

# RESISTIVITY RESEARCHES ON THE IONIAN METROPOLIS THEATRE IN 1991

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## A B S T R A C T

The determination of the parameters of the archaeological objects by using geophysical methods is one of the most important developments to direct the excavations. This new discipline referred to as archaeogeophysics is very active in exploring areas such as prehistoric areas, antique cities, tumuli and the other archaeological objects. The specific archaeological characteristics of the structure and also the geological and geomorphological characteristics should be taken into consideration. Due to the high noise level of the archaeological areas, it is obvious that the choice of the methods and process are very important.

In this paper, the resistivity search conducted on a fully covered Ionian theatre and the results of the study will be presented.

ΕΡΕΥΝΕΣ ΗΛΕΚΤΡΙΚΗΣ ΑΝΤΙΣΤΑΣΗΣ ΣΕ ΘΕΑΤΡΟ ΤΗΣ ΙΟΝΙΚΗΣ ΜΗΤΡΟΠΟΛΗΣ

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## Π Ε Ρ Ι Λ Η Ψ Η

Ο καθορισμός των παραμέτρων των αρχαιοτήτων με την χρησιμοποίηση γεωφυσικών μεθόδων είναι μία από τις πιο σημαντικές εξελίξεις στην καθοδήγηση των ανασκαφών. Αυτός ο νέος επιστημονικός κλάδος που αναφέρεται σαν αρχαιογεωφυσική είναι πολύ αποτελεσματικός στην εξερεύνηση περιοχών όπως περιοχές προϊστορικών αρχαιοτήτων, αρχαίες πόλεις, τύμβοι και άλλες αρχαιότητες. Τα ειδικά αρχαιολογικά χαρακτηριστικά της δομής καθώς και τα γεωλογικά και γεωμορφολογικά χαρακτηριστικά θα πρέπει να λαμβάνονται υπόψη. Λόγω του υψηλού θορύβου στις αρχαιολογικές περιοχές, είναι φανερό ότι η επιλογή των μεθόδων και της επεξεργασίας είναι πολύ σημαντική. Στην εργασία αυτή, η έρευνα με την μέθοδο της ηλεκτρικής αντίστασης έγινε σε ένα Ιωνικό θέατρο, εξ' ολοκλήρου καλυμμένο, και τα αποτελέσματα της μελέτης παρουσιάζονται.

## INTRODUCTION

The Ionian Metropolis, which was first built in the 3rd century B.C., is a very important archaeological site situated 12km away from Torbali (Izmir) between the villages so called

Yenikoy and Ozbey. According to the sources, the city developed rapidly around the 150 years BC. The archaeological researches and excavations prove that the city people subsisted on agriculture and trade. Though the city maintained its importance during the Byzantine period, it was fully deserted after this period. The systematic excavations started by Prof. Dr. Recep Meric in 1989 (Fig.1).

The Metropolis covers a very wide area. In addition, the city is covered with a thick layer of soil and is built on a schist bedrock. The city has not been widely excavated before, therefore this creates a further problem to direct the excavation.

