Remote Sensing Techniques & Computer Applications for Archaeological Monument & Site Assessment of Itanos in Eastern Crete, Greece.

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Abstract

Remote sensing techniques have been applied in the archaeological site of Itanos (Erimoupolis) in north-east Crete, to create an electronic map of and evaluate the surface and subsurface relics. For mapping cultural and environmental features in the region, a variety of geophysical, surveying and satellite methods has been applied, such as shallow and medium depth geophysical prospection, satellite and aerial remote sensing, as well as GPS geodetic surveying.

The purpose of the geophysical survey has been to map the subsurface relics, which were located at different ground depths and related to various historic occupation layers on the site. Geophysical prospection included magnetometry, soil resistance and conductivity surveys, resistivity tomography and ground penetrating radar surveys, while penetration depth varied from 0.5m to 10m depending on the configuration and the technique used. Geophysical data have been processed by image processing techniques (both in spatial and frequency domain) and cross-correlated for maximum efficiency. Electrical tomography has also provided the cross-sectional view of specific features. Subsequent excavations at selected areas have verified the archaeological findings explored in advance by the geophysical surveys.

The geophysical and topographic data of the surface features were superimposed on to the aerial photographs for further interpretation of the archaeological relics and identification of the extent of the ancient site. Seismic reflection and refraction techniques were also used for detecting the ancient port and for a 3-dimensional reconstruction of the subsurface basin, covered by alluvium deposits.

The overall assessment of archaeological and environmental features has been made using Landsat and SPOT satellite imagery. Ground truthing and registration of the images as well as accurate positioning of the geophysical grids and parts of the archaeological relics was performed with two GPS satellite receivers in kinematic mode. All of the data collected will be integrated in a Geographic Information System, which will be incorporated for managing and protecting the archaeological and environmental resources being under the threat of urban development. It is expected that the final product will be taken into serious consideration in the planning and developing under way in the region.

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Introduction

The geophysical campaign in Itanos (E. Crete), carried out with the collaboration of the Institute of Mediterranean Studies - F.O.R.T.H., the Technical University of Crete and the French School of Archeology in Athens, completed its 4th season of investigations, resulting in valuable information regarding the ancient site as well as the methodologies used.

Itanos, an ancient Hellenistic/Early-Christian port in Eastern Crete, lies close to the Vai Palm Forest. The archaeological site is surrounded by sea on the east, a mountain on the south and the provincial road from the west and north. There are two hills where the two acropolis of the ancient city are located. Most of the relics of the buildings are located in the region between the two acropolis. The site covers an area of more than 16,000 square meters. Archaeological excavations have covered an area of less than 1% of the site.

The purpose of the geophysical survey was to map the buried archaeological relics, such as remnants of buildings, streets and walls, in order to complete the picture of the ancient city plan. Furthermore, an additional module of research was concentrated on the mapping of the open area south of the acropolis, where the ancient port was assumed to be located. The ultimate goal of the research campaign in Itanos is to integrate the archaeological and surface and space remote sensing techniques in order to reconstruct the environmental settings of the site and maximize the archaeological information using non-destructive means of surveying.

Methodology & Results

Vertical magnetic gradient, soil resistance (Twin Probe array) and electromagnetic techniques were used for mapping the shallow archaeological remnants. The dry alluvium deposits of the site imposed certain limitations in the prospection strategies. The survey of the same regions by different techniques increased the confidence level of the interpretation process. Processing of the geophysical data continues with the application of a number of filtering procedures and processing packages (Spyglass, Geosoft, Surfer, ErMapper, a.o.) and it has been proved to be valuable in emphasizing the inner details of the geophysical maps and enhancing the corresponding images. Gradient operators evaluating the abrupt changes of measurements, directional derivatives emphasizing linear features and trends, and Laplace filters have been successful in enhancing the local anomalies - sometimes at the expense of increasing levels of noise. The last by-product of the filtering process, especially evident in the evaluation of the residual field, is minimized by upward continuation filtering through FFT techniques. Finally, shaded relief mapping and 3-D representations add a different perspective to the 2-dimensional data.

