

# Geophysical Data Presentation Using GIS

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**Abstract.** A GIS project was created in order to manipulate and present geophysical and topographical data from the archaeological site of Itanos, Crete, Greece. This GIS project can handle different types of geophysical images such as maps, depth or time slices, depth sections and three-dimensional images. Thematic information such as type of measurement, station spacing, size of the profile or grid can also be retrieved for each geophysical image. Another feature of the project is the superposition of selected geophysical images and other types of datasets like aerial photographs, as well as archaeological, geological and elevation maps. The combination of maps led to an easier way of presentation and a more valid interpretation of geophysical data. The outline of the ancient port of Itanos was revealed by combining seismic, soil resistance, magnetic gradient and soil conductivity data with a 3D elevation model of the site.

**Key words :** GIS, archaeology, geophysics.

## 1 Introduction

The Geographic Information Systems (GIS) are useful in archaeology mainly in evaluating known archaeological sites and in searching for new ones. The geophysical survey together with GIS is becoming increasingly integrated into archaeological investigations. The most popular geophysical methods in shallow depth archaeological prospection are the soil resistance and magnetic methods. (Sarris, 1992, Weymouth and Huggins, 1985). The electromagnetic method is used in archaeology to detect anomalies at larger depths. Seismic refraction is also used especially for mapping the bedrock in archaeological sites (Vafidis et al., 1995, Wynn, 1986).

Recent developments in the ability to use geographically registered data sets in what is known as Geographic Information Systems (GIS) enable the investigator to carefully study combinations of various data for a given site (Hohl and Mayo, 1997, Hutchinson and Daniel, 2000). Digital format data such as topographic maps and scanner-type remotely sensed data lend themselves to rapid and easy entry into such computer-contained record systems.

Many advantages of information management are apparent through the employment of GIS software. Among these are the rapid retrieval of data, the merging and interaction of georeferenced data, the mathematical manipulation of spatial information or other computational processing and the capability of addressing the variations in scales of the input data (Mosman, 2001). For geophysical data, GIS helps in the interpretation of the data, which becomes easier and more efficient by overlaying geophysical maps on a base map.

A GIS project was created in order to enhance the management of geophysical data from archaeological sites. This project has an appropriate interface for manipulating different types of geophysical data. As an example, the results of an integrated geophysical survey in the archaeological site of Itanos (Crete) are presented. The purpose of this

geophysical survey was to map buried relics of buildings, streets and walls of ancient Itanos and to explore the usefulness of combining conventional geophysical mapping techniques and high resolution imaging methods in delineating shallow targets of archaeological interest.

## 2 Itanos Archaeological Site

Itanos, an ancient port in Eastern Crete, is located 10 km north of Palaikastro, in Lasithi prefecture, close to the unique in Europe Vai Palm Forest (Figure 1). The archaeological site is located at the eastern coast, surrounded by a mountain from the south and the provincial road from the west and north. Its area 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 acropolis.

Itanos is marked mainly from three periods: Geometric, Roman and Early Byzantine, while the periods of original occupation and abandonment are not known. Demargne, a French archaeologist started excavations in Itanos during the summer of 1899 which led to the detection of the ruins from latter Roman period Basilica-type churches and a number of significant Hellenistic and Roman inscriptions (Spyridakis, 1970).

