

Research Article

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The Story of the Architectural Documentation of Hagia Sophia's Hypogeum

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Abstract: Hagia Sophia's hypogeum is a group of subterranean Roman tomb structures located in the area between the northeastern side of the structure and the *imaret* ("soup kitchen") of Hagia Sophia. Consisting of three chambers connected by a passage, the hypogeum is dated to the fourth century and older than the current Hagia Sophia. The story of the architectural documentation of the hypogeum is also interesting. As a matter of fact, exposed findings during the museum research still contribute to the dating studies of the structure. The first digital architectural visualisation of the space was made in 2020 within the documentation of the subterranean structures of Hagia Sophia. After the partial cleaning of the inner space at the end of 2021, a relatively more favourable environment allowed for its visualisation. This study presents the most recent architectural documentation of the hypogeum carried out, the first reconstruction plan proposal, and a virtual superposition of the structure with its superstructure. Completely cleaning the interior and top will enable this space to be thoroughly documented and dated. By including the narrative of the documentation story to the present, this study is expected to be the last visualisation of the hypogeum until it is completely cleaned. The lack of architecturally similar structures in Istanbul requires special attention to this subterranean structure.

Keywords: Hagia Sophia, hypogeum, architectural visualisation, subterranean, documentation

1 Introduction

Due to its location and usage, the north-eastern side of Hagia Sophia is closed to visitors, unlike its other sides. This side of the structure is attached by a series of structures dated before and after its construction. This series begins in the northern corner with the *Skeuophylakion* (Treasury), whose first construction phase dated to the Theodosian Hagia Sophia, and end in the northern corner with the Hagia Sophia Madrasa whose reconstruction was completed in 2022. There is the so-called "Vizier Garden" between Hagia Sophia and its imaret ("soup kitchen"), where a group of subterranean Roman tomb structures known as the hypogeum is located (Figure 1). The subject of this article is the documentation story of the hypogeum that was built before Hagia Sophia to the present. The history of the structure, whose architectural documentation was made after the museumisation of Hagia Sophia, shed light on this archaeological site during Late Antiquity. Despite its transformed state, the hypogeum, still can give insights about the early constructions in the area.

The story of the architectural documentation of the hypogeum is also as interesting as the structure itself. The structure was first discovered and published in 1946 after the conversion of Hagia Sophia into a museum in 1934. Although it was republished in 1962, it was completely forgotten. While it was rediscovered in 1985 by an interesting coincidence, its superstructure pavement was also exposed. Yet after the documentation, the superstructure was covered with soil again. The first digital architectural visualisation of the space was made in 2020 while documenting the subterranean structures of Hagia Sophia. After the partial cleaning of the

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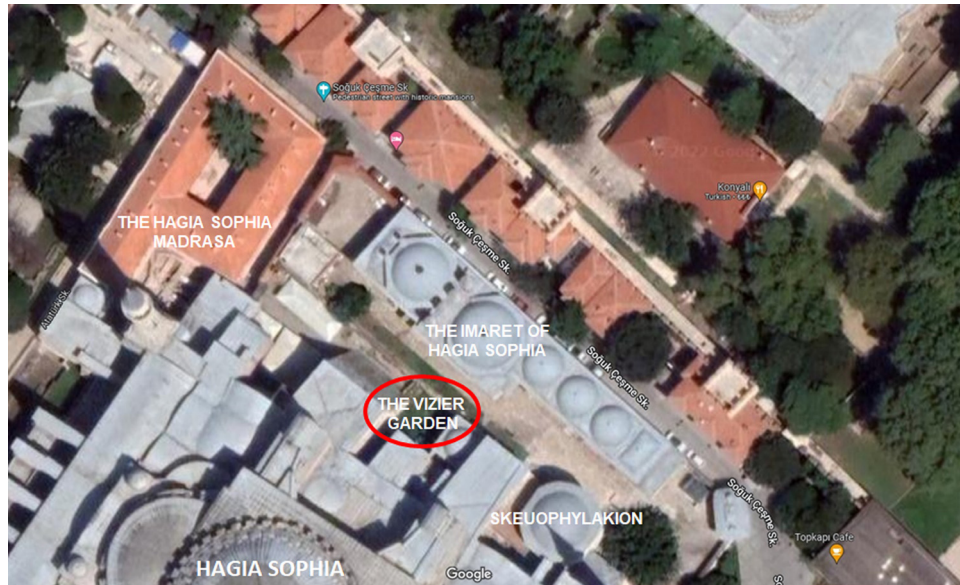


Figure 1: Aerial photograph showing the location of the Vizier Garden (Google).

interior space at the end of 2021, a relatively more favourable environment allowed for its visualisation. In this study, the most recent architectural documentation of the hypogeum carried out, and its first reconstruction plan proposal and the virtual superposition of the structure with its superstructure were presented. The lack of architecturally similar structures in Istanbul requires special attention to this subterranean structure.

It is important to consider what to gain and lose when shifting from traditional recording methods to digital ones (Scott, Roosevelt, Nobles, & Luke, 2021). Regardless the representations on hand matter to constructing knowledge (Hacıgüzeller, Taylor, & Perry, 2021). The accurate graphic survey of an archaeological site is a fundamental tool for its recognition, documentation, and study. Moreover, if the site is hidden under a building and is not accessible or visible, but covered, graphic documentation becomes essential. And these archaeological elements can only be known and recognised as by graphic and documental information (García-León, González-García, & Collado-Espejo, 2021). The cultural asset data, which enables recording, analysis, decision-making, and management, is the key to conservation (Sarıcaoğlu & Saygı, 2022).

2 Recent History of the Architectural Documentation of the Hypogeum

Before dating the hypogeum, it is important to mention the interesting architectural documentation chronology of the structure. As a matter of fact, exposed findings during the museum research still contribute to dating studies of the hypogeum in line with the documented traces. After Hagia Sophia was converted into a museum in 1934, the hypogeum next to Hagia Sophia was first discovered and published in 1946 by the museum director, Ramazanoğlu (1946). He dated this subterranean structure, which he observed as having two different layers on the superstructure floor, to the fourth century. He likened its discovery to a Roman columbarium while describing the hypogeum as a tomb of emperors. Stating that the stone walls that cut the spaces on both sides of this triple subterranean structure group together with their vaults were built to buttress the existing Hagia Sophia structure, the author stated that the hypogeum was not like the other Byzantine tombs in Turkey (Figure 2).

