

GEOPHYSICAL SURVEY AT THE KIMARIA SITE ON CEPHALONIA

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Introduction

The Applied Geophysics Laboratory of the School of Mining and Metallurgical Engineering of the National Technical University of Athens (NTUA), in collaboration with Heriot-Watt University and the Ephorate of Antiquities of Cephalonia and with an official permit from the responsible Directorate of the Ministry of Culture, organized a geophysical survey in the area of Kimaria (Vouni). The survey was sponsored by the Odysseus Unbound Foundation (OUF).

OUF is an educational charity dedicated to advancing knowledge of the ancient world. Specifically, it sponsors and supports scientific and historical research to identify the locations and features of historical sites that have been described in ancient literature. It is committed to publishing the results in order to advance understanding of the ancient world and the origins of our civilization today to everyone's benefit. The Foundation collaborates with academic experts and with scientists expert in geophysical and geological research.

Geophysical surveys have proved to be very effective in detecting buried

1. GEORGE APOSTOLOPOULOS, "Combined geophysical investigation for the detection of ancient metallurgical installations near Keratea City, Greece", *Journal of Applied Geophysics* 104, 2014, pp. 17-25. GEORGE APOSTOLOPOULOS, K. LEONTARAKIS and C. Orfanos., "Geophysical investigation in the Temple of Poseidon at Cape Sounio, Attica, Greece", *First Break* 32, 2014, pp. 53-59.

anthropogenic structures and the paleo-environment in areas of archaeological interest in a non-destructive way². At the Kimaria (Vouni) site (**fig. 1a**) on the Paliki Peninsula of Cephalonia Island, archaeological excavation has revealed tombs of various sizes carved out of the limestone and calcareous sandstone. These are configured with a corridor leading to a small entrance representing the doorway of a small chamber (**fig. 1b**). Two of the tombs are close together while some others are found at a distance to the east.

This area has an archaeological history. In 1951, Spyridon Marinatos reported on his excavation activities on the hill called Skiniotiko Vouni, located near the village of Kontogenada in the heart of the Paliki Peninsula. He described his excavation of a small tomb, without burial pit, which he surmised may have remained incomplete and unused as the corridor (dromos) was only partially carved³. Its exact location is a matter of debate today. In 2010, the 35th Ephorate of Prehistoric and Classical Antiquities, under the direction of its then director, Mr. Andreas Sotiriou, excavated two detached vaulted tombs⁴. In 2016, the EFA of Cephalonia, under the direction of its former head, Dr. Olympia Vikatos, the archaeologist Eleni Papafloratou excavated another similar tomb carved in the limestone (**fig. 2a**). It had three carved steps on the north end of a corridor (dromos) and four burial pits inside the circular chamber, three of which were quite deep (1.90m) and narrow (0.40-0.45m) (**fig. 2b**). The length of the corridor (dromos) is 3.10m, and the maximum width is 1.55m. During the excavation, scattered bones and sherds of vessels were found, substantially disturbed.

According to the pottery, the tomb is dated to the Late Helladic Period IIIc, without excluding possible earlier use. Regarding the architecture of the tomb,

2. ΣΠΥΡΙΔΩΝ ΜΑΡΙΝΑΤΟΣ, «Ανασκαφαί εν Κεφαλληνία», *Πρακτικά της εν Αθήναις Αρχαιολογικής Εταιρείας*, Αθήνα 1951, σσ. 185-186.

