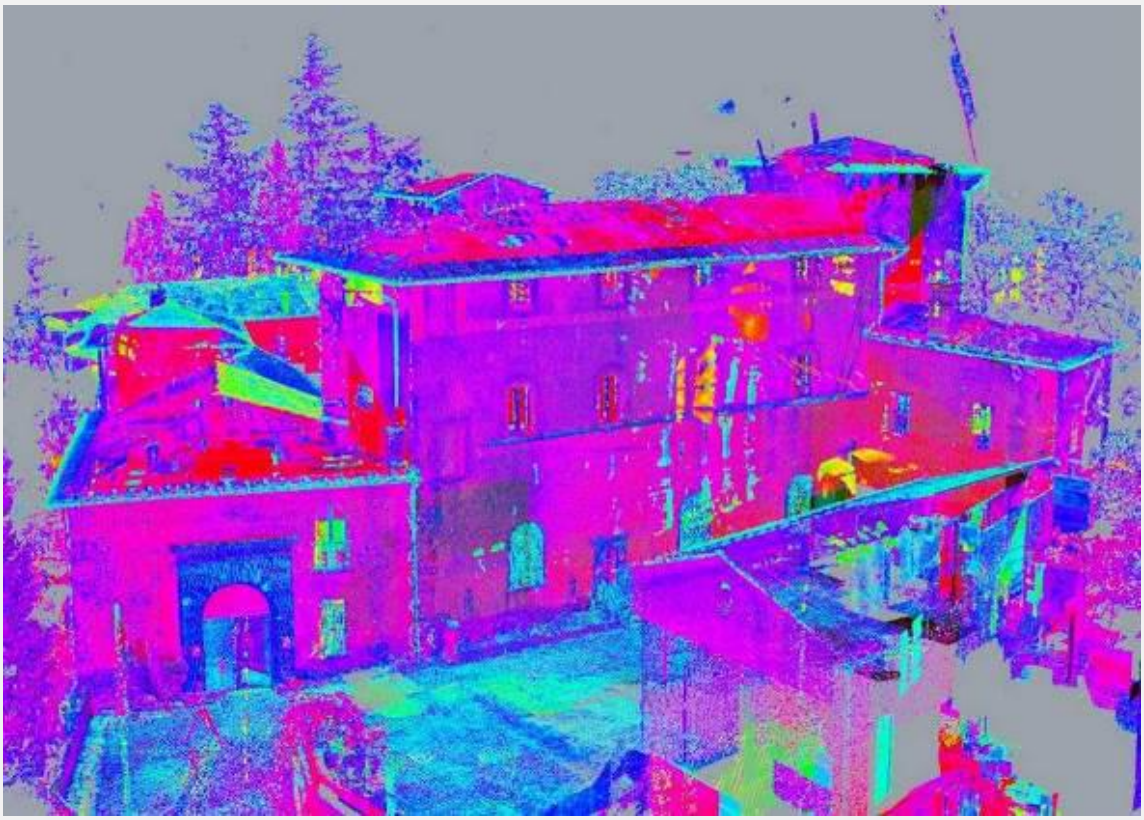
CAA-GR 2018

Spreading Excellence in Computer Applications for Archaeology and Cultural Heritage

Proceedings of the 3rd CAA-GR Conference
18-20 June 2018, Limassol, Cyprus

Edited by
Phaedon Kyriakidis · Athos Agapiou · Vasiliki Lysandrou



Limassol-Cyprus, 2019

3rd Computer Applications and Quantitative Methods in Archaeology (CAA-GR) Conference, 2018

ISBN 978-9963-697-36-6

3rd Computer Applications and Quantitative Methods in Archaeology (CAA-GR) Conference, 2018

Spreading Excellence in Computer Applications for Archaeology and Cultural Heritage

Phaedon Kyriakidis · Athos Agapiou · Vasiliki Lysandrou

Editors

Cyprus University of Technology

Editors

Prof. Phaedon Kyriakidis
Cyprus University of Technology

Dr. Athos Agapiou
Cyprus University of Technology

Dr. Vasiliki Lysandrou
Cyprus University of Technology

ISBN 978-9963-697-36-6 (ebook)

Front page picture: Castel Masegra Sondrio (Lombardy, Italy). A courtesy of Luigi Barazzetti (CAA Gr 2018 Conference best paper award)

Session 4

3D Reconstruction and Modelling

THE CAVE OF THE NYMPHOLEPT AT VARI – FAST CREATION OF A 3D SIMULATION MODEL OF AN IMPORTANT CULT CAVE IN ATTICA, GREECE

A. MARI[1], V. D. ANDRITSANOS[2], T. CHATZITHEODOROU[3] & G. CHATZITHEODOROU[2]

[1]Ephorate of Palaeoanthropology – Speleology (EPS), Ministry of Culture and Sports, Ardittou 34b, 116 36 Athens
amari@culture.gr
[2]Department of Surveying & Geoinformatics Engineering, University of West Attica, Aghiou Spyridonos, 122 10 Egaleo, Athens
[3] Department of Surveying, Engineering, Geoinformatics & Cadastre, Directorate for Research and Technical Support of Projects and Works of Restoration, Ministry of Culture and Sports, S. Trikoupi 16, 106 83 Athens

Περίληψη

Το σπήλαιο Νυμφολήπτου βρίσκεται στον νότιο Υμηττό και ανήκει στην περιοχή Βάρης. Αποτελεί μοναδικό μνημείο που μετατράπηκε κατά την αρχαιότητα σε ιερό προς τιμήν των Νυμφών, του Πανός, του Απόλλωνος, ενδεχομένως και του Ερμή. Η κάθετη, βαραθρόμορφη είσοδός του, διαμορφώθηκε στην αρχαιότητα με την λάξευση βαθμίδων, που διατηρούνται σήμερα έντονα φθαρμένες. Η μετατροπή του μνημείου σε επισκέψιμο χώρο για το ευρύ κοινό θα απαιτούσε αλλοίωση της μορφής του, διότι θα συνεπαγόταν, κατ' ελάχιστον, την κάλυψη της αρχαίας κλίμακας καθόδου ή την δημιουργία καινούργιας, δίπλα στην υπάρχουσα αρχαία.