Feridun Dirimtekin, one of the next museum directors, did not mention the flooring of the superstructure in his publication on the hypogeum in 1962 (Dirimtekin, 1962). Presumably, the flooring layer must have been

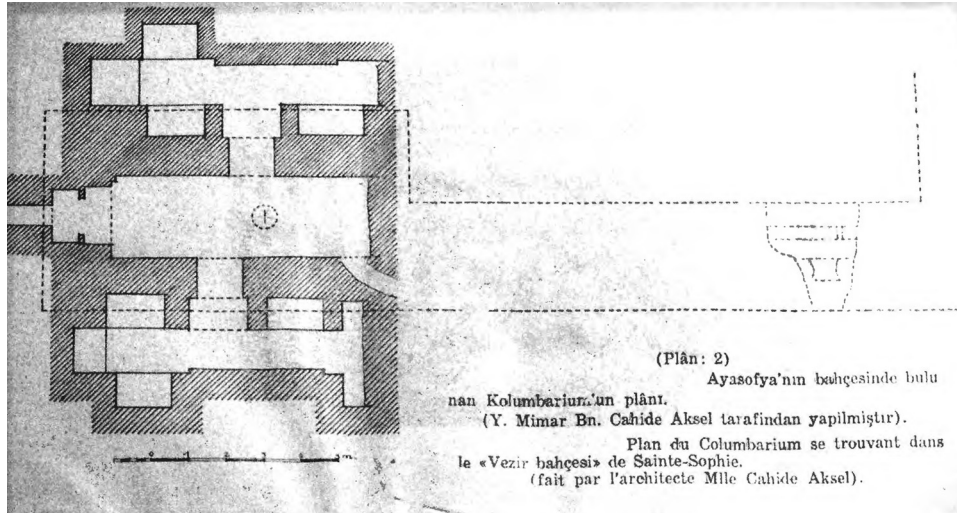
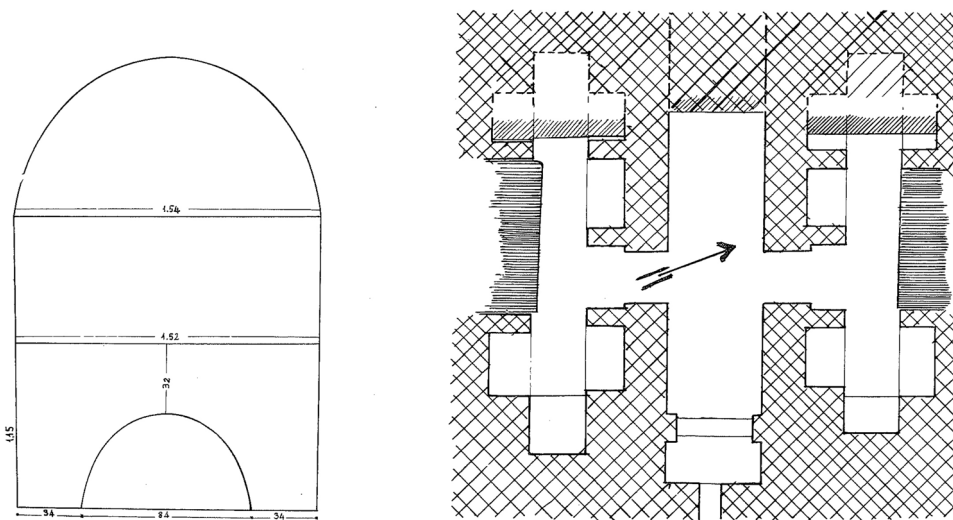


Figure 2: Plan of the hypogeum (Ramazanoğlu, 1946).

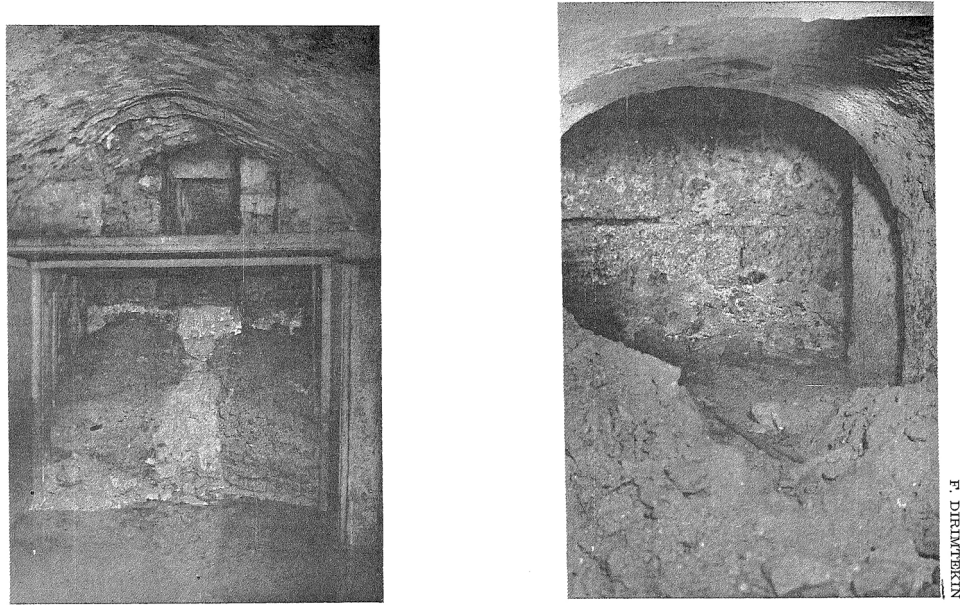
covered with earth during the intervening time. Dating the hypogeum to the end of the fourth century or the beginning of the fifth century, he stated that there were no similar structures in the nearby geography with examples and dated the similar structures to either a very early or a late period. Like the former director, Ramazanoğlu, he also associated the stone walls that cut the building on both sides with the retrofitting of Hagia Sophia (Figures 3 and 4). The relationship between Hagia Sophia and the hypogeum was also a reference for Nezih Fıratlı, the director of the Istanbul Archeology Museums of the period, in order to examine the burial plots in other Late Antique churches (Fıratlı, 1966).

Dirimtekin pointed out that the tunnels connected to the hypogeum structure from both ends were unplastered and stated that they belonged to the Ottoman period and were built during the construction of Architect Sinan buttresses dated to the last quarter of the sixteenth century. As a justification for this, he claimed the rainwater that had to be drained from the area between Hagia Sophia and Skeuophylakion was connected to the infrastructure system which is parallel to the north-eastern façade of Hagia Sophia. He



Ayasofya şimalindeki hipoje krokisi
Croquis de l'hypogée au nord de Sainte Sophie

Figure 3: Section and plan of the hypogeum (Dirimtekin, 1962).



Ayasofya şimalindeki hipojenin içi
 Interieur de l'hypogée de Sainte Sophie

Figure 4: Images of the hypogeum (Dirimtekin, 1962).

claimed that the rainwater was connected to the infrastructure system through the tunnel connected to the hypogeum from the upper level in a southeast direction and another tunnel connected to the hypogeum from the lower level in a northwest direction (Dirimtekin, 1962). However, the tunnel that continues from the hypogeum to the northwest is not located on the lower level, but at the upper level, just like the other tunnel coming from a southeast direction.

Another interesting piece of data regarding the annex partially above the hypogeum is seen in the Hagia Sophia survey prepared by the American architect Van Nice between 1965 and 1986, which is still used as a source (Van Nice, 1986). Despite being underground, Van Nice documented a plan of the hypogeum in the Hagia Sophia ground-floor survey plan by partially neglecting the annex and drew the first transversal section of the hypogeum in the northeastern section of Hagia Sophia. The annex building adjacent to the north-eastern façade of Hagia Sophia was partially displayed in his ground-floor plan together with a stone toilet inside. The function of this annex, which no longer exists today, will be discussed later when mentioning the repairs made in Hagia Sophia in 1985. This space, which was located partially above the hypogeum, was actually nothing more than an official shack, which was added to the northeastern façade of Hagia Sophia in line with administrative needs and was used as a guard room for a period. Considering that Ramazanoğlu could see the flooring, such a structure probably did not exist in 1946, or he did not need to mention it. The condition of this annex, whose spatial relationship with Hagia Sophia was documented in the plan (Figure 5) and section by Van Nice, can also be seen in photographs taken in 1985 (Figures 6–8). The north-eastern wall of Hagia Sophia, the Imaret building in a southeast direction, and the buttress with a north-western orientation were considered convenient walls for the guard room. After building a simple wall parallel to the north-eastern façade, this guard room was covered with a roof.