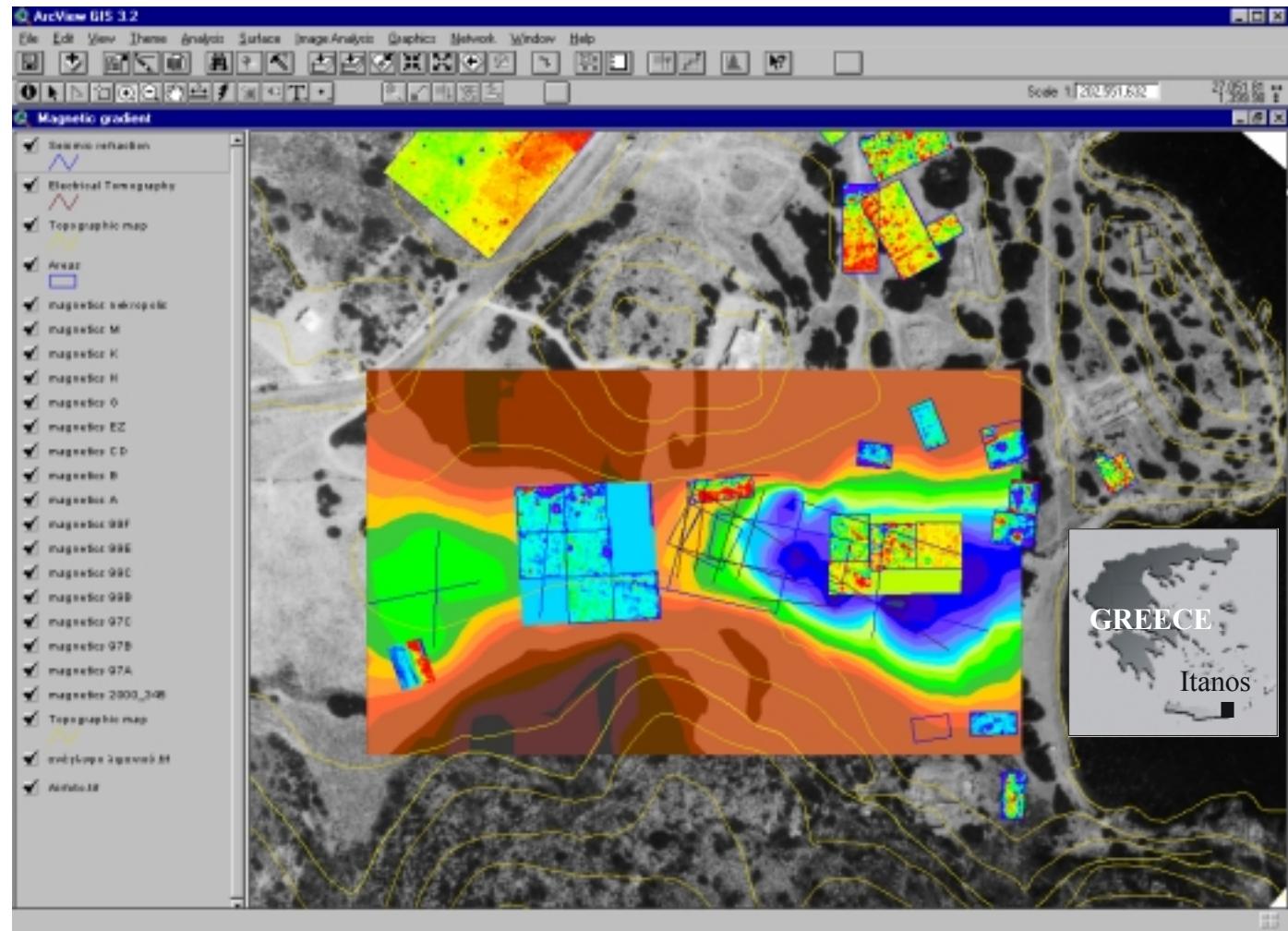
In 1950, French archaeologists started a second and more systematic archaeological campaign in Itanos. Excavations in Acropolis revealed a number of tombs from the Hellenistic period and pieces of early geometric period ceramics as well as traces of Minoan civilization. A new archaeological campaign started in Itanos in 1993 and is supervised by the French School of Athens and the Institute of Mediterranean Studies.

## 3 Data Registration

The available geophysical data consist of measurements from soil resistance mapping, 2D and 3D electrical tomography, magnetic mapping, electromagnetic mapping, seismic refraction and ground penetrating radar (Vafidis et al, 1996, Sarris et al, 1998, Poulioudis et al, 2002). The topographic data consist of the digitized elevation map of the area and the topographic layout of the geophysical transects and grids. Additionally, aerial photographs were available for the area under investigation.

First, the aerial photographs were registered by utilizing ground control points of known coordinates. Next, the topographic data were inserted in the project and a database containing the name of each point and its coordinates was automatically constructed. A layer (vector theme) including information about the geophysical transects and grids, was then created using the points that were previously inserted. These lines and grids were also linked to a database consisting of their attributes, namely the type of each grid and its name. The database included additional information about the lines and grids such as their dimensions, the survey methods, the station spacing and other related comments.

Utilizing geophysical data processing methods, the geophysical maps were created. The soil resistance, the magnetic gradient and the electromagnetic maps were inserted for the creation of successive layers of information. The bedrock relief at the ancient harbor was finally registered.



