system through a non-destructive way.

There have been many legends of a huge subterranean cistern under the *Megale Ekklesia*. Those legends are based on the notes of the travelers in the late Byzantine and Ottoman era. Some of them mentioned boats reaching as far as the sea<sup>16</sup> and 30 steps for descending to this cistern.<sup>17</sup>

According to Ruy Gonzalez de Clavijo (1406) « In this temple, there was a large underground cistern that contented a lot of water. The legend has it that 100 galleys could sail in this huge construction »<sup>18</sup>. According to Cristoforo Buondelmonti (about 1420) « From the ground floor till the bottom of the foundations is a cistern that contained very clear water » and « Its (Hagia Sophia) height, from the ground to the vault, 134 cubits; and that of the foundations, from their foot, where the cistern of the church is located, to ground level, is 22 cubits »<sup>19</sup>. Stephen of Novgorod (1349) had written

<sup>15</sup> A. M. SCHNEIDER, *Die Grabung im Westhof der Sophienkirche zu Istanbul*, Berlin, 1941, Taf. 27, photo. 1.

<sup>16</sup> « Ces degrés font pour descendre aux robinets par ou sort l'eau de la grande citerne de l'église. Tout le dessus de ce temple est carré et rempli des eaux qui découlent du dessus de son toit. C'est ce qui a fait croire a quelque gens que l'on pouvait aller en bateau depuis Sainte Sophie jusqu'a la mer par des canaux souterrains »: J. G. GRELOT, *Relation nouvelle d'un voyage de Constantinople*, Paris, 1680, p. 111.

<sup>17</sup> J. MORENO, *Viage a Contantinople en el anno de 1784*, 1789, p. 216.

<sup>18</sup> R. G. DE CLAVIJO, *Embassy to Tamerlane: 1403-1406*, Engl. Transl., London, 1928, p. 76.

<sup>19</sup> J. P. A. VAN DER VIN, *Travellers to Greece and Constantinople: Ancient Monuments and Old Traditions in Medieval Travellers' Tales*, Amsterdam, 1980, p. 668.



that « St. Sophia has many fountains with sweet water in addition to those in the walls of the church and between the walls. You will not know it, but they are at the level of the church floor »<sup>20</sup>. According to Zosima the deacon (1419-1422) « There are seven wells in St. Sophia and a lake beneath it »<sup>21</sup> and Pero Tafur (1435-1439) « Beneath this chapel there is a great cistern which, they say, could contain a ship of 3,000 boats in full sail »<sup>22</sup>.

In our survey we identified eight wells in the nave and courtyards of the Hagia Sophia, five of which still holds water. The wells in the nave have been explored through underwater diving methods and the others through caving methods.

The first well (no.1 in Fig. 1) which had been explored through diving, was situated at the northwest of the nave and was discussed initially by Grelot, as the well that opens into the grand cistern under Hagia Sophia. We managed to enter the very same well after 318 years.

It is located 10.5 m. south of the northwest pier of the dome. The mouth is closed with an iron cover with a diameter of 44cm. The depth of the well is 11.6 m and it holds an average of 10 m of water during the year.. The 2005 water level of the first well was 1.9 m below the floor level in November and 1.55 m below the floor lever in December. In comparison, the water levels measured by Antoniadis in October 1904<sup>23</sup> and by Van Nice in April 1940<sup>24</sup> were 1.8 m and 1.4 m below the floor level respectively. Despite the almost 100 year gap, the difference between the November, 2005 measurement and the 1904 measurement is only 0.1 m. This shows that, aside from slight rises after rainy periods, the level of the water remains fairly stable during the seasons. This measurement also explained the notes by Buondelmonti mentioning a 22 cupid (app. 11m.) high cistern as it corresponds to the depth of the well which we have entered in. It is also depicted in the drawings by Grelot showing an Ottoman driving water from it. Buondelmonti, like Grelot might had considered this well as an opening to « the great cistern »<sup>25</sup>. We have not found any passage to a bigger cistern from this well.

<sup>20</sup> Transl. G. MAIESKA, *Russian Travellers to Constantinople in the Fourteenth and Fifteenth Centuries*, Washington, 1984 (Dumbarton Oaks Studies 19), p. 232.

<sup>21</sup> Ibid.

<sup>22</sup> VAN DER VIN, *Travellers to Greece and Constantinople* cit. (note 19), p. 698.

<sup>23</sup> E. M. ANTONIADIS, *Ekphrasis de la Sainte Sophie*, Paris, 1907, p. 39.

<sup>24</sup> W. EMERSON, R. L. VAN NICE, *Hagia Sophia, Istanbul: Preliminary Report of a Recent Examination of the Structure*, in *American Journal of Archaeology*, XLVII,4 (1943), p. 409.

<sup>25</sup> « Il y a icy une petite ouverture ronde comme celle d'un puits. C'est par là que l'on tire de l'eau de la cistern qui est sous l'Eglise, pour s'en servir aux usages du Temple »: Grelot, *Relation nouvelle d'un voyage de Constantinople* cit. (note 16), p. 110.

The walls of the well, from the well mouth to 2.38 m below the floor, are constructed of irregular pieces of brick and stone joined with mortar which does not show any stratification. It has a 44cm of diameter at the entrance where it gets larger downwards.

The remaining length of the well-shaft was dug from the natural rock on which Hagia Sophia stands. At this point of the nave the natural rock stands 2.38m. below the present floor.

A large stone 0.26 m. thick is visible in the well at 2.12m. from the floor which Emerson thinks that belongs to the previous church comparing the level of the stone with the level of the sill of the entrance to the previous basilica.

The very primitively dug steps on the natural rock is visible 4m. below the surface (Fig. 27). This well is the probably oldest water source in this area which is probable to exist before the ecclesiastical constructions.

There is a thick layer of mud at the bottom of the well which made it impossible to reach the natural rock bottom. It is visible a metal WW I canteen and a glass flask over the mud (Fig. 28)

The second well (no.2 in Fig. 1) in the south nave which have been explored through diving technique is located in the southwest of the building close to the Ottoman marble urn. It has not been possible to enter those two wells with our scuba tubes as they were too narrow so we had to use hookah technique leaving the source of air on the surface.

The depth of the second well from the well-mouth to the bottom is 8.8 m with a water level of 6.5 m. The marble ring of the mouth is 75cm. thick beginning from the floor level. It shows completely different characteristics than the first well.

It is paved with regular travertine stones that are cut to fit the shape of the well with a very elaborated technique (Fig. 29) and, thus, the water is very clear because of the smooth and clean surface. This well has 80 cm of diameter and it keeps the same width till its bottom.

Its water is very clear. The well is 8.8 m. deep and it has 6.5m. of water in it. It is visible a water channel 2.3m. below the mouth to drain excess water. This channel was probably opening to the tunnel which was going towards the marble urn on the southwest. It is possible to see the natural rock at 5.3m. where the pavement was destructed. There are architectural fragments, Late Roman ceramic and amphora pieces, a broken piece of green Thessalian marble and animal skeleton in it. This well seems to carry the signs of the fires and earthquakes at its bottom as burned wood and marble pieces are visible (Fig. 30). No restoration has been made on the floor slabs around.



This well was closed with a heavy marble cover which was sealed with cement making it almost imperceptible. It is notable to see the massive marble well ring below the floor level.

The rock and water samples were taken from the two wells. The geophysical analysis of the rock demonstrated that the wells were carved from Grovac which is a Thracian formation and formed 300 million years ago during the Palaeozoic Period. The rock is very hard and is not porous but water can still flow through the cracks in the rock. Electrical conductivity analyses which examined the dissolved materials were performed on the water samples from the two wells and suggested a similar chemical and mineral composition of the samples. The results of the well samples when compared to the tap water around Hagia Sophia signaled a significant difference in electrical conductivity which suggested that there is neither a connection with tap water nor is there a direct connection with rain water. Thus, the channels must be fed through ground water. Chloride analysis made on the same sample group gave the same results.

The third well is in the western courtyard on the west of the late Byzantine NW outer buttress and on the same axis with the first well mentioned before. It is also visible the bare natural rock in this well like in the first well. It has 10.5m. of depth and had 3.4m. of water till the mud at the bottom in June 2009 (we had measured it as 4m. in December 2005). It had been explored through caving techniques as the water level was low for diving. The well is 40cm. wide as diameter in the beginning and gets larger reaching 1.6m. at the beginning level of the water and continues getting larger towards downwards.

The marble ring over the well is moved aside and two grooved marble slabs of 75 cm of height (revetment marbles?) were reused as parapet (Fig. 31). The east wall of the well is made out of brick till the beginning of bare natural rock. And it is visible a 20 cm high water conduit going towards east. The dimensions of the bricks used in this well is 35cmx4-5 cm. It is also interesting to note that the northwest pier named « the weeping column » which is always wet, stands on the same axis and in between first well we have mentioned and this well which shows us the existence of the source of ground water.

The fourth well had been also explored through caving methods in the southern courtyard where the tombs of the Ottoman sultans are situated. It takes place in the south east of the tomb of Sultan Mustafa I and Ibrahim (baptistry) The mouth is protected by a 95cm high marble ring. It has 9.25 m. of depth. Its entrance is 42 cm wide and it is square shaped from its

mouth till 5.35m. of depth and this part is paved with brick and stone (Fig. 32). The bare natural rock begins after that point. The dimensions of the bricks used in this well is 40x4-5cm. and there has been found the base and mouth parts of Gaza amphora in this well. The Gaza amphorae are seen beginning from the second half of the Vth century in Constantinople. The following part gets circular and larger where it is possible to see the bare natural rock. The water begins after 1.5 m. from the rock level and there is 2.4 m. of water in it (water level was 3m. in December 2005). A 40 cm. high water conduit is connected to this well 2.05 m. down from its mouth in the north direction.

If we were to make a comparison between the first well on the northwest of the nave and this well in the south west we can assume that there is a high decrease in the slope of natural rock from north towards south.

All of the wells which have been mentioned, before were situated on the same axis at the western half of the building and its courtyards. The fifth well takes place on the eastern part of the south courtyard at the back of the Sultan Selim II's tomb. It has an 11.85 m. of depth with a 5 m. of water in it by June 2009 (it was 4.8 m in December 2005). This well has a 1.5 m. of diameter and keeps the same width till its bottom. The marble ring at the mouth of the well is 65 cm high. It is paved with stone (Fig. 33). The bare natural rock is visible 1.5 m. above the water level which means that the natural rock starts 5.45 m down from the surface.

We have also identified the place of another well in the Southeast outer buttress in the room to the south of the minaret (well no.6) but it was not possible to explore it. It was coinciding with the place of the sacred well which was mentioned by Antoniadès<sup>26</sup>, Ebersolt<sup>27</sup> and Mamboury<sup>28</sup> after Silentiarius.

We may say that all of the wells in and around Hagia Sophia are between 9m.-12m. in depth and they can be classified in two types of construction technique. First type is irregular for its shape with narrow mouth and getting larger towards the bottom. The mouth is paved with brick and stone till 2-3m. of depth and followed by bare natural rock. The second type is dug regularly with the same width from the mouth to bottom and paved with stone. Well no.3 and 4 had been also fed by the supply lines.

<sup>26</sup> ANTONIADIS, *Ekphrasis de la Sainte Sophie* cit. (note 23), pp. 51-52.

<sup>27</sup> J. EBERSOLT, *Sainte Sophie de Constantinople. Etude de topographie d'après les cérémonies*, Paris, 1910, p. 34.

<sup>28</sup> E. MAMBOURY, *Topographie de Sainte-Sophie*, in *Studi Bizantini e Neoellenici*, VI,2 (1940), pp 207,208.



The same classification can be seen for the wells studied by Hulya Tezcan (1989) at the Topkapı Palace area but their depth differs about 22-30 m. as this area has a higher altitude.

Apart from the need for daily life, we know the importance of water for the rituals of both pagan and monotheistic religions. We believe there are a lot of the wells in the acropole area remaining from the pagan period as well as some of the wells in and around Hagia Sophia. Despite that we were not able to find a big cistern under the building itself, we had enough proof for the enormous water capacity which could be one of the reasons for the legends.

From the records of water levels in the wells that we have taken in December 2005 and June 2009, we can conclude that the water level is almost the same which is another proof for the existence of continuation of the subterranean water source. Point H6 is around 5m. below the surface and a fragment of a marble structure was seen and there was still clear water escaping from the bottom. This is another proof of the subterranean source of water at this level. This may be the location of the tabs that had been mentioned by Grelot (1680) and believed to be fed by the grand cistern under Hagia Sophia.

The wells with no 7 and no 8 on the Plan do not contain water and they are totally filled with stone and waste material. We were informed by the report of the ex-manager Alpaslan Koyunlu that in 1981, there was water in those wells but some of the wells were filled in order to avoid the humidity problem as a faulty precaution<sup>29</sup>.

