ANCIENT ITANOS (ERIMOUPOLIS, LASITHI): AN ARCHAEOLOGICAL SITE AS A REMOTE SENSING LABORATORY

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Abstract

For the past 4 years, a coalition of European researchers has been studying the archaeological site of Itanos in North-East Crete, Greece from various archaeological, environmental and geophysical aspects. The project, supervised by the Institute of Mediterranean Studies in Crete and the French School of Archaeology in Athens, has integrated a number of surveying techniques for accessing the archaeological and environmental parameters of the wider archaeological region.

The purpose of the geophysical project has been to map the buried archaeological relics, including remnants of buildings, streets and walls in the extended area of the archaeological site. Furthermore, the site has been used for testing a number of high resolution conventional and modern survey techniques.

Seismic refraction and reflection techniques were used for detecting the ancient port of Itanos and mapping the bedrock of the area, covered by alluvium deposits. The ancient port was also the target of GPR and electrical tomography prospecting, which encountered serious problems due to the shallow depth of the water table.

The geophysical, topography and archaeological survey data have been superimposed on to an aerial mosaic of the region. The overall assessment of archaeological sites has been extended through the use of Landsat and SPOT satellite imagery (the last of which has been re-sampled to 5m accuracy, through pixel-mixing techniques). Sub-centimetre accuracy with GPS receivers has been used specifically for the above image registration as well as for precisely locating the archaeological, environmental and geophysical features.

The archaeological site of Itanos has been evolved to be a natural Remote Sensing lab, where different scientific approaches have been applied to effectively extract the archaeological information of the site.

Introduction

Since 1994, a joint expedition of the Institute of Mediterranean Studies - F.O.R.T.H., the French School of Archaeology in Athens and the Technical University of Crete has been studying the Early Christian/Hellenistic site of Itanos from the perspective of non-destructive surveying. Land-based and satellite remote sensing techniques have been used for mapping the subsurface relics of the site and reconstructing the environmental settings of the ancient settlement and its surrounding region.

The site, an ancient Hellenistic/Early-Christian port in Eastern Crete, lies close to the Vai Palm Forest, surrounded by sea on the east, a mountain on the south and the provincial road from the west and north. The structural remains of the settlement, found in the area of the two hills consisting the two acropolis of the site, include remnants of temples, a cemetery and a number of residential units. The location of the harbor used to be an open question, which stimulated the prospection survey. The site covers an area of more than 16,000 square meters and it was soon realized that the assessment of the archaeological monuments of the site and its surroundings could be accomplished only through the utilization of geophysical and satellite remote sensing techniques. At the same time, limited archaeological excavations and restoration activities are in process in order to promote the importance of the archaeological site.

Mapping of the subsurface remains was carried out with a number of geophysical techniques, including measurements of the vertical magnetic gradient and soil resistance and electromagnetic techniques. Ground penetrating radar surveying and electrical tomography were used for maximizing the information inventory, along transects above features characterized by a strong geophysical signature. The purpose of these experiments was aimed towards the acquisition of 3-dimensional information of the subsurface (since there are at least 2 occupation layers) and to the refinement of the prospection strategies and methodologies used in the particular geomorphologic conditions. Seismic techniques were also applied for locating and capturing the form of the port's basin and aerial and satellite imagery, combined with GPS surveying, was used for the further assessment of the archaeological relics.

Methodology & Results

The goal of the Itanos campaign is the reconnaissance of the monuments of the site and its surrounding environmental settings through the use of archaeological and remote sensing techniques. Both surface and subsurface archaeological relics are mapped and analyzed using topographical measurements, geophysical prospection techniques, aerial photographs, and satellite imagery.