3. ΑΝΔΡΕΑΣ ΣΩΤΗΡΙΟΥ, «ΛΕΕΠΚΑ», 2000-2010 Από το ανασκαφικό έργο των Εφορειών Αρχαιοτήτων, ΥΠ.ΠΟ.Τ. 2012, on line στο: <https://www.culture.gr/anaskafes/index.html>, Α. ΣΟΤΙΡΙΟΥ, «Excavations at Kefalonia during 2005-2013», *ό.π.*, p. 3. ΑΝΔΡΕΑΣ ΣΩΤΗΡΙΟΥ-ΕΛΕΝΗ ΠΑΠΑΦΛΩΡΑΤΟΥ-ΙΩΑΝΝΗΣ ΒΟΣΚΟΣ-ΕΛΛΗ ΤΖΑΝΝΗ, «Μυκηναϊκή Κεφαλονιά: οι πρόσφατες ανασκαφικές έρευνες στο νησί», *Πρακτικά Α' Συνεδρίου για το Αρχαιολογικό Έργο στη ΒΔ Ελλάδα και στα Ιόνια Νησιά*, εκδ. ΤΑΠΑ 2018, σσ. 757-766.

4. ΟΛΥΜΠΙΑ ΒΙΚΑΤΟΥ, «Το έργο της Εφορείας Αρχαιοτήτων Κεφαλληνίας 2015-2017», *Κυμοθόη*, τόμ. 28, Αργοστόλι, 2018, σ. 18, εικ. 6. ΟΛΥΜΠΙΑ ΒΙΚΑΤΟΥ-ΕΛΕΝΗ ΠΑΠΑΦΛΩΡΑΤΟΥ, «Εφορεία Αρχαιοτήτων Κεφαλληνίας: χρονικά ετών 2014-2015», *Αρχαιολογικό Δελτίο*, Αθήνα (υπό έκδοση). ΟΙ ΙΔΙΕΣ, «Το έργο της ΕΦΑΚΕΦ: οι πρόσφατες ανασκαφικές έρευνες της Εφορείας και οι εργασίες αντιμετώπισης των προβλημάτων μετά τους πρόσφατους σεισμούς», *Πρακτικά του Β' Συνεδρίου για το Αρχαιολογικό Έργο στη ΒΔ Ελλάδα και στα Ιόνια Νησιά*, Ιωάννινα 2017 (υπό έκδοση).

local elements typical of certain palatial tombs, such as the stairs carved at the beginning of the corridor (dromos) and the completion of the roof of the chamber with stone slabs, were found.

The overall location is important as, in addition to the Mycenaean cemetery on the slopes of the hill, the site shows traces of habitation, also continuing in later years, to the N / NW where the slope is more gentle.

The geophysical survey

The geophysical survey examined two areas, one adjacent to the tombs (“A”) and the other to the north where two flat terraces exist (“B”). The survey was undertaken before the EFA excavation in 2016. The purpose in the first area was to detect other possible buried tombs while in the second the purpose was to look for possible anthropogenic structures related to the tombs.

The IGME geological map in **fig. 4** shows the survey area outlined by a red line and indicates that the area is dominated by limestones of various ages and calcareous sandstones. Any tombs carved in these formations, or indeed any other anthropogenic structures, would be of dense material, so having low conductivity, while the loose material filling or covering them would be of higher conductivity. This leads to the use of two geophysical methods. Firstly, the electromagnetic (EM) method was deployed, with conductivity meter measurements up to an effective detection depth of 3m (**fig. 5**) covering the survey area and resulting in a map showing the horizontal distribution of apparent conductivity for the material from the surface to this 3m effective depth.

Readings for area “B” are depicted in the first charts below (**fig. 6a,b,c**), and for area “A” are shown in the charts immediately below them (**fig. 6d,e,f**). The apparent conductivity maps in both areas (**fig. 6a,d**) show some local changes in conductivity that may be of natural origin (erosional features) or of anthropogenic origin. Localised higher conductivities than those of the surrounding area indicate the presence of loose conductive material and they reveal some anomalies in the in-phase component maps, where an anthropogenic influence is more evident. The shaded relief of apparent conductivity maps (**fig. 6b,e**), emphasize lateral inhomogeneities and in these we observe some linear features in area “B” (“3” & “4” in **fig. 6b**) which are separated from the local anomalies. So, in summary, area “A” (**fig. 6d,e,f**) shows some local features, while area “B” (**fig. 6a,b,c**) also shows some linear features, all of possible anthropogenic origin.