#### HYPOGEUM IN THE 'VEZIR'S COURTYARD' (Fig. 34)

Location is indicated by Point A on Fig. 1

To the north of Hagia Sophia, between the NW and NE outer buttresses there is the hypogeum which has lost its function as burial place and has been transformed into a cistern being all covered by hydraulic mortar. It is made out of three chambers covered with barrel vault (h:210cm+ 20 cm) and connected to each other through lower corridors (northern corridor h:110cm., eastern corridor h:150 cm) (Fig. 35).

The original entrance is from the eastern extremity of the main chamber at the middle where the marble doorframes of the original structure is still

<sup>29</sup> A. KOYUNLU, *Ayasofya Müzesi Yıllığı* (12), 1992, pp. 36-37.

visible (Fig. 36). Probably it had been possible to descend down to the entrance through the steps which do not exist anymore. This chamber is without *kline* and has the dimensions of 8.10 m of length and 2.26 m of width. The southern *kline* chamber has the dimensions of 7.61 m length and 1.40 m width with a 1.85 m long and 1.10 m high arched corridor connecting it to the main chamber. The northern *kline* chamber has the dimensions of 7.88 m length and 1.26 m width and connected to the main room with a 1.50 m high and 1.90 m long arched corridor.

The *kline* chambers are at the flanks of the main chamber containing ten *kline* which have survived to our date. It is probable to be two more *kline* at the western end of southern *kline* chamber which was blocked by a later wall which will be mentioned below.

The *kline* chambers are broken up by a wall made of big blocks of re-used marble, a very thick layer of mortar and rubble at their western extremity breaking down the *kline* at that part (Fig. 37). This wall may be the foundation of the late byzantine buttress at the northwest.

Two water conduits are added to the west and east ends of the main chamber after the structure had been converted to a cistern (Fig. 38). 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 the direction of skeuophylakion. The *kline* which are placed in the niches and made out of marble with 5cm.thickness do not 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.

Both of the *kline* chambers are broken up by the 3,60 m wide piers of greenstone blocks from their north and south (Fig. 39). The piers breaking through the vault are obviously visible (Fig. 40). Those might be the same piers mentioned by Dirimtekin<sup>30</sup>.

The structure is all covered with a very thick layer of hydraulic mortar at a later date. The vaults of both the southern and the northern chambers have

<sup>30</sup> F. DIRIMTEKIN, *Un hypogée dans le jardin dit "du vezir" au nord de Sainte Sophie*, in *Ayasofya Müzesi Yıllığı*, X (1962), pp. 110-111.



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 (Fig. 41). 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<sup>31</sup>. 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<sup>32</sup>) The later usage of hypogeum as a cistern can be related to a probably Justinianic structure – Great Baptistery?<sup>33</sup> that is taken in the same context with the brick and greenstone pier which is visible on the west of the northwest outer buttress (Fig. 42). Dark and Kosteneč suggested a rectilinear structure<sup>34</sup> comprising also the area over hypogeum. If this is the case, the hypogeum-cistern remains under the eastern end of the suggested structure.

#### THE ROOM UNDER THE NORTHWEST RAMP (Fig. 43)

Location is indicated by Point B on Fig. 1

A long T-shaped room in the direction of north-south is reached through the conduit which is turning east in continuation of the line coming from the structure under the narthex. The long arm of T is covered with barrel vault whereas the short arm is covered with cross vault (Figs. 44, 45). Its dimensions are 8.8 x 2m. at its narrower end and 2.8 m at its wider end.

<sup>31</sup> A. KOYUNLU, *Die Bodenbelage und der Errichtungsort der I.II.III. Hagia Sophia im Lichte einer Ausgrabung*, in *Ayasofya Müzesi Yıllığı*, XI (1990), pp. 147-156.

<sup>32</sup> Dimensions of the bricks belonging to Skeuophylakion are based on K. DARK, J. KOSTENEČ, *The Hagia Sophia Project, Istanbul, 2004-8*, in *Bulletin of British Byzantine Studies*, XXXV (2009), pp. 56-68, in part. 65.

<sup>33</sup> J. EBERSOLT, *Sainte Sophie de Constantinople. Etude de topographie d'après les cérémonies*, Paris, 1910, p. 34.

<sup>34</sup> *Ibid.*

Although it is full of debris, looking to the contours of the wall, it is possible to say that the ceiling is elevating up towards north possibly in accordance with the ramp running parallel on the upper layer (Fig. 46). It is in a higher level than the conduit line and became reachable depending on a collapse in its base at its southwest end. The conduit continues towards east passing under that room. The room is full of debris mostly composed of broken bricks.

#### THE SUBSTRUCTURE UNDER THE WESTERN COURTYARD (Fig. 47)

Location is indicated by Point C on Fig. 1

To the northwest of the atrium there is a rectilinear substructure covered with semi-arches. (Fig. 48). This brick structure is blocked with a wall from the Middle Byzantine period at its south end. The remnants of a stone block pier at the same point may be the foundations from the first phases of the building complex (Fig. 49). The brick dimensions are 35 cm length with 5 cm of thickness and 6cm of mortar. The height from the floor to the vault is 2.30 m. at the apex, and 2.05 m. at the side. The surviving part of the structure is 7.50 m long and 90 cm wide. The vault on the north side is crushed and the structure is blocked by the foundations of recently made tourist toilets in the western courtyard. This substructure can be attributed to the vaulted substructures to carry the Theodosian (also the Justinian's) atrium as the ground level drops sharply towards the west of the church. As it is well known Schneider excavated the area lying to the west of the present outer narthex and found the remnants of the colonnade which is approached by six steps. He has identified the wall which is around 4m eastward of this entrance portico as the west wall of the Theodosian church. To the west of the colonnade, the remains of a paved road can be seen. Schneider had suggested the Theodosian atrium to the west of the colonnade. Mainstone did not agree with Schneider's claim depending on « the sharp fall in the ground further westward, and the absence of earlier substructures there »<sup>35</sup>. According to Mainstone if there was a previous atrium, it must have been to the east, with the portico serving as a monumental entrance to it. The substructure that we have found is out of the range of the atrium that is

<sup>35</sup> R. J. MAINSTONE, *Hagia Sophia Architecture, Structure and Liturgy of Justinian's Great Church*, London, 1988, p. 136.



suggested by Schneider and it is further down in the northwest direction. If this substructure had been belonging to an atrium, it could belong to a larger one. If a detailed work could have been carried on about the dating of the substructure, it could have been possible to comment for the existence of an earlier and larger atrium at that point.

THE CROSSVAULTED SUBTERRANEAN STRUCTURE  
AT THE SOUTH OF THE 'HOROLOGION' (Fig. 50)

Location is indicated by Point D on Fig. 1

The substructure is reached through the channels which are connected to its north and south ends. It is full of debris and broken earthenware water pipes to the level of the beginning of vault arches so it is not possible to know the real dimensions of this structure. Though, at the middle of the room it is possible to see the original ground level so we may conclude that the height of the room at the highest point of the arch is app.2 m. The cross vaults continues both towards east and west. The structure seems to be made of pure brick (the average length of bricks is 38-40 cm and the average thickness is 5.5-6 cm). The channel at the south is connected at the level of the top of this room's vault (Fig. 51). That channel continues towards augusteion but it is blocked after the exit door of the museum because of the modern works carried there by İSKİ (İstanbul Water and Sewage Disposal Administration). It is one of the highest channels that we have discovered under Hagia Sophia and its courtyards. The channel at the north end is lower and it is visible that this channel is connected with the room at a later date breaking its north wall.

CONCLUSION

All of the findings in and around the Hagia Sophia were indicating a complicated system of water supply and drainage. The channels both for the passage of the supply pipes and for the drainage of the excess water, can be dated mostly to the 5th and 6th centuries and are evidently continued to be used and maintained in the following centuries. The wells are possible to be constructed even before the ecclesiastical phase of the area. According to the evidences that we have discussed during the previous paragraphs, their

negligence in the modern times is creating important problems in the building such as humidity.

A lucky coincidence of our survey has been the findings concerning the subterranean structures which are discussed as detailed as possible. However, it is our concern to inform that those structures may face obliteration in the near future due to the official neglect of their existence.

As it is mentioned in the beginning, unfortunately the part of the research related to Hagia Sophia had to be performed in a very short time span. Due to the severe time restrictions put by the museum management we were able to work 3 days in 2005 and 6 days in 2009, after waiting 3 years for the new permission.

We hope to be able to continue our research and collect more data and answer the questions about this less researched part of the Hagia Sophia complex.



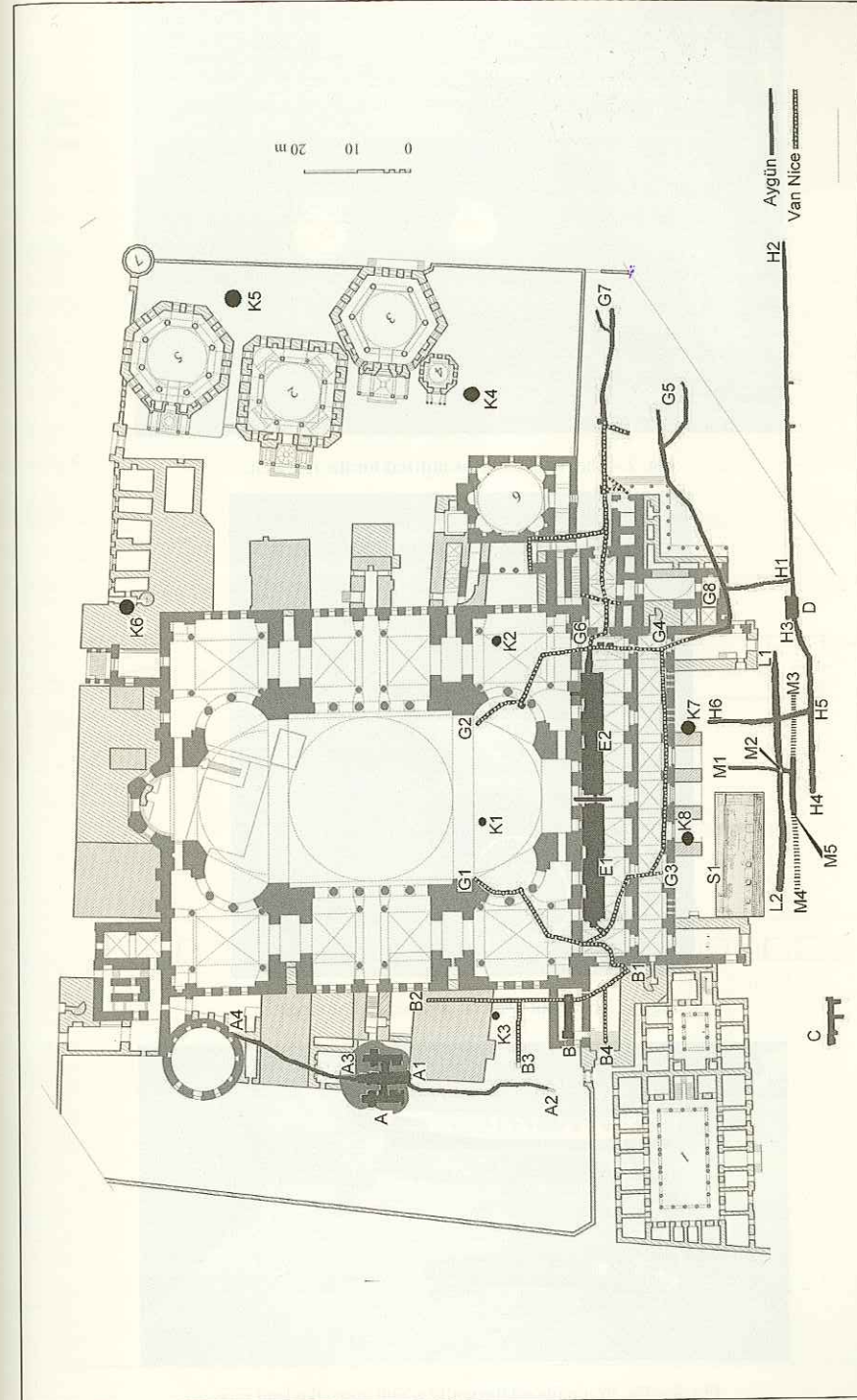


Fig. 1 - Plan of the subterranean channels and the structures at Hagia Sophia.

NEW FINDINGS ON HAGIA SOPHIA (M. BIRMANIAN)

As it is mentioned in the beginning, unfortunately the part of the research related to Hagia Sophia is not finished as a new study was started. Due to the severe time constraints, the research was completed in a short time. To work 3 days in 2002 and 6 days in 2004 after a waiting 3 years for the new permission.