The hypogeum once again had to be considered, when a septic tank was to be added to the guard room in 1985. This strange preservation story, which started with the roof repair of the guard room and ended with the rediscovery of the hypogeum, was narrated by Alpaslan Koyunlu, the architect who carried out the repairs of Hagia Sophia during that period (Koyunlu, 1990a,b). Although Koyunlu claimed that this room was from the Ottoman period without citing any source, its construction date is uncertain. As the available visual data show that it was a structure from a more recent period, it is also possible that it was built after Hagia Sophia was turned into a museum. The museum administration requested the repair of the guard room which could not be used because it was in a dilapidated condition in 1984, but only the roof tiles and valley gutter were repaired

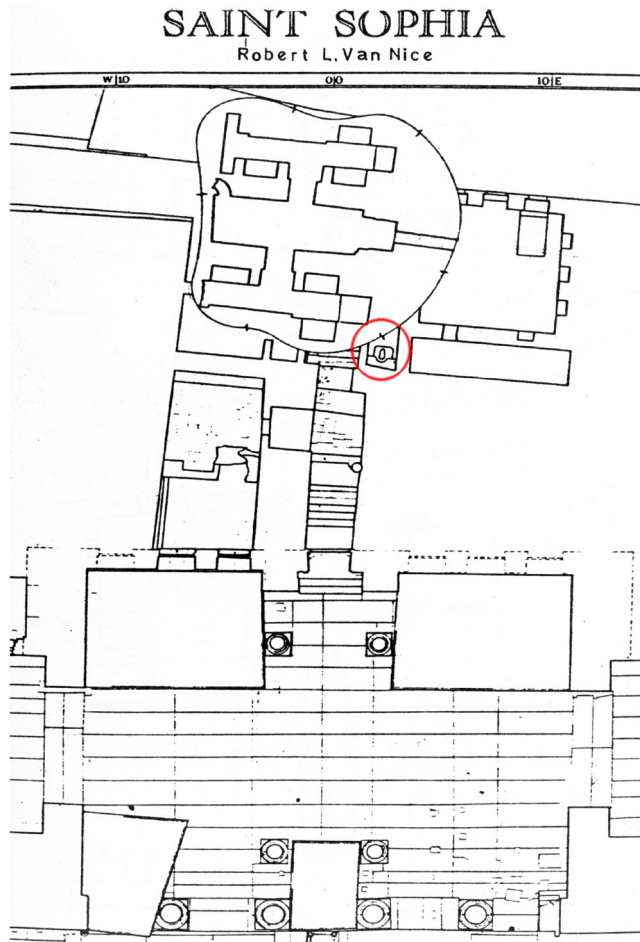


Figure 5: Detail from the ground floor plan of Hagia Sophia (Van Nice, 1986). (The stone toilet is visible in the red circle).

due to lack of funds. The remaining repairs to the room were left to the schedule for the following year. In 1985, when the efforts to unclog the toilet drain of the guard room failed, it was decided to open a 2 m × 1.5 m cesspool for the toilet located at the corner where the north-eastern façade of Hagia Sophia meets the wall of the Imaret building (Figures 9 and 10). As the excavation area expanded, the Byzantine wall fabric began to appear under the Ottoman wall with a southeastern orientation. And when the excavation enlarged 2 m more in a north direction, it was discovered that soil was flowing into a cavity, which led to the hypogeum. However, when it was understood that this space led to the hypogeum, the plan to add a toilet drain here was abandoned.

Koyunlu narrated this work, which evolved from a cesspool excavation to an involuntary archaeological excavation, as if he, with great success, had discovered the hypogeum for the first time. As a matter of the fact, his statements about the hypogeum show that he was unaware of the location of this subterranean structure and the relevant publications of the previous museum directors. However, within the scope of this work, although the hypogeum structure was haphazardly found again after about 23 years, the activity of digging a septic tank in the area continued because Koyunlu and his team were not aware of the Late Antique pavement in its superstructure as well as the hypogeum.

As the excavation deepened, the original pavement of the hypogeum's superstructure was revealed. In the pavement, the green ophite marbles which are not found in the pavement of Hagia Sophia's interior, but used here together with white Marmara marbles, were exposed. The existence of two square-planned traces on the pavement suggested the presence of a colonnade here. Another small white marble surface with its marble baseboard from an earlier period was also found approximately 40 cm lower than the upper level. Koyunlu questioned whether the floor on this lower level belonged to the first Hagia Sophia, and the floor on the upper



Figure 6: View of the Vizier Garden from the southeast, Istanbul Directorate of Surveying and Monuments Archive, 1985. (The guard room on the left and the lodging building on the right no longer exist).

level belonged to the second Hagia Sophia. These floor surfaces at two different levels, mentioned by Ramazanoğlu in 1946, were documented in plan and section within the scope of Koyunlu's work and still provide grounds for dating the hypogeum (Figures 11–13).

Koyunlu stated that there were chimneys within the vaults of each side of the hypogeum, and since the space in a northeast direction was under the imaret, no intervention could be made. Yet for the opponent side,



Figure 7: View from the front of the guard room, Istanbul, Istanbul Directorate of Surveying and Monuments Archive, 1985.



Figure 8: View from the roof of the guard room, Directorate of Surveying and Monuments Archive, 1985.

the situation was different because the space with a south-eastern orientation was under the guard room and Koyunlu suggested that the relationship of this chimney with the ground could be dealt when the upper part was cleaned. As the excavation progressed towards the wall in a northeast direction separating the imaret and the Vizier Garden, it was revealed that the unearthed marble floor continued towards the bottom of the Imaret's court. However, during the excavation at the bottom of this wall, it was discerned that the wall was built without a foundation. Upon realising this, the wall was suspended and the lower part was emptied. In this process, the concept of protection by covering up its history, which is still somehow the case, came to the fore again (Figure 14).

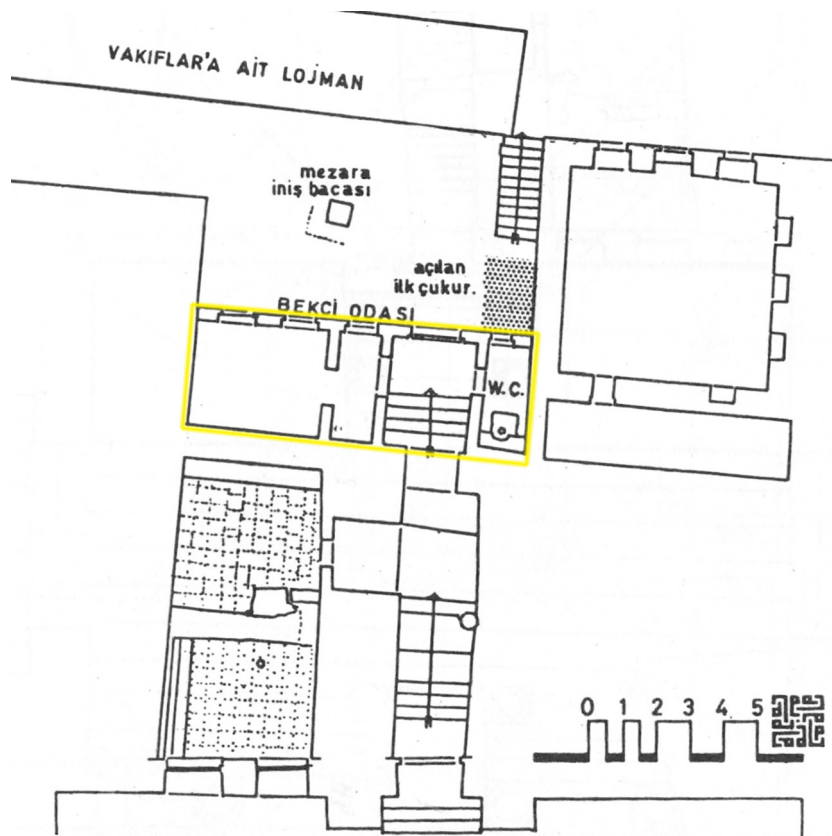


Figure 9: Plan of the guard room (Koyunlu, 1990a).