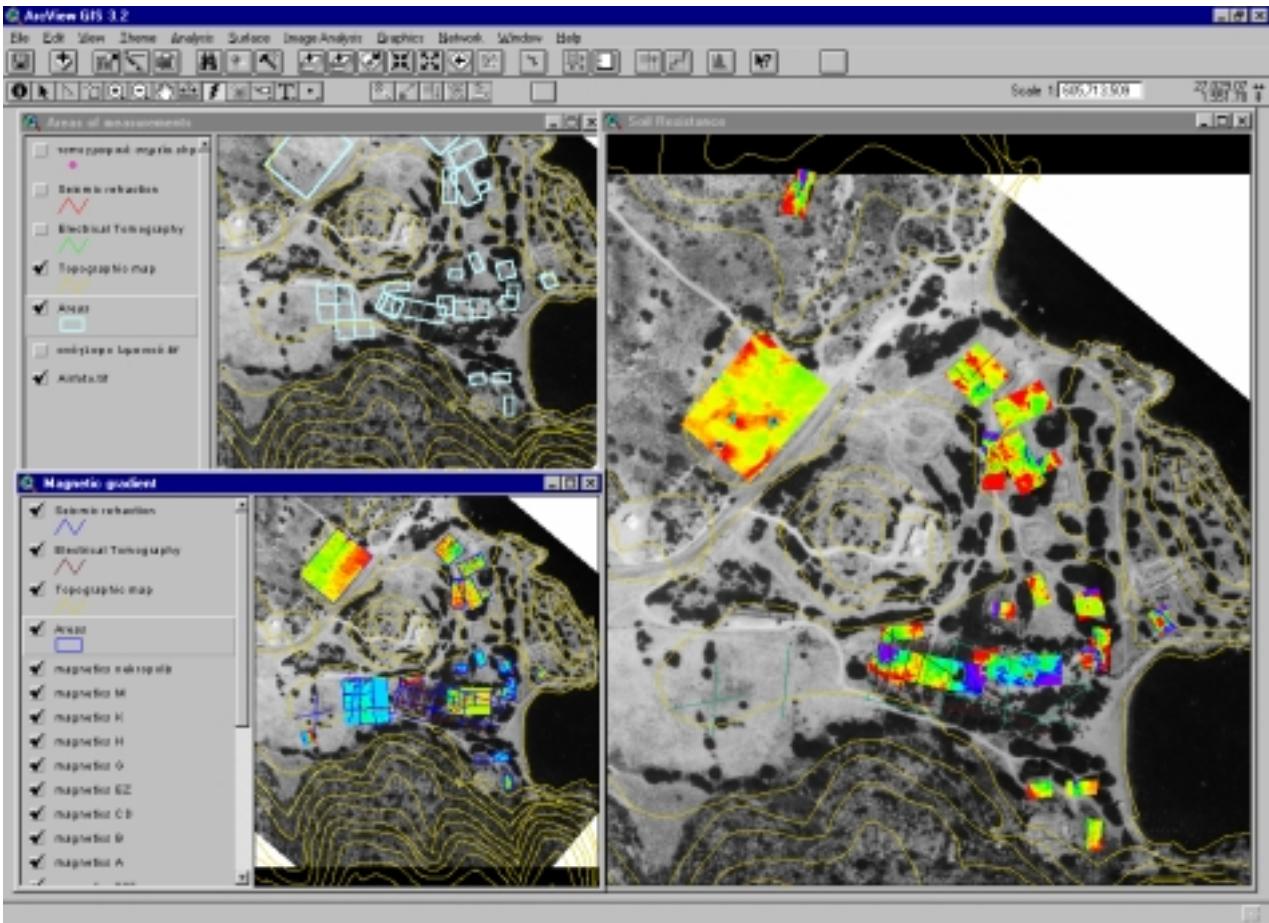
**Fig. 1.** A typical geophysical data presentation in GIS. The georeferenced datasets from the ancient port in Itanos are listed to the left. The magnetic gradient map consists of several small subgrids (red denotes high values). The large color image corresponds to the bedrock relief (blue denotes low elevation). The elevation contours in yellow exhibit 4 m contour spacing. The aerial photograph is displayed on the background.

Electrical tomography and seismic refraction survey lines are also displayed.

