Sci. Annals, School of Geology; Univ. Thessaloniki, 1, 25 (1989)

GEOPHYSICAL INVESTIGATIONS IN THE AREA OF THE TUMULUS OF "ALIKI" NEAR KITROS, ANCIENT PYDNA.

By

TSOKAS,G.N.,[1], ROCCA,A.CH.[1], BESSIOS,M.[2]

(1) Geophysical laboratory, University of Thessaloniki, Greece
(2) 16th ephoria of Prehistoric and Classical Antiquities, Thessaloniki, Greece

Abstract: *The present paper deals with geophysical prospecting methods applied in the area surrounding the tumulus of Aliki, near Kitros, in Pierria. The area belongs to the territory of ancient Pydna.*

Electrical resistivity and magnetic mapping were attempted. The procedures of the data aquisition and processing are described.

The geophysical results leading to archaeological excavational targets of the site are presented and discussed.

1. INTRODUCTION

During the last few years, a part of the activities of the Geophysical Laboratory of the University of Thessaloniki has been directed towards geophysical prospecting of archaeological sites.

Through a historical course of thousands of years, numerous localities in Macedonia have been occupied and disturbed by human activities. It can be found there, the whole evolution of building forms, structural materials e.t.c. The relics of such human made structures are situated in different geolophysical and morphological environments. Consequently, as far as geophysics are concerned a wide variety of problems are offered in the field of detecting buried ruins.

In the present paper, geophysical investigation of the area surrounding the tumulus of Aliki near Kitros in Pierria is performed. The site was suspected to conceal an acient cemetery. Prospecting was carried out employing electrical resistivity method, almost exclusively. Application of the inexpensive magnetic method was attempted as well but it provided noisy and insecure results. The reasons for that are also discussed in this paper.

The course of the archaeological investigations in the site under study can be summarised as follows.

In 1983, after an intensive looting activity in the area, the 16th Ephoria of Prehistoric and Classical Antiquities started an excavating project on a big tumulus at Aliki, near Kitros, in Pierria.

The only part of the tumulus not yet investigated is its northern area, along with its periphery that extends to the nearby fields. The maximum height of the tumulus is 9m and the diameter of its circular base 50m.

Under this huge tumulus two smaller ones were revealed. Each of them had a diameter of 15m and was 1m high.

One of them was covering an intact grave of the Early Iron Age, 10th cent. B.C. A ramp was leading to a subterranean chamber whose entrance was sealed with roughly hewn stones. The chamber contained two burials. The find is very interesting since this type of grave is the first to be found in an Early Iron Age Macedonian cemetery.

The second small tumulus, covered a large pit grave 4.5X3m and 2.80m high, is dated in the late 5th century B.C. The grave was looted by ancient robbers through a rectangular in section 1.60m wide and 1.90m high tunnel, 25m long, starting from the edge of the tumulus.

The process of the excavation will soon clarify whether the huge tumulus, analogous in dimension only to the late 4th and 3rd century B.C. tumuli, is concealing another monumental tomb or if it was erected just to cover the late 5th century pit grave, a case without any parallel, for the time being, in Macedonia.

2. DATA AQUISITION AND PROCESSING

Wenner electrode configuration was employed for the electric mapping, of the site close to the tumulus as shown in figure

The spacing of 1.5m was justified to be a reasonable one, satisfying two criteria. First, graves, expected to be concealed in the region, should exhibit an anomaly of about a few meters wavelenght and second the burial depth, of the above structures, should have an average thickness of 0.5-0.8m.

Wenner array seems to be the more convenient one to carry out surveys of that attitude, excluding "twin probe" array (Aspinall and Lynam 1974). The use of wooden frame (Aitken 1974) is avoided since one current electrode is moved each time a new measurement has to be made. On the other hand, Wenner array has a better response for high resistive targets and provides undisputable distinction of anomalies (Tsokas et al 1986a).