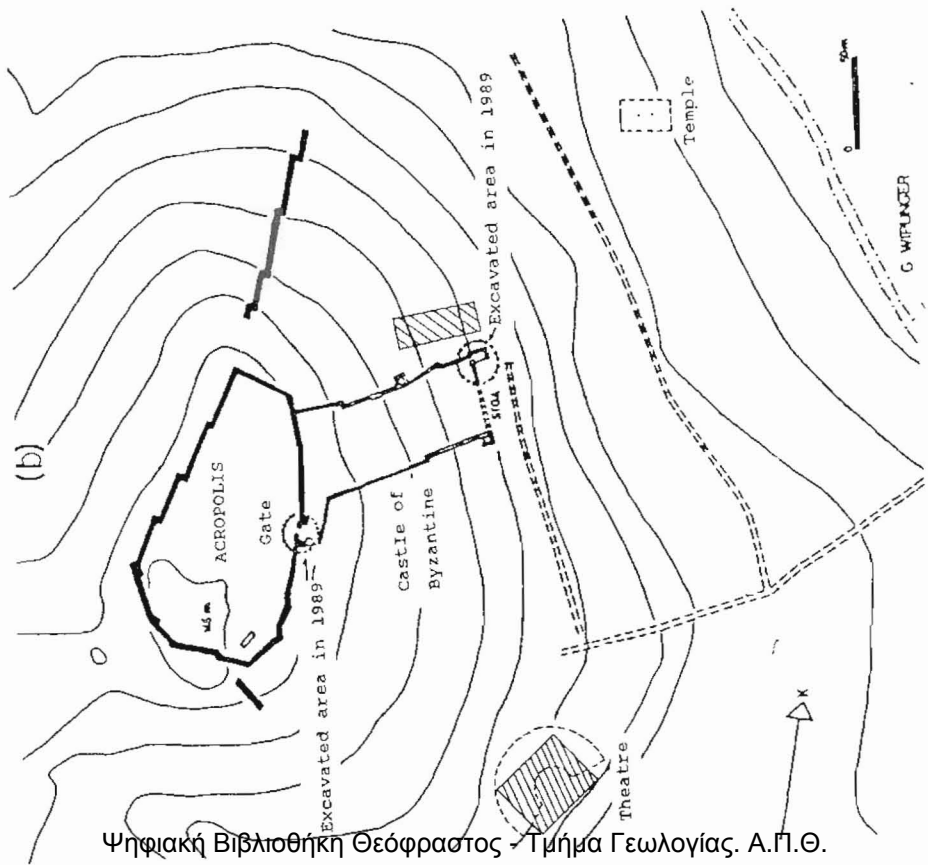
Consequently, a geophysical research plan was constructed which aimed to search the whole Metropolis, and direct the excavations by determining the urban planning of the city (Drahor, 1991).

Therefore, some resistivity researches were made on the theatre and North Stoa between December 1990 and May 1991. The research was based on resistivity profiling and vertical electrical sounding (VES) (Fig.2). The data obtained were then subjected to signal processing methods in order to increase the signal/noise ratio.

#### DATA ACQUISITION AND PROCESSING

In order to determine the relationship between the extensions of the theatre and the bedrock, the first survey on the theatre was realised with profiling measurements in accordance with Wenner array on the northwest direction with a 5m spacing. The data were obtained by measuring 18 profiles being 2.5m apart each from the other. After mapping, it has been observed that there were high resistivity contours on the northern and southern part of the area while the resistivity decreases rapidly in the western part. The data obtained were then applied on 1 and 2 dimensional filtering (low, high and band-pass), cross-correlation and signal detection filtering. The basis and the results of the signal detection filtering used in archaeological areas were introduced by Sores (1986) and Pattantys (1986).

The data were firstly subjected to spatial low-pass (smoothing) filters to eliminate the noises originated from measurement mistakes and surface inhomogeneity near the electrodes. Fullers method (1967) and filter coefficients of Pattantys (1986) were used in two dimensional convolution filtering. Low-pass Fuller filtering were applied with 0.025, 0.05, 0.1 and 0.15 cycles/data intervals. It was observed that 0.1 cycles/data interval was the best to define the main structure (Fig.3). One of the main specific characteristics of the Metropolis is the existence of Byzantine buildings near the surface. The depths of these buildings varies between 0.5 and 1m. The Hellenistic structures are in a depth of 2 and/or 3m. The data were applied on high and band pass filters in order to detect the effects of structures near to the surface. In addition, signal detection filters were used to detect the wall characterized structures. The signal detection filters were obtained



Ψηφιακή Βιβλιοθήκη Θεόφραστος - Τμήμα Γεωλογίας, Α.Π.Θ.

(a)



Fig.1. (a) Western Anatolia cities in the antique era. (b) City plan of the Ionian Metropolis.

