

Mycenaean Dimini: Integration of Geophysical Surveying and GIS

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Abstract. The employment of geophysical prospection techniques proved valuable in the mapping of subsurface monuments of Mycenaean Dimini, revealing a wealth of information regarding the structural planning of the settlement. Magnetic, soil resistivity, and electromagnetic surveys were carried out covering an area of more than 29,000 square meters, mainly to the south and west of the neolithic settlement. Of the above techniques, magnetic surveying was particularly successful in outlining the architectural remnants of the site and guiding the excavations in a precise way. Up to date excavations by the 13th Eforia of Prehistoric and Classical Antiquities uncovered two megaron-type monumental buildings, Megaron A and B, with an open space, perhaps a central court, between them. The two Megara consist of different rooms identified as storage areas, workshops, cult areas and residence places, covering an area of 3,500m².

For the better management of the archaeological site and monuments, the geophysical maps were registered on the topographic layout and the aerial imagery of the wider region. A Geographic Information System was developed for the interactive management of the above information layers through the Internet, providing a different dimension of the usage of geophysical survey in archaeological research.

According to the present archaeological data, Mycenaean Dimini constituted an administrative centre, which reached its peak in the 14th-13th ce. B.C. The importance of the Mycenaean megaron structures and the close associations of the settlement with the rest of the Greek mainland, Asia Minor and the Levant suggest that it can be identified with ancient Iolkos.

Key words: Geophysical prospection, GIS, CRM, Dimini.

1 Introduction

The archaeological site of Dimini is located in Thessaly, central Greece and it is well known of its Neolithic settlement, excavated in the early 20th century. Within the period of 1977 – 1997, many rescue excavations took place to the east of the hill on the Neolithic settlement of Dimini covering an area of 1,200m². Traces of habitation were dated to all phases of the Bronze Age, while the best-preserved traces were dated to the Late Bronze Age. The Neolithic hill was also used as a cemetery during the Middle and the Late Bronze Ages. We do not have enough evidence for the size of the settlement in each period or a possible movement or interruption of habitation. According to the present data, the area of Dimini has traces of habitation dated from the Late Neolithic to the Late Helladic period. By the end of the 13th cent B.C. the settlement was abandoned (Adrimi-Sismani, 1996; 1992).

Until 1997, to the E of the hill of the Neolithic settlement (Fig. 1), 11 houses dated to the Mycenaean period were uncovered, together with a kiln dated to the early phases of the Mycenaean era. The houses were built with a common orientation (W → E) almost parallel to a wide road (45 x 4,50m), which leads through the settlement (Adrimi-Sismani, 1994:23-26).

Geophysical mapping was carried out in four phases (1997, 1998, 2000 and 2001). After the 1997 campaign (conducted in area A1), intensive excavations have started and the first monumental buildings, places of residence of the rulers of Dimini, have been uncovered. The 1998 survey was expanded in regions A1 and A2, while the last two phases of the survey explored the areas south and south-west of the Neolithic settlement (regions A3, A4, A5 & A6). Up to now, the total area

of coverage with geophysical techniques is over 29,000 sq. m., with small regions of overlap during the different survey seasons (Sarris, *et al*, 2001; Sarris & Jones, 2000).



Fig. 1. The wider region of the archaeological site of Dimini and the areas that became the focus of geophysical research.

2 Geophysical Survey Methods

A large part of the site has been explored with more than one geophysical technique (Fig. 2), including magnetic, soil resistance and electromagnetic methods. A number of controlled experiments conducted above specific targets in 1997, the coverage of the site with a small sampling interval (1-0.25m) and the verification of a large number of potential targets enhanced the interpretation of geophysical maps.

