

# Two Cave Sanctuaries of Meter in Ionia and Mysia

## Exploring the Potential for the Archaeological Documentation and Interpretation of Cavernous Structures Using 3D Models

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### 1. Introduction

Cave sanctuaries dedicated to Meter, the Phrygian mother goddess, have long been a subject of archaeological interest due to their unique cultural and religious significance in ancient Anatolia. These sites, often located in remote and rugged terrains, present unique challenges for archaeological documentation and interpretation. This paper focuses on two cave sanctuaries of Meter located in the regions of Ionia and Mysia (present-day western Türkiye)<sup>1</sup>. The paper aims to explore the potential of three-dimensional (3D) recording, specifically using the structure-from-motion (SfM) photogrammetry method, in improving the comparability of the sites and enhancing the archaeological interpretation of these cavernous structures.

### 2. Data

The primary subjects of this paper are two cave sanctuaries: the Ballık Cave in Mysia, located in the vicinity of the ancient city of Pergamon, and the Uyuzdere Cave Sanctuary in Ionia, situated near the ancient city of Metropolis. The Ballık Cave was only recently discovered in 2020 as part of the archaeological survey of the German Archaeological Institute's Pergamon Excavation project in the southwestern Kozak Mountains (Pirson, 2020; Pirson, 2021). It is situated in a remote valley, where the course of the stream narrows into a deep canyon. The cave has been used as a settlement site since the Epipalaeolithic period (12.000 BCE). Later, from the 6<sup>th</sup> century BCE onwards, a sanctuary developed in which Meter was worshipped. This is proven by the numerous terracotta finds that were unearthed during rescue excavations in 2020 and 2021. A very close comparison is a cave sanctuary in the Uyuzdere Valley near Metropolis. The sanctuary, which was excavated by the Metropolis project in the 1990s, consists of two separate caves on the slope of a mountain ridge (Meriç, 2013). It was in use from the 3<sup>rd</sup> century BCE to the 2<sup>nd</sup> century CE.

Both caves have been subject to limited documentation due to their challenging access and complex internal topographies to date. For the caves of the Uyuzdere sanctuary, for example, only one section

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<sup>1</sup> We want to thank the Directorate of the Metropolis Excavation for the possibility to record the cave.

was drawn and a few photographs were taken in the 1990s. As part of a collaboration between the two projects, high-resolution photographic data was therefore collected in 2023. This data includes a comprehensive series of overlapping photographs capturing the cave interiors and exteriors, taken from various angles and distances to ensure complete coverage. The data set was used to generate accurate 3D models that provide improved visualization for archaeological analysis and interpretation and ensure comparability between the two sites.

### **3. Methodology**

The methodology employed in this paper involves the application of structure-from-motion (SfM) photogrammetry, a well-established technique in digital archaeology. SfM involves capturing multiple overlapping images of the cave structures and processing them using specialized software to generate 3D models. The steps include image acquisition, preprocessing, alignment, dense point cloud generation, mesh creation, and texturing. The software utilized for this process includes Agisoft Metashape. The resulting 3D models are currently undergoing analysis for the presence of (artificial) features relevant to the archaeological study of the sanctuaries. Moreover, as part of the data processing procedure, numerous sections and floor plans are generated from the 3D models and subsequently converted into digital drawings. The paper also addresses the specific spatial conditions of the cave, with a particular focus on the lighting conditions within the cave and the surveying conducted both within and outside the cave during the data collection procedure.

### **4. Results and discussion**

The architectural style of a building can be discerned from the exterior, allowing for its identification at a glance. In contrast, a cave is a negative space, in that we can only see its interior. Its extent and structure — depending on its size — are almost never fully visible. In the case of the cave sanctuaries presented in this paper, this issue was addressed by the creation of 3D models through the use of SfM photogrammetry.

#### **4.1 Data collection and archaeological documentation**

The data acquisition in the field has already been completed, thus allowing for the presentation of experiences, results, and conclusions regarding the methodology. The use of SfM enabled the acquisition of high-resolution, accurate, and non-invasive data without the need for physical contact with the cave walls, which can be fragile. The complex geometry could be documented in a comparatively time- and cost-efficient manner compared to 3D scanning technologies or traditional methods such as hand drawings and measurements. In addition to the advantages, potential problems will also be addressed. One such problem is whether the method can provide complete documentation of the cave interior, including areas that are difficult to access.

#### **4.2 Post-processing and archaeological interpretation**

The models created using SfM provide a new basis for better comparability of such cave sanctuaries in general and for individual archaeological interpretation. They allow for advanced spatial analysis,

such as examining the spatial relationships between different features within the caves, which can aid in understanding site usage and organization. The 3D models serve as a digital archive, preserving the current state of the sites for future research and providing a reference point for monitoring changes over time.

In addition, the 3D models offer the opportunity to expand our research activities and develop new research questions aimed at both the natural environment and the human use of these special places: It is possible to simulate and visualize different lightning conditions, which is of interest from various perspectives. On the one hand, the lightning conditions are influenced by natural factors, including the spatial setting and the orientation of the caves. The entrance of the caves of the Uyuzdere sanctuary, situated on the slope of a ridge of the eponymous mountains, open to the southeast. In contrast, the Ballık cave is located in a canyon-like section of a river valley and opens to the south. On the other hand, however, literary sources from the 5<sup>th</sup> and 4<sup>th</sup> century BCE attest that the rituals for Meter took place at night (Roller, 1999), necessitating the use of artificial illumination, which is corroborated by the discovery of lamps. It would be of interest to ascertain whether it is possible to simulate the interior of the cave with flickering lamps and torches. What was the minimum number of lamps and torches required for adequate illumination? Was the act of illumination a component of the ritual?

## 5. Conclusions

In conclusion, the integration of SfM photogrammetry in archaeological research, as exemplified by the cave sanctuaries of Meter in Ionia and Mysia, presents a powerful tool for enhancing the documentation and interpretation of cave sanctuaries with complex geometries. The capacity to generate precise and detailed digital representations offers new possibilities for the preservation, analysis, and interpretation of these spaces, taking into account both the natural environment and the human use of these sites.

## References

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