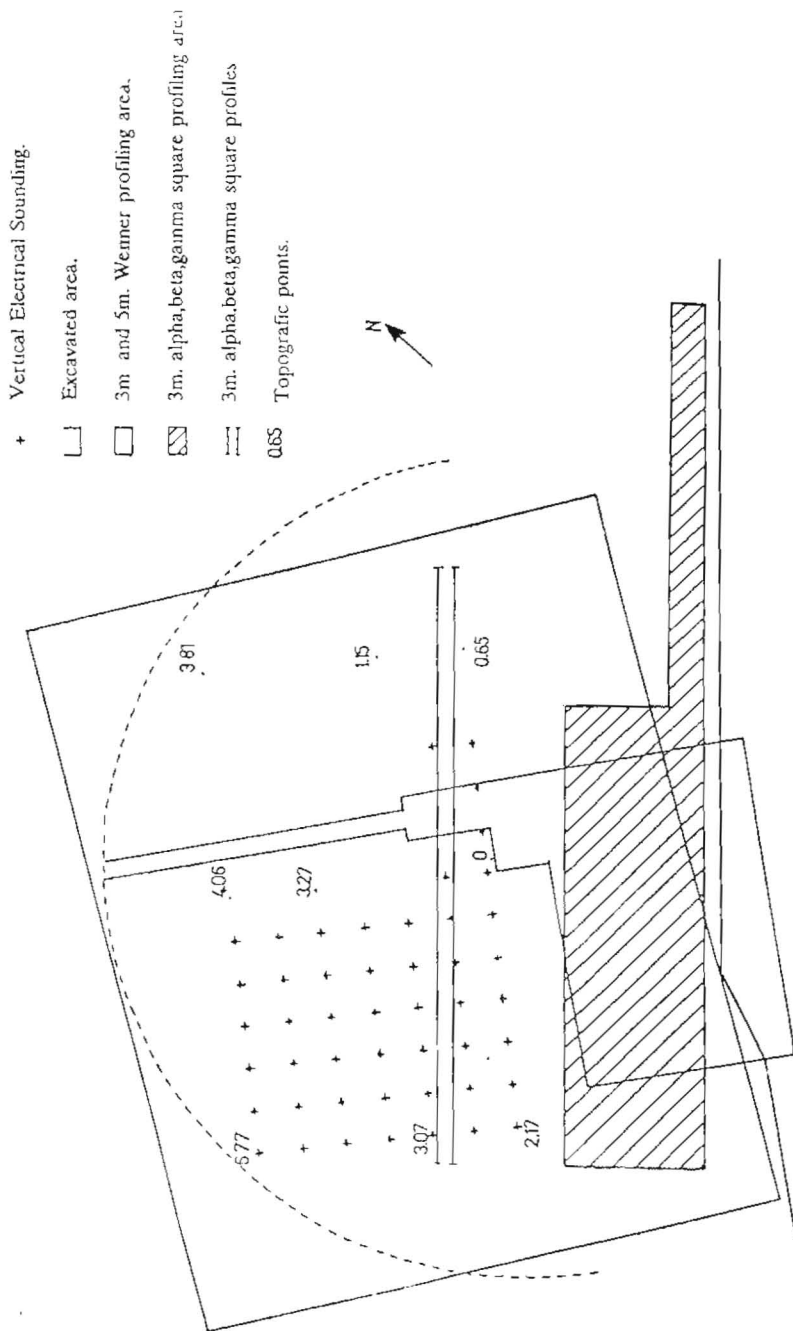


Fig.2. Resistivity research plan of the Metropolis theatre.

