| O13-9 | TWO AND THREE DIMENSIONAL ELECTRICAL TOMOGRAPHY INVESTIGATIONS IN THE ARCHAEOLOGICAL SITE OF ITANOS, CRETE, GREECE |
|---|---|

**A. VAFIDIS**[1], A. SARRIS[2], G. SOURLAS and Y. GANIATSOS
[1]Applied Geophysics Lab. Dep. of Mineral Resource Eng. Technical Univ. of Crete ,Chania, Greece 73100
E-mail: vafidis @ mred.tur.gr.
[2]Laboratory of Geophysical-Satellite Remote-Sensing, and Archeoenvironment Institute of Mediterranean Studies, F.O.R.T.H., Rethymnon, 74100, Greece

In archaeology, geophysical methods such as resistivity and magnetic mapping are useful in the investigation of specific areas of archaeological interest because they complement the data obtained by excavation procedures. During the last decade conventional geophysical methods are integrated with high-resolution techniques like ground penetrating radar, electrical tomography and seismic refraction (Tsokas et al., 1995, Vafidis et al., 1995, Pipan et al., 1996, Tsokas et al., 1997). Also, aerial photography and satellite imaging are integrated with ground based geophysical data for archaeological prospecting using Geographic Information Systems (Linford 1994).

In September 1998, a geophysical survey was conducted in the archaeological site of Itanos located in Northeastern Crete, Greece. Itanos, is an ancient port close to the unique in Europe Vai Palm Forest. The area of the archaeological site does not exceed 16000 square meters. Archaeological excavations cover only 1% of the archaeological site. Most of the relics of the buildings are seen in the region between the two acropolis of the city. Itanos is marked mainly from three periods: geometric, roman and late christian, while the periods of original occupation and abandonment are not known.

Electrical tomography surveys map areas with complex subsurface geology where conventional resistivity sounding or profiling surveys are inadequate (Loke and Barker, 1996). Such surveys employ a number of electrodes laid out with consecutive address numbering. A computer-controlled system selects automatically the active electrodes used for each measurement. Two different pairs of electrodes are selected for the next measurement and so on until the survey is completed.

In Itanos, the Sting / Swift, a memory earth resistivity instrument, was used to collect field data for resistivity imaging. Electrical tomography in two dimensions was performed with the dipole-dipole and Wenner configurations. Although all geological structures are 3D in nature, 3D resistivity surveys are carried out rarely at the present time compared to conventional 1D resistivity sounding or even 2D resistivity tomography surveys. A 2D model for the subsurface gives reasonably accurate results in areas with elongated geological structures. However a 3D subsurface model can only adequately represent more complex structures. The main problems in applying 3D electrical tomography so far were the lack of suitable field equipment and the requirement of powerful computers to process the data. Nowadays, the existing equipment for 2D electrical tomography can be also used for 3D.

To perform a 3D survey, first a rectangular grid is superimposed in the area under investigation. For convenience the electrode spacing is kept the same in both x- and y- directions. The pole-pole array is utilized due to limited number of available electrodes. Two poles of the array (current and potential) are located at the nodes of the grid while the other two poles are located at opposites sides of the grid at distances greater than 10 times the large side of the rectangle. The way that pole-pole array works here is as follows. In the beginning the current electrode is placed on the first node and we measure the potential at the rest of the nodes of the grid. Then, the electrode at the second node becomes current electrode and we measure the potential at the nodes with index number greater than 2. Note that because of reciprocity, it is only necessary to measure the potentials at the electrodes with higher index number than the current electrode. The procedure stops when all electrodes become current ones.

The processing of the readings includes inversion with the smoothness-constrained least-squares method. In the 3D model, the subsurface is divided into several layers and each layer is further subdivided into a number of rectangular blocks. The blocks within each layer have the same size. For the blocks in the topmost layer each corner of their upper side coincides with a node of the grid. The thickness of the top layer is set at 0.70 times the node spacing. The thickness of each subsequent layer is increased by 15%. The optimization method basically tries to reduce the difference between the calculated and the measured apparent resistivity values by adjusting the model resistivities. After the iterative procedure is finished the user can display the model or the apparent resistivities in the form of slices parallel to x, y, z axis.

During the 1998 campaign in Itanos, both 2D and 3D resistivity measurements were taken. The total length of electrical tomography profiles in 2D was 350 meters. Figure 1 shows the results from an electrical tomography line that was parallel to an excavated trench. The electrodes were configured in a dipole-dipole array with minimum electrode spacing of 2m. The resistivity tomogram shows two high-resistivity zones at horizontal distances 4.5-5m and 9-9.5m that coincide with buried walls present in the excavation trench. Additional high resistivity zones are outlined in the tomogram. The 3D measurements taken on two grids covering an area. The results from the inversion of the apparent resistivity data showed that the optimum electrode spacing is 1m. In future experiments apparent resistivities will be measured on subsequent grids with electrode spacing of 1m and maximum depth of investigation of less than 2 meters thus minimizing the number of measurements. The three dimensional electrical method gave improved images which give additional information in terms of the size location and depth of burial of targets spotted on the geophysical maps. This small electrical tomography test survey in Itanos proved that it is a very powerful tool for archaelogical prospection. A large-scale electrical tomography survey is planned for the 1999 campaign in Itanos.