The study was carried out in the courtyard of Hagia Sophia. The main purpose of the study was to determine the location of the subterranean channels and to determine the location of the subterranean structures. The study was carried out in the courtyard of Hagia Sophia. The main purpose of the study was to determine the location of the subterranean channels and to determine the location of the subterranean structures.

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Fig. 2 - The robot cameras utilized for the research.

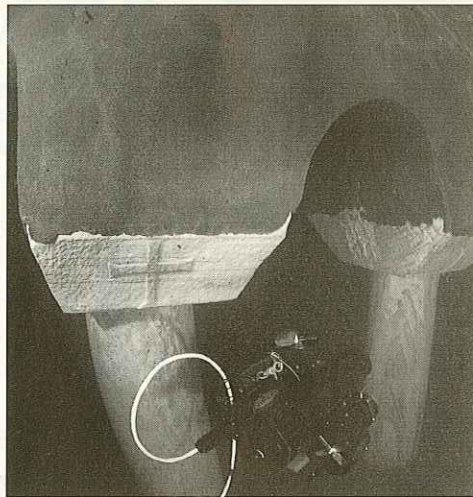


Fig. 3 - The robot cameras utilized for the research.



Fig. 7 - The iron nails on the walls which carry the lead pipe.

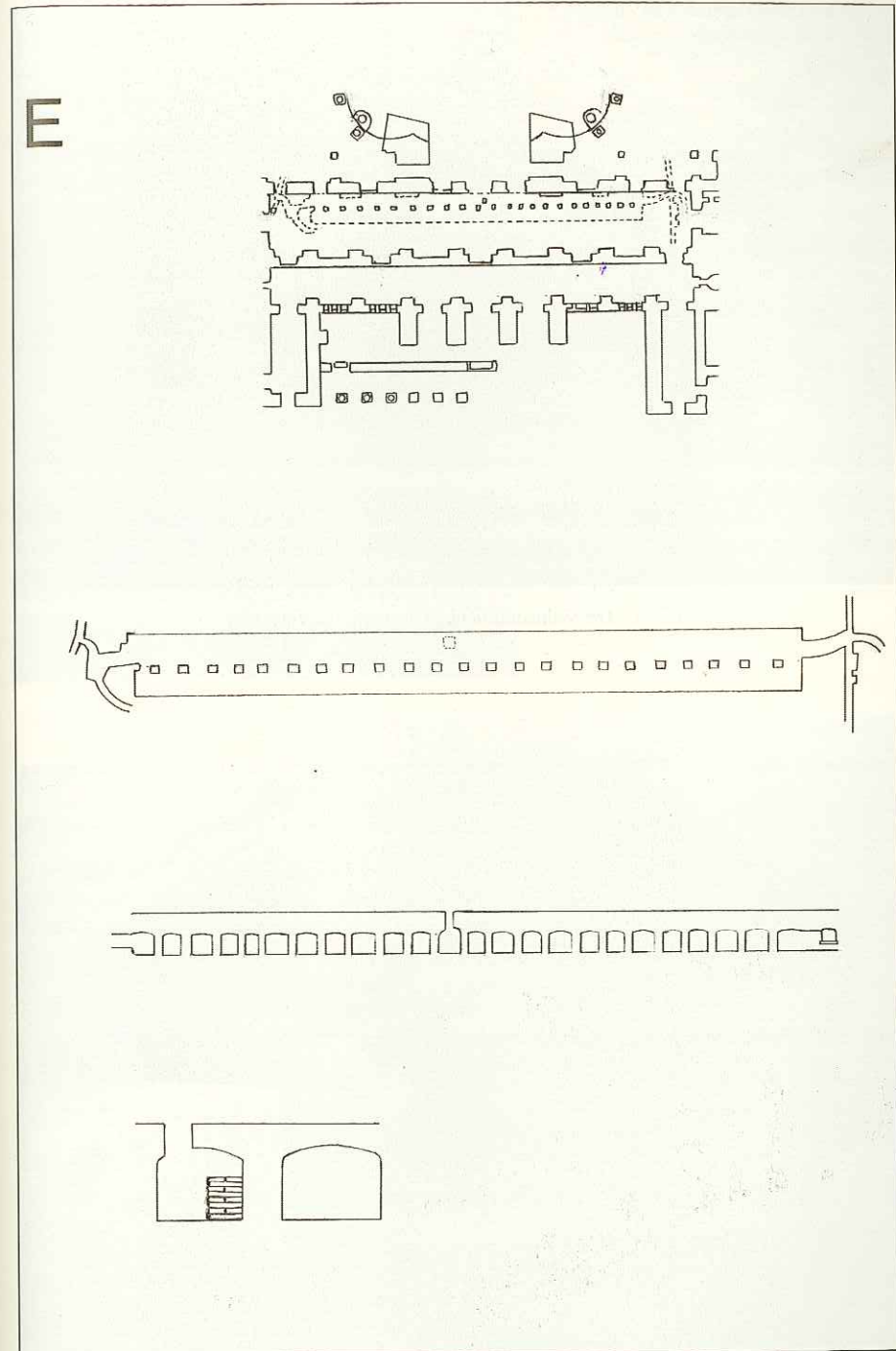


Fig 4 - The Vaulted Structure Under the Esonarthex.



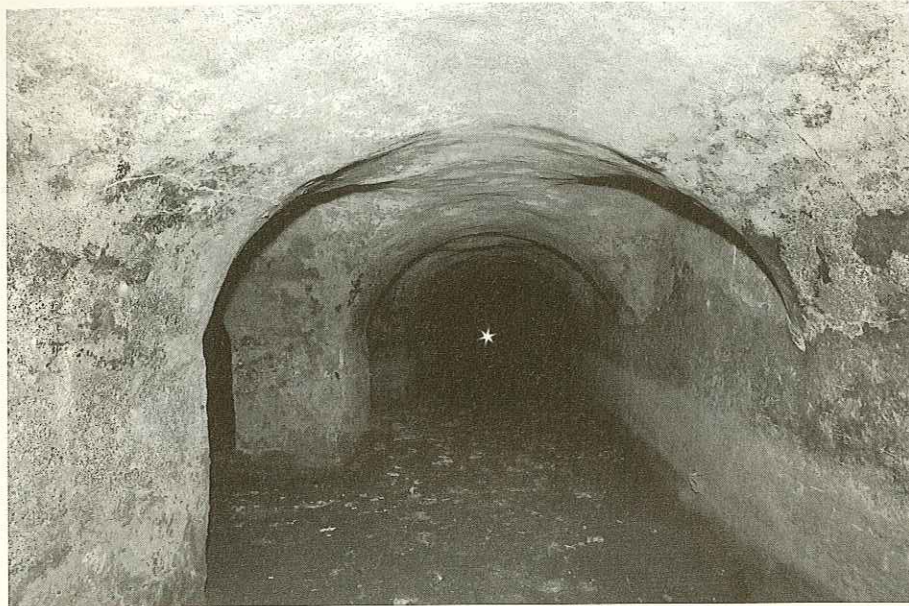


Fig. 5 - The Vaulted Structure Under the Inner Narthex.

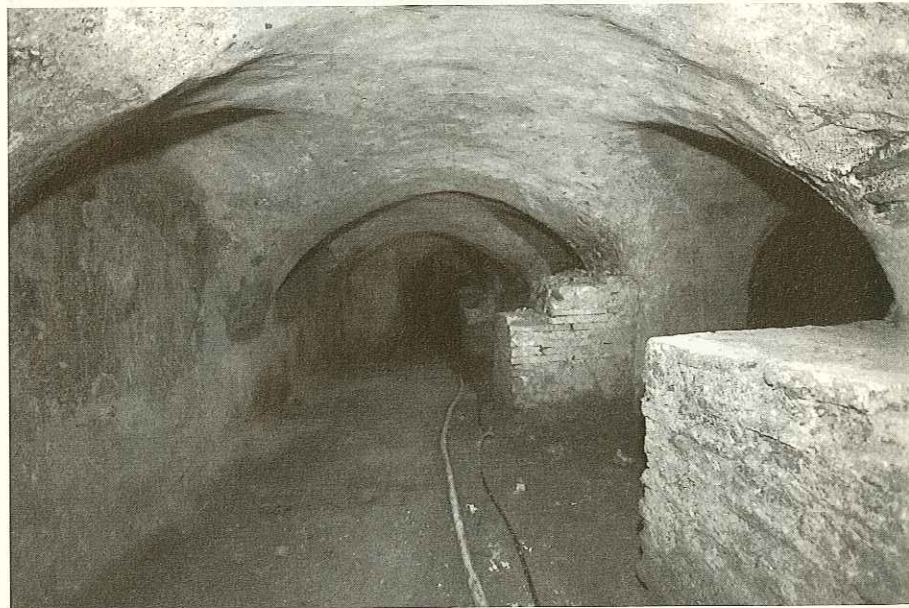


Fig.6 - Later additions to the piers.

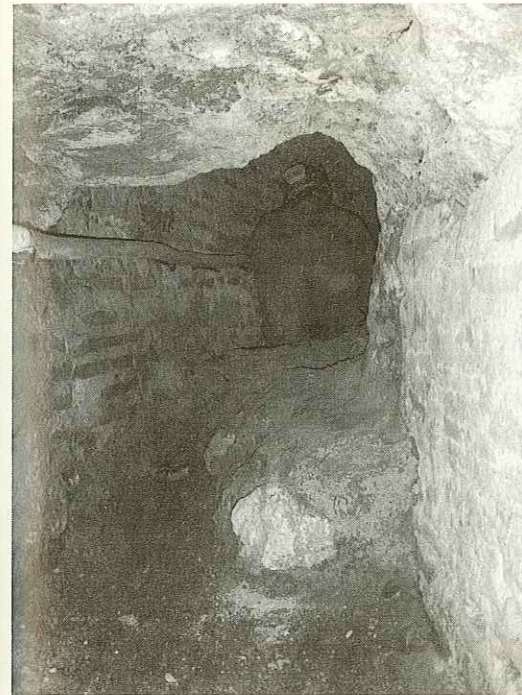


Fig. 8 - Remainings of the former buildings which are in situ.

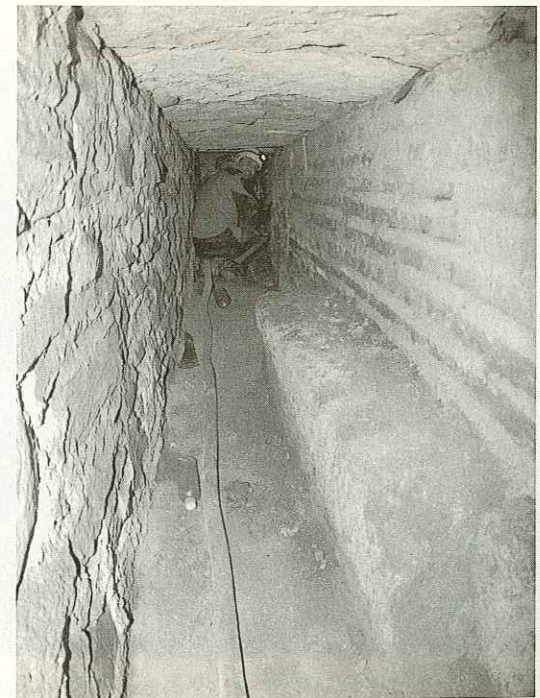


Fig. 9 - Remainings of the former buildings which are in situ.



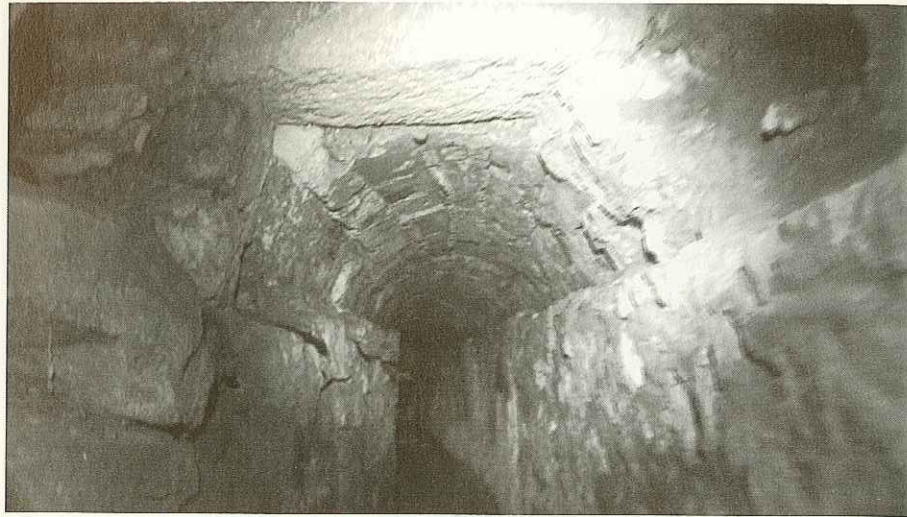


Fig. 10 - The channel H2-D on Fig. 1.