The second method applied in the area was the use of Ground Penetrating Radar (GPR) with a 250MHz MALA shielded antenna (**fig. 7a**). The GPR

profiles covered the two areas wherever the terrain permitted acquisition of reliable data and this coverage is shown by the dashed lines in **fig. 6**.

α

In area “B”, the three GPR sections (**fig. 8a,b,c**) have revealed local features producing multiple reflections in the same positions as the features detected by EM (**fig. 8d**). More specifically:

- There are three layer interfaces (continuous in-line reflections) denoted by lines of different colours (green, yellow and orange lines).
- There are individual places with multiple reflections (outlined by dashed red lines), implying variations in coarse material, while in the rest of the area the material is relatively homogeneous.
- These collections of coarse material are of potential interest as they may indicate successive stages of building activity with stones.
- The multiple reflections in the GPR section depicted in **fig. 8b** are of high amplitude, suggesting more significant accumulations of coarse material such as building stones.

The GPR section in area “A” (**fig. 8e**) has revealed the following:

- Excluding two vague interfaces at 1.2m and 2m depths, the most important findings are to be seen in the two places where significant multiple reflections imply variations in coarse material, while in the rest of the area the material is relatively homogeneous.
- These collections of coarse material are significant since they coincide with the two features detected by EM in the locations “3” and “2” (**fig. 6d,e**).
- The lack of evidence via GPR of the very significant feature detected by EM in location “1” (**fig. 6d,e**) simply reflects the fact that the GPR profile could not be executed in this area because of difficult field conditions.

Conclusions

The geophysical survey at the Kimaria (Skiniotiko Vouni) site has revealed encouraging findings, especially in light of the challenging field conditions at this location.

The EM survey has identified several sites of potential interest where the

contours and apparent conductivity values suggest features not typically of natural origin. This is more evident in the shaded relief maps of apparent conductivity, where the features identified suggest the potential for the existence of anthropogenic activity.

The GPR survey has identified features producing multiple GPR reflections in the same areas of potential interest, thereby revealing the presence of inhomogeneities below the surface, another potential indicator of anthropogenic activity.

Of course, at times nature can create unexpected features and this is why, at sites of interest like these, excavation is recommended in order to ascertain what the features really represent.

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ΠΕΡΙΛΗΨΗ

ΓΕΩΦΥΣΙΚΗ ΕΡΕΥΝΑ ΣΤΗΝ ΑΡΧΑΙΟΛΟΓΙΚΗ ΘΕΣΗ ΚΙΜΑΡΙΑ ΣΤΗ ΝΗΣΟ ΚΕΦΑΛΟΝΙΑ

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Οι γεωφυσικές έρευνες έχουν αποδειχθεί αποτελεσματικές στον εντοπισμό θαμμένων ανθρωπογενών κατασκευών ή του παλαιο-περιβάλλοντος, αρχαιολογικού ενδιαφέροντος, εφαρμόζόμενες με μη καταστρεπτικό τρόπο. Στη θέση Κιμάρια, στη Χερσόνησο της Παλικής της Νήσου Κεφαλονιάς, η αρχαιολογική έρευνα έχει αποκαλύψει θαλαμωτούς τάφους, διαφόρων μεγεθών, λαξευ-