The area under investigation was divided into four sectors, each one forming a grid. After the grids were established, they were mesured at profiles

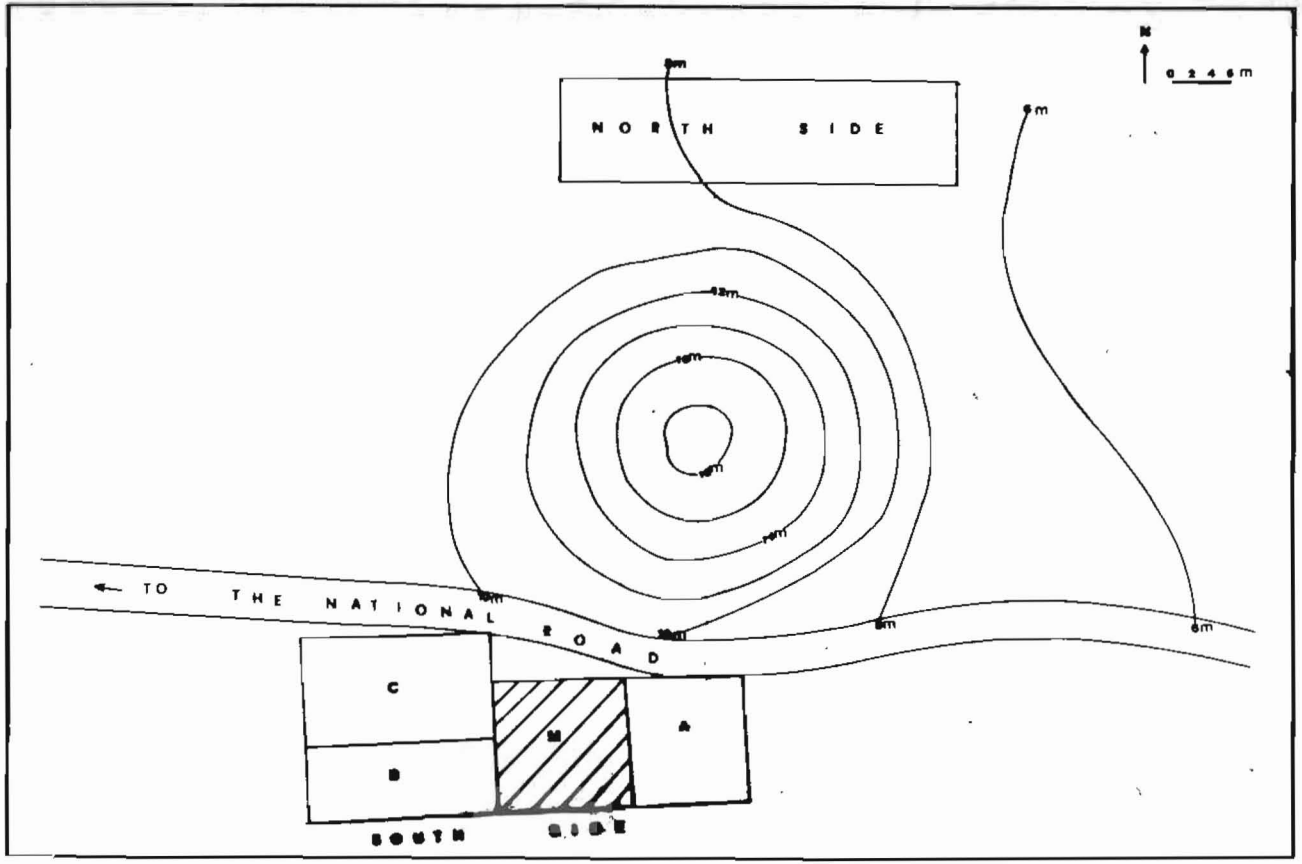


Fig.1.- Scetch map of the area surrounding the tumulus of Aliki Kitros-Pierria. Sectors composing the surveyed area are also illustrated.

spaced 1.5m apart each other, at 1,5m intervals. Measurements were carried out during a four hours time intervals, every working day. The affection due to evaporation of moisture content has been considered negligible during that short time interval. Furthermore, dry summertime days favour the stability of moisture content hypothesis to be approached satisfactorily.

The field crew was equiped with a resistivity meter Bison, model-2390, which belongs to the Geophysical Laboratory. The frequency of the square waveform introduced into the ground was selected to be 5Hz. Since the instrument averages out 10 full circles and it displays the mean value, the former specific value enables achievement of non time-consuming rate of measurements. On the other hand, 5Hz is not a high enough frequency to count the involvement of "skin effect" (Keller and Frischknecht 1979).