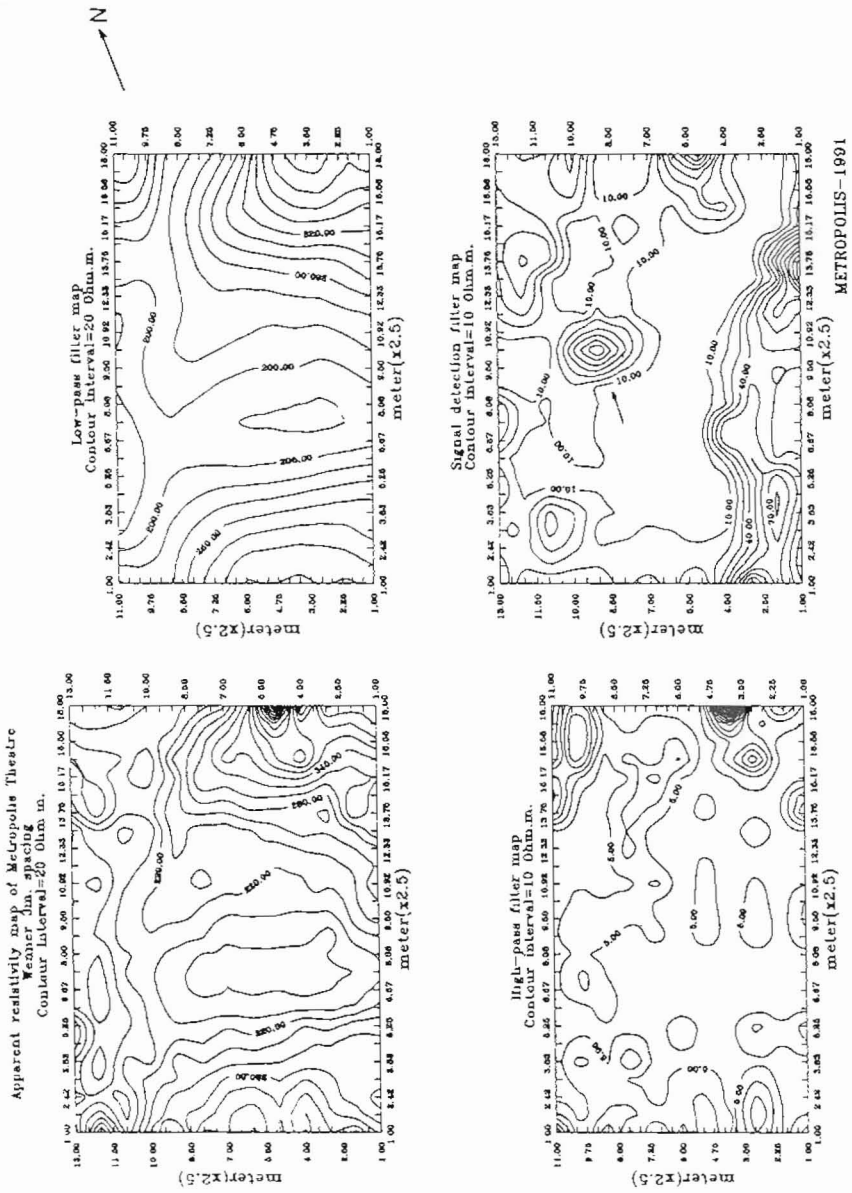


Fig. 3. (a)

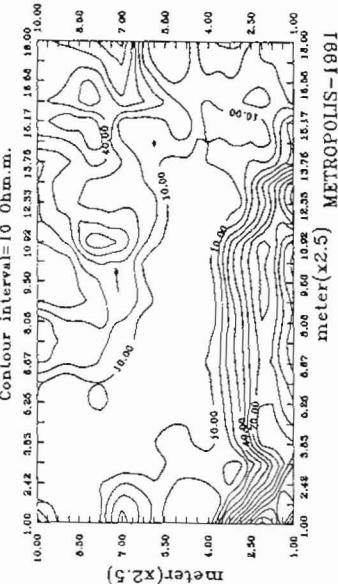
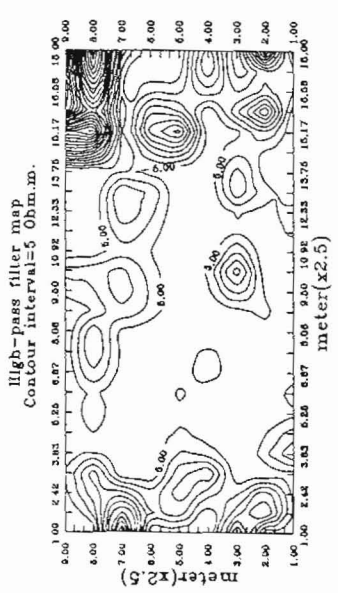
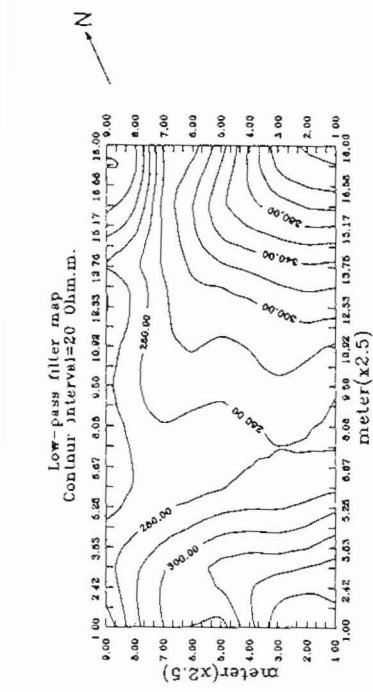
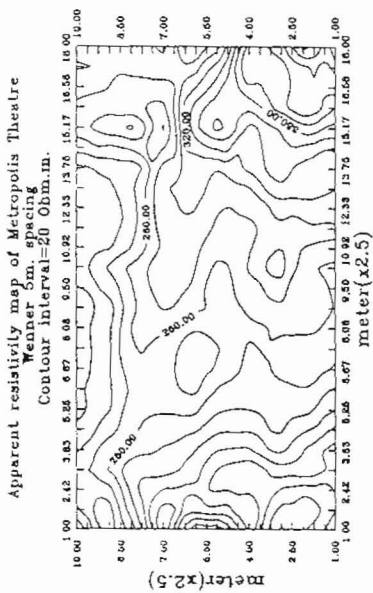