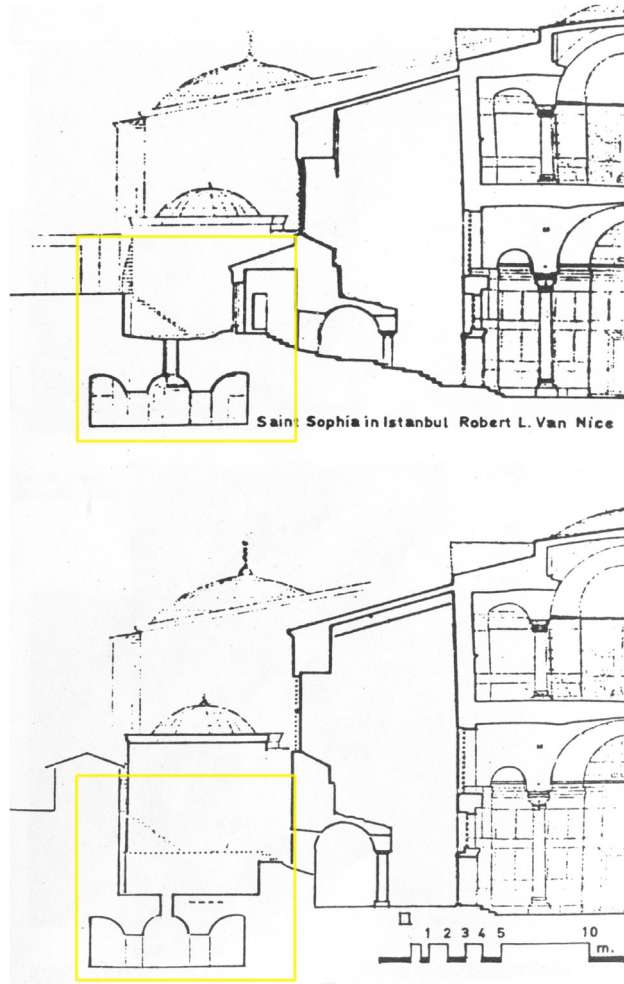


Figure 10: Views of the guard room over the hypogeum before and after the demolition, depicted in sections by Van Nice (1986); Koyunlu (1990a).

After the unearthed marble pavement was documented, it was covered with bituminous cardboard and 10 cm of sand fill was laid over it to protect it. Then, large stones without mortar were placed on the sand laid on the baseless lower level of the imaret wall, and a retaining wall was built with cement mortar over these stones. Such an intervention may have been due to the material and technical difficulties of the process or the possible political pressure of a new Byzantine invention in Hagia Sophia. Koyunlu stated that this covering intervention was made in order to protect the marble flooring that was unearthed so that large-scale research could be carried out in the future. However, this ambiguous period, which was defined as “in the future,” has not yet expired, and the superstructure of the hypogeum is still covered with soil. The retrofitting works on the lower part of the retaining wall separating the Imaret of Hagia Sophia from the Vizier Garden in this period have been inefficacious due to the serious material losses of the wall at present. In the course of time, parts of the stone blocks from the retrofitted retained wall detached and fell to the garden level, and the wall is at risk of collapse in its current form (Figure 15).

These developments, which started in 1985 as an attempt to find the toilet drain of the guard room, whose roof was repaired a year earlier, ironically resulted in the removal of this annex of Hagia Sophia after the archaeological findings. The traces of the roof of the guard room, which was demolished while revealing the superstructure of the hypogeum, can still be seen on the Ottoman walls, which were the side façades of this structure by force (Figure 16). This process which Alpaslan Koyunlu conveyed as directly as possible in his publications despite everything, and the photographs in the archive of the Istanbul Directorate of Surveying

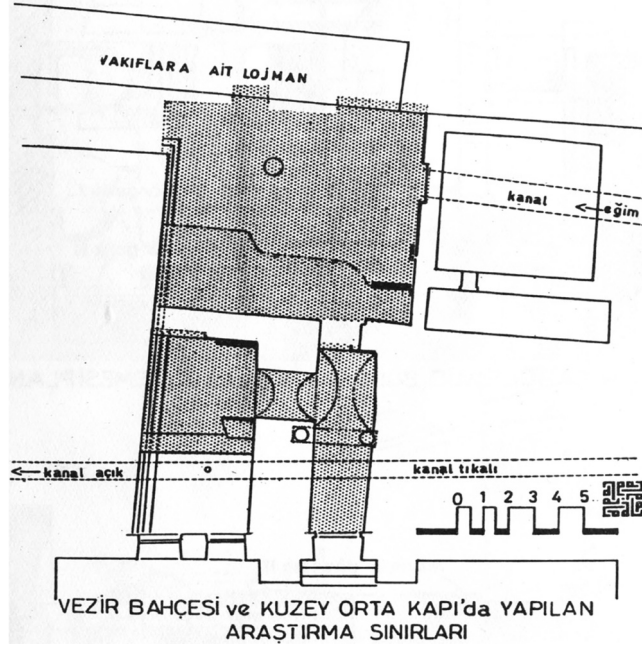


Figure 11: Excavation plan of the hypogeum superstructure (Koyunlu, 1990a).

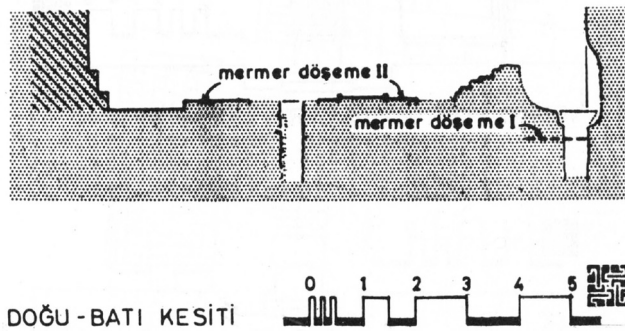
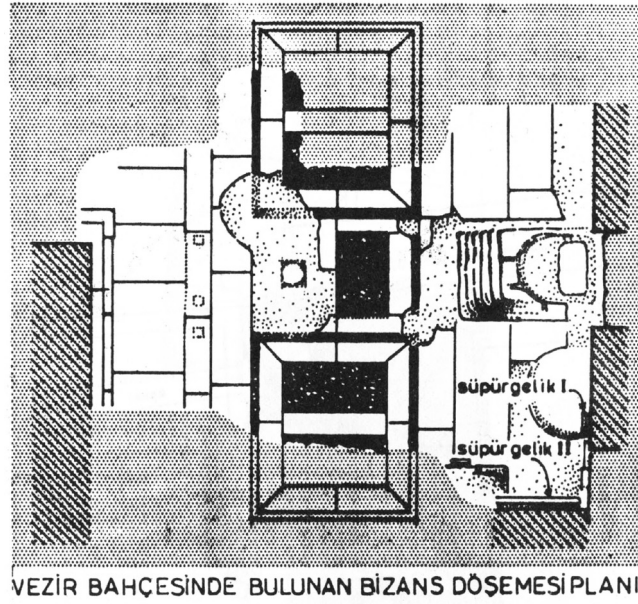


Figure 12: Plan and section of the hypogeum superstructure (Koyunlu, 1990a).