It becomes obvious that rapidness of execution of measurements is not only of financial significance. The elapsed time, for a sector to be measured is a parameter of consistency for the aquired data set. Otherwise, a reduction factor should be entered, by remeasuring at the base station in small time intervals (Tsokas et al 1986a). The procedure of relocating the electrodes at the base point is usually avoided, considering the drift potentials and placement errors (Habberjam 1979).

Magnetic prospecting was carried out in a part of the area covered by sector A.A. new grid, which had 1m grid unit, was established.

Measurements were taken at two different height levels, one at height 1.5m and the other one at 2.5m. In such a way, a differential of the field intensity was approached (Aitken 1974), and at the same time the total field intensity was measured. It has been proved (Evjen 1936, Peters 1949) that first derivative of potential fields accentuates near surface anomalies, delineates them and removes regional trends. The differential, which was measured, may be reasonably considered as an approach to the first vertical derivative. In practice, such a way of surveying archaeological sites proved to be a rapid reconnaissance tool (Tsokas et al 1986b).

Two proton-precession magnetometers were employed for the magnetic prospecting (Scintrex-MP2), belonging to the Geophysical Laboratory. One of them served as base station in order to record the diurnal variations of the earth's magnetic field during the course of the field work. Neither magnetic storms nor micropulsations were observed during the survey.

The produced data set of electrical mapping, consisting of the values of apparent resistivities, was statistically treated. The purpose of this procedure was to remove the positive anomalies, which exceed normal background values. North and south parts, with respect to the tumulus, formed different data sets. Frequency histograms were constructed for each data set. Then, the values which belong to the positive extreme of the distribution were plotted in the field place where they were observed.

Magnetic measurements were reduced to a standard level after the introduction of the appropriate numerical time dependent factor. Then, a simple 3-point running average (1:2:1 weigheted) smoothing operator was applied along each profile of measurements.

3. RESULTS

The contour isoresistivity maps of the southern and northern parts of the site, surrounding the tumulus are shown in figures (2) and (3), respectively. As it can be observed, regional trends predominate the maps and distort the pattern of anomalies. Resistivities, in general, show rather small values, fact which was expected for clay soils (Keller and Frischknecht 1979).

Prospecting targets should expose themselves as positive anomalies on the resistivity maps. Although the wavelenght is more or less predictable, their magnitude is controlled by several factors and it is the matter of actual field conditions.

Positive anomalies observed in figure (2) appear with small magnitude over normal background values and they are about 17-19 Ohmm. Although they can hardly be observed, they have an acceptable wavelenght. On the other hand, several of them, are clustered in the east side. In other words, they confront the hypothesis of an ancient cemetery. Different anomaly patterns can be attributed to different structural forms, burial depths and destruction of the structures e.t.c.

Our experience has tought us to rool out negative anomalies, which usually exist due to local water pockets and ashes lenses.

The isoresistivity map of the northern site of the tumulus, shown in figure (3) has a simplified appearance. Regional trends range in the E-W direction, condensed in the southern part of the map. They are caused by the soils, dug out and stacked there during recent excavations. Only five positive anomalies appear. The more interesting one is that formed by distortion of regional trends near the middle of the map. It is located to the perimetry of the tomb, fact which supports the idea for a possible existance of a feature with archaeological interest. It must be noticed that about 100m north of the surveyed area, an unlooted Macedonian monumental tomb was discovered.

Clay soils exhibit a rather large magnetic effect due to their susceptibility (Tite 1972). Furthermore, the area under study consists of cultivated land. Consequently, those fields have been certainly exposed to fire, in order to be cleared up. It has been proved that burning soils, the antiferromagnetic forms of the iron oxides haematite and goethite, are converted into the strongly ferrimagnetic form of maghaemite (Le Borgne 1960, Tite and Mullins 1971). Thus, cultivated land aquires a top soil cover with enhanced magnetic susceptibility. As a result, a ditch, for exapple, would cause positive magnetic

anomaly. However, taking into account possible existence of subsurface hollow spaces and the ancient burial customs to put several articrafts with the dead body, the magnetic response is expected to be complicated.