μένους σε ασβεστόλιθους και ασβεστιτικούς ψαμμίτες, με δρόμο που οδηγεί στο στόμιο του θαλάμου. Δύο από τους τάφους ευρίσκονται πλησίον μεταξύ τους, ενώ κάποιοι άλλοι βρέθηκαν ανατολικότερα. Το Εργαστήριο Εφαρμοσμένης Γεωφυσικής της Σχολής Μηχανικών Μεταλλείων Μεταλλουργών του Εθνικού Μετσόβιου Πολυτεχνείου, σε συνεργασία με το Πανεπιστήμιο Heriot Watt της Σκωτίας και υπό τη Διεύθυνση της Εφορείας Αρχαιοτήτων Κεφαλονιάς, μετά από άδεια της αρμόδιας Διεύθυνσης του Υπουργείου Πολιτισμού, διεξήγαγε γεωφυσική έρευνα στην περιοχή. Η έρευνα χρηματοδοτήθηκε από το Odysseus Unbound Foundation. Εξετάστηκαν δύο υπο-περιοχές, μία στην περιοχή με τους δύο κοντινούς τάφους και η άλλη βορειότερα που βρίσκεται σε δύο επίπεδα. Στην πρώτη περιοχή σκοπός ήταν να εντοπιστούν άλλοι τυχόν θαμμένοι τάφοι, ενώ στη δεύτερη πιθανές ανθρωπογενείς κατασκευές σχετιζόμενες με τους τάφους. Εφαρμόστηκαν δύο γεωφυσικές μέθοδοι. Πρώτα οι περιοχές καλύφθηκαν με τη βοήθεια ηλεκτρομαγνητικών μετρήσεων με χρήση μετρητή αγωγιμότητας και ενεργό βάθος 3μ με αποτέλεσμα τη δημιουργία χάρτη που δείχνει την οριζόντια κατανομή της φαινόμενης αγωγιμότητας του υλικού από την επιφάνεια έως το ενεργό βάθος. Οι χάρτες αγωγιμότητας και οι αντίστοιχοι με φωτοσκίαση (που αναδεικνύουν παράπλευρες ανομοιογένειες) ανέδειξαν και τοπικές δομές αλλά και αντίστοιχες γραμμικά επιμήκεις. Η δεύτερη εφαρμοζόμενη γεωφυσική μέθοδος ήταν αυτή του γεωραντάρ χρησιμοποιώντας θωρακισμένη αντένα 250MHz. Οι περιοχές έρευνας καλύφθηκαν με τομές γεωραντάρ κατά μήκος γραμμών εκεί όπου είναι δυνατή η απόκτηση αξιόπιστων δεδομένων. Στα ραδογράμματα παρατηρούνται περιοχές πολλαπλών ανακλάσεων στις ίδιες θέσεις, όπου τα ηλεκτρομαγνητικά εντόπισαν τοπικές δομές. Οι γεωγραφικές συντεταγμένες των γεωφυσικών δεδομένων ευρίσκονται με μεγάλη ακρίβεια μέσω χρησιμοποίησης διαφορικού GPS. Τα γεωφυσικά αποτελέσματα με τις εντοπισμένες τοπικές δομές είναι στη διάθεση της Εφορείας Αρχαιοτήτων για να αξιοποιηθούν σε μελλοντικές στοχευμένες ανασκαφικές έρευνες.

ΠΑΡΑΡΤΗΜΑ ΕΙΚΟΝΩΝ



Fig. 1. a) view of the Kimaria site, b) one of the old excavated tombs.

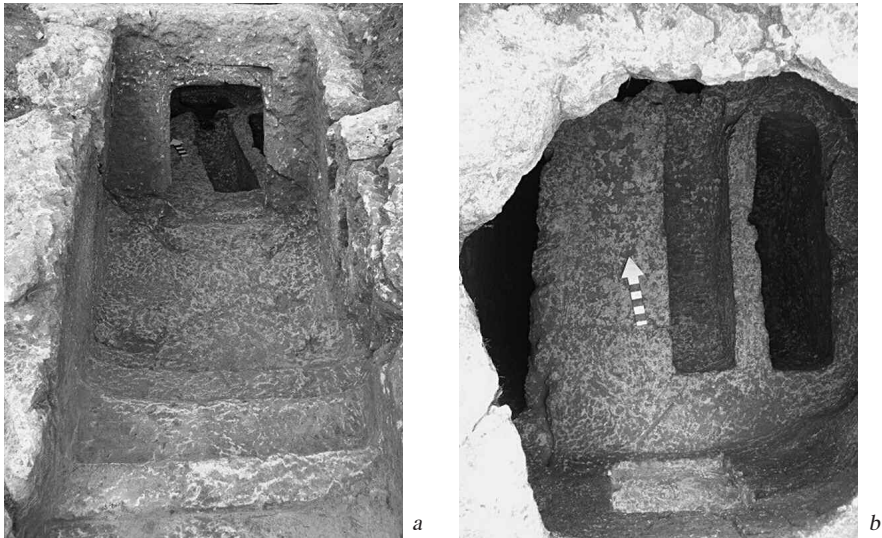


Fig. 2. The tomb excavated by EFA in 2016.