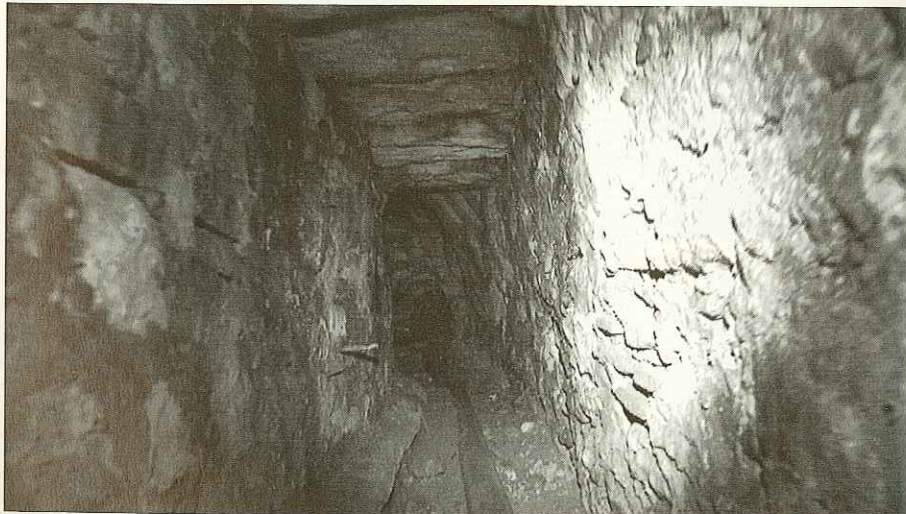


Fig. 11 - The channel H3-H4 on Fig. 1.

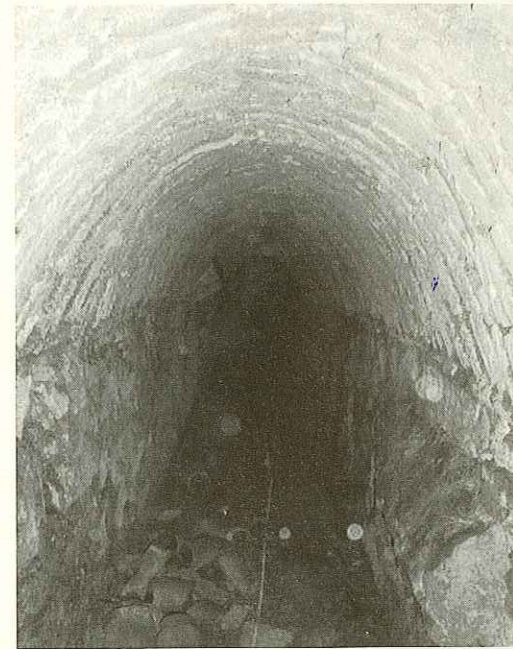


Fig. 12 - The channel L1-L2 on Fig. 1.



Fig.13 - Channel A3-A4 which is connected to the hypogeum from its east.



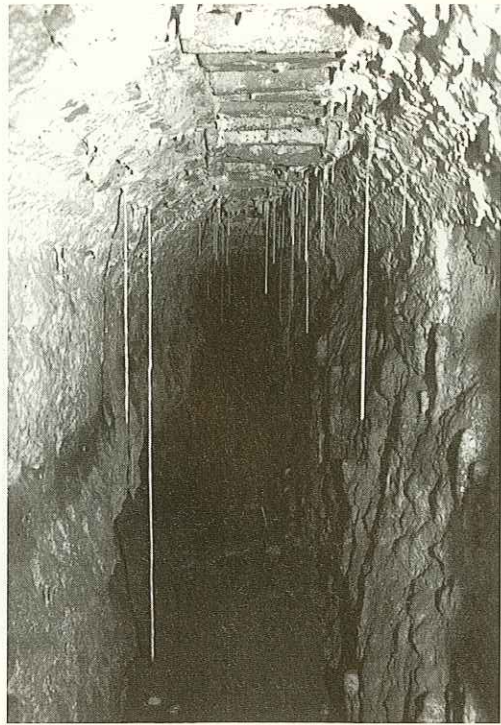


Fig.14 - Channel A1-A2 which is connected to the hypogeum from its west.

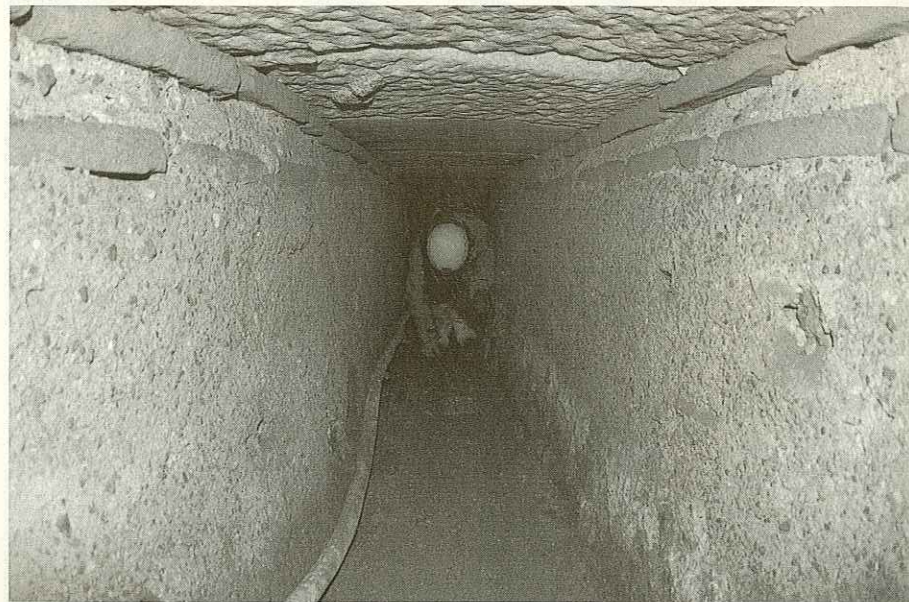


Fig. 15 - The lead pipeline with 7,2 cm. inner diameter.

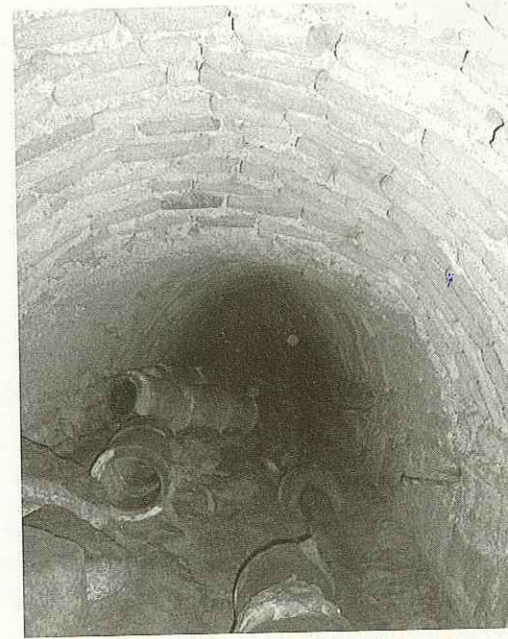


Fig. 16 - The terracotta pipes with 22cm of inner diameter and the iron pipeline parallel to it.



Fig. 17 - The teracotta pipes in the western courtyard.



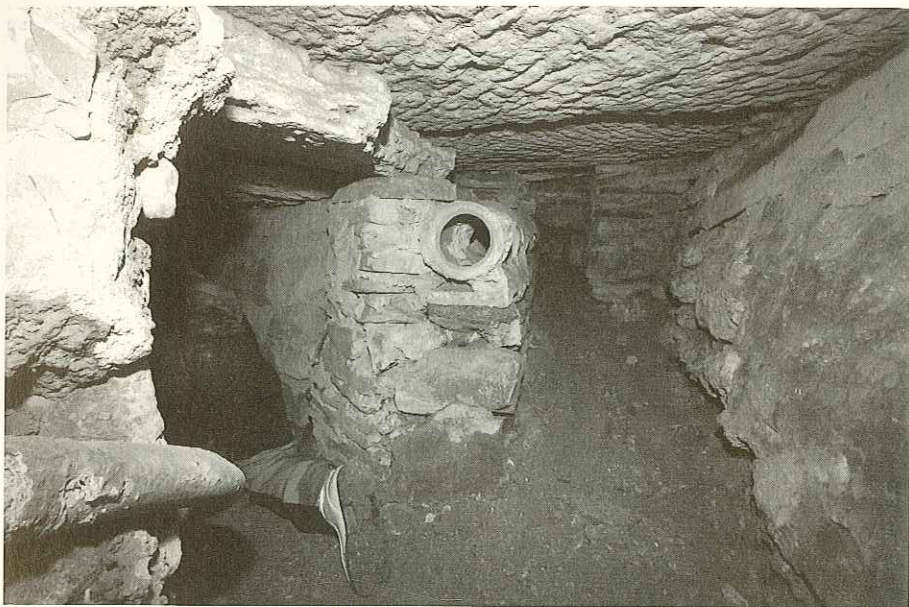


Fig.18 - The terracotta pipeline under the exonartex ( point G3 on the Fig. 1) coming in from the western direction.

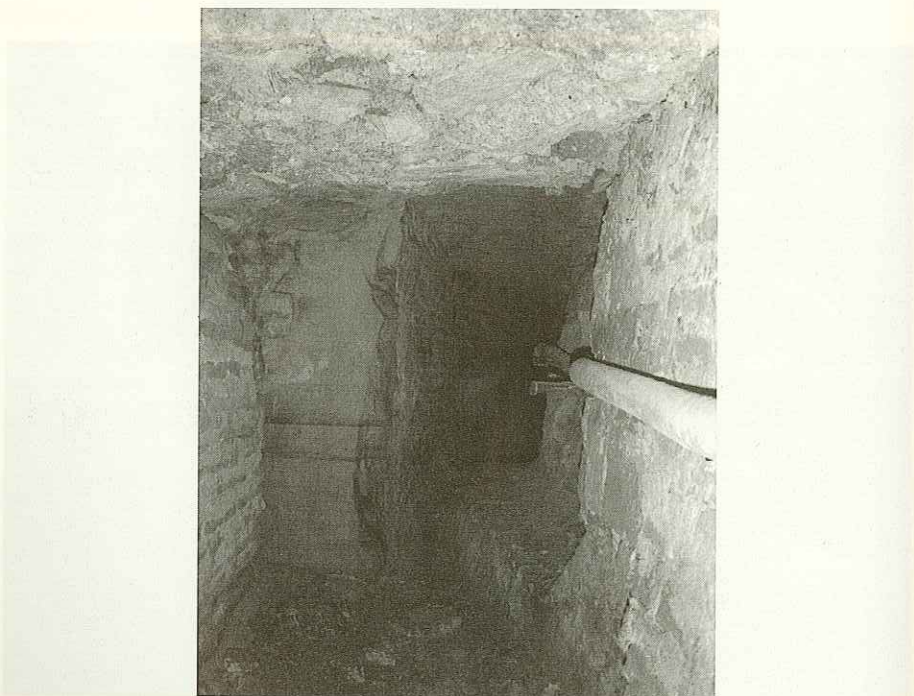


Fig. 19 - The in situ marble piece which could be belonging to a door jamb of the earlier basilica .



Fig. 20 - The fragment of sima found in the channels originally belonging to the epistyle of the Theodosian atrium.



Fig. 21 - The spolia marble frieze with a repeated vegetal pattern.



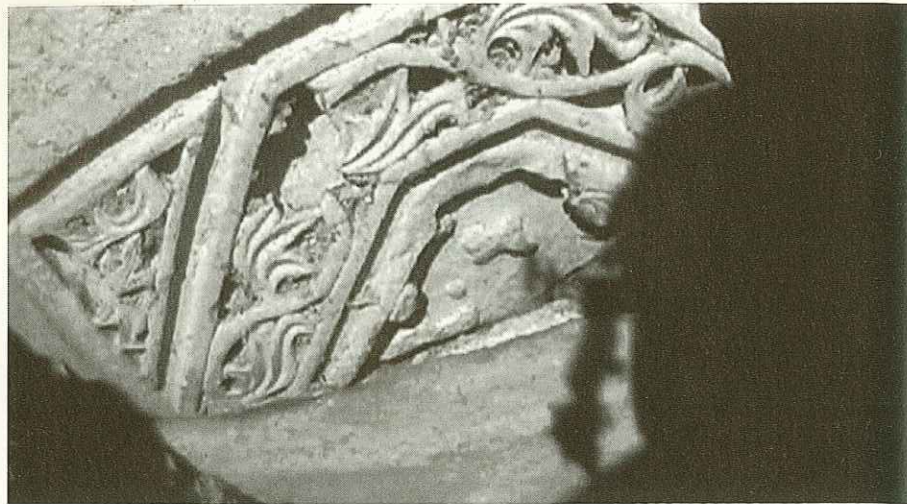


Fig. 22 - The fragment of a marble architectural element - reverse side is reused as floor slab of the porch.