Fig.3.(b) The maps of the Metropolis theatre which are applied various filter process. (Wenner 3 and 5m spacing in a and b respectively).

by equalizing the summation of coefficients to zero after normalizing the sampled theoretical anomaly.

The filtering process was achieved by convolution between these coefficients and the measured profile. The negative peaks of filtered profiles are the result of swinging which corresponds to the edges of buried walls. It was observed that the effects near to the surface were more intensive especially in the N-NW and S-SE parts of the map.

In order to observe the effects of the structures of the seats, scene and orchestra, some new measurements were taken on the points of the same profiles employing the Wenner spacings of 3m. The same processes as for the 5m measurements were then applied to the data obtained (Fig.3). It is assumed that the high resistive symmetrical anomalies are originated from the seats of theatre as can be seen from the map. The anomaly which is marked by an arrow on the map which is supposed to be generated by structures near to the surface. Also some anomalies on the southern parts of the map are more apparent than they are observed in the maps of 5m Wenner spacing.

In order to better determine the structures concealed on the southern and southeastern parts of measurement area and also to reduce the effects caused by the configuration anisotropy, a new survey carried out on the southern part of the theatre. The area, was then searched again on 8 profiles with 3m of spacing and 1m of gridding intervals with square alpha, beta and gamma arrays. The theoretical approaches of these methods were first introduced by Habberjam and Watkins (1967) and they are not so much effected due to the configuration anisotropy. The data obtained were processed as the previous measurements. The existence of a structure with high resistivity on the southwestern part of the map was observed on all the arrays (i.e. alpha, beta, gamma). After filtering, it has been observed that the effects of the structures begin from the surface and continue in different depths. In addition, the high resistivity anomalies on the southern and southeastern part of the map are observed especially on beta array. However, this anomaly can not be observed in gamma array, but it can be observed slightly on alpha array (Fig.4,5). The low resistivity values observed on the northwestern part of the map are supposed to be generated from the orchestra part of the theatre.

To investigate the northwestern quarter of the theatre, and to determine the resistivity parameters and depths of the layers, 42 Schlumberger VES were made with being 2.5m apart each from the other. The interpretation of the data with inversion and other techniques, proved that the low resistivity values shown on the northern part of the map continue up to 3.5 meter. The results, show that the depths of the upper seats of the theatre are 1.5 and 2m while the depth of the part supposed to be the theatre is between 3 and 3.5m. Furthermore, some structures with high resistivity values had been observed. These are supposed to be the base of the Byzantine buildings.

At the last stage of the study, some additional investigation was carried out on some anomalies interpreted as due to the scene. Therefore, a few profiles were measured using the dipole-dipole array with 2 and 4m spacing. Two anomalies were