Η λεπτομερής αποτύπωση του εσωτερικού του σπηλαίου καθώς και του υπερκείμενου ψηφιακού μοντέλου τοπογραφίας πραγματοποιήθηκαν με στόχο τη δυνατότητα αναπαράστασης του μνημείου σε φυσική κλίμακα, σε ασφαλή επίγειο χώρο, κατάλληλα διαμορφωμένο ως επισκέψιμο για το ευρύ κοινό. Το σπήλαιο αποτυπώθηκε ταχύτατα αξιοποιώντας την τεχνολογία της τρισδιάστατης ψηφιακής σάρωσης laser. Σημαντικό ρόλο στην επιλογή των προδιαγραφών της αποτύπωσης διαδραμάτισαν οι αρχαίες επεμβάσεις στο μητρικό πέτρωμα του σπηλαίου Νυμφολήπτου καθώς και η τελική αξιοποίηση του τρισδιάστατου μοντέλου.

Abstract

The Cave of the Nympholept is located on the south side of Mount Hymettos and north of modern Vari. During antiquity, it functioned as a sanctuary dedicated to the Nymphs, Pan, Apollo, and, perhaps, Hermes. Its small vertical mouth was embellished with carved steps which are worn today. The creation of a new descent for the safe entering of visitors into the cave would demand at least a complete alteration of the original form of the cave mouth.

The purpose of the production of an exact full-scale model of the cave, located in a safe place suitable to function as a visiting site, was based on the detailed survey of the interior as well as the digital terrain model of the area. The cave was considered by 3D laser scanning. The final decision on the survey specifications was made according to the archaeological details and the idea of the 3D model simulation.

Λέξεις Κλειδιά/Keywords: Cave of the Nympholept, Vari, 3D laser scanning, 3D simulation model

1. Introduction

One of the most important caves of Attica used as a place of intensive cult since the 5th century BC is the Cave of the Nympholept, also mentioned as Cave of Pan or Cave of Archedimos (Fig. 1). The specific grotto preserves numerous elaborations upon its parent rock which establish it as a unique archaeological monument of universal value situated within Greek territory. It was a sanctuary dedicated to several deities who played a significant role on the lives of the women (namely the entering in adolescence, the phase of marriage, of conception and pregnancy, of giving birth and of raising children), but also on everyday life of shepherds and farmers too (for securing the fertility of their land and their flocks).

After the rise of Christianity, the existence of the cave was gradually forgotten. It was relocated again by Richard Chandler in 1765 and since then it became a favorite destination of all the Europeans who were crossing Attica while traveling to Greece and the Orient (Weller 1903, 264, note 2) in order to become acquainted with the place which gave birth to the ancient Greek civilization (Kokkou 1997).
An excavation lasting 10 days at the end of February 1901 was conducted by Charles H. Weller, archaeologist of the American School of Classical

Studies at Athens (Weller 1903, Wickens 1986, 90-121). It was then that the first plan and sections of the cave were drawn (Weller 1903, pls. I, II), while a second more detailed ground plan was published by the German archaeologists Schörner and Goette approximately one century later (2004, Beil. 3).

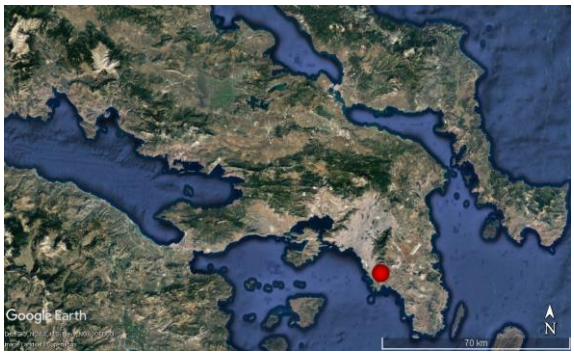


Figure 1. View of Attica with the location of the Cave of the Nympholept (Google Earth. Image @ 2018. Digital Globe).

The survey and documentation of a cave constitute an important part of its exploration. Classical as well as modern survey methods have been used during the past century in order to properly model caves of historical importance. The survey of a cave is a difficult task due to the special subsurface environment: the exact orientation of the cave is the initial quest. The usual survey methods have to be modified in order to fit the needs of the undersurface mapping of an archaeological monument which requires careful treatment and modified geodetic methods in order to attain the desired result.

The classical survey methods are divided into pure geodetic (Judson 1974, Dasher 1994) and photogrammetric ones (e.g. Chandler and Fryer, 2005). The main drawbacks of classical cave surveys are based on the large amount of time and resources needed in geodetic methods and on time consuming computation procedures of the photogrammetric. Traditional cave surveys utilize not very precise object representation techniques which are affected by errors due to the environmental conditions (Vouklari *et al*. 2017).

Terrestrial laser scanning (TLS) is an alternative modern technique for the exact representation of a cave (Παγούνης *et al.* 2004, Rüther *et al.* 2009, Tyszkowski *et al*. 2016, Vouklari *et al.* 2017). The appropriate manipulation of a large amount of data, the fast survey procedures, the quality of the representation, and the mapping resolution are the main advantages of TLS. In the case of a cave of archaeological interest, TLS can be used without any contact with the surveyed surfaces (geodetic techniques) and without establishing any special lighting installation (photogrammetric techniques).

The outcome of TLS is the point cloud of the observed object. The resolution of the point cloud permits the construction of a 3D model of the cave being studied. This model can be used in the representation of the monument in detail. Views, sections and cross-sections of the cave can be extracted from the final model.

Taking into consideration the morphology and the size of the cave, the present study will show how the survey of a monument with a 3D laser scanning can be used for the production of a 3D simulation full-scale replica at a safe visiting place.