Geophysical mapping was carried out in various grids through vertical magnetic gradient, soil resistance, and electromagnetic techniques. The depth of investigations varied from 0.5m to 6m. The subsurface alluvium layers of the site contain at least 2 occupation levels at varying depth from the current surface of the ground. The complementary surveying of the site by different prospection techniques was decided in order to examine the behavior of the geophysical signals and increase the confidence level of the interpretation process. Enhancement of geophysical images was achieved through the convolution of gradient, Laplacian, high-pass and band-pass

operators. Butterworth and Gaussian filtering in the frequency domain have been proven effective in outlining the short-range anomalies related to the architectural remains of the site. Linear features and other details were emphasized through the application of directional filtering (1st and 2nd horizontal derivatives). The removal of the local trend, especially evident in the electromagnetic data, was necessary to enhance the residual anomalies.

The Sting / Swift system was used to collect field data for resistivity imaging. Both Wenner and dipole-dipole arrays, with electrode spacing 0.5-1m, were employed 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. Electrical tomography was applied in the area of grid H, where excavations verified the existence of a number of wall structures identified by other geophysical techniques, and in the open area south of the two acropolis. In addition, a pulse EKKO 1000 ground penetrating radar was employed in the same regions. Pre-processing of the radar signals included a signal saturation correction and a DC level removal. Continuity of the reflecting signals was assessed by the application of a gain control filter, inversely proportional to the signal strength. 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 purpose of the above experiments was twofold: first to obtain a clear picture of the signal expected by architectural remains and second to correlate the data with the results of coring and seismic survey.

Seismic surveying was performed to map the top of the basement and calculate the thickness of the overburden, which consists of alluvium deposits. Both reflection and refraction methods were employed. 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, whereas 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 the coastal installations of the site due to its geographic properties.

The ground-based prospection survey was implemented by geodetic surveying using an Ashteck total station and a mobile unit. "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). The above measurements were used for the registration of SPOT panchromatic and multispectral imagery.

Final Remarks

Site recovery will continue following the same directions of surveying. Further geophysical prospection work will be carried out through the use of conventional and non-conventional techniques, refining the geophysical signature of subsurface targets and improving the interpretation process. In this way, excavations will only be required to investigate regions of significant interest, providing a feedback to the process of data manipulation. The goal is to study in depth the dynamic potential of the methodologies used and take the appropriate actions towards the improvement of the techniques and sensors, thereby supplying a valuable infrastructure for a more productive application of them. The 3-dimensional model of the port's basin will be integrated by further seismic surveys and the resulting model will be fed to the DEM of the surrounding region to recreate the environmental settings of the particular area in question. SPOT Panchromatic imagery, geological and environmental parameters, and archaeological data of the wider region will be synthesized to an interactive Geographic Information System, which could be used for a more rational management of the cultural and environmental resources of the region. This type of integration of ground and satellite prospection, GPS and GIS technologies will continue in an even more systematic way nominating Itanos as a natural remote sensing lab where experiments would allow us to expand and modify the research strategies for the future.

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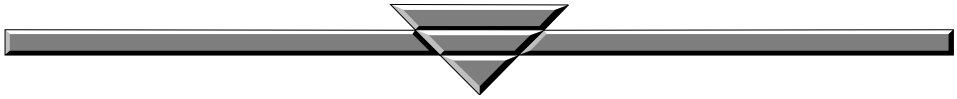
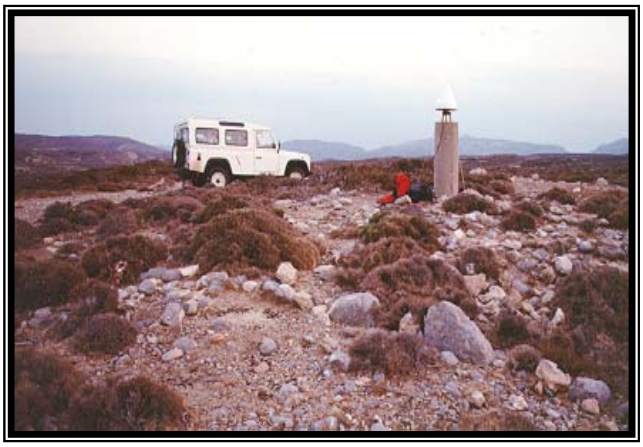