Figure 13: Marble floor slabs at two different levels unearthed in the superstructure of the hypogeum after excavation, Istanbul Directorate of Surveying and Monuments Archive, 1985.



Figure 14: Post-excitation view of the hypogeum superstructure, Hagia Sophia Museum Archive.



Figure 15: View of the Vizier Garden (hypogeum top cover), 2021. (The retaining wall is visible on the left).



Figure 16: The view of the northeastern façade of Hagia Sophia from (the retaining wall back) court of Hagia Sophia Imaret, 2022. (The roof traces of the demolished guard room can be seen on the wall surfaces on the left and right).

and Monuments, describe the reason for the existing roof traces on the side walls. The current datings of the Hagia Sophia hypogeum are still based on the publications and visual data left by Koyunlu.

3 Current Dating Studies of the Hypogeum

The catacombs were not exclusively used by Christians, and the majority of third-century catacombs – and the large ones in particular – are likely to have been established for the households of the imperial and other elite families. As religion was of little importance when it came to the mode of burial, the joint use of the catacombs by pagans and Christians only triggered a desire to activate their Christian identity in a small minority of individuals (Borg, 2016). Because they are so numerous, Christian sarcophagi from Rome are the most important group of objects for the creation and invention of a Christian iconography (Jensen & Ellison, 2018). The saints of Rome have always been among the most venerated and the most popular heavenly patrons in Christendom, and integrated into emerging Christian cultures. From the apostles and Early Christian martyrs through the Early Modern period and beyond, the Roman saints significantly impacted the rise of the cult of saints (Vedriš, Klaniczay, & Uhrin, 2021).

The laws of the fourth and sixth centuries outlawed any type of burial in the city outside the empire, but the archaeological evidence shows that these laws were not fully enforced in Constantinople (Dark & Kostenec, 2019; Rebillard, 2009). On the other hand, the data on the relationship of the Skeuophylakion (Treasury), which has a southeast orientation with the hypogeum, give insights on the first construction phases. However, the problems in determining the architectural history of the Vizier Garden in Hagia Sophia are mainly due to the regular addition of late Byzantine and Ottoman annexes and especially retrofitting structures (Taddei, 2018, p. 241). Although the buttress wall that cuts the chamber in a southeast direction is associated with the buttress of the existing Hagia Sophia structure, the presence of a similar wall in the other room in a northeast direction makes this less likely. These walls, which cut the chambers in parallel directions on both sides, are considered to be the colossal foundations of a later structure, probably from the sixth century.

After Taddei's examination of historic sources regarding the early constructions in this area, he concluded that there is a different building than the surviving baptistery located on the southwestern side of Hagia Sophia. He considered that this building, known as the "Great Baptistery," was located parallel to the northeast façade of Hagia Sophia, next to the Skeuophylakion. After entering the Skeuophylakion during the ceremonies, Hagia Sophia was accessed through this baptistery that no longer exists today from the left side nave, that is from the northern central door (Taddei, 2018, p. 243). Synthesising these historical data with their observations based on archaeological findings in the field, Dark and Köstenc argue that the hypogeum, with its monumentalised multiple tomb form, has been a feature of the complex since the fourth century (Dark & Kostenc, 2019, p. 62). They also suggest that if the Skeuophylakion was originally built as a funerary structure in the fourth century, or if it also had a secondary function as an aristocratic shrine, it could also highlight the role of the hypogeum here (Dark & Kostenc, 2019, p. 21). Hypothesising the findings around the hypogeum with the wall remnants that they dated to the Justinianic era within the buttresses, the authors claimed that a sixth-century longitudinal structure parallel to the north-eastern façade of Hagia Sophia might have existed with a width of 13.5 m and a length of 24.5 m. They argued that this building was covered with a vault (perhaps a series of cross-vaults) and approximately reached the gallery level of Hagia Sophia. In this context, the white marble pavement within the lower layer of the superstructure of the hypogeum dated to the fourth century, and it is evaluated that it may be a contemporary of the first Hagia Sophia. The pavement on the upper layer is dated to the sixth century because it is at the level of the lower edge of the buttresses that partially survives and is made of brick and stone (Dark & Kostenc, 2019, p. 61). The relationship between this proposed large rectangular planned building and the hypogeum necessitates the existence of a staircase leading directly down into the hypogeum from the building. Thus, it can be thought that in the sixth century, these two structures were probably combined in a single ritual order, and the veneration at the hypogeum or the saints buried in it is partially preserved. While discussing the possibility that this presumed building was part of the aforementioned "Great Baptistery," an effort was made to establish a connection between the hypogeum and its continuing religious use. These limited findings associated with the narratives in the sources may indicate the existence of a large sixth-century courtyard to the northeast of Hagia Sophia (Dark & Kostenc, 2019, p. 63).

4 Methodology of the Architectural Documentation

The first terrestrial laser scan survey on the subterranean structures of Hagia Sophia was carried out in 2020. The scanning process was accomplished by using a Faro Focus S 150 Terrestrial Laser Scanner (TLC) in large and complex subterranean structures, while a Leica BLK360 Camera Laser Scanner was used in low and narrow channels as it was easier to carry. Even though the images were in low resolution, the obtained point cloud enabled a presentation of general silhouette sections of the subterranean structures of Hagia Sophia (Diker & Esmer, 2021). The digital architectural visualisation of the current state of the hypogeum in this article is the first three-dimensional survey work after the documentation of the subterranean structures of Hagia Sophia. The state of the hypogeum, which was observed during the documentation of the subterranean Hagia Sophia in 2020, required cleaning the debris within for redocumentation. The cleaning work, which started on 15 November 2021, was terminated on 14 December 2021 due to the difficulty of seasonal conditions and the requirement of a much more comprehensive and long-term excavation process that include other subterranean structures. Only 3,875 kg of mud and debris were removed from the hypogeum during the cleaning process and the rest remained. After the temporary removal of rainwater inside the structure with a motor pump, a more favourable environment was provided for the visualisation of the space.