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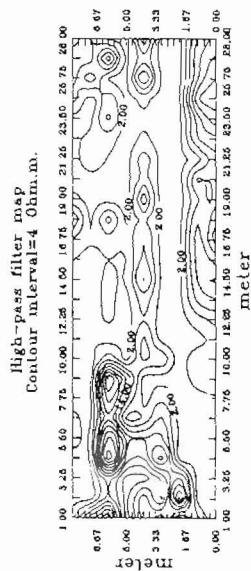
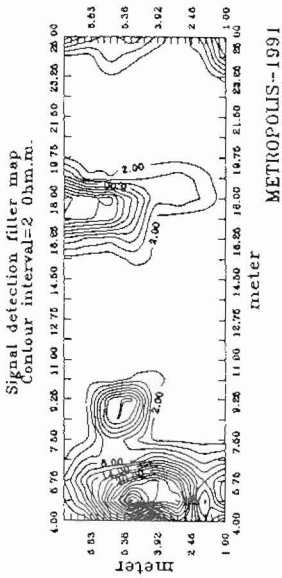
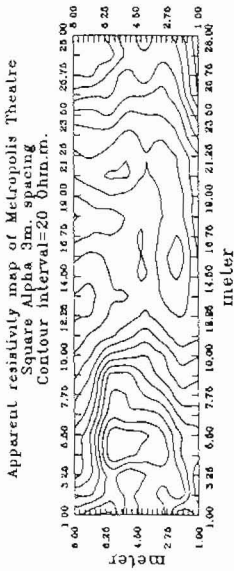
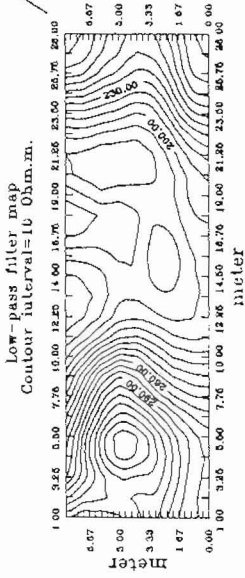


Fig. 4. (a)

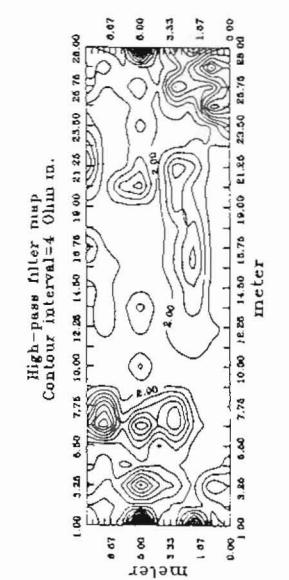
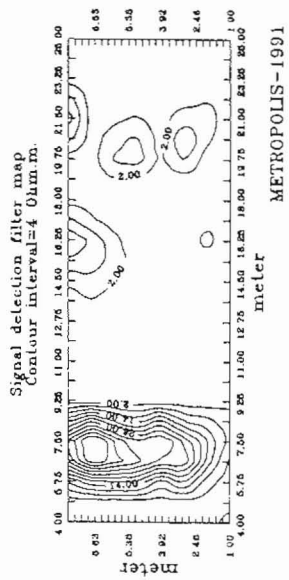
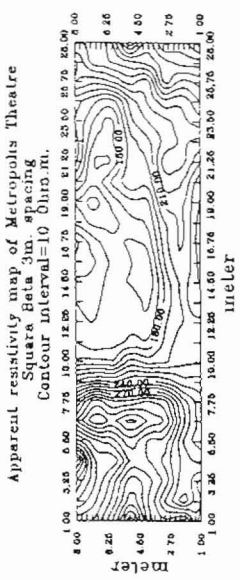
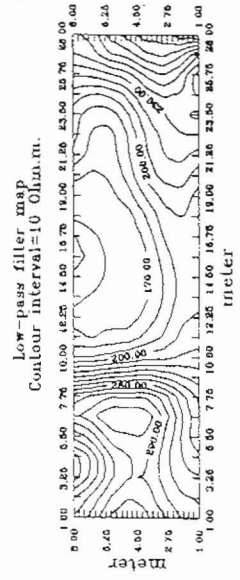


Fig.4.(b) The maps of the Metropolis theatre which are applied various filter process. (Square alpha and beta 3m spacing in (a) and (b) respectively).