Fig. 23 - Miscellaneous spolia from the channels.

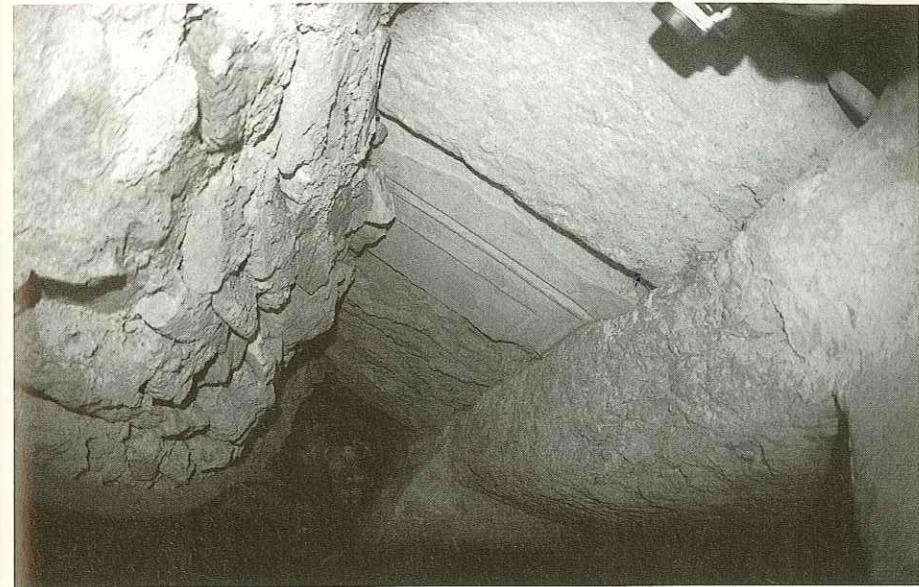


Fig. 24 - Miscellaneous spolia from the channels.

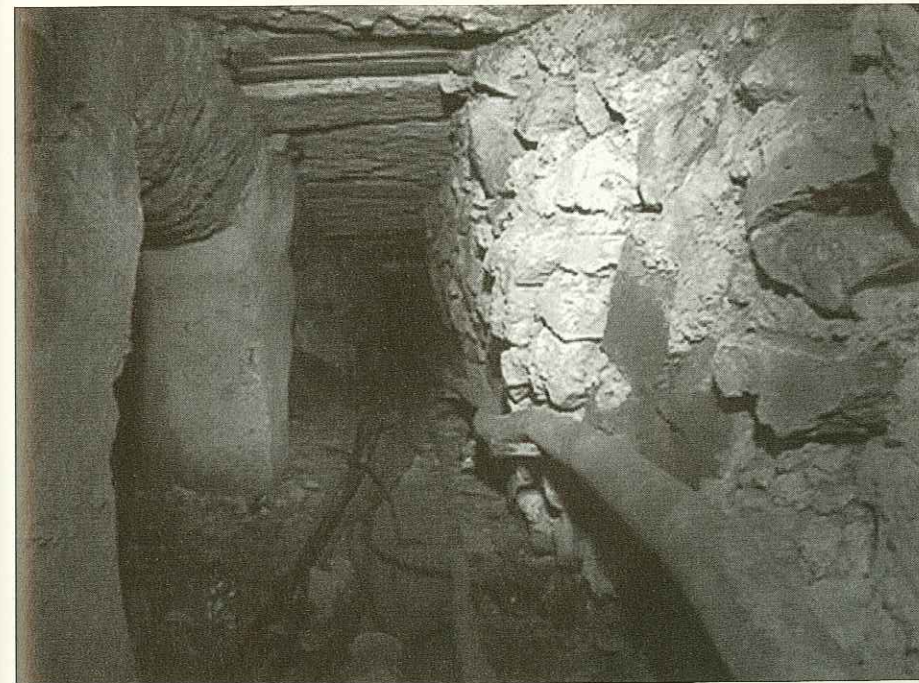


Fig. 25 - Miscellaneous spolia from the channels.





Fig. 26 - Miscellaneous spolia from the channels.

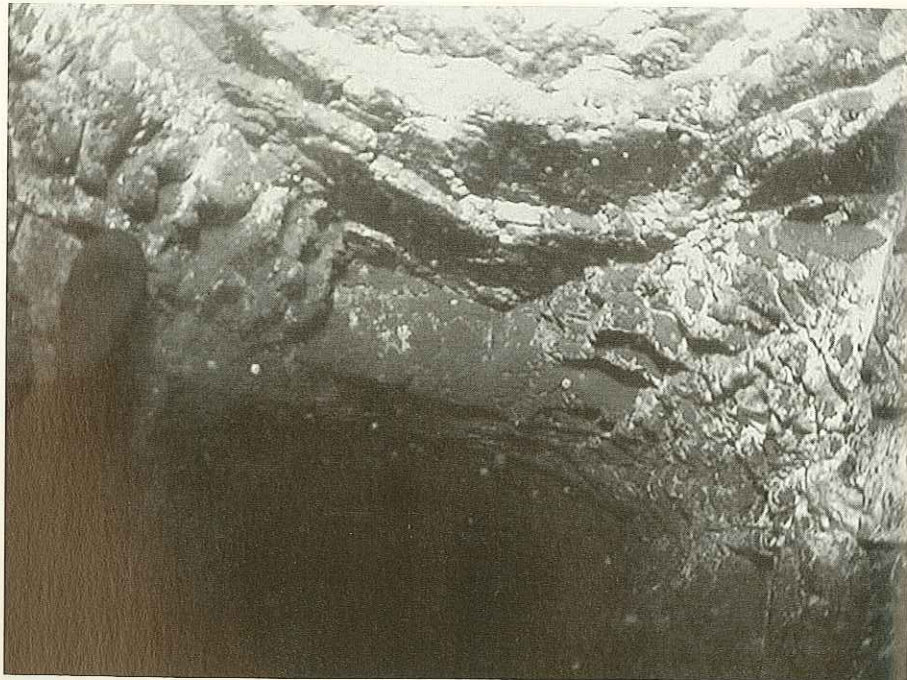


Fig. 27 - The steps on the natural rock of the well no.1.

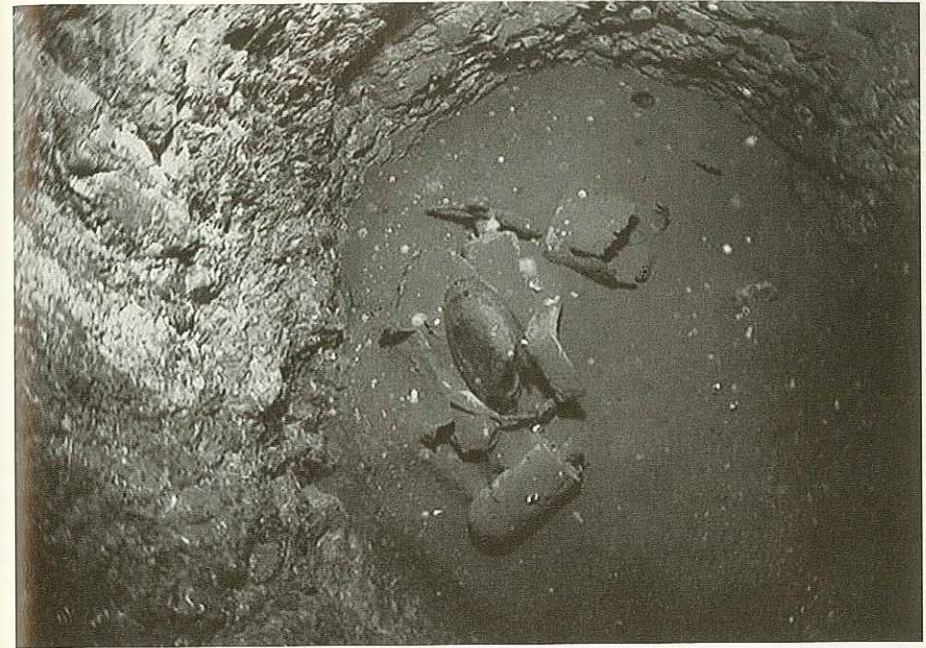


Fig. 28 - The metal WW I canteen, a glass flask over the mud (well no.1).

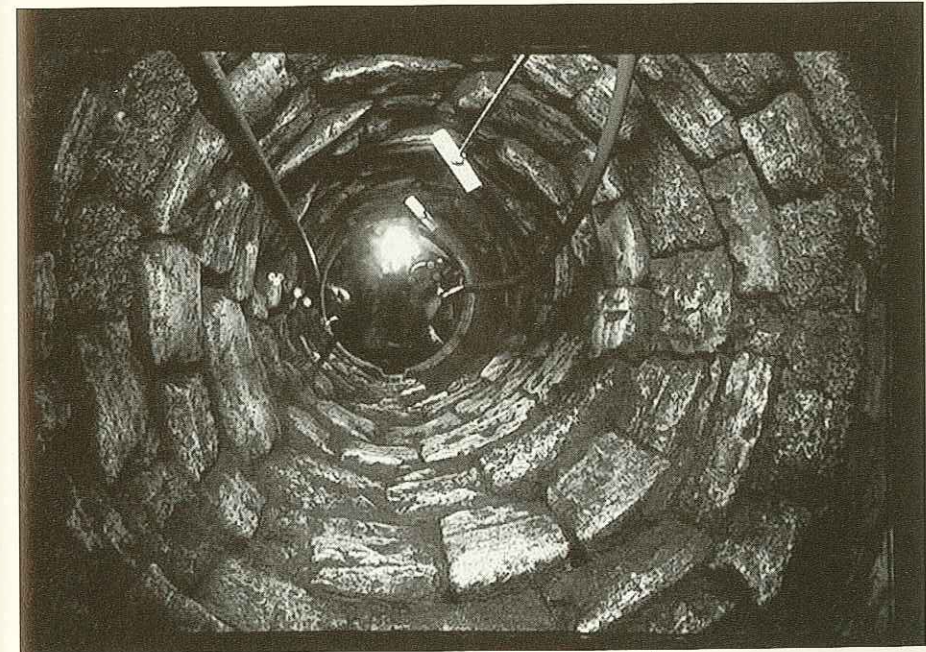


Fig. 29 - Well no.2.



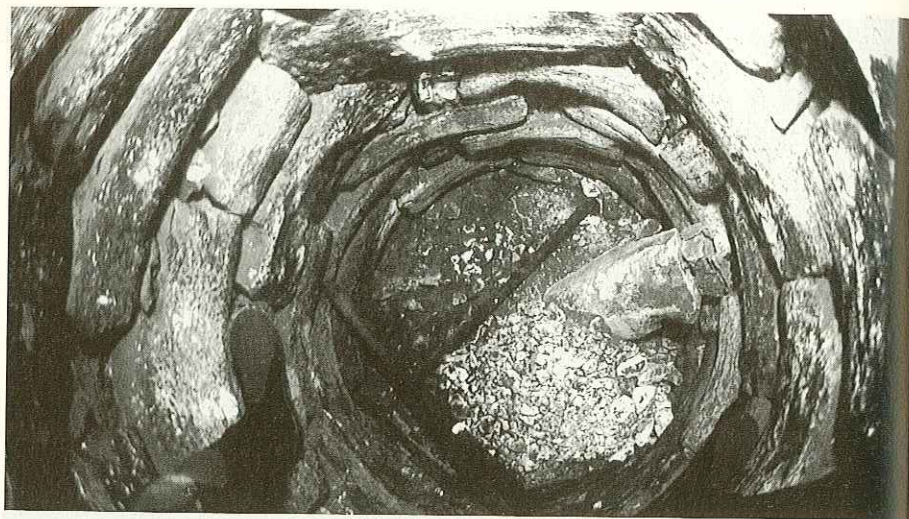


Fig. 30 - The burned wood and marble pieces at the bottom of the well no. 2.