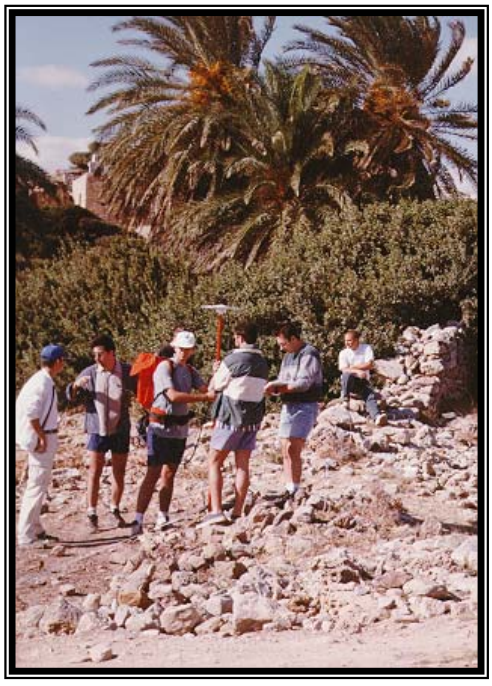
Seismic Survey (Seis-gun)

Electrical Topography

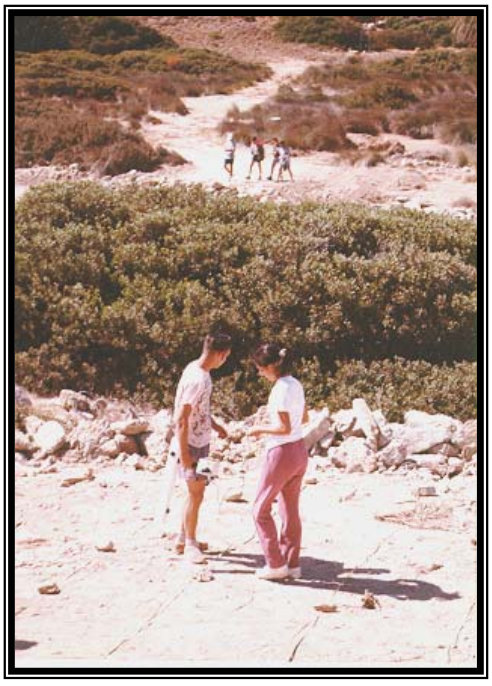


Global Positioning System (Base Station)

Electromagnetic Survey



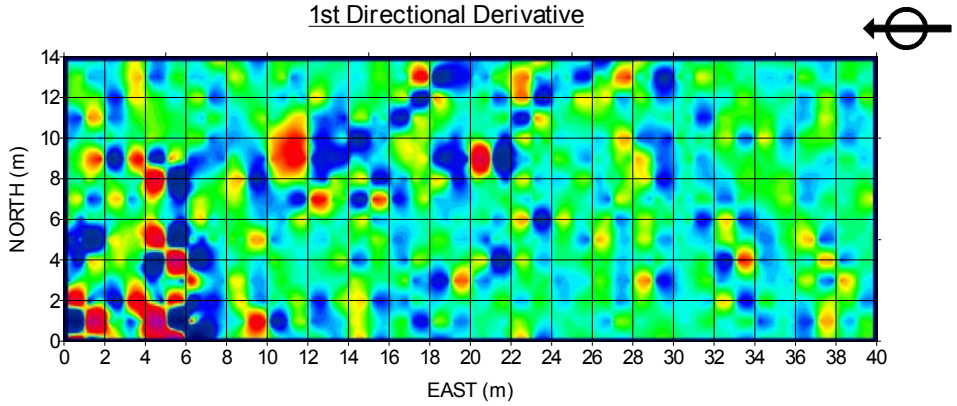
Global Positioning System (Mobile Unit)