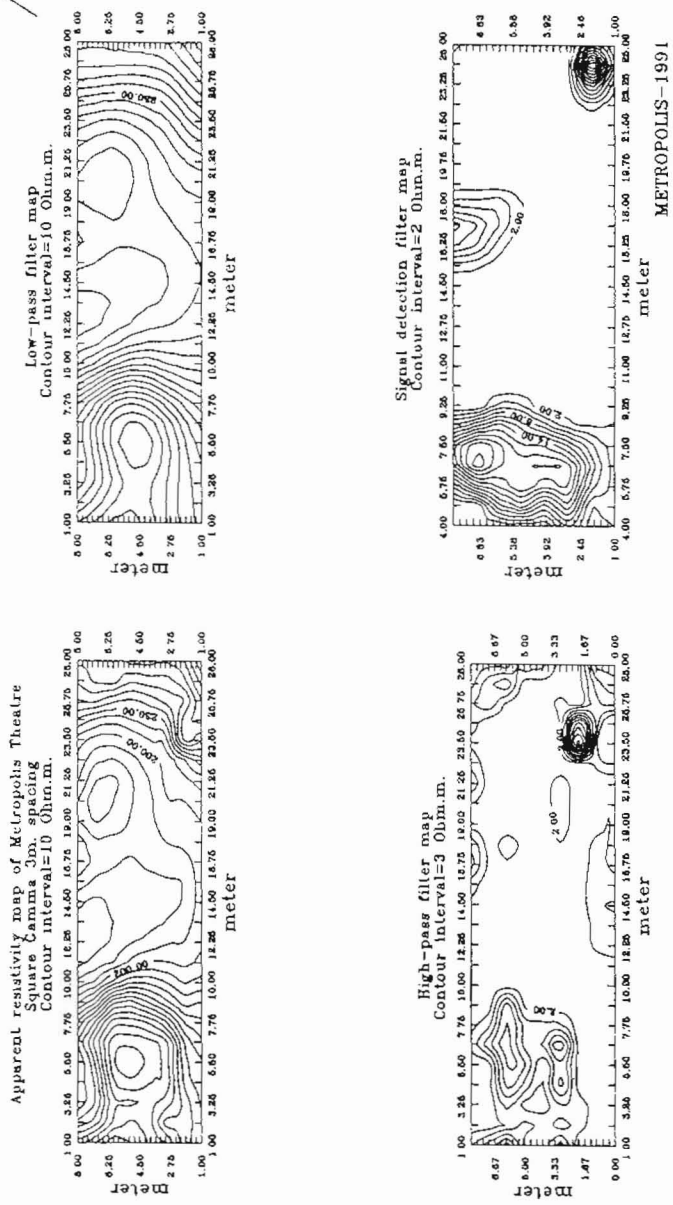


Fig.5. The maps of the Metropolis theatre which are applied various filter process. (Square gamma 3m spacing).



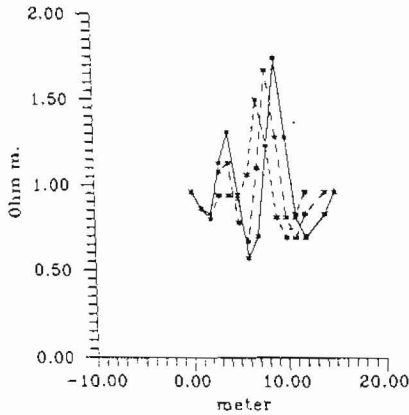
**Photo: A.** The scene of the Metropolis was found with resistivity survey.



**Photo: B.** The bases of the Byzantine building that shown on Fig.3 and 4 with arrow.

Theoretical models produced for scene of Metropolis Theatre

— 4m. distance between model walls  
 - - - 3m. distance between model walls  
 ····· 2m. distance between model walls



Dipole-dipole resistivity profile on East-West direction  
 — Observed anomaly      - - - - - Smoothed anomaly  
 — Signal detection anomaly  
 Walls and Columns explored after excavation