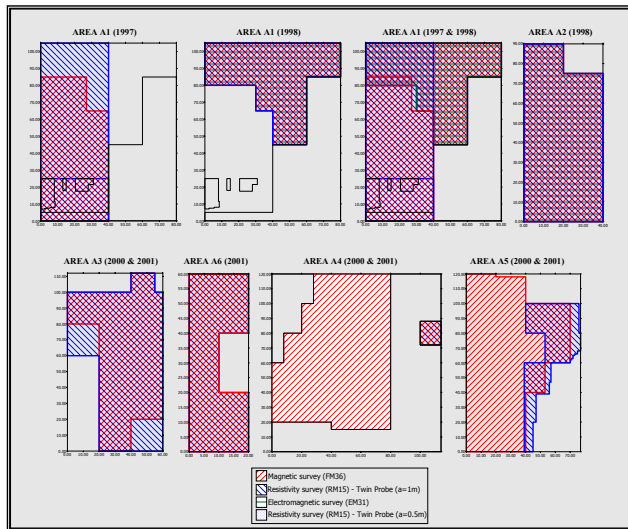


Fig. 2. Geophysical grids and method of geophysical prospection applied in each area of the archaeological site.

Soil resistance measurements were carried out using a Geoscan RM15 resistivity meter with a Twin Probe configuration (1m sampling interval and 1-0.5m electrode spacing). The vertical magnetic gradient was measured with a Geoscan FM36 fluxgate gradiometer with a 0.5-0.25m sampling interval and a 0.5m sensor height. Finally, a Geonics EM31 was employed for the measurements of both soil conductivity and magnetic susceptibility. The use of more than one technique was necessary due to the multiple occupation layers of the site, the difference of the surface soil conditions in various parts of the site and the variation of the depth of the expected subsurface targets.

Processing of data was carried out with Krigging gridding techniques and the application of directional derivatives, high and low pass smoothing filters, compression of the dynamic range of the original values and removal of trend. A few parts of the site exhibited a systematic noise, originating from land cultivation.

More specifically, during the second, third and fourth seasons of high-resolution gradiometer survey, high noise-to-signal ratios were encountered in regions A2, A4 and A5, due to land clearance practices, conducted by pulling around a burning tyre, the internal thin metal matrix of which was dispersed all over the region under study. This noise is presented in a form of a directional trend from SE to NW. Smoothing of noise was achieved with the application of directional derivatives or the application of shading techniques (Sarris, 1998).

3 Geophysical Results

Areas A1 and A2 are located southeast of the Neolithic settlement and they were surveyed with EM, soil resistance and magnetic techniques. The soil resistance measurements are in agreement to the EM data. The latter show a number of anomalies in the central and western side of the region, emphasized by the application of shading techniques and the calculation of directional derivatives (Johnson, et al 1999). The regions located at (x=0-8E, y=65-75N), (x=15-20E, y=27-37N) and (x=25-30E, y=50-56N) were identified as potential targets,

and registered in the magnetic data. The first target was excavated and it was found to correspond to a large structure of megaron type (megaron A), which was extended towards region A2.

A number of linear characteristics are obvious all over the region covered by magnetic techniques (Fig. 3), some of which are easily distinguished from the regional magnetic trend (e.g. the region x=25-45E, y=55-100N). These potential targets were identified for further investigation and some of them were excavated, revealing 2 large structural complexes of megaron type, in good conservation conditions. Creating a diagrammatic representation of the geophysical anomalies, it becomes evident from both soil resistance and magnetic data that the structures of the Mycenaean settlement are laid in a SE to NW direction. This is also in agreement to the results of older excavations.

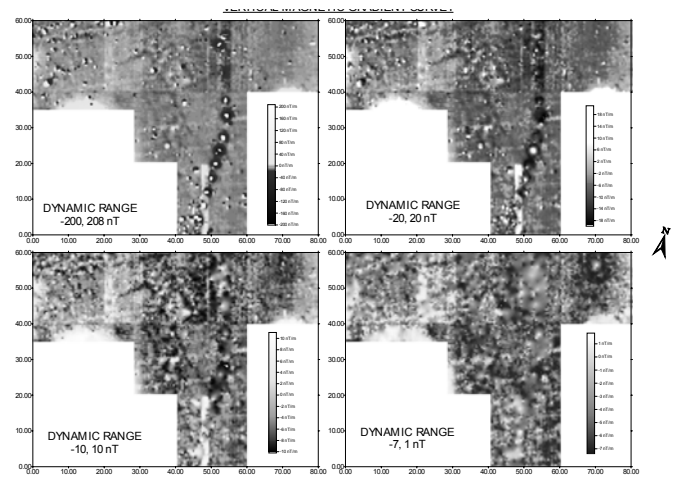


Fig. 3. Compression of the dynamic range of the original values of the vertical magnetic gradient was successful in revealing the outline of subsurface architectural structures.