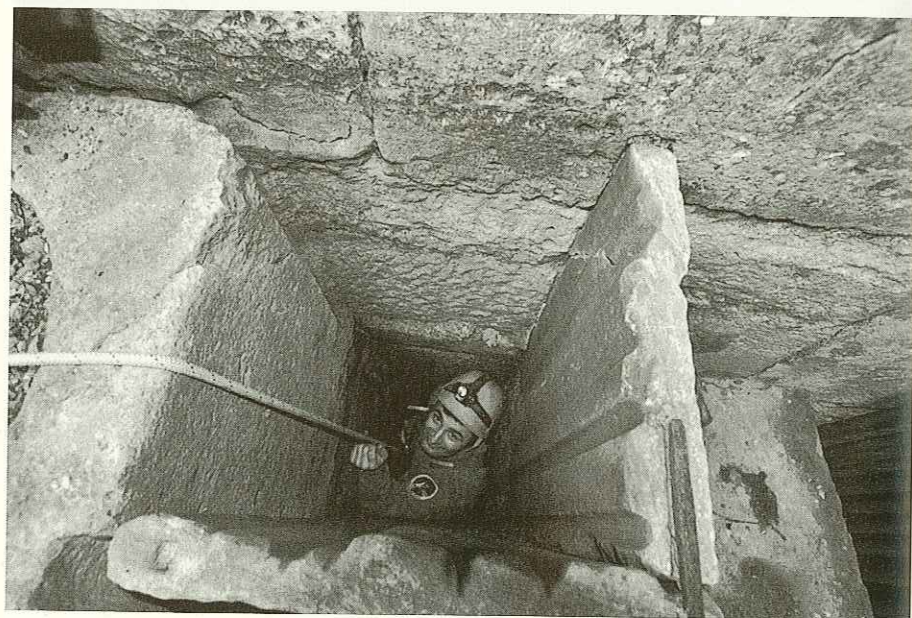


Fig. 31 - The grooved marble parapet around the well no. 3 and view from inside.

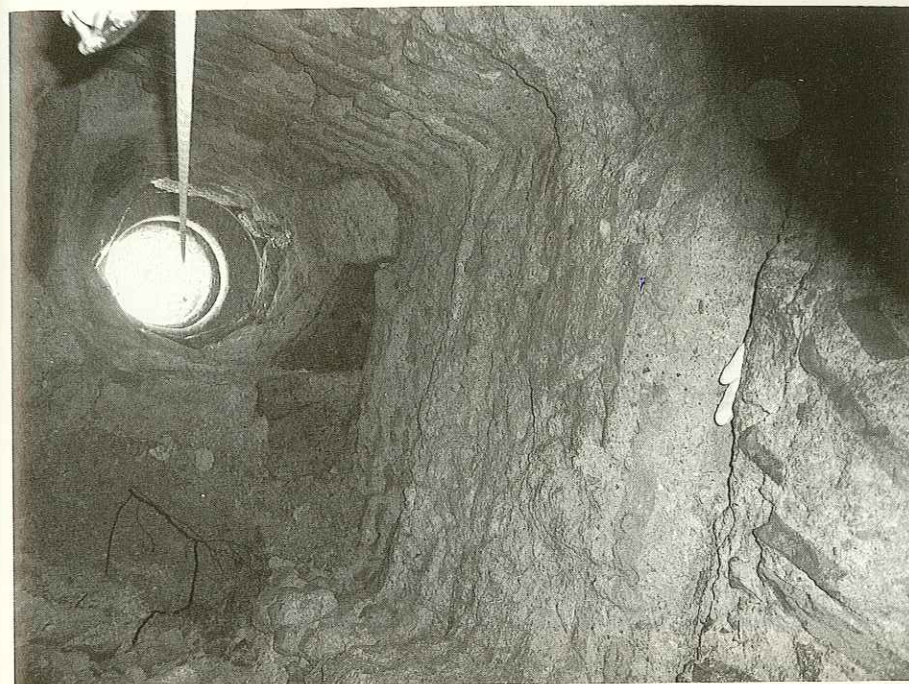


Fig. 32 - Well no. 4.

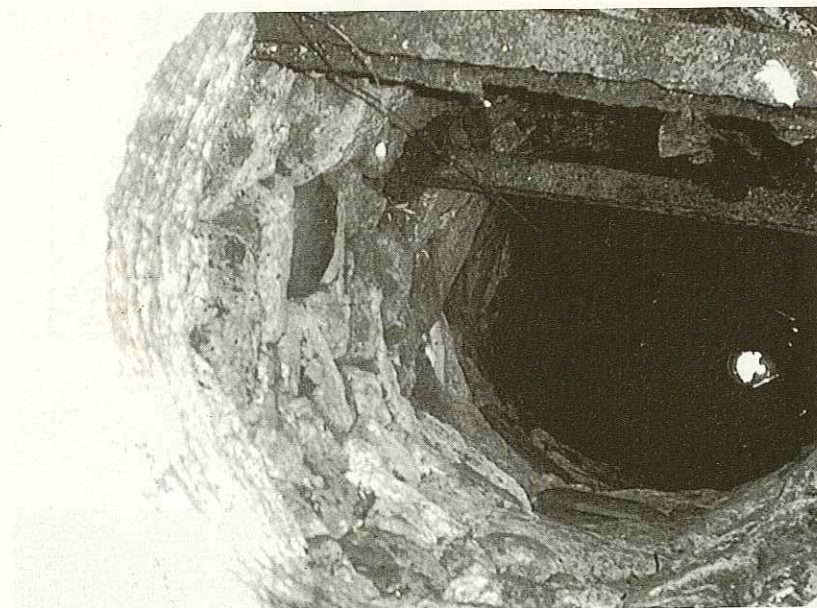


Fig. 33 - Well no. 5.



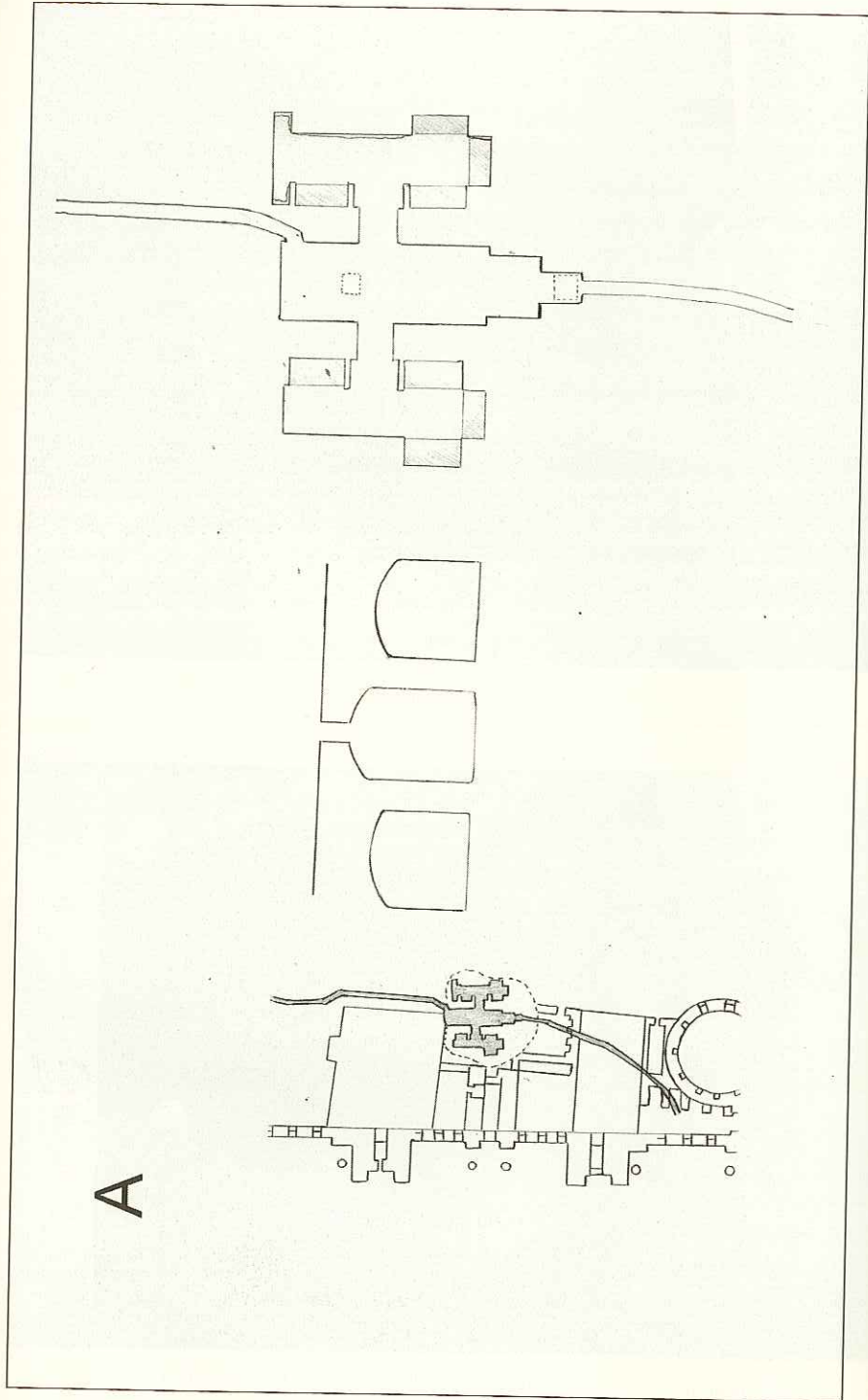


Fig. 34 - Hypogeum.

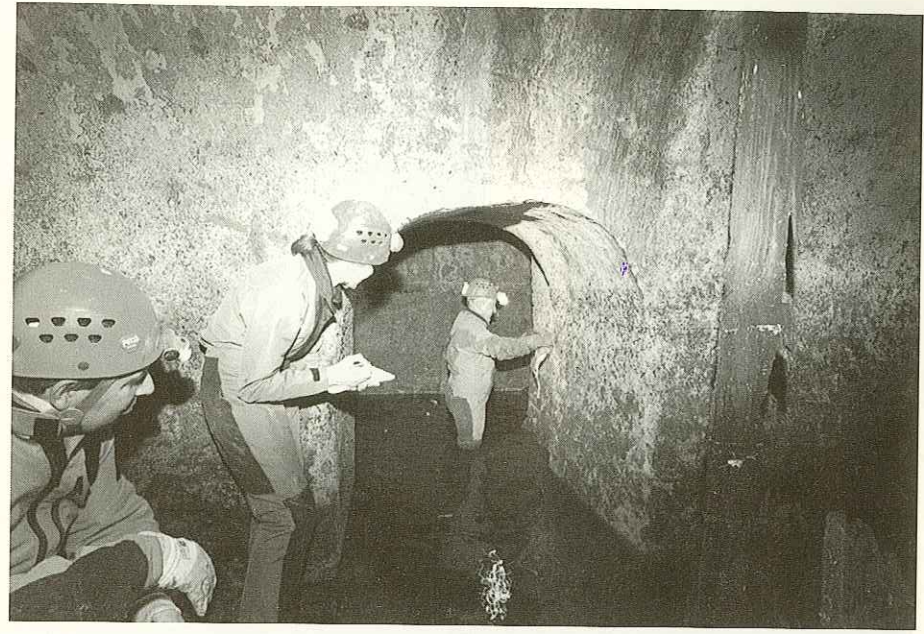


Fig. 35 - Hypogeum - Connection of the two chambers.

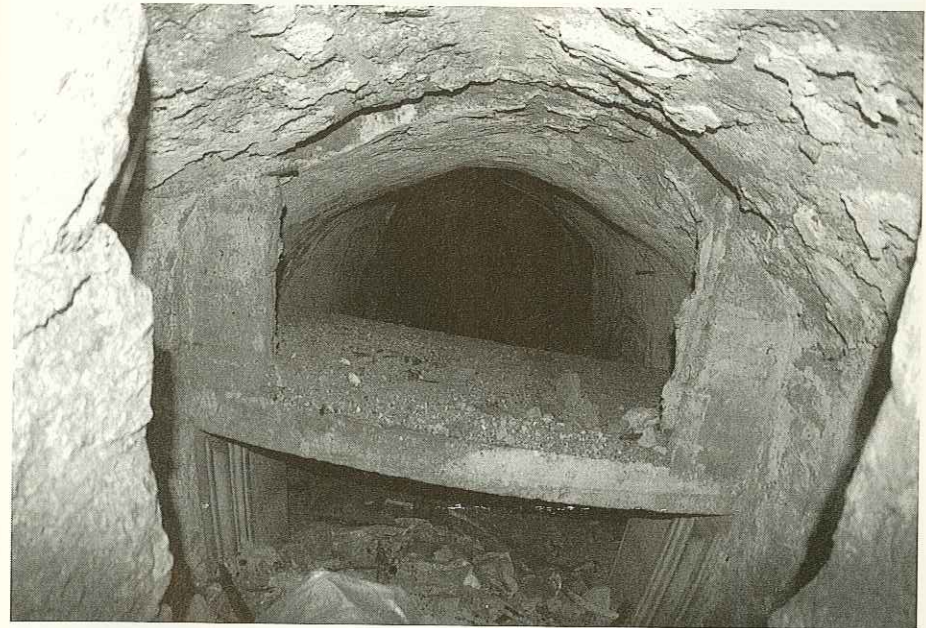


Fig. 36 - Hypogeum- Door frame.