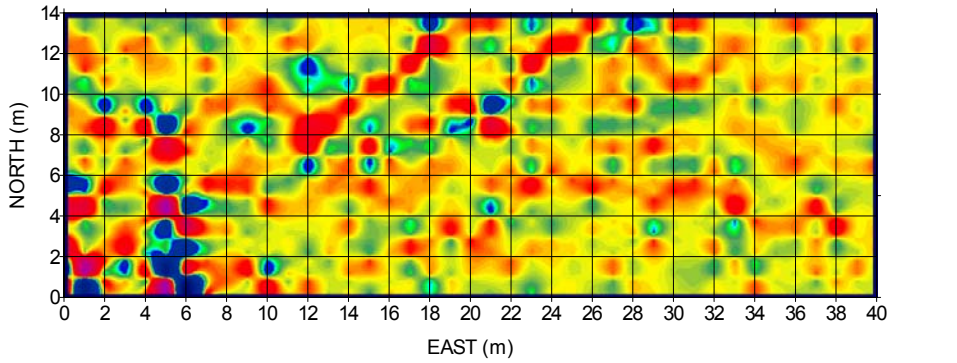
Vertical Magnetic Gradient Survey

ITANOS - E. CRETE
1997 FIELD SEASON
VERTICAL MAGNETIC GRADIENT - GRID 97B