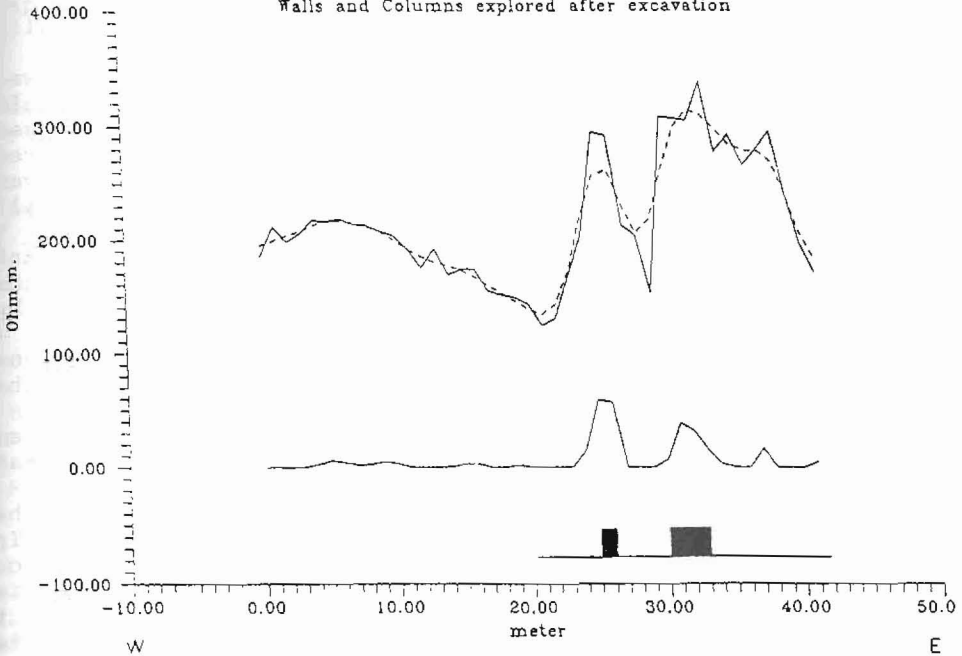


Fig.6. (a) Theoretical models produced from the scene of the Metropolis theatre. (b) Resistivity profile on east-west direction.

spotted in both profiling spacings. Furthermore, modelling was attempted in order to study the structures which cause these anomalies.

In the former investigation the studies of Bernabini et al. (1987, 1988), Sores (1986) and Hesse et al., (1986) were taken into account. The tank analogue models of Apparao et al. (1968), Apparao and Roy (1971) and Apparao (1979) were also used. The wall models of neighboring structures were obtained by superposing the anomalies of the models computed for different depths and parameters. During the studies, the anomalies of two and three walls (2,3 and 4m away from each other) were calculated and cross-correlated with the data obtained from the area. Following these model studies, it has been found out that two wall models with 4m of intervals is the best anomaly to point out the scene (Fig.6). After the data were processed with these models, it has been interpreted that the anomaly on the front has been generated from a small a narrow wall, while the anomaly with wide wavelenght on the back could be generated either from a wide wall or from two adjacent walls (Fig.6).

Afterwards, it has been decided to propose a test excavation on the eastern part of the theatre. Consequently, the scene was explored in harmony with the geophysical data.

## RESULTS AND CONCLUSIONS

As a result of the resistivity research in the Metropolis between 1990-1991;

a) Following the modelling and signal analysis, it was clarified that there existed a scene in the theatre which could be formed by two or three walls. A test excavation was proposed according to the geophysical studies and the scene was explored during the excavations. After the excavation, it has been proved that the scene was constituted from the columns with a big wall behind these columns (Photo 1,2).

b) As a result of resistivity exploration, important conclusions were obtained about the location of seats and the orchestra. The depths of seats and orchestra were determined by VES and these are proved after excavations.

c) After resistivity soundings it was clarified that the low resistivity values on the western and northwestern part of the theatre are due to destructions.

d) During the excavations on the anomalies were revealed wall structures near to the surface: It was also concluded that these were the bases of Byzantine buildings.

The resistivity search confirmed the role of the archaeogeophysical methods in directing the excavations. In addition, it should be mentioned that the signal detection filtering applied in this research is also very informative to determine the archaeological structures. On the other hand, it was also concluded that the choice of the arrays according to the location of the area is very important in resistivity studies for archaeological sites (Tsokas and Rocca, 1986 and Hesse et al., 1986). It is very necessary to use some arrays which are effected very slightly from anisotropy. Furthermore, taking into consideration the archaeological areas have high noise levels, it can be emphasized that the choice of the method and processes is very important.

## ACKNOWLEDGEMENT

I am particularly grateful to Prof. Dr. Recep Meric for supporting me during the research in the Metropolis, Mr. Ertan Unver, the Mayor of Torbali for supporting the geophysical research in the Metropolis, to Prof. Dr. A. Gungor Taktak, for his interest in this study; Mr. Akin Ersoy, Archaeologist for guiding me about the archaeology of the area and for valuable discussions, to my students geophysicist A. Levent Akyol, Engin Deniz, geophysicist Ozkan Bayri and Levent Temizer, for their self sacrifice and persevering efforts in every step of the research; and my brother A. Cemal Drahor, electronics engineer, for his companionship and for his contributive efforts for all my projects in every stage.

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