2. The archaeological data

The Cave of the Nympholept is located upon the hill of Krevati, on south Mt. Hymettos (37º51΄29.31΄΄ N, 23º 48΄06.62΄΄ E), and belongs to the Municipality of Vari Voula Vouliagmeni. It is a cave formed within calcareous rock, with an almost circular ground plan comprising a vertical, inconspicuous entrance, at the W edge of which is formed a rock with a massive westward elongation that constitutes a partition between the two chambers of the cave: the dark, small north room, and the light, larger south room. It is interesting to note that the cave preserved a water spring on the west end of the northern chamber until a few decades ago (Weller 1903, pl. 1:ι).

As soon as one descends the flight of stairs carved upon the rock of the entrance, one lands on the east part of the north chamber where (upon the natural rock) the first ancient inscription is visible. The sign introduces us to the sacred place, embellished by Archedimos from Thera (probably the Cycladic island), who did all his work at the instructions of the Nymphs, because he was a nympholept. Being a nympholept meant that someone was possessed by the Nymphs and therefore he had the ability to communicate with them.

While crossing the north chamber westwards, there is a niche to the left with an inscription beneath, suggesting it was dedicated to Grace or Graces (“XAPITO”). These were deities of fertility, responsible for all the nice things happening in people’s lives and they were escorting most of the Olympian Gods (Κακριδής 1986, 279).

Before the niche of the Grace(s), a crudely made lion’s head was visible until the first decades of the 20th century. The relief was depicted in Gell’s and Monck’s diaries after their visit to the cave in 1805 and is also mentioned by Dodwell (Dodwell 1819, 550-552, Schörner and Goette 2004, Taf. 20, Weller 1903, 269, 276).

Almost opposite of the niche of the Grace(s) stands another, scribbled inscription, giving strict injunctions to wash outside the cave the entrails

brought as offerings to the gods (Schörner and Goette 2004, 44-46). A few meters after this inscription one sees to the right a carved water basin with a maximum depth of 0.815m, which maintains

"an inlet drain … cut at one end" (Weller 1903, 282), walls covered with hydraulic plaster, and a double leveled bottom with a circular shallow depression in the middle. The basin was suitable for purifications of the believers who would cross afterwards the rest of the small hall in total darkness which would generate intensive emotional charge and would prepare their souls for an elevation as soon as they came, through a carved threshold, into the biggest, light south room where the main cult would take place (Κύρου in print) (Fig. 2).

Figure 2. View of the south chamber of the Cave of the Nympholept, from W (K. Xenikakis 2017. Archive of the EPS).

Upon the west wall of the large south room is discernible a large human relief depicting Archedimos (stated twice by his carved name to the left), holding his pickaxe and his angle and moving to the right, with his head turned to the left, as if he is looking somewhere towards the northeastern part of the chamber. Beside him is a double altar carved on two levels which preserved an inscription destroyed during the last quarter of the 19th century as suggested by the drawings and the descriptions of the travelers of the time (Dunham 1903, 296, Schörner and Goette 2004, 47). According to these drawings, the altar was dedicated either to Apollo of the Dew ("ΑΠΟΛΛΩΝΟΣ : ΕΡΣΩ", see Weller 1903, 271, Dunham 1903, 296), or, most likely, to Apollo and Hermes ("ΑΠΟΛΛΩΝΟΣ : ΕΡΜΩ", where M might have been carved vertically or at an angle due to the lack of space. See Conor 1988, 182-183, Κύρου in print). Hermes, born in a cave by a Nymph, father of Pan, closely associated with Apollo in the eponymous Homeric Hymn (Kalligas 2017), leader of the Nymphs as depicted upon several marble votive reliefs, and protector of the herds (Spathi 2013, 407), fits perfectly well with the other gods honored in this cave.

One more carving (corresponding to another niche) is discerned on the north wall of the light chamber. With the exception of a sign ("ΣΠΗΛΑΙΟΝ ΝΥΜΦΟΛΗΠΤΟΥ") carved unfortunately on it, in the 20th century, it bears no element attributing it a specific function. However, it maintains a characteristic temple - like façade (Weller 1903, 267). The same applies for the biggest and best preserved altar, situated at the east part of the hall, beneath which can be read the word "ΠΑΝΟΣ" (of Pan). To the right of the altar of Pan is a carved three dimensional headless enthroned figure, which probably bore a head made from a different material, destroyed by Christians. Despite the fact that it is less than life-size, its elevated position (upon a low height platform) and the carved cuttings behind it for the placing of offerings, imply this figure played a central role to the cult. The existence of locks of hair on its shoulders presents no definite indication that the small statue depicts a female goddess as originally thought (Connor 1988, 185-186, Schörner and Goette 2004, 116-117, Weller 1903, 168-269). The fact that beside it, at a higher level, used to stand an omphalos appearing in the drawings of the travelers (Schörner and Goette 2004, Taf. 22: 2, 25:2, 28:2), but also in photographs taken before 1940 (Weller 1903, 268, fig.4, Παπαγιαννόπουλος - Παλαιός 1951, 79: eik. 2), has lead researcher Dr A. Kyrou (Κύρου in print) to suggest convincingly that the statue most likely depicted Apollo. God of light, patron of herdsmen and farmers, leader of the Nymphs (as evidenced in an inscription from the Corycian Cave, near Delphi), and protector of prophecy, Apollo was anyway one of the main deities honored in the cave. The interpretation of having a statue of Apollo fits also with the later use of the cave in the 4th century AD by followers of the neoplatonism who seem to have chosen this cave as a ritual place precisely because the god Apollo had already been worshipped there (Κύρου in print, Καλλιγάς 2017, 13-14: note 3, Kalligas 2017).

3. Previous surveys of the cave

Two classical surveys of the Cave of the Nympholept were carried out during the past years. The first effort was performed in 1901, using classical methods (obviously compass, measure tapes, triangles), and produced a plan upon which all the carved details are indicated by a Greek letter (Weller 1903, pl. I).