Figures (4) and (5) illustrate the total magnetic field intensity and the refered magnetic differential, respectively. It can be easily observed that both

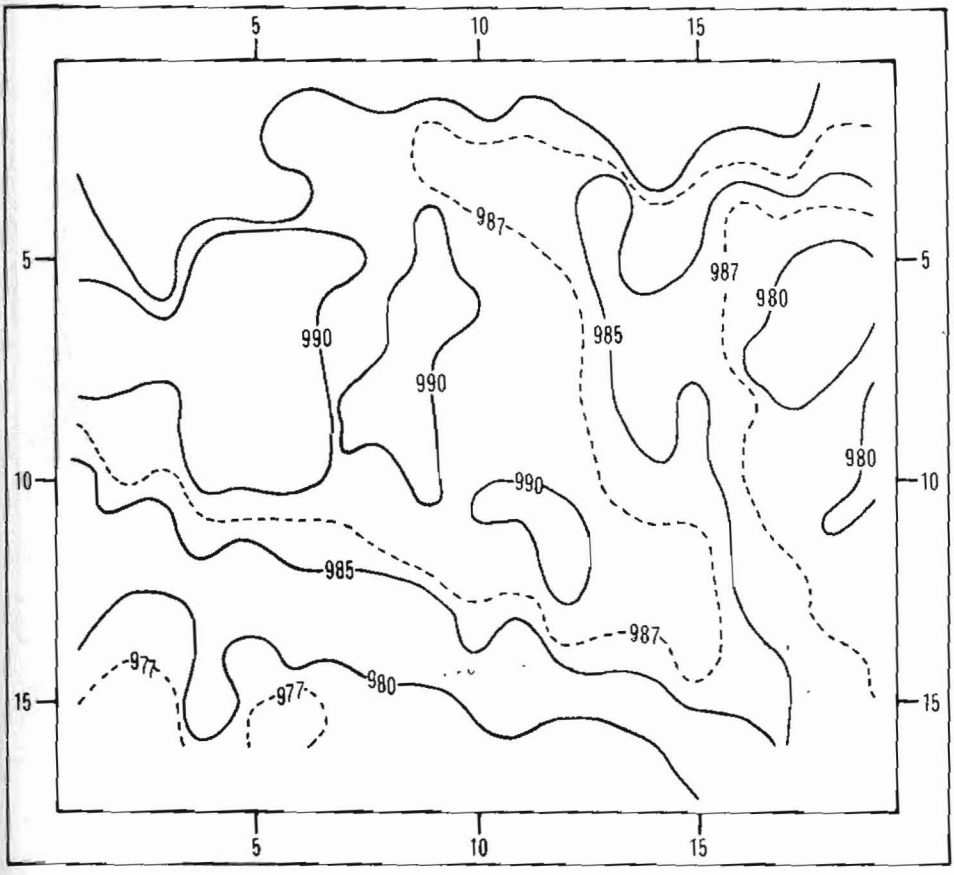


Fig.4.- Total magnetic field intensity contour map

maps are predominated by confusing regional features. The total magnetic field figure seems to have no practical use.

The resolution of the magnetic field by the differential did not provide clear appearace of anomalies. However, it is of interest to observe that the anomalies in the north-east part of the map coincide with the electrical anomalies in this region.