In area A3, located south of the Neolithic settlement, in the lower slopes of the hill which extends south of the archaeological site, a number of Mycenaean tombs have been exposed, a few of which extend up to 50-70cm below the surface. Compression of the dynamic range of the vertical magnetic gradient data revealed a number of isolated anomalies and a few other linear high intensity anomalies. One of them is located in the northern region, running in a diagonal direction (from east to west) for more than 60m. Similar characteristics appear in the western section of the area, which are especially evident in the resistivity measurements (Fig. 4). A high resistivity curvilinear anomaly extends throughout the western section of the region, for more than 100m in a SE to NW direction. A few other similar anomalies seem to start from the latter and extend towards the NE. The isolated anomalies could be correlated to the presence of Mycenaean tombs, while it has been suggested that the curvilinear anomalies could originate from the presence of Roman monuments, such as an aqueduct. Actually, the large curvilinear anomaly to the west follows an iso-elevation contour surrounding the lower slopes of the hill.

Area A4 constitutes the extension of area A2 to the southeast. The southern side of the area is at the limits of the modern village of Dimini. The measurements of the magnetic gradient survey were also influenced by the past plowing activities of the field, showing diagonal lines in the SE to NW direction (Fig. 5).

The eastern side of the region shows a number of linear anomalies in agreement to the anomalies detected in area A2. A linear trend appears in the western section of the area, which after extending for more than 45m in a west to east direction, makes a turn and probably continues further to the north. The latter anomaly lies west of an excavation trench, which brought to light megaron A, located in area A2. The signal of the anomaly suggests that it consists of two parallel parts better preserved than the rest linear anomalies. The latter may have been partially destroyed due to the plowing activities in the neighboring field. Finally, the dipole character of the high intensity anomaly at (x=24E y=67N) suggests that it could be caused by the presence of a kiln structure of dimensions 5x5m.

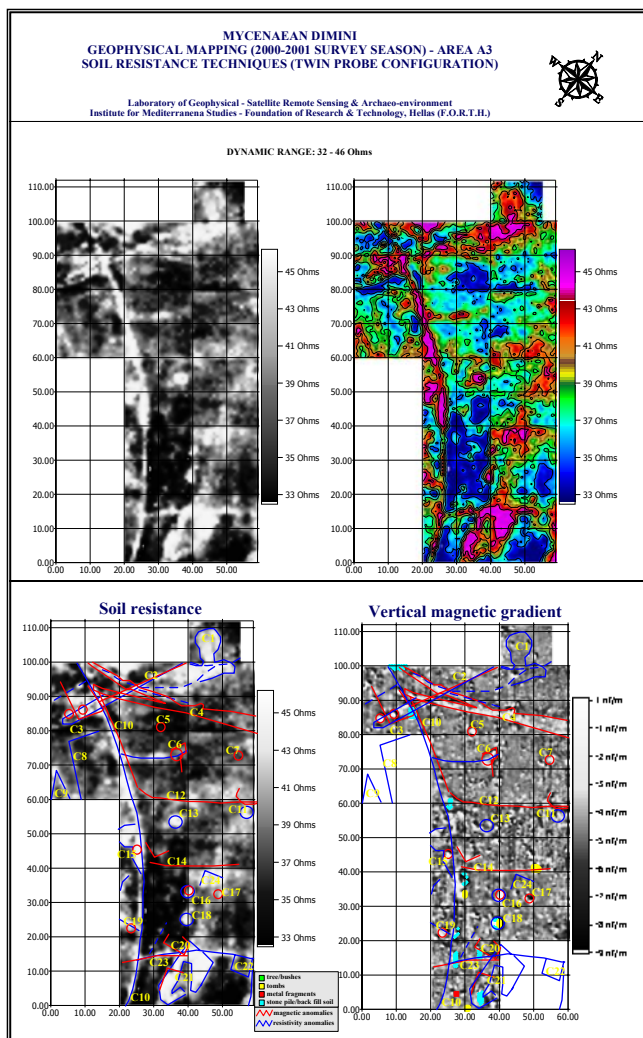


Fig. 4. Soil resistance techniques applied in Area A3 revealed a number of potential archaeological targets (above). The final interpretation was based on the comparison between the soil resistance and the vertical magnetic gradient maps. The diagrammatic representation of the anomalies is shown in the corresponding maps (below).