It is interesting to note that in the specific plan the main hall is located on the south part of the cave with a downward slope towards the west. According to the graphic scale, the total area of the cave is approximately 250 m^2. Two cross-sections were also depicted (Weller 1903, pl. II, also reproduced in Schörner – Goette 2004, abb. 1). Their horizontal graphical scale implies a 20 m maximum distance of the cross-section in the North-South direction. Unfortunately, no further information on the vertical

scale is provided and thus there is no data concerning the height mapping of the cave.

Another topographical plan of the monument was published by Schörner and Goette in 2004 (Beil. 3). For the survey of the cave, classical geodetic instrumentation (theodolite) was used (H.R. Goette, personal communication 2018). The surveying procedure was integrated on the field in 2000 during one week. The final drawings were re-processed by an architect based on in-situ measurements and photographs. Compared to the 1903 plan, the 2004 survey mapped a slightly different geometry of the cave. First of all, the area based on the graphic scale is estimated approximately 300 m^2. In addition, the orientation of the cave is completely different to the one presented in Weller 1903: the main hall is depicted on the eastern part of the 2004 plan while the second room lies in the western part of the cave. The totally different result following the above-mentioned surveys and the need for an exact simulation model of the cave led to the TLS survey procedure adoption.

4. The TLS survey procedure

4a Network establishment

Due to the special cave environment a control base was established near its entrance. This base was referenced to the Greek Geodetic Reference System 1987 (GGRS1987) using GPS satellite observations and the Hellenic Positioning System (HEPOS – Gianniou, 2008) as reference network. The receiver Magellan ProMark 500 RTK System was used providing cm accuracy in the position. Given the orientation of the base, 20 new stations were created inside the cave at the location of the desired laser scanner sites (Fig. 3). The loop closure residuals of the closed transverse were computed at the level of 3˚ in the angle and 3mm in the distance measurements. The height residual was calculated at the sub-mm level.

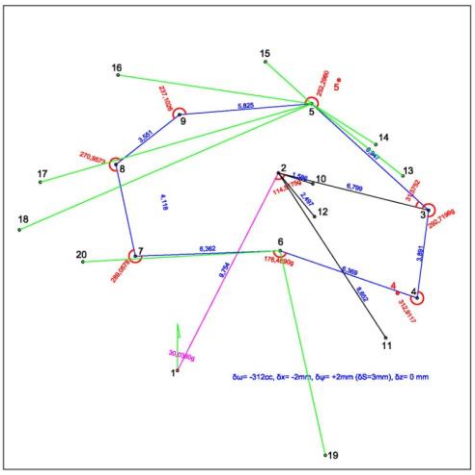


Figure 3. Cave of the Nympholept. Diagram of the control network and the stations of the laser scanner.

4b Cave scanning procedure

A cave as a scanning object needs special treatment due to the large amount of survey details. Additionally, the environment inside a cave is not ideal for scanning procedures: humidity, low lighting, high inclination and slippery floor are the major problems dealt with during a cave mapping. The scanning of the specific cave was performed with a Leica Scanstation 2 TLS and the appropriate ancillary equipment (target spheres etc). Leica Cyclone © software was used in the data collection and the point cloud processing. The method of direct georeferencing was used during the scanning procedure. This means that due to the known coordinates of each station, the georeferencing of all independent scans was achieved as well as their registration in a common system. In this way, the scanner was set up over a known point (and its height over the point measured), it was centred, levelled and oriented towards another known target where a spherical reflective target of known diameter (15 cm) was used as backsight mark, like a total station. The acquired scans taken from multiple scanner stations were already in the same reference system and were easily merged into one dataset. The spherical reflective targets were scanned with an accuracy of 1-2 mm and the RMS error of the direct georeferencing was in the order of a few cm.

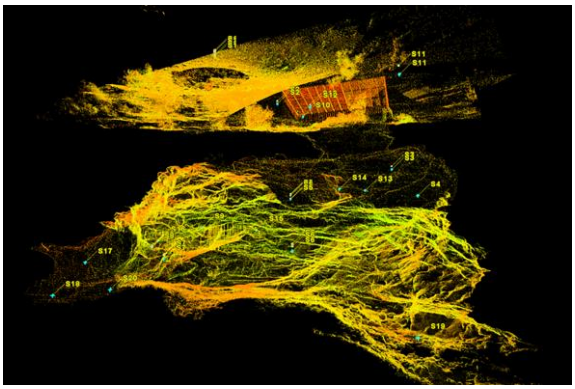


Figure 4. Cave of the Nympholet. The final point cloud.

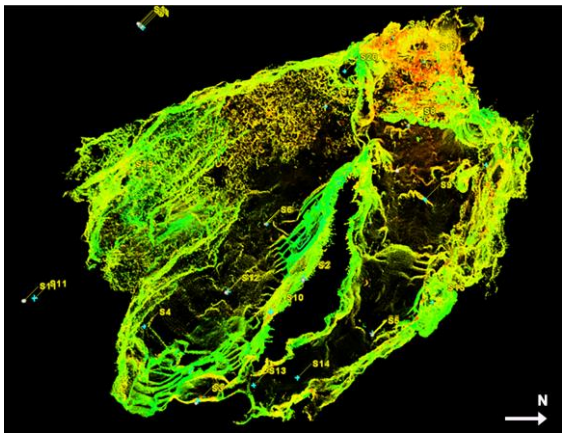


Figure 5. Cave of the Nympholept. Top view of the point cloud

A resolution of 1 cm was chosen as basic scanning setup, while 1 mm was decided for the important historical details of the cave. The horizontal range of the scanning was set from 0° to 360°, while 0° - 270° was the range on the vertical direction. The archaeological details were scanned in a special procedure using the maximum resolution. The duration of each scan was approximately one hour. An effort was made to maintain short distances (up to 10 m) between the scanner and the object in order to fully cover the cave walls. In Fig. 4 the final point cloud is shown where the entrance and the shape of the cave are clearly depicted.

The top view of the point cloud can be seen in Fig. 5. The two halls, some of the set-up stations chosen for the scanning procedure, and the shape of the cave are clearly presented.