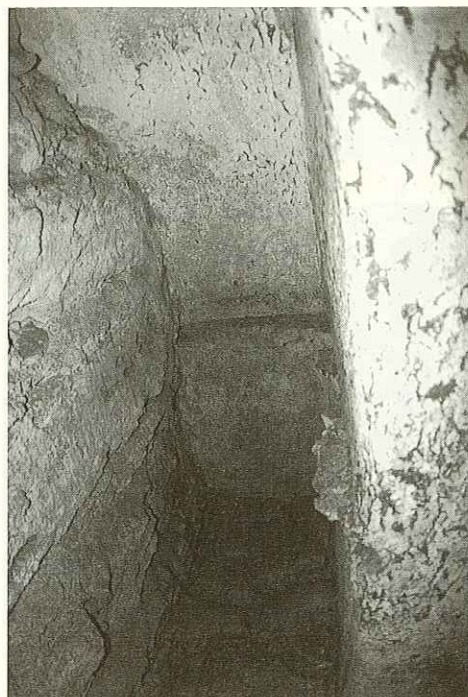


Fig. 37 - The western extremity of hypogeum with the broken kline.

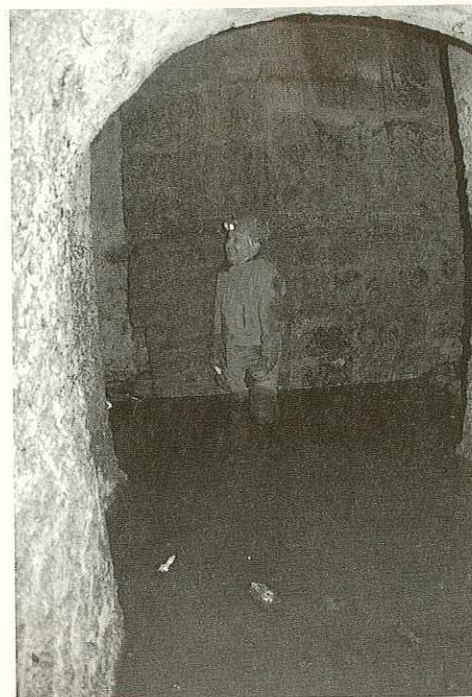


Fig. 39 - The greenstone piers interrupting the north and south walls of the hypogeum.

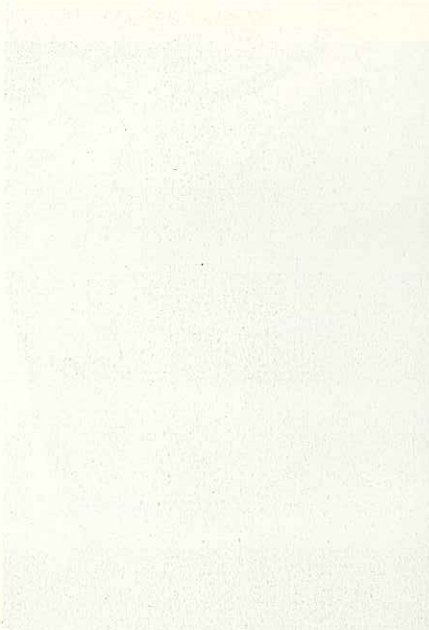


Fig. 38 - The water conduits added to the hypogeum after its conversion into a cistern.

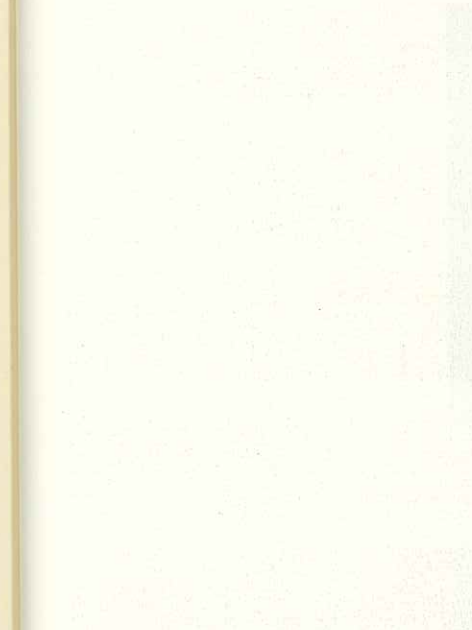
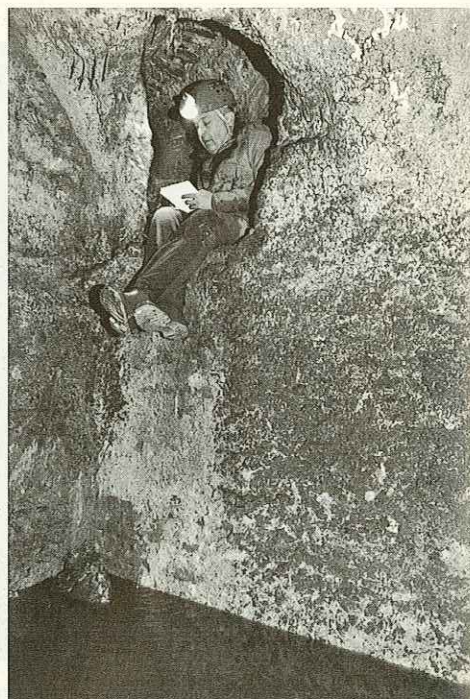


Fig. 40 - The greenstone piers interrupting the north and south walls of the hypogeum.

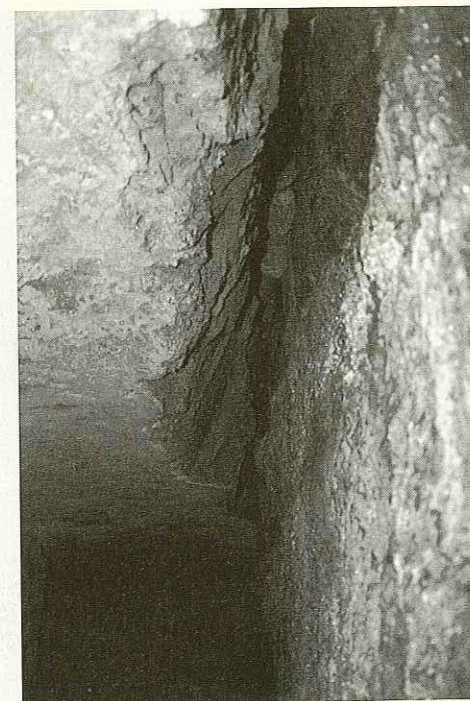






Fig. 41 - The pipe on the vault of the hypogeum and the white marble slab from its earlier phase.

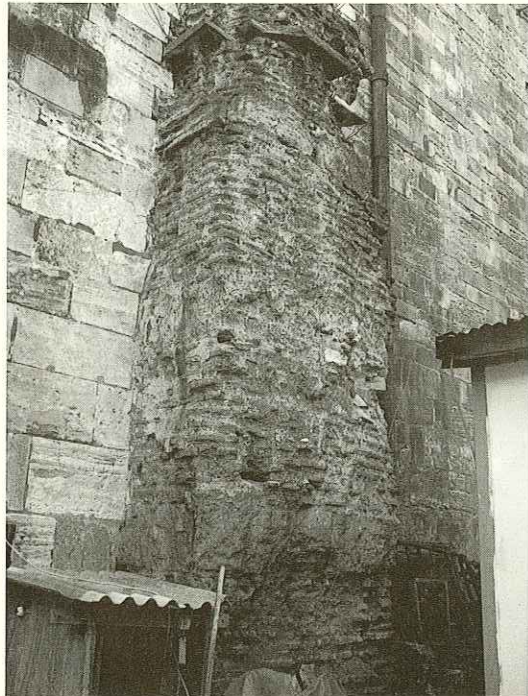


Fig. 42 - The greenstone pier which is visible on the west of the northwest outer buttress.

B

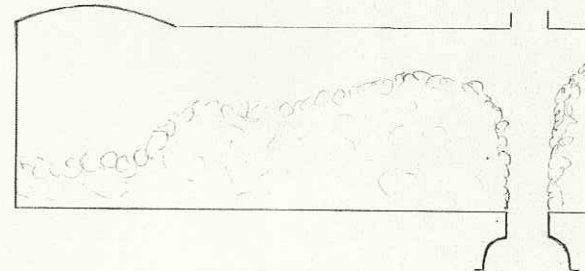
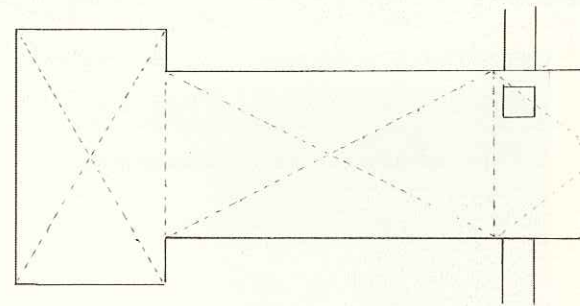
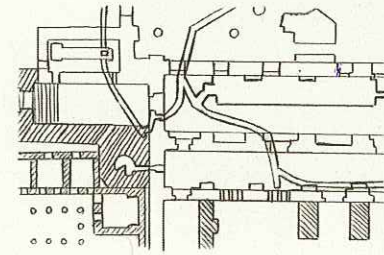


Fig. 43 - The Room Under the Northwest Ramp.



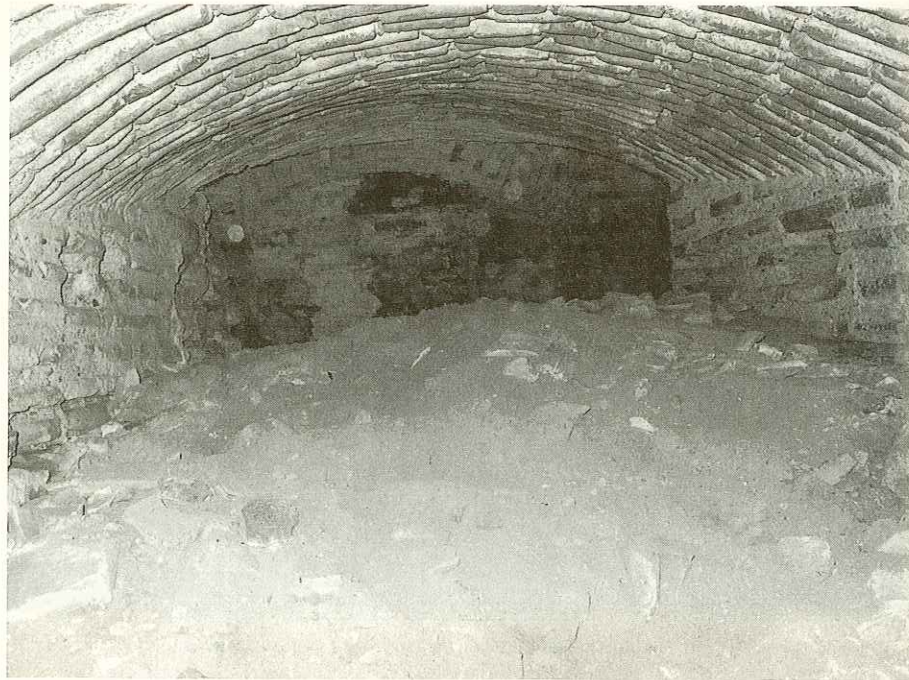


Fig. 44 - The Room Under the Northwest Ramp.



Fig. 45 - The Room Under the Northwest Ramp.

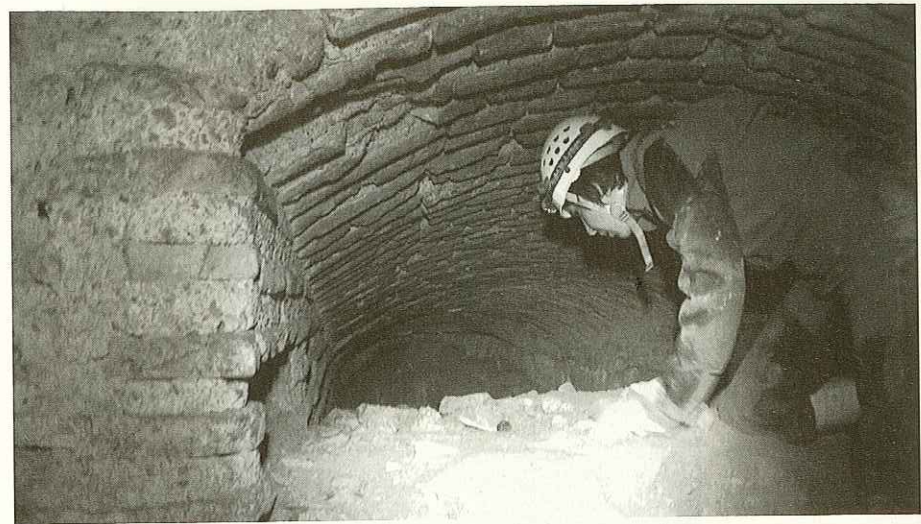


Fig. 46 - The Room Under the Northwest Ramp, elevating up towards north.