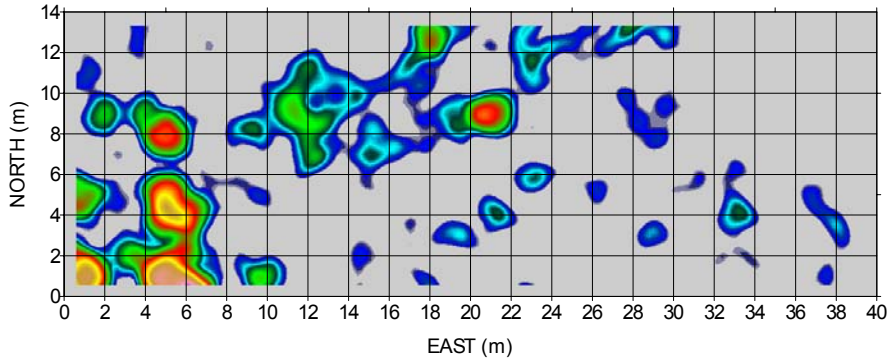
1st Directional Derivative



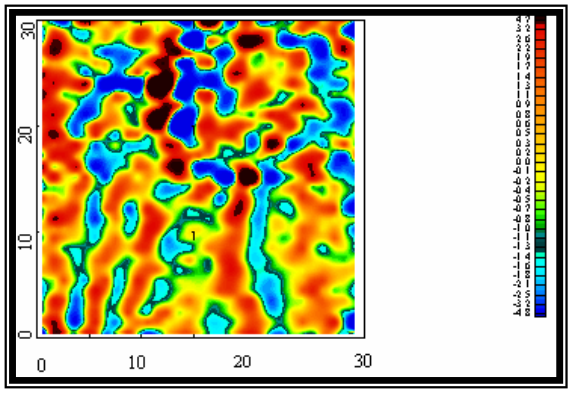
1st Directional Derivative