4c 3D model creation

Before the reconstruction of the 3D model, all the unwanted information (e.g. plants and moisture) called noise, which interferes in the final object mapping, has to be reduced, i.e. manually removed, from the point cloud. This task is time consuming but very critical in the modeling procedure. A noisy point cloud can lead to a 3D model with blunders and spikes that do not represent the survey object. Another important issue is to fill-in the gaps of the scanning. This can be done by an interpolation procedure through triangulation. The point-to-polygon (mesh) process is a very sophisticated and resource intensive one, even for specialized 3D modeling software and still under research investigation. In the present study, the final point cloud was imported into 3D SYSTEMS GEOMAGIC © software in order to be modeled properly. The initial 3D model of the cave is constructed by converting a number of given points into a consistent polygon format (mesh). The spikes of the initial phase are removed using a smoothing – interpolation algorithm. In addition, the gaps of the initial meshing procedure were filled in manually by a re-triangulation method through GEOMAGIC (Mesh Doctor and RE-mesh procedures). The final 3D model of the cave is presented in Fig. 6.

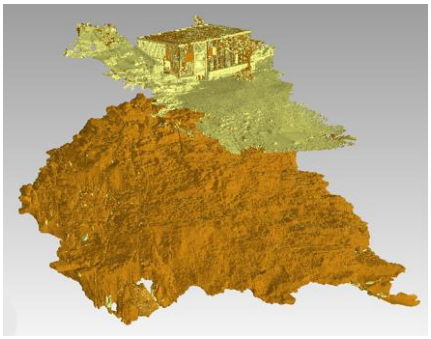


Figure 6. Cave of the Nympholept. The final 3D model (in yellow: the surface features. In orange: the subsurface details).

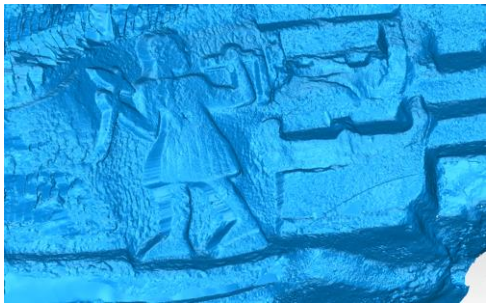


Figure 7. Cave of the Nympholept, south chamber. Model of the figure of Archedimos and of the altar of Apollo.

As mentioned above, a number of sculptures and inscriptions were chosen to be modeled using the TLS procedure with a fine resolution of 1 mm for the proper identification of the carvings. These archaeological features are isolated from the complete model in order to be mapped in detail.
The 3D models of the carved figure of Archedimos, of the altar of Apollo and Hermes, of the altar of Pan and of the headless statue are presented in Figs. 7- 9.

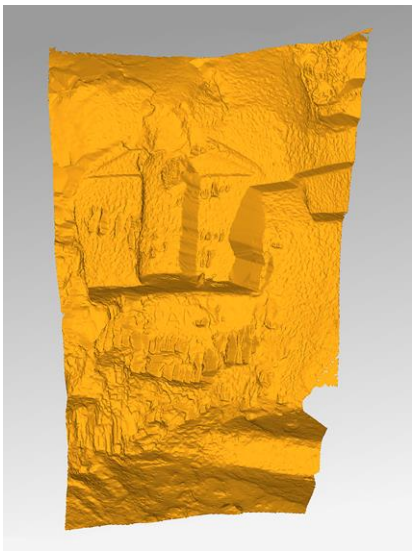


Figure 8. Cave of the Nympholept, south chamber. Model of the altar of Pan.

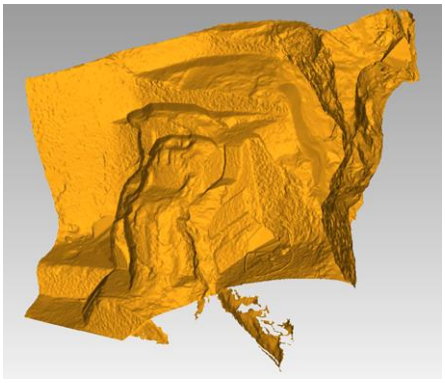


Figure 9. Cave of the Nympholept, south chamber. Model of the headless statue.

4d Photorealistic features and video

The texture map of the features of archaeological interest was based on photographs taken (by K. Xenikakis) inside the cave using professional cameras and using various light conditions. Nevertheless, the information imported from the photos enriched the 3D model with the specific texture map of the object's detail. The image manipulation was performed using GEOMAGIC © software in an automated manner. The texture map was constructed using the registration procedure of common points. The final photorealistic objects contain the metrics from the modeled point cloud and the texture from the embedded photos (Figs. 10-13).

Figure 10. Cave of the Nympholept, south chamber. Detail from the texture map of the carved figure of Archedimos and of the altar of Apollo and Hermes.

Figure 11. Cave of the Nympholept, south chamber. Detail from the texture map of the altar of Pan.

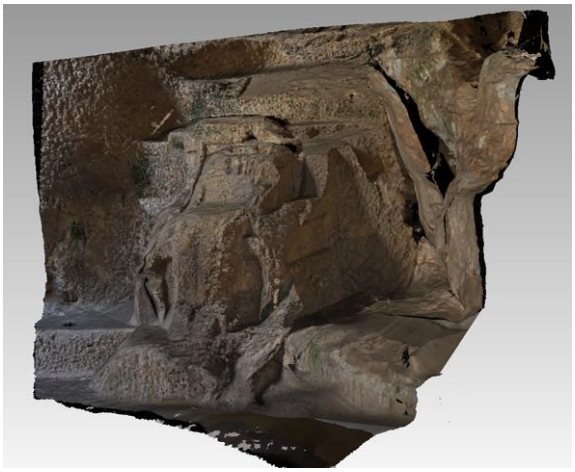


Figure 12. Cave of the Nympholept, south chamber. Detail of the texture map of the headless statue.

Figure 13. Cave of the Nympholept. Texture map of the first inscription in the north chamber.