Due to the complexity of the subsurface layers, electrical tomography and ground penetrating radar were employed to refine the accuracy of the conventional techniques and add further information to the geophysical inventory. The Sting / Swift system was used to collect field data for resistivity imaging. Electrical tomography was performed with both dipole-dipole and the Wenner configurations. The electrode spacing varied from 0.5 to 1m in order to measure apparent resistivity values at different depths. The 2-D inversion of the measured apparent resistivity data, through finite-difference forward modelling and a non-linear least-squares optimization technique, into true resistivity was

necessary for accurate depth determination and interpretation of the data. A number of electrical tomography experiments, under controlled conditions, were carried out in the area of grid H, where excavations verified the existence of a number of wall structures identified by other geophysical techniques.

A pulse EKKO 1000 ground penetrating radar operated complementary to the above investigations. A sampling of 10cm was most appropriate taking into account the dimensions of the expected targets (width of 25-70cm). Pre-processing of the radar signals included a signal saturation correction and a DC level removal. A gain control filter, inversely proportional to the signal strength, was capable in equalizing all signals of different times. In this way, the continuity of reflecting events was assessed, with some loss of the relative amplitude information. A horizontal average filter was applied along the profile of the data in a trace to trace manner, for emphasizing flat-lying/slowly dipping reflectors in the ground. The above methods were also applied in the area of the ancient port in order to examine their correlation to the results of the seismic surveys.

Coring and seismic methods (refraction and reflection) were also performed to map the top of the basement and calculate the thickness of the overburden, which consist of alluvium deposits. Seis-gun and hammering were responsible for the generation of seismic waves that were recorded by 48 units of 14Hz geophones. The seismic traverses were set up in approximately south-to-north and east-to-west directions. Parallel profiles were separated a distance of about 15-25m and geophone separation was 2m for all profiles. Shots were performed at the middle of the arrays, at both edges and at offset of varying distance when this was possible to achieve, depending on the restrictions of the landform and vegetation coverage. In all sections, processing of the data resulted in three layers of the subsurface. In addition to seismic refraction techniques, a high resolution seismic reflection survey was carried out along one of the profiles, with the use of a seis-gun, 100Hz receivers and a 0.5m geophone separation. The optimum window (offset between source-first geophone) was 7m. Processing of the seismic reflection data included geometry corrections, trace muting, AGC, stacking, deconvolution and migration. Processing of the refraction data has offered the first 3-dimensional model of the ancient port which has been identified in the region south of the two acropolis. The model is in agreement to the theoretical assumptions, which proposed the specific location as a better candidate for coastal activities due to its geographic properties.

An Ashteck total station and a mobile unit were used in the geodetic surveying. "Stop & Go" technique was applied for the kinematic surveying of the wider region of Itanos, taking a number of high-accuracy readings of ground control points (G.C.P.) to be used for the geometric correction of aerial and satellite images. A number of experiments of static surveying were conducted for testing the accuracy of the system and registering the geophysical grids and profiles to the general topographic layout of the site. Measurements were obtained in UTM and then transformed to the Greek Geodesy System of Axes ('87).

Final Remarks

Based on the current successes of the geophysical campaign, further geophysical prospection work is scheduled for the next two years of investigations. Conventional geophysical mapping will be performed in other regions of the site, close to the port, in an effort to detect any relevant structures. Seismic surveys will be carried out to complete and refine the reconstruction of the subsurface basin of the ancient port. Digitization of the modern topography is under progress, in order to integrate the above data to the 3-dimensional digital elevation model of the site and its surrounding region. SPOT Panchromatic data are in the processing stage, where pixel-mixing techniques, applied to images of different seasons, will try to decrease the spatial resolution to 5m. Future activities include the construction of a G.I.S., which will integrate the information acquired by aerial and satellite images, geophysical maps (both 2-D & 3-D) and other archaeological information from the wider region, providing the infrastructure for the protection and management of the cultural and environmental resources of the region.

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