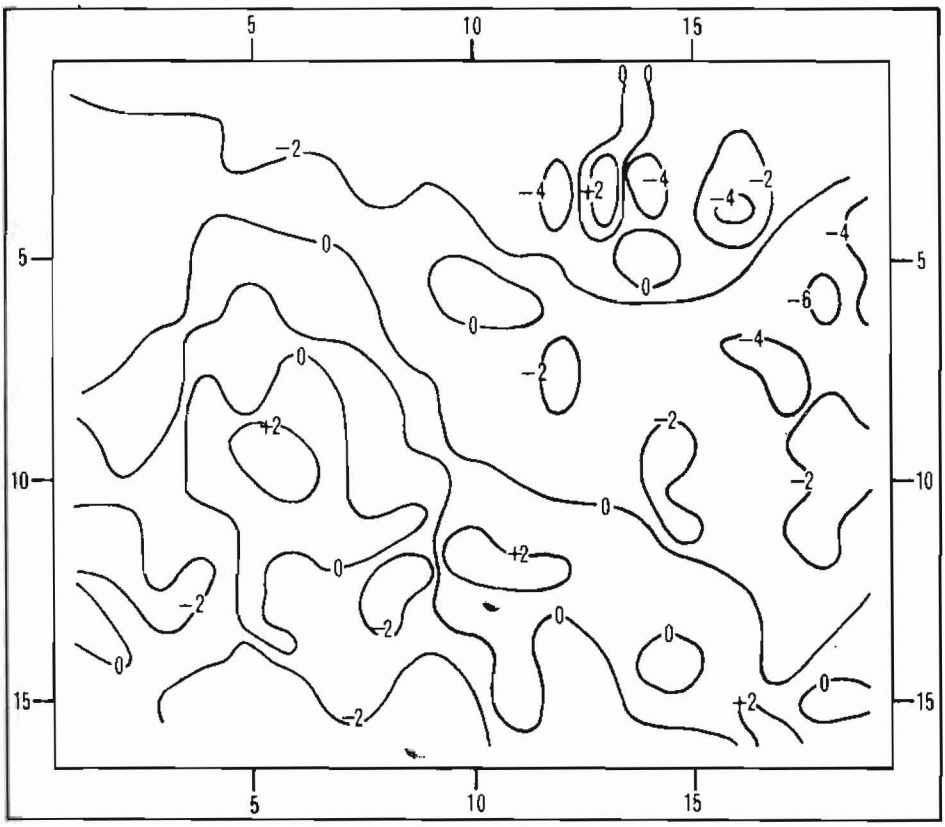


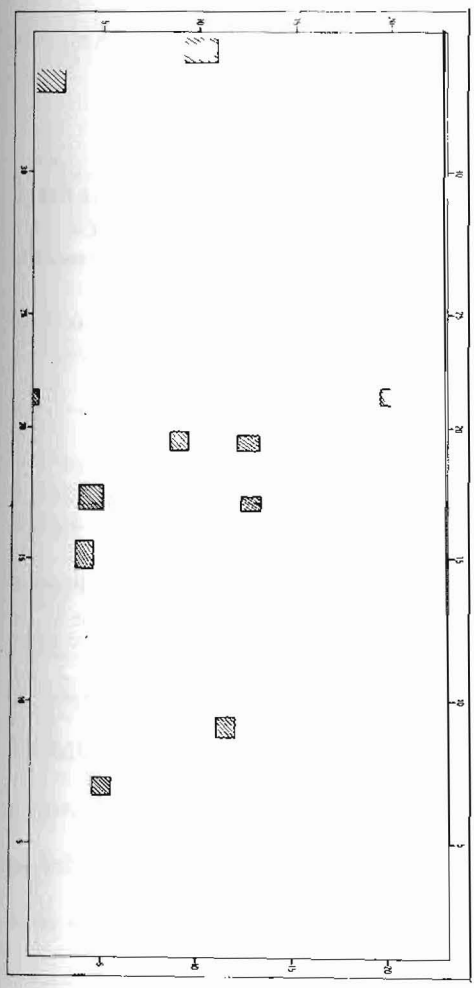
Fig.5.- Contour map of the differential magnetic intensity.

The magnetic responce is due to the enhanced magnetic effect of the topsoil which covers the site. We have undisputably a "masking effect" that obscures all the anomalies in the area with some exceptions. This fact led us to avoid the extensive use of the inexpensive and rapid magnetic prospecting.

As refered, resistivity values were treated statistically. Figures (6) and (7) show the spatial distribution of the values composing the positive extreme of frequency histograms. Localization of anomalies can be readily, visually obtained.

4. CONCLUSIONS

Several anomalies, in the isoresistivity maps, were justified to be caused by



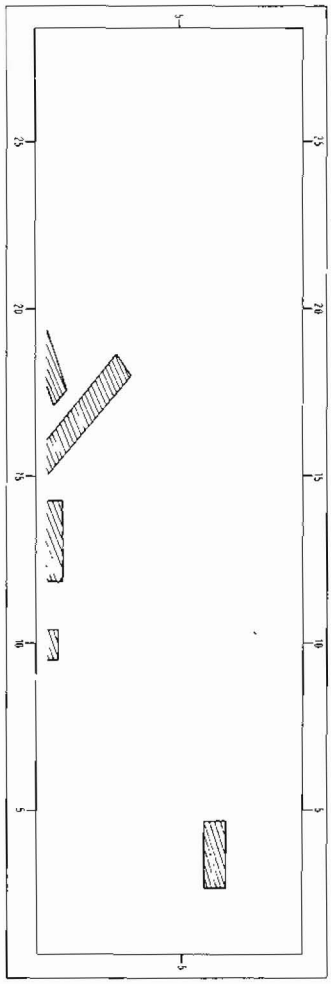


Fig.6.- Localization of electric anomalies composing the positive extreme of the frequency histogram of the southern part of the surveyed area.