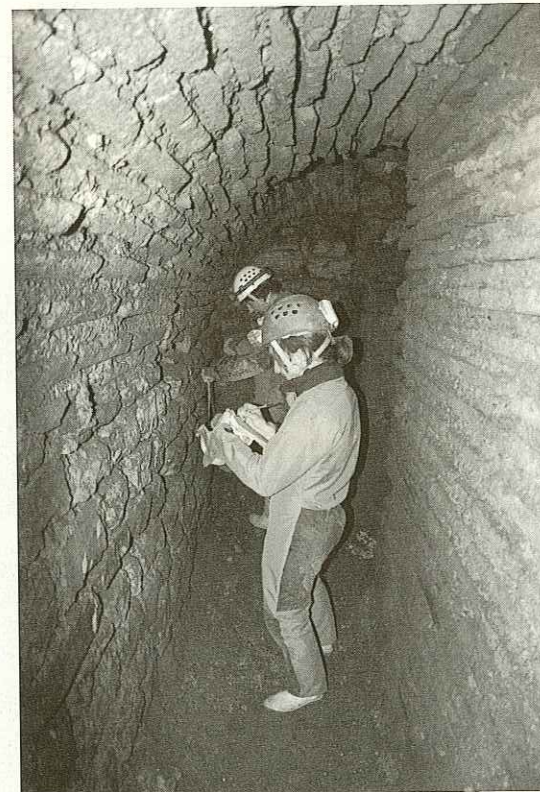


Fig. 48 - The Substructure Under the Western Courtyard.



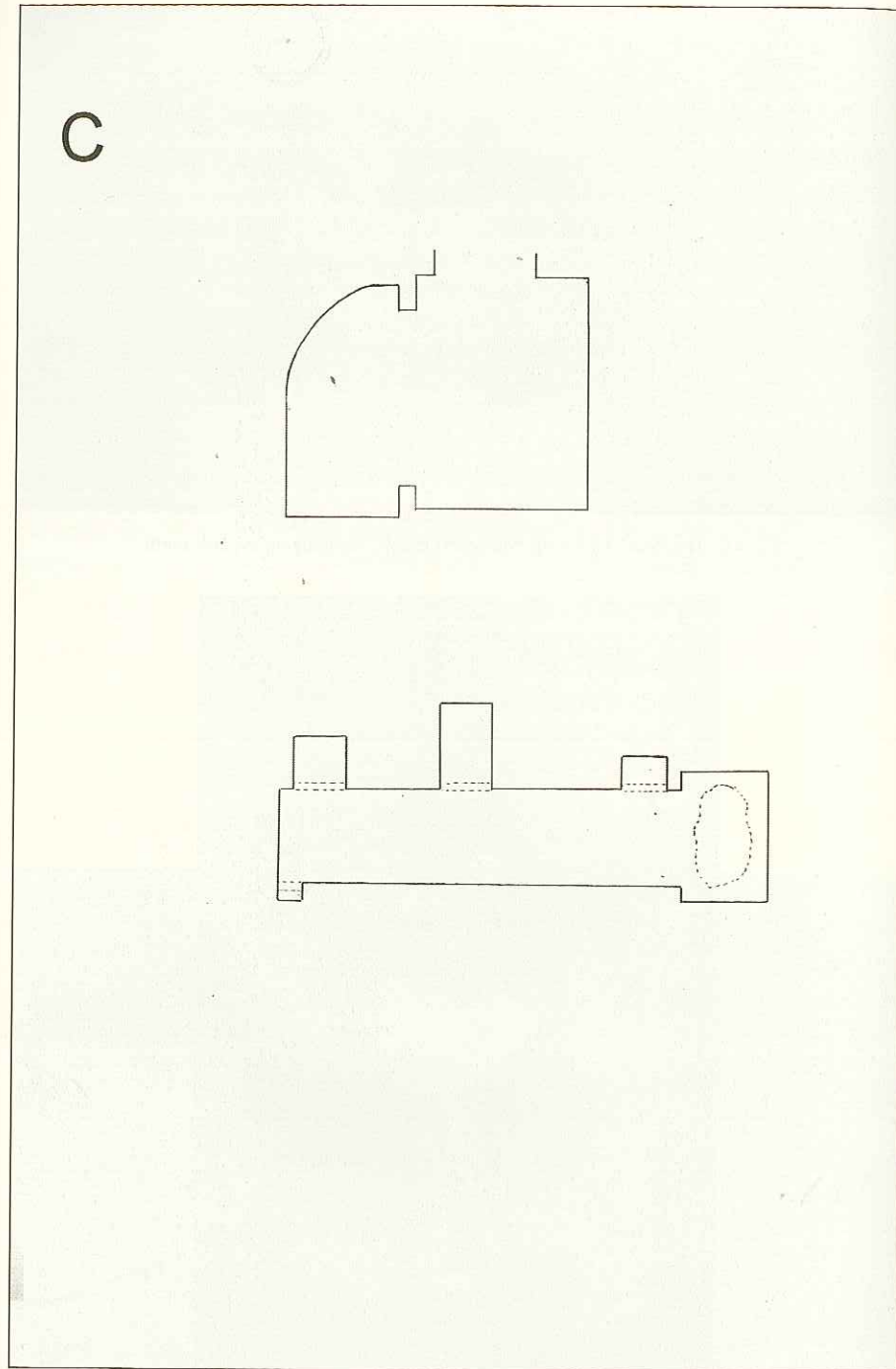


Fig. 47 - The Substructure Under the Western Courtyard.

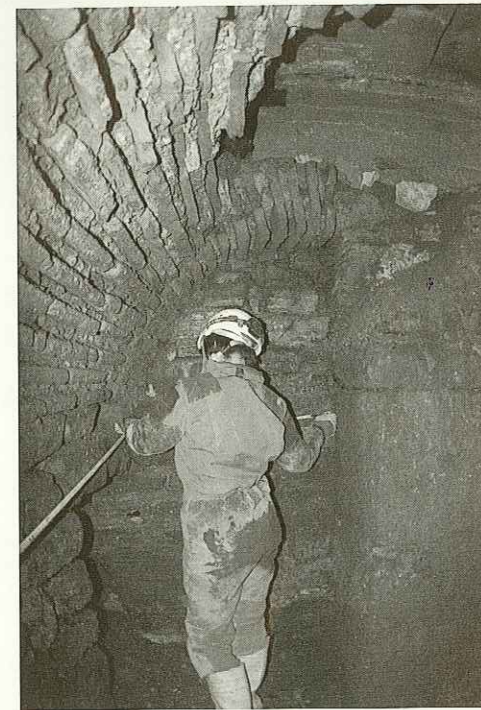


Fig. 49 - The remnants of a stone block pier.

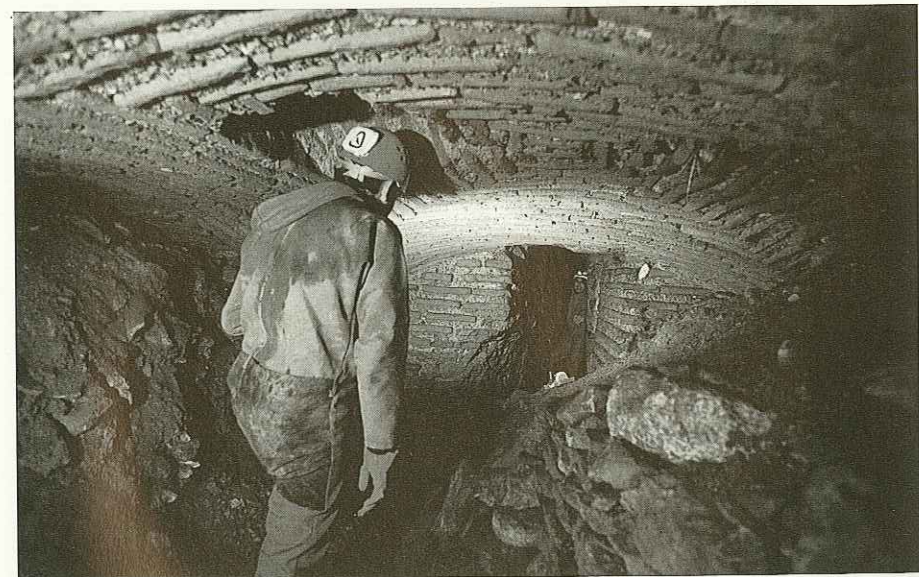


Fig. 51 - The Crossvaulted Subterranean Structure at the South of the 'Horologion'.



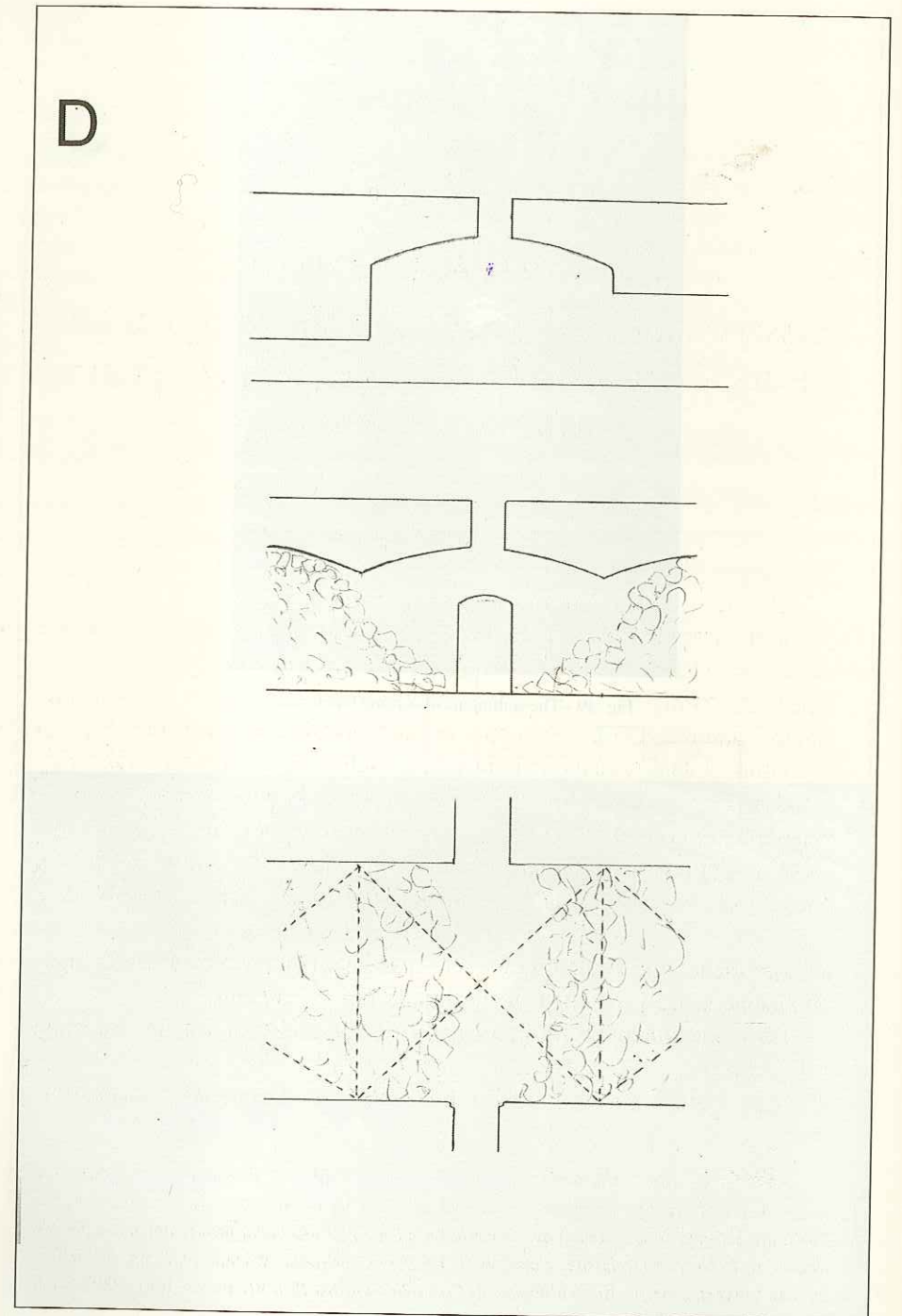


Fig. 50 - The Crossvaulted Subterranean Structure at the South of the 'Horologion'.