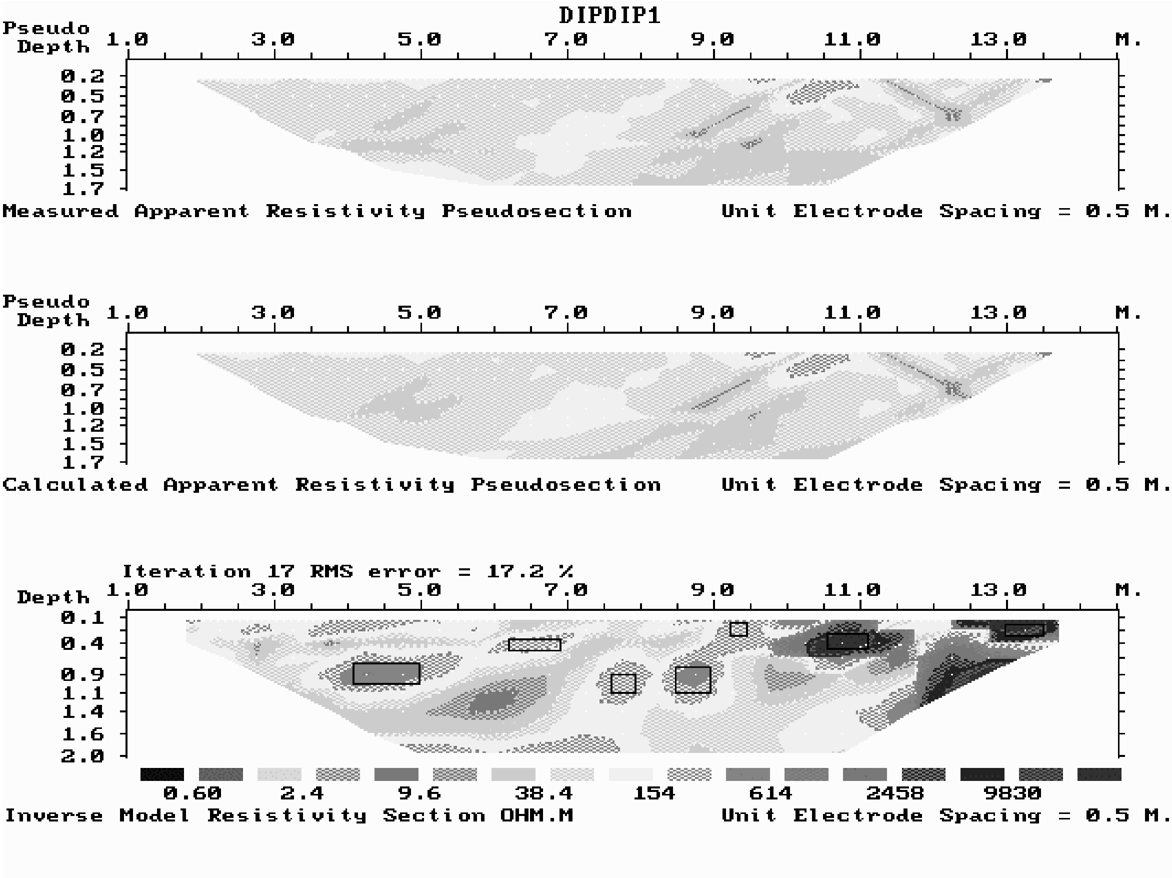


**Figure 1.** Electrical tomography pseudosections and cross section across a line parallel the excavated trench.

## References

Linford, R., 1994, The English Heritage geophysical surveys database: Archaeol. Prospection,**1**.

Loke, M.H. and Barker M., Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method, Geoph. Prosp., **44**, 131-152.

Pipan, M., Finetti, I., and Ferigo F., 1996, Multi-fold GPR techniques with applications to high-resolution studies: two case histories, Eur. Journ. of Envir. and Eng. Geoph., **1**, 83-103.

Tsokas G.N., Papazachos, C.B., Vafidis, A., Loucoyannakis, M.Z., Vargemezis, G., and Tzimeas, K., 1995, The detection monumental tombs buried in tumuli by seismic refraction: Geophysics, **60**, 1735-1742.

Tsokas, G.N., Sarris, A., Pappa M., Bessios M., Papazachos C., Tsourlos, P., and Giannopoulos A., 1997, A large scale magnetic survey in Makrygialos (Pieria), Greece: Archaeological Prospection, 4, 123-137.

Vafidis, A., Tsokas, G.N., Loucoyannakis, M.Z., Vasiliadis, K., Papazachos, C.B., and Vargemezis, G., 1995, Feasibility study on the use of seismic methods in detecting monumental tombs buried in tumuli: Archaeol. Prosp., **2**, 119-128.