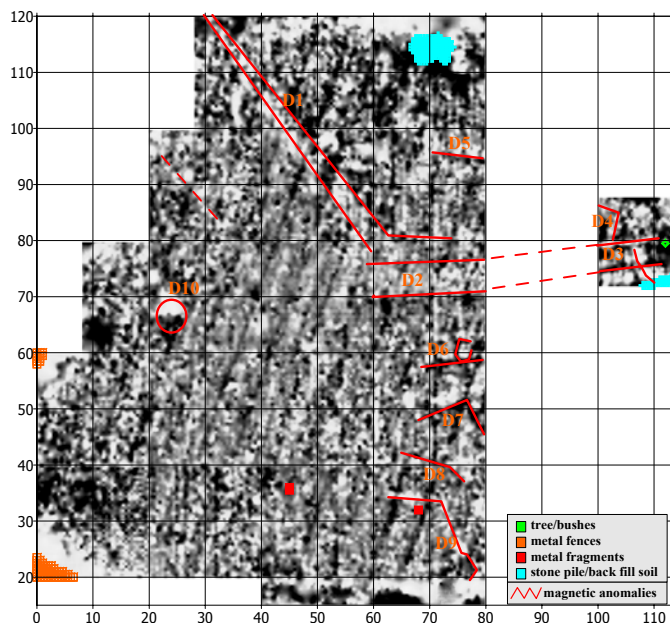


Fig. 5. Results of the magnetic survey in Area A4.

Area A5 is located SW of the Neolithic settlement and extends between two secondary roads, one of which leads to the main entrance of the archaeological site. The area was also cultivated until recently when it was expropriated, together with area A4, by the Archaeological Service.

Most of the site was explored by magnetic techniques, while the eastern section of it, which is located close to the fence of the Neolithic settlement, was explored by soil resistance techniques. Most of the interest of the geophysical anomalies is focused on the eastern section of the area, where magnetic data suggest a potential enclosure wall (possibly part of the Neolithic settlement), which extends to the south, together with a few more rectangular features that could be identified with structural remains (Fig. 6). A few other structures are also suggested by the resistivity measurements in the NE section of the region.

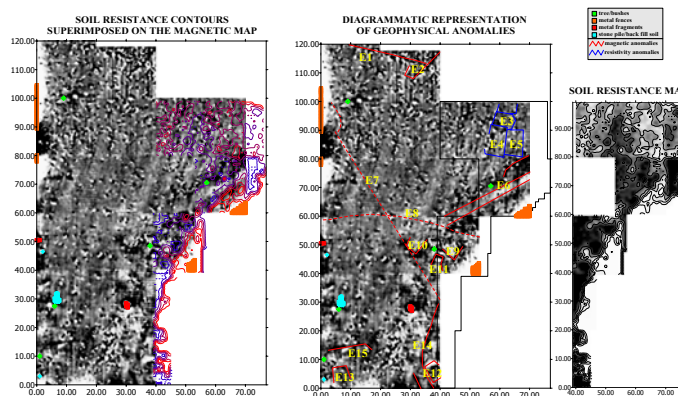


Fig. 6. Overlay of the soil resistivity contours on the vertical magnetic gradient map (left), together with the diagrammatic representation of the candidate targets (middle) and the map of the soil resistance measurements (right).

Area A6 extends NE of area A1, having a slight overlap with it to the north. A few meters northeast of area A6, excavations revealed a dense distribution of structures belonging to the Mycenaean settlement. Similar results were concluded by the application of geophysical techniques. A dense network of linear anomalies is present mainly in the magnetic data suggesting that the region was also part of the central habitation segments of the settlement (Fig. 7).