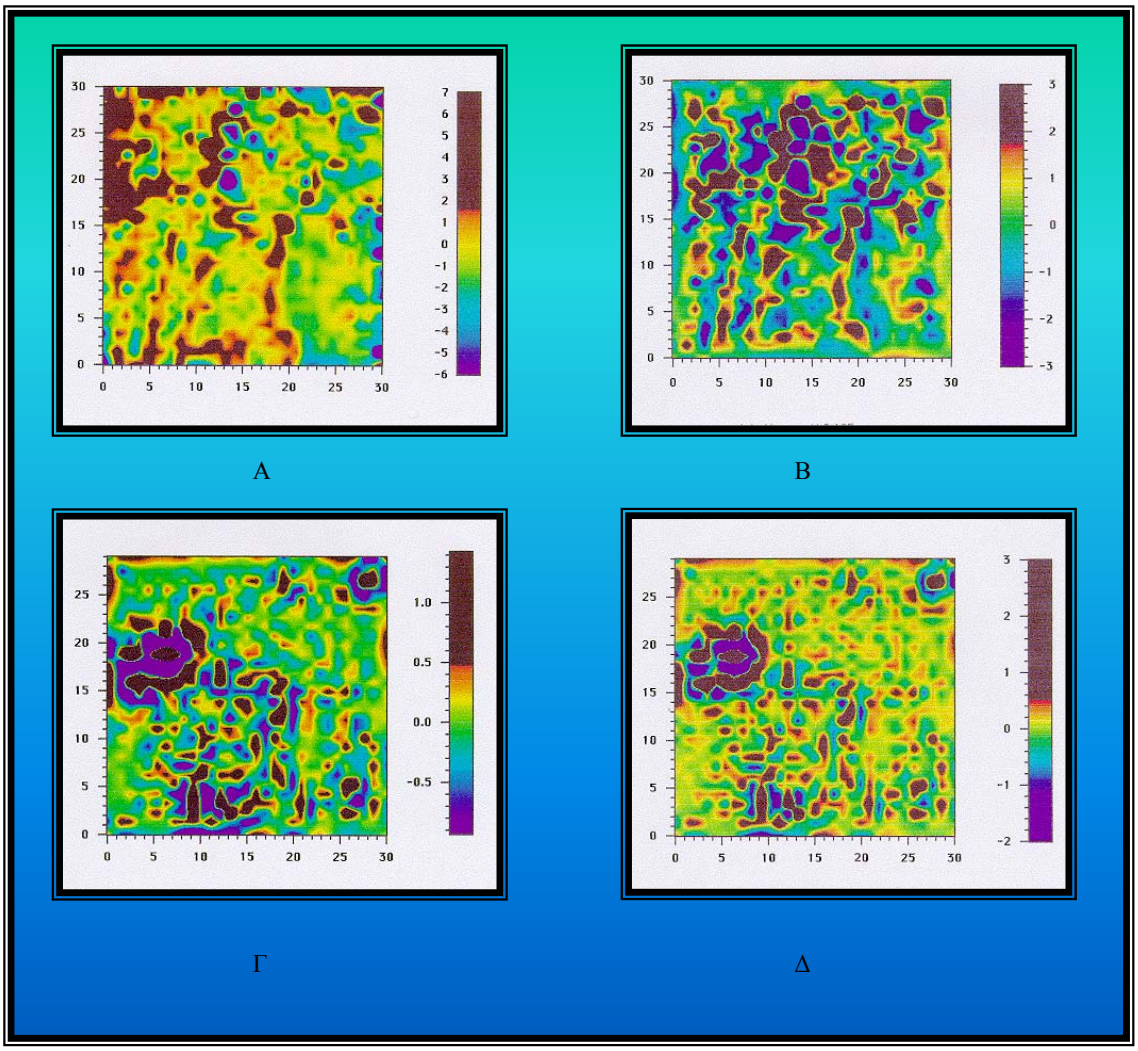


Residuals - high pass filtering

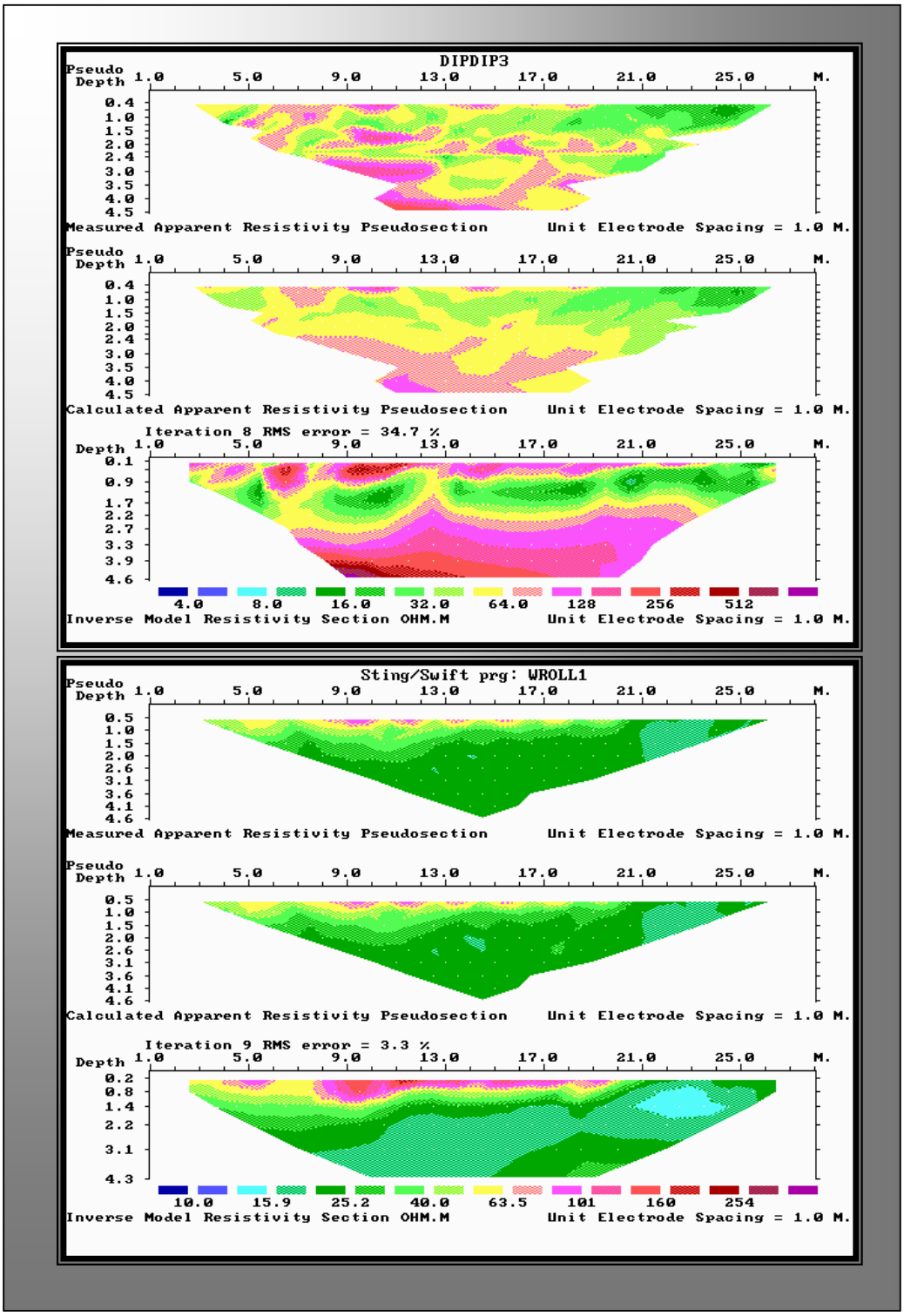


Bandpass filter - Grid H (Magnetics)