4e Section and cross-section plans

The main parameters used to define a line section are (Vouklari 2017):

- *Thickness*, to define a volume around the plane where points are selected and possibly projected on it
- *Tolerance*, to control noise and alignment problems of different point clouds
- *Length*, for the minimal measure of the constructed segments
- *Distance*, which has to be minimal among the selected points.

Many studies deal with this subject. In some cases, the construction of a 3D model relies on a sequence of many nearby sections. The same method is applied to mechanical or freeform objects (e.g. Kyriazis *et al.* 2007) with the goal of representing a generic shape, in the best possible way.

In this study, the main axes chosen for the section and cross-section plans relied on the GGRS87

reference system. The choice of a georeferenced section plan was decided in order to have a link to the final simulation model of the cave. Autodesk AUTOCAD © and Leica Cloudworx © menu were utilized in the point cloud manipulation and section plans. A grid spacing of 1 m was chosen in Z direction and 13 section plans were created. In addition, cross-section plans of 1.5 m resolution were created (Fig. 14). The area of the cave as computed considering the section plans were estimated approximately 270 m^2. As far as the cross-section plans are concerned, the height difference from the bottom of the cave to the surface is approximately 13 m, and specifically from 266 m above MSL (Mean Sea Level) to 279 m above MSL. The heights are referenced to the Hellenic Vertical Reference System; its zero level was estimated by tide-gauge observations of 18.6 years at Piraeus harbor (Mylona-Kotroyianni 1989).

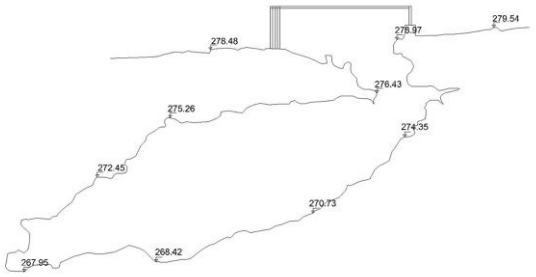


Figure 14. Cross section (no 8) of the Cave of the Nympholept.

5. Proposal for the construction of a replica

Requests of people to visit the Cave of the Nympholept increase day by day as they realize its uniqueness. However, the danger comprised in the attempt of descending the ancient narrow and worn steps of the entrance, having to confront a gap, approximately 6m deep, next and to the south of the steps and another one 3m deep to their north, designates the exclusion of most of the potential visitors.

A possible construction of a modern flight of stairs on top of the ancient ones, made of stainless steel (ISCA *et al.* 2014, 10) and having a protective balustrade, seems to be out of the question since it would involve an alteration of the original form of the cave mouth definitely affecting the archaeological character of the monument. Moreover, according to the recommendations of the Adjunct Secretary of the International Union of Speleology, the official opening of a show cave to the public should offer the possibility of access to people with reduced mobility (Bartholeyns 2016). In our case such a project would be equivalent to a complete destruction of the small vertical entrance whose opening measures 4.0 m length X 2.0 m width.

On the other hand, keeping tourists away from the original site seems to mean less damage of this persistently harassed monument which actually deserves better treatment (Κύρου in print).

The application of a 3D virtual tour should not be ruled out since it can offer quite satisfactory results by allowing people to "get" inside and "wander" within the monument. Depending on the concept of the tour, it might also help people have a virtual reconstruction and thus visualize how this cult place might have functioned in antiquity. Yet, this one seems to be a compromise which cannot offer the visitor a complete sense of the dimensions of the cave and of its carvings.
Therefore, the possibility of constructing a full-scale model of the cave at a suitable visiting place should be taken into serious account as an ideal solution.

An excellent example of a similar case constitutes the Chauvet cave discovered in 1994, in south France. It constitutes a magnificent monument with an area of approximately 20.700 m². Upon its walls are preserved the most ancient drawings of various painted, drawn or engraved animal species, dated between 32000/30000 BP and 27000/26000 BP (Clottes 2003). The French authorities had to confront various problems: the blocked prehistoric entrance; the destabilization of the ancient stalagmitic structures in the first chamber; the need for ongoing study of the cave by scientists; and, most of all, the fragile nature of the drawings along with the fear of causing damage and pollution to the cave which is a UNESCO World Heritage site. Thus, they decided to proceed to the building of a full-scale replica so as to be used as a visiting site. The replica leans against a modern metallic frame. The construction of its walls was accomplished with the use of 6.000 digital images (which were overlapped in developing sketches), and with the collaboration of sculptors, painters and blacksmiths. In this way, this special visiting place was ready within three years and opened at the nearby cave Pont D' Arc, in spring 2015. The site comprises half of the area of the Chauvet Cave and constitutes the largest replica of cave in the world (www.dailymail.co.uk/ travel_news/article-3009681/ Replica-Chauvet-Pont-d-Arc-Cave-open-France. html).

The "Lascaux 4" is another well-known replica housed in a half-buried building of concrete and glass unveiled in 2006 (https:/ /phys.org/news/2016-12-france-lascaux-prehistoric-art-cave.html). It replicates the dimensions, the artwork and colours of the original Lascaux Cave, in southwest France, which preserves on its walls prehistoric art estimated to be up to 20000 years old (Lima and Psaila 2012).

Other replicas of caves include parts of the Cave of Altamira in Spain with paintings which seem to date between 14000 and 22000 years ago (https://www.nytimes.com/2014/07/31/arts/international/back-to-the-cave-of-altamira-in-spain-still-controversial.html). Caves like those in Dunhuang western China (Mogao Caves), the Yungang Grottoes near Datong city in Shanxi – Shanghai, and the Ajanta and Ellora Caves in Maharashtra state of India, constitute monuments with paintings and/or rock-cut sculptures of a much later date (see for example www.getty.edu/ conservation/ publications_ resources/ newsletters/31_1/peerless_caves.html, https://medium.com/shanghaiist/look-3d-printed-replicas-of-buddhist-statues-from-the-yungang-grottoes-9ae657fa1866, and https:///timesofindia.indiatimes.com/city/pune/Tourist-centre-to-house-replicas-of-Ajanta-caves/articleshow/15358809.cms respectively).