Fig 3. Google Earth map showing the geophysical survey area (green shaded area) and some tombs excavated before 2016 (chambers marked with red stars and the end of the dromos with yellow stars). Remains of possible structure to the north-east (upper-right) outlined by a red line.

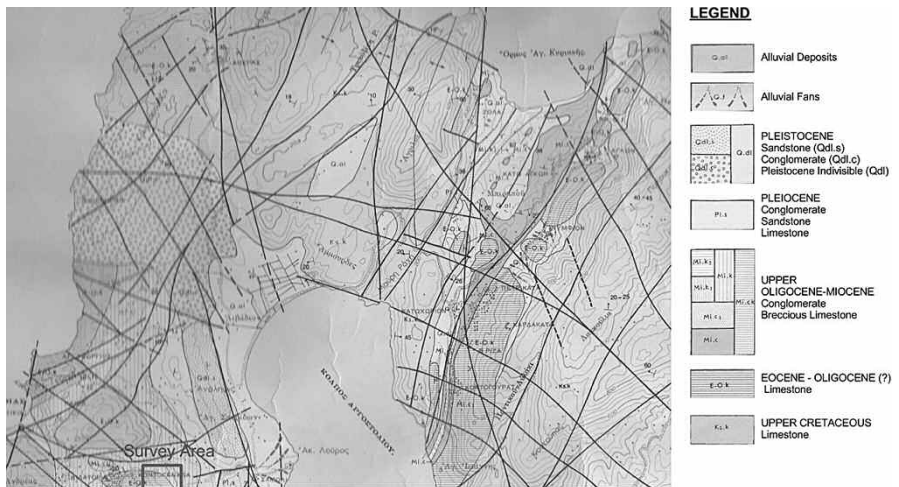


Fig. 4. Geological map with the survey area outlined with a red line.



Fig. 5. Electromagnetic measurements being recorded with GF Instruments' CMD-2 conductivity meter.

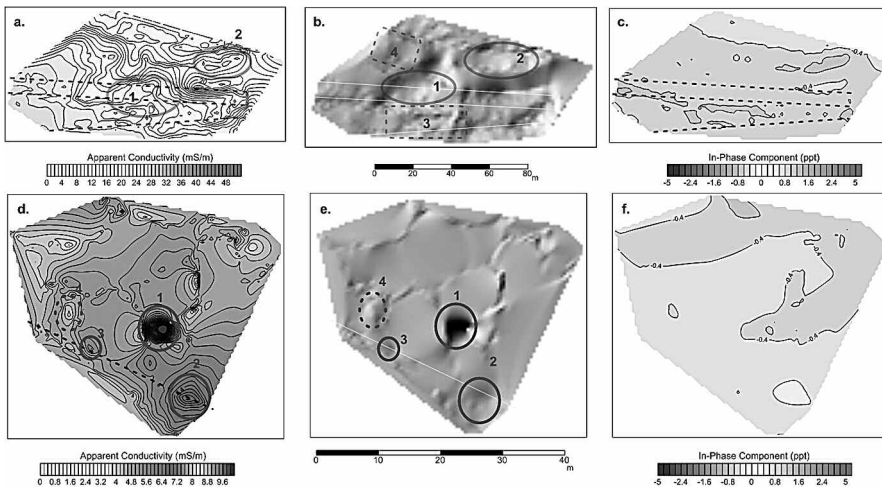


Fig. 6. Apparent conductivity map (a), shaded relief map (b) and in-phase component map (c) for area "B" (above), and apparent conductivity map (d), shaded relief map (e) and in-phase component map (f) for area "A" (below). Noteworthy features are outlined with purple lines and numbered.