For the particular redocumentation of the hypogeum, image-based modelling technique as an easier method rather than TLC preferred, as there was no budget and a possible repair cost related to it being a risky work area. Since the licence of Agisoft Metashape Professional program version 1.5.2 was available, we needed to use it, and the structure was modelled in a higher density than the previous one. So, the camera NIKON D5200 was used with the lens of AF-S DX NIKKOR 18–105 mm f/3.5–5.6 ED VR. In order for the digital

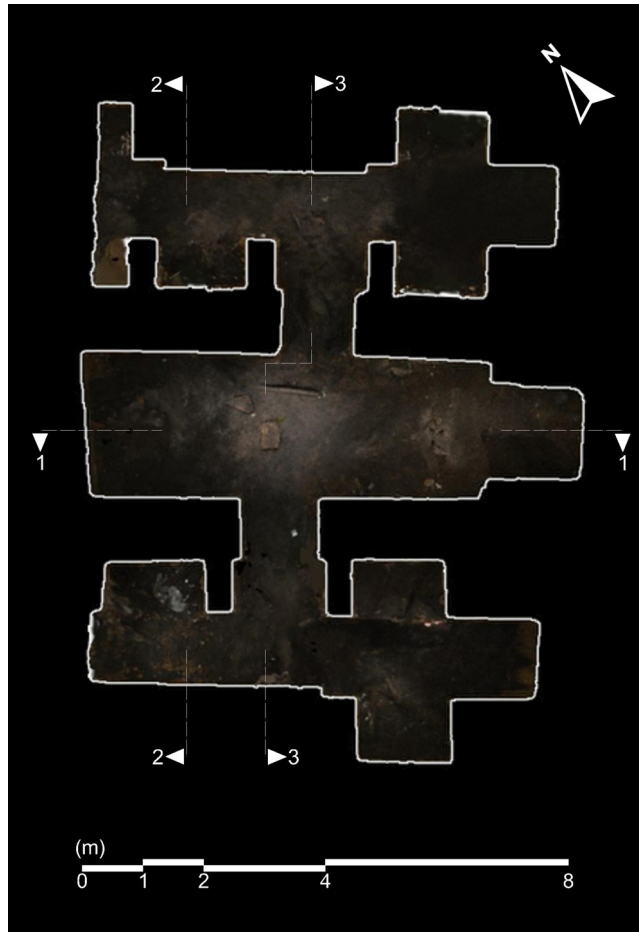


Figure 17: Plan survey of the hypogeum.

survey work carried out in January 2022 to progress smoothly, the rainwater collected from the hypogeum floor was drained with a water pump, and three-dimensional imaging of the space was made. Although the floor of this subterranean structure is still full of debris and mud with a depth of approximately 1 m, the structure was visually 3D documented with its current state. A total of 958 photographs were taken from inside and 596 photographs outside with a resolution of 300dpi. So the hypogeum was visualised in higher resolution than the previous one in 2021.

5 Current State of the Hypogeum

The hypogeum is a group of subterranean tomb structures located between Hagia Sophia and the Imaret. This structure group is approximately 60 m² and 4 m below the existing ground level. It consists of three rectangular-planned spaces with a long side of approximately 8 m. Apart from the circular hole covered by an iron lid that allows access to the middle space of the hypogeum from the ground level, there is also a gradual transition gap allowing entrance to the southeastern end of the space. These three spaces built parallel to each other in a southeast-northwest direction are connected to each other by an arched passage in the middle. The chambers in the middle and southwest directions are under the Vizier Garden, while the other with a northeast orientation is under the courtyard of the Hagia Sophia Imaret. The chamber in the middle has a unique marble door jamb on its southeastern edge. In the side spaces, there are niches known as “arcosolia” where the remains of the dead were kept. The arcosolia in the hypogeum are empty. The 3D digital architectural

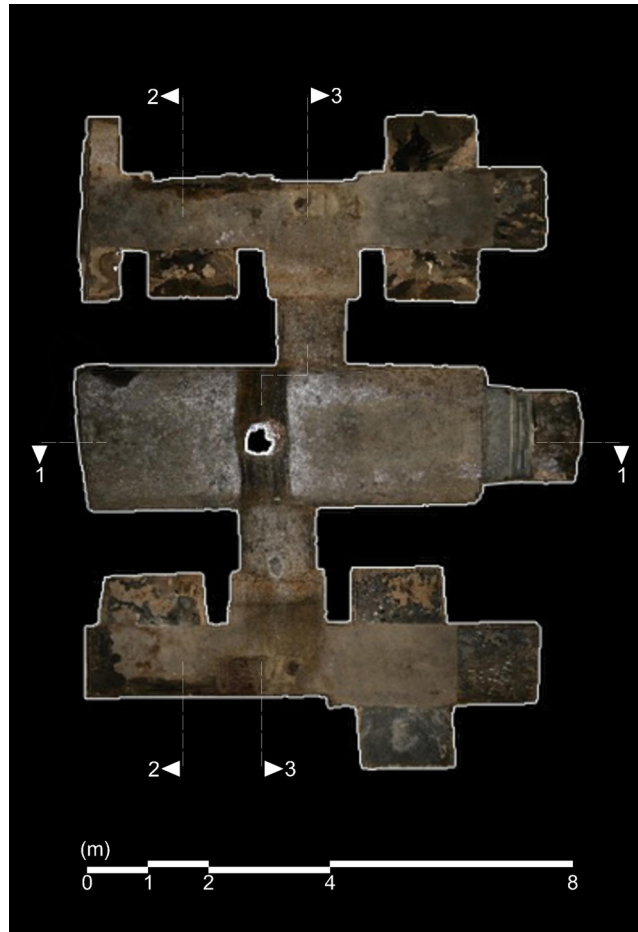


Figure 18: Ceiling plan survey of the hypogeum.

visualisations of the hypogeum produced within the scope of this study show the current state of the structure through plans and sections (Figures 17–22).

In both sections shown in Figures 21 and 22, the material losses in the retaining wall separating the Vizier Garden from the Imaret of Hagia Sophia are visible.

The three chambers of the hypogeum were built of bricks, and they are covered with cavetto vaults. The original walls and vaults are plastered, and there are no traces of decoration on their surfaces, perhaps suggesting they were never decorated. Approximately one third of the two-side chambers of the hypogeum was filled with cut stone walls in a later period. These walls must have been built in a period after the hypogeum lost its original function. The cut stone walls built in the direction of the long sides (northeast and southwest) of the side rooms were raised towards the upper level by cutting the vaults of these two spaces, except for the arcosolia in a southeast direction. Since the wall with a north-eastern orientation is under the courtyard of the imaret, it is not possible to visually observe its vertical continuity. As the superstructure is covered with soil on the other side, it also cannot be visually observed at which elevation the southwestern wall ends. The fact that the vaults, which were cut in one-third by these walls built later, still function as cantilevers without showing any structural weakness shows how solidly the hypogeum structure was built (Figure 23). Apart from the cut stone added to the side rooms, other stone walls were built on the north-western sides of the three chambers of the hypogeum in a later period. These foundation walls, which are thought to have been built during the construction of the buttress built by Architect Sinan in the last quarter of the sixteenth century to buttress Hagia Sophia, were built with rough stones, unlike the other infrastructure built with cut stone.



Figure 19: Perspective sections of the hypogeum (1-1, 2-2, 3-3).

The original ceiling height of the place is still uncertain, as the floor is filled with mud and debris (Figures 20–22). The pipes which were mentioned as chimneys by Koyunlu can be observed in the ceiling vaults. Both the current appearance of the door jamb and the uneven floor surface caused by the water and mud on the ground suggest that the original ground level of the structure is approximately 1 m lower than the existing mud surface. There are two tunnels connected to the hypogeum from the southeast and northeast. The tunnel, coming from a southeast direction, starts from the rain gutter at the ground level in the area between Hagia Sophia and the Skeuophylakion, continues with an inclination and ends at the upper level of the south-eastern edge of the middle chamber. The other tunnel, which starts from the upper level of the northwestern corner of the same middle space, continues in a northwest direction. However, the tunnel is clogged while turning southwest, and from there, it probably continues towards the northwest ramp of Hagia Sophia. While the tunnel coming from the southeast reaches the hypogeum under the buttress built by Architect Sinan, the other tunnel continues in the northwest direction near the other buttress built by Architect Sinan, after which it was clogged (Figure 24).