In the case of the Cave of the Nympholept, things would be rather easy because of the small size of the cave (around 270.0 m²), which would imply less time and cost for the realization of such an ambitious but feasible project. The Cave of the Nympholept does not preserve paintings but rock-cut carvings and sculptures, difficult to be harmed by people exhaling carbon dioxide. It should be mentioned though, that the loss of humidity due to the open entrance and to the various environmental and other changes, transform gradually the crystalline calcium carbonate of the cave into amorphous calcium carbonate, and thus, cause damage to the carvings (V. Giannopoulos, personal communication). Additionally, there is always the danger of cyanobacteria which grow not only upon the surface of the sculptures but inside them as well because of the light entering the cave through its vertical entrance (Pantazidou *et al.* 2012, 264). By creating a replica, we will gain the protection of the original cave and its preservation for the future generations. At the same time we will offer the opportunity to people of different ages, not related to athletic speleology, to learn about and admire the work of a man who lived 2500 years ago and invested a lot of time and labour for embellishing this important sacred place.

It should be stressed that the Ephorate of Palaeoanthropology – Speleology accepted during the previous years to guide groups of people asking for permission to visit this cave, so as to develop gradually the awareness of the public of the cultural and historical significance of this irreplaceable archaeological monument and of the necessity for its safeguarding. However, since 2017, permission to visit the cave is only granted to speleologists, archaeologists and students of archaeology, in order to minimize the possible risk of accidents. Other groups of people wishing to visit the cave are encouraged to accept guiding outside the entrance of the cave with the use of educational material (maps, coloured photographs, ground plans and drawings).

In our opinion it is about time to proceed to the creation of a replica, having in mind that we can borrow the relevant know-how and the necessary experience by the specialized technicians of other countries who have already worked upon such undertakings. The location of a proper place, at a close distance, upon Mount Hymettos, whether it might be a natural cave or a built subterranean artificial one to house this special site, should not be assumed a difficult issue. Simulated stone face plaster or resin might be used to represent the natural rock, the speleothems (stalagmitic material) and Archedimos' carvings. The contribution of specialized sculptors, who will collaborate with photographers, engineers, and various technicians, is considered substantial.

The entrance of the replica might be constructed in a wider version for the addition of a small elevator for people with special needs. The flight of stairs might have on the north side a protective metal handrail whereas the deep gap at the south side might be covered with a transparent unbreakable material. Due to the small dimensions of the north chamber, a single pathway which will be used as the walking surface for the visitors will be adequate along with a couple of broader areas where a small group could be gathered to listen to a guide or enjoy the scenery (cf. ISCA *et al.* 2014, 9).

6. Conclusions

The Cave of the Nympolept constitutes an important cult place, possibly functioning as such from the beginning of the 5th century. It was embellished by Archedimos with carvings, inscriptions, reliefs and a statue, after 450 BC (Schörner and Goette 2004, 107). His name was inscribed four times upon the walls of the cave, twice upon a loose stone block and once upon a fragment of a marble stele (Κριτζάς 2001, 19-20), testifying for the decisive role he played in transforming the cave into a special sanctuary dedicated to several gods.

The uniqueness of this cave created the need for its exact representation by using terrestrial laser scanning (TLS). TLS provided a permanent digital record, which can be of primitive importance in the future conservation and restoration of the monument. Moreover, it produced the maximum detail and the metrically accurate dataset in order to acquire the 3D model of the cave which can and should be used for the development of a full-scale replica that will function as a visiting site.

For its construction, assistance can be offered by countries which have already completed similar projects [see paragraph 1, article 13, of the *World Heritage Convention of the General Conference of the United Nations Educational, Scientific and Cultural Organization meeting in Paris from 17 October to 21 November 1972, at its seventeenth session*. Also: article 12 of the *Confirmation of the European Convention on the Protection of the Archaeological Heritage (revised)* (ΦΕΚ 203/A/19-8-2005)].

In this way we will gain an impressive visiting site of main attraction, offering information of great archaeological value.

Acknowledgements
Warm thanks are addressed to: Dr A. Kyrou for providing access to an unpublished paper and for suggesting -along with D. Artemis- the bibliographical reference of Παπαγιαννόπουλος-Παλαιός; Dr S. Phillippo for providing information about Sir Charles Monck's diary and his visit to the cave in 1805; Professor H.R.Goette and Dr V. Giannopoulos for information about the ground plan in Schörner and Goette 2004 (Beil. 3) and about the environment of the cave, respectively; colleagues Th. Kontrolozos, H. Bougadhis and A. Mavrakis for participating in the cleaning of the cave in order to be photographed by K. Xenikakis. Last but not least, Dr K. Trantalidou was the first person to argue for the necessity of constructing a replica of the cave presented here. We thank her a lot for reading and making suggestions upon an earlier version of the paper.

References

Bartholeyns, J. P. 2016. 'Best practice in Show Caves management', *5th European Speleological Congress, Dalsbridge – Yorkshire, United Kingdom, August 2016.* www.uis-speleo.org/downloads/ Best_ practice_in_showcaves_management_Final.pdf

Chandler, J. H. and Fryer, J.G. 2005. 'Recording aboriginal rock art using cheap digital cameras and digital photogrammetry', in *Proceedings of the CIPA 2005 XX International Symposium,* Sept. 26th – October 1st, 2005, Torino, Italy. Edited by S. Dequal, pp. 193 – 199.

Clottes, J. 2003. *Chauvet Cave. The art of earliest times.* The University of Utah Press, Salt Lake City. (Tranlated by P.G. Bahn).

Connor, W. R. 1988. Seized by the Nymphs: Nympholepsy and symbolic expression in Classical Greece. *Classical Antiquity* 7: 155-189.

Dasher, G. R. 1994. 'On station – A complete handbook for surveying and mapping caves'. *National Speleological Society*, 242 pp. Huntsville, Alabama.

Dodwell, E. 1819. *A classical and topographical tour through Greece during the years 1801, 1805 and 1806*. 2 vols. London.

Dunham, M. E. 1903. The cave at Vari. Inscriptions. *AJA* 7: 289-300.