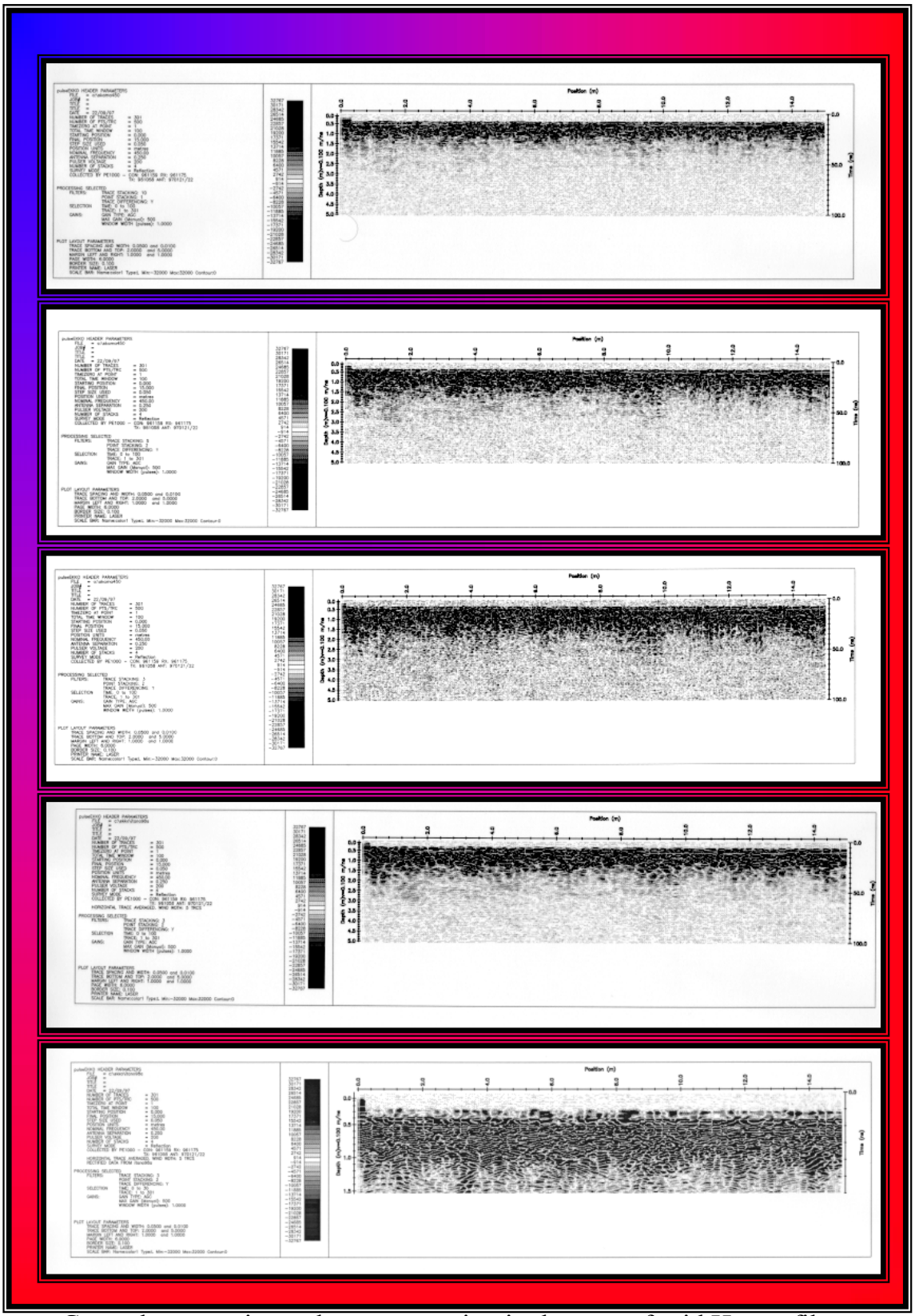




A: Grid H. Upward continuation of magnetic data (8m above the surface)
B: Grid H. Butterworth filtering of magnetic data (cut-off: 0.125)
Γ: Grid H. Butterworth filtering of magnetic data (cut-off: 0.250)
Δ: Grid H. Butterworth filtering of magnetic data (cut-off: 0.300)



Dipole-Dipole and Wenner tomography (a=1m) , parallel to the excavation trench (DIP3 top, Wenner bottom).



Ground penetrating radar cross-section in the area of grid H - profile along the direction of the trench (W to E).