In Figure 1, the aerial photograph, the elevation map, the bedrock relief map, the magnetic gradient map and selected seismic and electrical tomography lines are superimposed. Overlaying various levels of information is a main feature for data presentation with GIS (Pratt, 2001). A three-dimensional elevation model was also generated from the digitized topographic map of the archaeological site. The topographic map is useful in checking known topographic points.

For the presentation of the geophysical data three graphics windows ("views") were utilized (Figure 2). In these views, the basic layers of information were the aerial photograph and the elevation contour map of the archaeological site. The first window (upper left) shows the grids of geophysical measurements.

On the second window to the right, the soil resistance map is



superimposed while on the third one to the lower left, the magnetic gradient map is displayed. The electromagnetic data consisted of measurements of the inphase and quadrature components. The quadrature component describes the conductivity properties of the subsoil. Thus, not only the soil resistance map but also the quadrature component map are displayed on the second window.

**Fig.2.** For the presentation of the geophysical data three graphics windows (“views”) were utilized. The first window at the upper left outlines the grids of geophysical measurements. On the second window to the right, the soil resistance map is superimposed, while on the third one at the lower left, the magnetic gradient map is displayed

Seismic refraction and electrical tomography lines were also drawn, in the graphics windows mentioned above (Figure 2). On the window to the right, the seismic refraction lines are displayed in green and the lines of electrical tomography in black.

#### 4 Creation of interface

Arc View software, which was utilized for the creation of this project, has an “open” architecture and allows the user to write scripts for customized tools (Pratt, 2001). Also, the user can create a customized user-program interface. For this project an interface for geophysical data management was created (Figure 3). To the left, the graphics window (“view”) displays the elevation map, the soil resistance map and the aerial photograph in Itanos port as well as the surveyed lines.

On the upper right part the tools for data management are included. The attribute table is shown to the middle right. When the user selects a grid, its attributes are highlighted on this table. The window on the lower right part displays a resistivity section selected by the user, which has been obtained from the electrical tomography experiment along the line P2. In this section the high resistivity anomalies A1 and A2 (red color) at depth less than 1m are shown. These anthropogenic anomalies are also present on the soil resistance map.

The data management window on the upper right includes controls for

- editing layers,
- choosing tables related to specific layers,
- handling the display of the vector shapes for each layer and

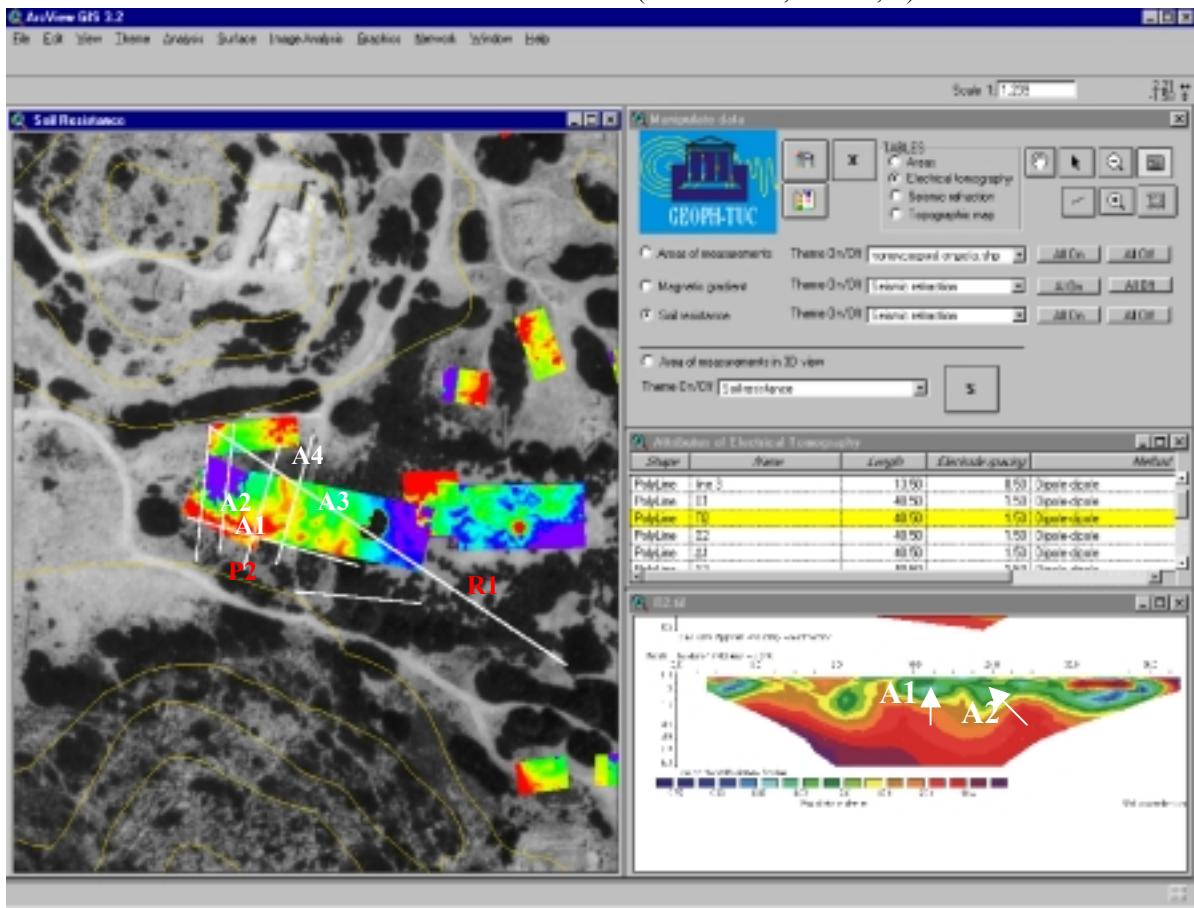
- (d) displaying the vector shapes on a graphics window and their tables.