6 Discussion

The 3D architectural visualisation of the subterranean structures of Hagia Sophia was carried out just before the conversion of Hagia Sophia into a mosque in 2020 (Figures 25 and 26, Diker & Esmer, 2021). In this research, the use of the hypogeum as a cistern in the later periods was questioned and evaluated that a cistern in this location would not be very functional because it would not offer any benefit to its surroundings. In other words, the benefit of using the hypogeum as a rainwater-filled cistern in a location where its access is difficult, and its impact on its environment may be extremely limited is debatable. On the other hand, it is possible for



Figure 20: 1-1 Section survey of the hypogeum.

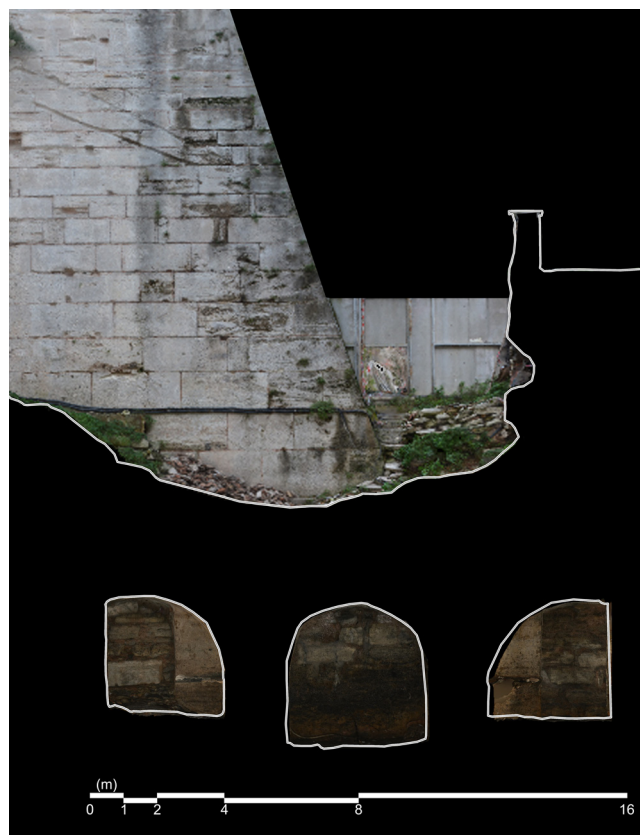


Figure 21: 2-2 Section survey of the hypogeum.



Figure 22: 3-3 Section survey of the hypogeum.



Figure 23: View from the stone wall that cuts the northeast room of the hypogeum and view from the vault it cuts, 2020.

the rainwater coming from the tunnel to the southeast to be discharged from the tunnel in a northwest direction if the water accumulated in the hypogeum rises to the levels of these two tunnels that are approximately at the same level. This is not a sustainable and functional approach in terms of use, as it would require the hypogeum to function as a pool for the drainage of rainwater. Moreover, if the real purpose of these tunnels, which are understood to be contemporary with the buttresses of Architect Sinan, was to drain the rainwater in the area behind the Skeuophylakion, the excess water would be directed towards Soğukçeşme Street to the northeast, which was possible at this time, since the Hagia Sophia Imaret had not yet been built at

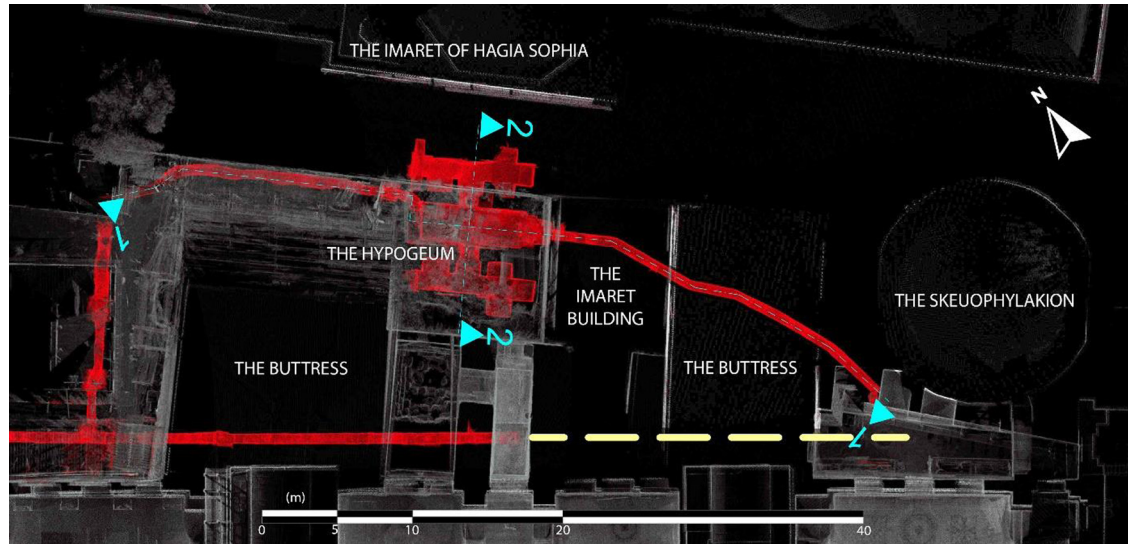


Figure 24: On the current plan of the hypogeum with its attached tunnels, the clogged canal defined by Koyunlu in Figure 11 is indicated by a dashed yellow line.

that time. As a matter of fact, it is considered that the clogged canal (Figure 11) that continues in a southeast direction, which Koyunlu discovered and documented, was built as a component of the original infrastructure to drain the rainwater collected between the Skeuophylakion and Hagia Sophia (Figure 24).

Considering all of these possibilities, it can be thought that the hypogeum was used as a ventilated cellar for storage during the Ottoman period after the tunnels were connected, or it was incorporated into the infrastructure with its convenient linear architecture for the ventilation of Hagia Sophia. Since the tunnels connected to the hypogeum from two directions are currently filled with mud, the function given them during the Ottoman period will be better understood after they are cleaned. Although it is just next to Hagia Sophia and older than it, the existence of the hypogeum was only noticed and documented after Hagia Sophia was turned into a museum. Yet even the fact that this exceptional subterranean structure was documented in the academic literature did not prevent its use as an inappropriate infrastructure for the guard room of the museum for a period. Today, although the hypogeum does not have any infrastructure function, it still awaits the attention and care it requires as it is in a derelict state filled with rainwater and mud accumulated from the gaps.



Figure 25: 1-1 section on the plan in Figure 24.

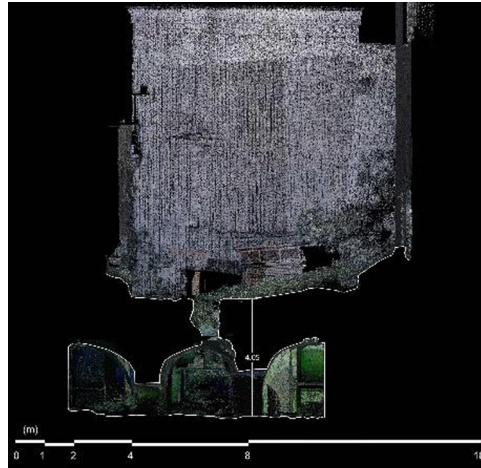


Figure 26: 2-2 section on the plan in Figure 24.