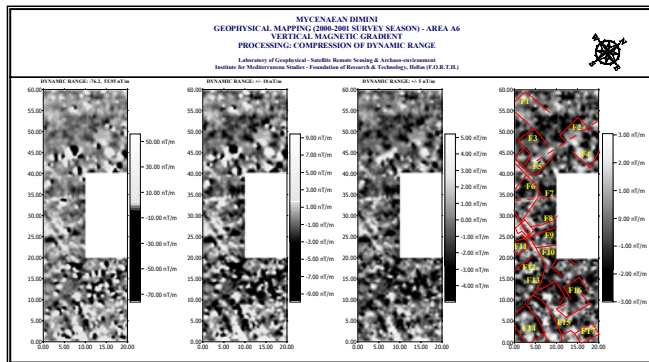


Fig. 7. Area A6. Compression of the dynamic range of the magnetic values and diagrammatic representation of the magnetic anomalies.

4 Integration of Results and construction of a GIS

The geophysical campaign conducted in the wider region of the archaeological site of Dimini since 1997 has contributed significantly to the planning of excavations and the general promotion of the Mycenaean settlement. Geophysical prospection was responsible for mapping the habitation units of the site, indicating two main complexes of megaron type and suggesting the extent of the settlement to the southeast.

Still, it becomes obvious that it is hard to combine all the results of the geophysical survey carried out in different time periods and within a different spatial context. For the better management of the archaeological site and monuments, the geophysical maps were registered on the topographic layout and the aerial imagery of the wider region. A Geographic Information System was developed for the interactive management of the above information layers, providing a different dimension of the usage of geophysical survey in archaeological research.

The background layers of the Geographic Information System consist of the Digital Elevation Model of the area, created by digitization of the 4m elevation contours taken by a 1:5000 scale map of the Geographic Service of the Hellenic Army, the elevation contours, two aerial photos (one showing the landuse of the region and another representing the current state of the landscape), the recent road network and the outline of the main buildings and private estates of the modern village (Fig. 8).

The geophysical maps were overlaid on the above layers creating three main thematic maps: resistivity, magnetics and diagrammatic representation of the geophysical anomalies (Fig.9). The above layers can be interactively activated to show the relation between the results of the excavations and the geophysical prospection survey and the continuing expansion and development of the modern village.

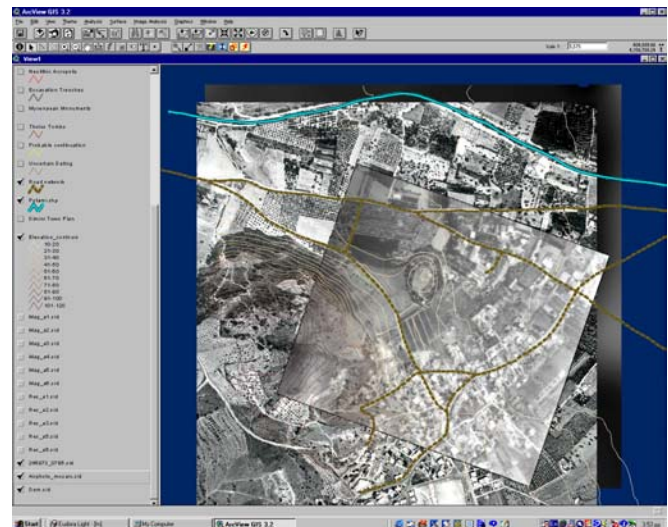


Fig. 8. Background layers of the Geographical Information System, which was created for the better representation of the results of the geophysical survey and the management of the cultural resources of the archaeological site of Dimini.

Experiments were also carried out to link the various information regarding the geophysical grids. A number of hotlink extensions (such as the Hotlink Visual Studio, Slideshow, HotPotato, etc) were tried out. The GMI's Hotlink Manager was found as the most satisfactory for our purposes, since it was easily incorporated to the GIS environment, allowing different degrees of freedom in managing links to files, which were even not native to the ArcView platform. One of the advantages of the extension is that the files open in their native or associated software (Fig. 10). In this way, it became possible to link the polygons of the geophysical grids (in transparent color) with the corresponding data and data processing software (Surfer), the excavation plans and the corresponding design software (in Acad), etc. In this way, it is possible to apply further processing of the raw geophysical measurements, view a number of images or videos regarding the methodology of the employment of the geophysical techniques and the corresponding environmental conditions of the site, refine the plans of the monuments based on the excavation results and update the GIS layers of the system in a much more interactive and effective way.