There is also a “button” for displaying an image, which is connected to a specific vector shape, at the lower right graphics window. At the middle of the data management window there are controls for selecting one of the graphics windows (“view”) displayed on Figure 2 namely “Areas of measurements”, “Magnetic gradient” and “Soil resistance”. At the middle there are menus for selecting layers (“themes”) to be displayed in the specific graphics window. Additionally, the interface can handle three-dimensional geophysical data (“Area of measurements in 3D View”). Finally, there is a “button” for exporting an image in several raster formats.

## 5 Presentation of geophysical data

The aerial photograph was first combined with the three-dimensional elevation model of the archaeological site originating from the digitized topographic map. The geologic, topographic and geophysical data were then integrated for the creation of the bedrock relief model in Itanos port. The bedrock consists of phyllites-quartzites and is covered by recent deposits. Information about the bedrock in Itanos port originates mainly from a seismic refraction survey.

The bedrock relief (Figure 4, lower right and Figure 1) indicates that the ancient port is located south of the acropolis. It extends to the west about 100 m from the present seashore. It covers a rectangular region of approximately 9000 m<sup>2</sup> (Vafidis et al, 2002 a, b). This bedrock relief model and the



**Fig. 3.** Interface for geophysical data management. Lower right, electrical tomography section (line P2)

The combination of the aerial photograph, the three-dimensional bedrock relief model and the soil resistance map aided the interpretation of the geophysical data. The high resistivity anomaly (white arrow) is probably anthropogenic. This anomaly is located at a region where the absolute bedrock depth is low (-2m to -3m). Thus, this is possibly attributed to relics of buildings of the ancient harbor.

The blue arrow indicates also a high resistance anomaly attributed to the bedrock itself, because at this location it is outcropping. The three-dimensional image of the bedrock relief (Figure 4, lower right) correlates well with the results from electrical tomography. In particular, on the resistivity section along the line P2 (Figure 3, lower right) the 30 Ohm-m contour of this image exhibits depths compatible to those of the top of the bedrock.