Gianniou, M. 2008. Modernizing Greece's Geodetic Infrastructure HEPOS: Designing and Implementing. *Geoinformatics* (Jan. – Feb. 2008): 10 – 13.

I.S.C.A., I.U.C.N., U.I.S. 2014. Recommended International Guidelines for the development and management of show caves. Developed by the International Show Caves Association (I.S.C.A.), the International Union for the Conservation of Nature (I.U.C.N.), and the International Union of Speleology (U.I.S.). *7th International Congress of I.S.C.A. at Jenolan Caves, Australia, November 2014*. https://www.uis-speleo.org/documents/Recommended_International_Guidelines_published_version.pdf

Judson, D. 1974. Cave survey for expeditions. *The Geographical Journal* (2) 140: 292 – 300.

Κακριδής, Ι. Θ. 1986. Χάριτες. *Οι Θεοί, Ελληνική Μυθολογία, τόμος 2*: 278-281. Αθήνα: Εκδοτική Αθηνών.

Καλλιγάς, Π. 2017. Ο Πλατωνισμός στην Ελλάδα. Συνέχειες και ασυνέχειες μιας αρχαίας φιλοσοφικής παράδοσης. *Ανθέμιον (Ενημερωτικό Δελτίο της Ένωσης Φίλων Ακροπόλεως)* 28: 1-14.

Kalligas, P. 2017. 'Honey from Hymettus: Platonic Philosophy in the cave of Pan?' Presented in 29/3/2017 in the American School of Classical Studies at Athens www.ascsa.edu.gr/index.php/newsDetails/videocast-honey-from-hymettus-platonic-philosophy-in-the-cave-of-pan

Κριτζάς, Χ. 2001. Επιγραφικό Μουσείο. *ΑΔ* 51 (1996), Χρον. Β1: 19-21.

Kyriazis, I., Fudos, I. and Palios, L. 2007. Detecting features from sliced point clouds. *GRAPP (GM/R)*: 188-196.

Κύρου, Α. Κ. In print. Το σπήλαιο του Νυμφολήπτου. Από τους χορούς των Νυμφών στον Νεοπλατωνικό διαλογισμό, στον *Τιμητικό Τόμο για τον Καθηγητή Γεώργιο Στυλ. Κορρέ*.

Lima, P. and Psaila, Ph. 2012. *The many metamorphoses of Lascaux. The artist's studio: from*

prehistory to today. Synops Editions. (Translated by V. Bell).

Mylona - Kotroyianni, E. 1989. *The 1st order Hellenic Vertical Network. Adjustment and computation (in greek)*. Hellenic Army Geographic Service internal report. 25 pages.

Παγούνης, Β., Καλυκάκης Σ., Μπίζα Π. και Παπαδόπουλος Χ. 2004. «Η χρήση της τρισδιάστατης σάρωσης ως μεθοδολογία στην αποτύπωση σπηλαίων. Εφαρμογή στο σπήλαιο Αγ. Γεωργίου Κιλκίς». Δελτίο Ελληνικής Γεωλογικής Εταιρίας XXXVI: 1244 – 1251.

Pantazidou, A., Lambrinou, V., and Oikonomou, A. 2012. 'Cyanobacteria associated with ancient sculptures and the abiotic parameters of cave Nympholeptos in Greece', στο *Πρακτικά 5ου Συμποσίου Ελληνικής Αρχαιομετρικής Εταιρείας*. Επιμέλεια Ν. Ζαχαριάς, Μ. Γεωργακοπούλου, Κ. Πολυκρέτη, Γ. Φακορέλλης, και Θ. Βάκουλης, σσ. 255-265. Αθήνα. Εκδόσεις Πανεπιστημίου Πελοποννήσου.

Παπαγιαννόπουλος - Παλαιός, Α. Α. 1951. Το παρά την Αιξωνήν άντρον των Νυμφών. *Αιξωνή* 1951: 77-82.

Rüther, H., Chazan, M., Schroeder, R., Neeser, R., Held, C., Walker, S.J., Matmon, A. and Horwitz, L.K. 2009. Laser scanning for conservation and research of African cultural heritage sites: the case study of Wonderwerk Cave, South Africa. *Journal of Archaeological Science* 36: 1847 – 1856.

Schörner, G. and Goette, H. R. 2004. *Die Pan-Grotte von Vari*. DAI Athen. Verlag Philipp von Zabern, Mainz am Rhein.

Spathi, M. 2013. 'The cave of the Nymphs at Keratsini, Attica: a new location for the popular female cult of the classical period and some intriguing finds', στο *Θεμέλιον, 24 μελέτες για τον Δάσκαλο Πέτρο Θέμελη από τους μαθητές και τους συνεργάτες του*. Επιμέλεια Ε.Π. Σιουμπάρα και Κ. Ψαρουδάκης, σσ. 395-415. Αθήνα. Εταιρεία Μεσσηνιακών Αρχαιολογικών Σπουδών.

Tyszkowski, P., Kramkowski, M., Wisniewska, D. and Urban, J. 2016. 'Use of terrestrial laser scanning for the documentation of quaternary caves'. *EGU General Assembly 2016, 17-22 April, 2016, Vienna Austria. Presented at the EGU General Assembly 2016, 17-22 April, 2016, Vienna Austria.* To appear in the Proceedings.

Vouklari E., Papanikolaou, D., Pagounis, V., Zacharis, V., Tsakiri, M. and Arabatzi, O. In print. 'Caves as Cultural Heritage: 3D Documentation of Dikteon Cave in Crete'. *10th International Symposium on the Conservation of Monuments in the Mediterranean Basin Natural and Anthropogenic Hazards and Sustainable Preservation. 20 – 22 September, 2017, Athens*.

Weller, C. H. 1903. The cave at Vari. Description, account of excavation, and history. *AJA* 7: 263-288.

Wickens, J. M. 1986. *The archaeology and history of cave use in Attica, Greece, from prehistoric through late roman times. Vols I and II*. PhD thesis in Classical Archaeology. Indiana University.