Fig.7.- Localization of electric anomalies composing the positive extreme of the frequency histogram of the northern part of the surveyed area.

subsurface features with approximate dimensions of the expected graves. An excavational priority has been given to the above localities.

Statistics, certainly help the spatial resolution of observed anomalies and provide more confident suggestions.

Magnetic prospecting in clay soils requires a lot of attention and must be avoided.

ACKNOWLEDGEMENTS

The authors are greatly indebted to Professor B.C. Papazachos for the instrumentation supplied to the field crew and the careful and critical comments, suggested by him during the data processing and for the final presentation of this paper.

The project has been carried out on behalf of the 16th Ephoria of Prehistoric and Classical Antiquities.

REFERENCES

AITKEN,M.J., Physics and Archaeology, second edition, Clarendon press Oxford, pp. 291, 1974.

ASPINALL, A. and LYNAM, J.T., An induced polarization instrument for the detection of near surface features. *"Prospezioni Archaeologishe"*, 5, 67-75, 1970.

EVJEN, H.M., The place of the vertical gradient in gravitational interpretations. *"Geophysics"*, 1, 127-136, 1936.

HABBERJAM, G.M., Apparent resistivity observations and the use of the square array techniques. Gerbruder Borntraeger, Berlin, pp. 1-152, 1979.

KELLER, G.V. and FRISCHKNECHT, F.C., Electrical Methods in Geophysical Prospecting. Pergamon press, Oxford, pp. 1-523,1979.

LE BORGNE, E., Influence du feu sur les proprietes magnetique du sol. *"Annales Geophysicae"*, 16, 159-195, 1960.

PETERS, L.J., The direct approach to magnetic interpretation and its practical application. *"Geophysics"*, 14, 290-320, 1949.

TITE, M.S., The influence of geology on the magnetic susceptibility of soils on archaeological sites. *"Archaeometry"*, 13, 209-220, 1971.

TSOKAS, G.N., ROCCA, A.CH. and PAPAZACHOS,B.C., Some aspects concerning with the application of geophysical prospecting methods at "Dion" archaeological site. *"P.A.C.T."*, 15, 153-162, 1986a.

TSOKAS, G.N., ROCCA, A.CH. and PAPAZACHOS,B.C., Geomagnetic prospecting at the prehistoric site of village Mandalo in northern Greece. *"P.A.C.T."*, 15, 143-152, 1986b.

ΠΕΡΙΛΗΨΗ

ΓΕΩΦΥΣΙΚΗ ΔΙΑΣΚΟΠΗΣΗ ΣΤΗΝ ΤΟΥΜΠΑ ΤΗΣ «ΑΛΙΚΗΣ», ΠΕΡΙΟΧΗΣ ΚΙΤΡΟΥΣ, ΣΤΗΝ ΠΕΡΙΟΧΗ ΑΡΧΑΙΑ ΠΥΔΝΑ

Γ.Ν. ΤΣΟΚΑΣ[1], Α.Χ. ΡΟΚΚΑ[1], Μ. ΜΠΕΣΣΙΟΣ[2]

(1) Εργαστήριο Γεωφυσικής, Πανεπιστήμιο Θεσσαλονίκης
(2) 16η Εφορία Αρχαιοτήτων Προϊστορικής και Κλασικής Εποχής, Θεσσαλονίκης

Η παρούσα εργασία ασχολείται με την εφαρμογή μεθόδων γεωφυσικής διασκόπησης για τη μελέτη της περιοχής που περιβάλλει την τούμπα της «Αλικής», στην περιοχή Κίτρος της Πιερρίας, η οποία ανήκει στην Αρχαία Πύδνα.

Περιγράφεται η διαδικασία συλλογής των γεωφυσικών δεδομένων καθώς επίσης και η επεξεργασία τους. Επί πλέον, γίνεται προσπάθεια αποτύπωσης της ηλεκτρικής αντίστασης και της έντασης του μαγνητικού πεδίου της περιοχής.

Τέλος, παρουσιάζονται τα αποτελέσματα αυτής της γεωφυσικής διασκόπησης, τα οποία δείχνουν πιθανές περιοχές αρχαιολογικού ενδιαφέροντος.

Τα χειρόγραφα κατατέθηκαν στις 4.2.86