Comparing the previous section (Figure 26) and present visualisations of the hypogeum (Figures 20–22), the necessity of this research can be evaluated better, not only regarding the resolution differences but also in dimensional terms. As the colour values are closer to real, the filled materials in different periods can be perceived better. Although the debris remaining on the floor still prevents the visibility of the actual height and original floor of the space, the next step of the visualisation after cleaning the completely hypogeum will enable a comparison of the actual height of the structure. The previous plan visualisations could not easily enable a determination of the fillings according to the unclear plan borders. Nevertheless, the present plan give clues of the hypogeum's original plan based on the state of the arcosolia that were filled in two different periods (Figure 27). It may be assumed that each of two arcosolia in the northeast and southwest walls (marked with blue dashes) must have been filled with cut stone wall in the sixth century. The northwestern parts of the

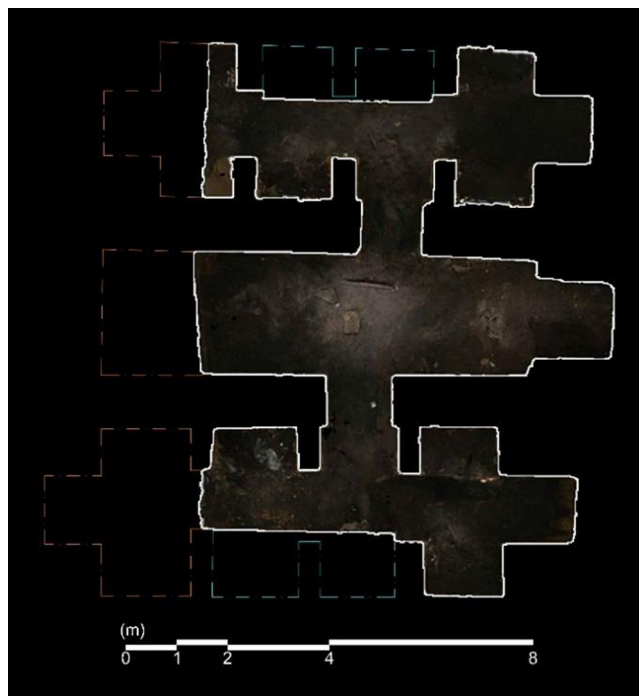


Figure 27: Reconstruction plan proposal of the hypogeum.

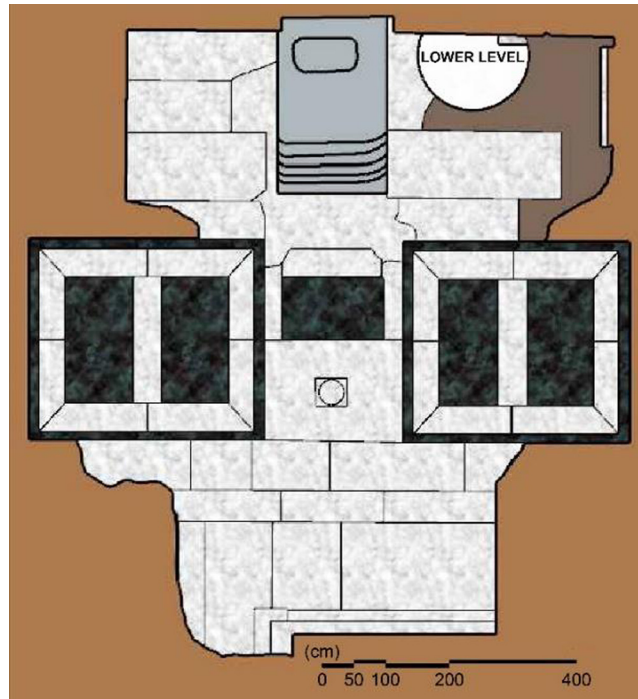


Figure 28: Rendered plan of the superstructure.

chambers (marked with orange dashes) must have been cut by the foundation of the sixteenth-century buttress. This planning proposal was prepared by presuming four arcosolia on each side and one on each end of the side chambers. The side chambers were evaluated as having same numbers of arcosolia. So this visualisation allows for a hypothetical reconstruction of its fourth-century original plan, based on the data available.

This study deals the architectural documentations and evaluations of the Hagia Sophia's hypogeum up to the present. The last architectural documentation of hypogeum in this article is the first particular 3D visualisation of the structure. Finally, to recall the superstructure of the hypogeum that was covered with soil in 1985, this marble pavement was also rendered (Figure 28) according to its documentation (Figures 12 and 13). And this superstructure superposed with the 3D model prepared for this study in order to highlight the multi-layers of Hagia Sophia's history. Here, the hypogeum is virtually visualised with its original superstructure and the current top layer (Figure 29). With the help of digitalisation methods enabled a combination of both the visual and non-visible documented layers.

7 Conclusion

Conservation of the subterranean structures and their accessibility to visitors is a difficult question (Luvidi et al., 2021). Many interesting archaeological sites, especially the subterranean structures remain unnoticed by the public because of their inadequate presentation. But, passing on only information is not nearly enough; interpretation is an art, the main aim of which is not instruction but provocation. Therefore, a connection should be established with the viewer and induce the urge to conserve cultural heritage. In this context, computer-aided visualisation offers a deepened insight into the cultural monument and is at the same time quickly comprehended (Lužnik-Jancsarya, Horejsb, Kleinc, & Schwall, 2020).

Although today, regeneration of Underground Built Heritage (UBH) for sustainable reuse is becoming increasingly popular, no generally accepted common definition has been proposed so far (Varriale, 2021).



Figure 29: Superposition of the hypogeum with its superstructure and current top layer.

Therefore, the determination of the artefacts built below the zero level in application of the so-called negative building culture requires it to be specially evaluated (Varriale & Genovese, 2021). Accurate and complete documentation of archaeological underground environments is a challenging task in order to promote public information, to favour the conservation of the sites, and to prevent the risk of information's loss. In this context, contemporary visualisation techniques are important for survey and 3D documentation of these environments (Ebolese, Lo Brutto, & Dardanelli, 2019). The direct relationship with the works of art and places can never be replaced by virtual means but undoubtedly they allow for a more detailed analysis of the context of the work (Valzano & Mannino, 2020).

Hagia Sophia has been a matter of curiosity since its first construction to the present. As the early constructions no longer survive and cannot be documented, their surrounding and related constructions need to be studied to reconstruct its construction history. The hypogeum is the oldest structure on the site of Hagia Sophia. So the evaluations of this structure according to the depth of its documentations will document not only its own history but also Hagia Sophia in general. Although the interior and top of the hypogeum

were not completely cleaned, the presented visualisations in this study intend to encourage the complete cleaning and documentation as soon as possible. An archaeological cleaning process will enable this space to document and date more accurately. By including the narrative of the documentation story to the present, this study is expected to be the last visualisation of the hypogeum until it is completely cleaned. Even the accessibility of this subterranean structure is not so possible for the moment, computer-aided visualisations shed light on the hypogeum and raise awareness of many subterranean structures like it. Visualisation of the hypogeum may be a bridge for the visualisation of other subterranean structures that should be perceived architecturally. A lack of architecturally similar structures in Istanbul requires special attention to this subterranean structure. The documentation and perception of this unique subterranean structure in Istanbul are very essential for understanding the multi-layered relationship of the hypogeum with Hagia Sophia in a spatial and historical context.

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