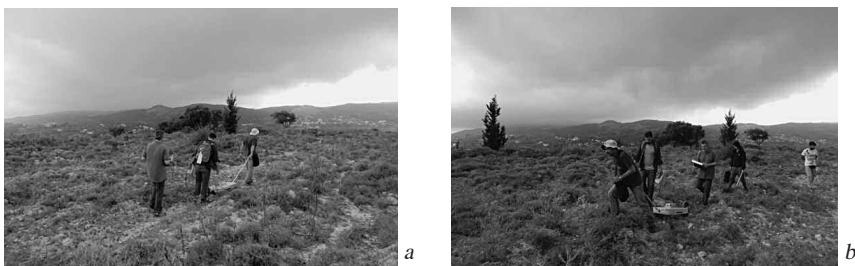


Fig. 7. Photos of the GPR measurement in the survey area.

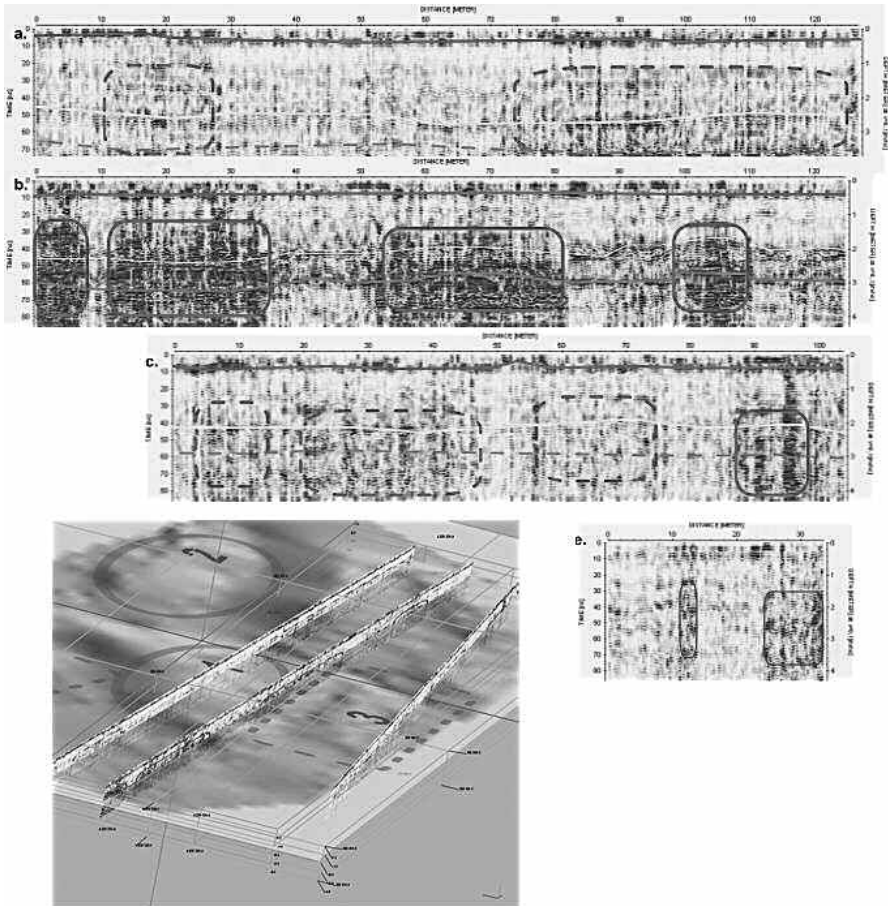


Fig. 8. Area "B" GPR sections post-processing, with layer interfaces (continuous in-line reflections) denoted by lines of different colours (green, yellow and orange lines) and multiple reflections outlined by red lines.