## 6 Conclusions

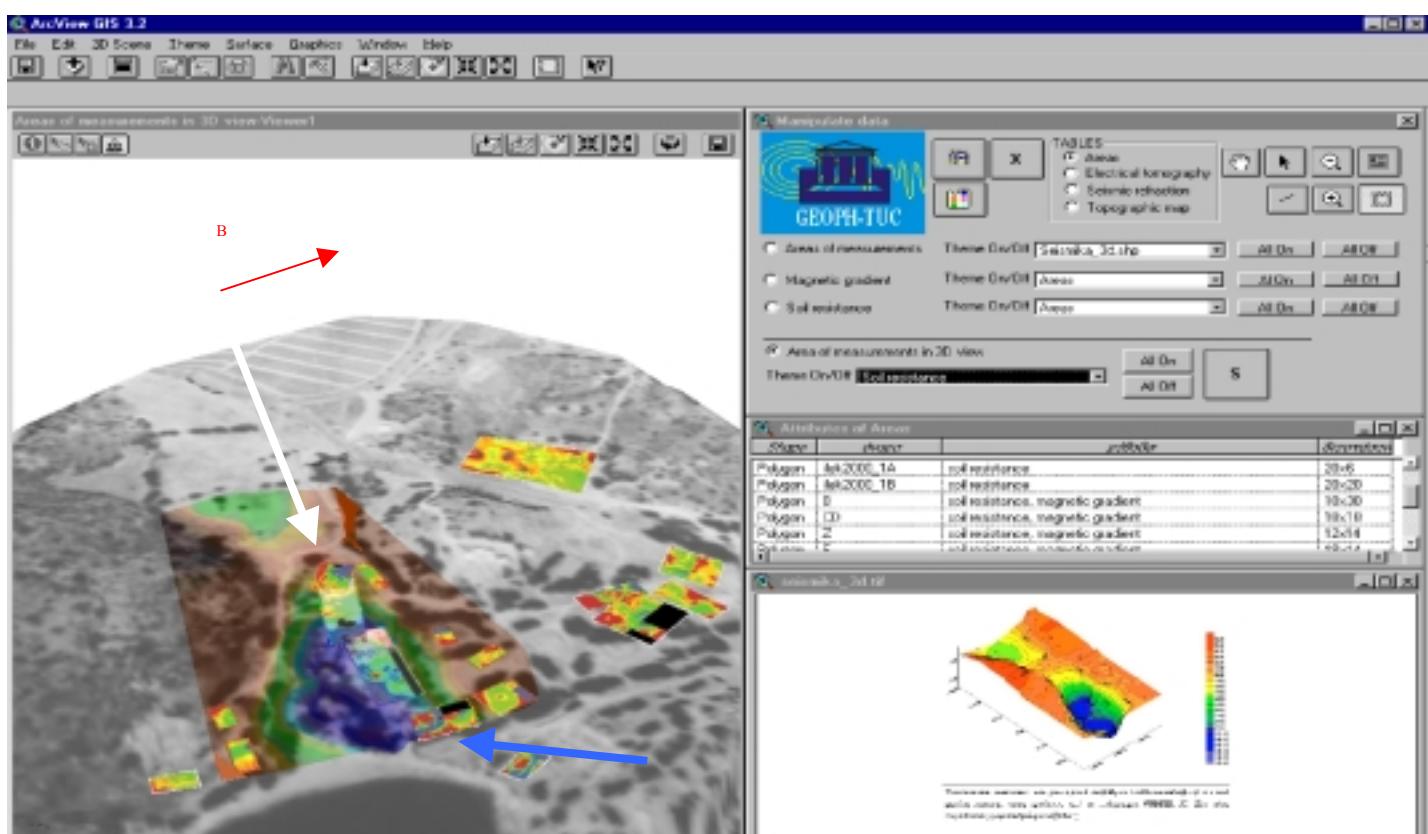
This project improved the efficiency of geophysical data interpretation by grouping together geophysical data in one project, viewing maps simultaneously and combining geophysical attributes. This also facilitated the comparison of geophysical data necessary for the verification of the interpretation. Two and three-dimensional views and the combination of geophysical and topographical data with aerial photographs are some of the features of this project.

One of the features of this project was the superposition of selected geophysical images as well as other types of datasets

**Fig.4.** The three-dimensional elevation model of the bedrock, in the area of the harbor superimposed on the aerial photograph. Also the geophysical map of electrical resistivity is displayed. The aerial photograph is partially (30%) transparent. The white and blue arrows show high values of soil resistance in the geophysical map. Lower right is the image of the bedrock in three-dimensional relief

like aerial photographs, archaeological maps, geological maps and elevation maps. Therefore, the geophysical images can be easily compared.

In Itanos, the location of the ancient port was revealed by combining the three dimensional image of the geologic basement relief, obtained by the seismic data, with the magnetic gradient, soil resistance and electromagnetic maps and the digital elevation model. Electrical tomography images in the same location correlate well with the information deduced by the seismic data. Geophysical data integration with the GIS aided to a better understanding of the archaeological site of Itanos.



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