Thus, the final system can be used as a tool to direct excavations based on the results of the geophysical survey, updating continuously its geographic information context. Of great importance is also the fact that in this way it can be possible to monitor the progress of the excavations and compare the results of the excavations with the interpretation of the geophysical maps, checking the signal generated by the corresponding targets. This operation allows the creation of a more synthetic picture of the archaeological site and its architectural monuments (Fig. 11). Finally, the modification of the system and its installation to a Web environment has been proposed to act as a model for the creation of electronic geophysical databanks in the Mediterranean (Jones & Sarris, 2001).

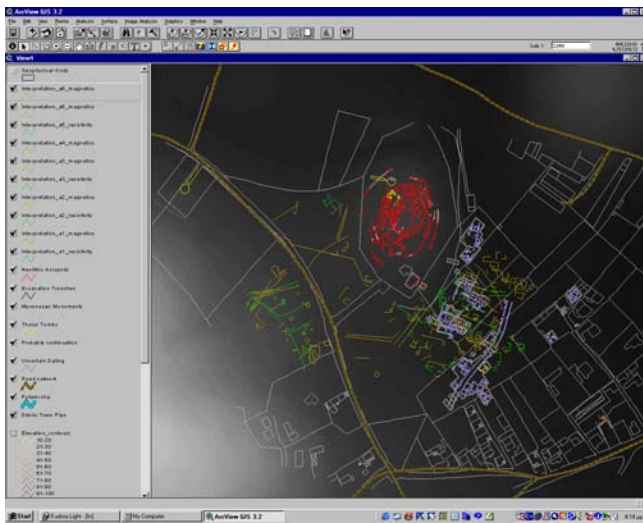
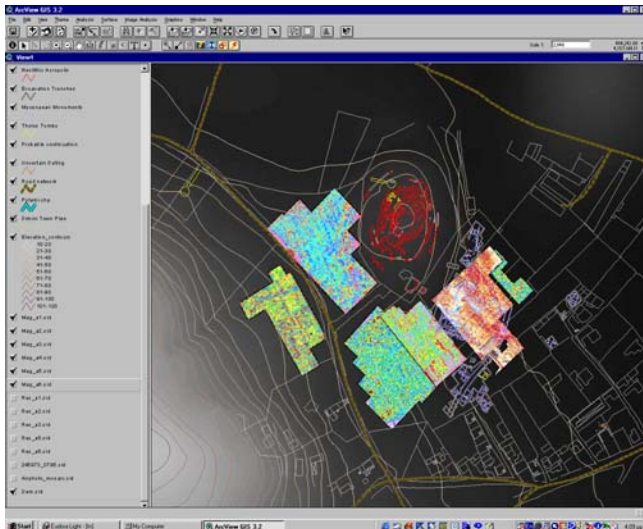
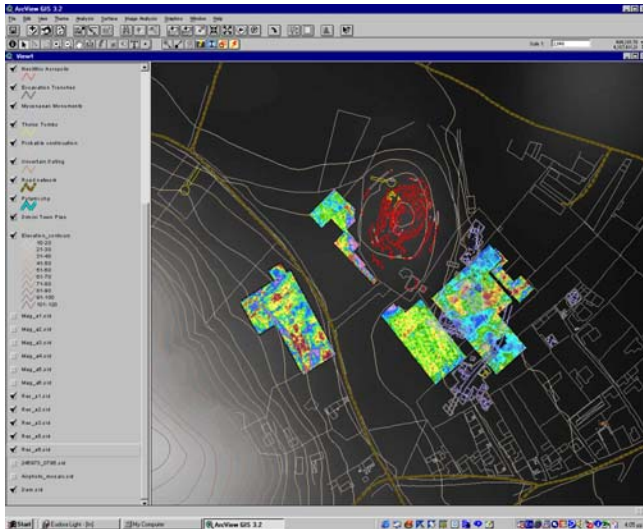


Fig. 9. Overlay of the layout of the surface monuments, excavation results and geophysical maps on the DEM and the topographic layout of the modern settlement. Creation of thematic maps: Resistivity (above), magnetics (middle) and interpretation of geophysical anomalies (below).

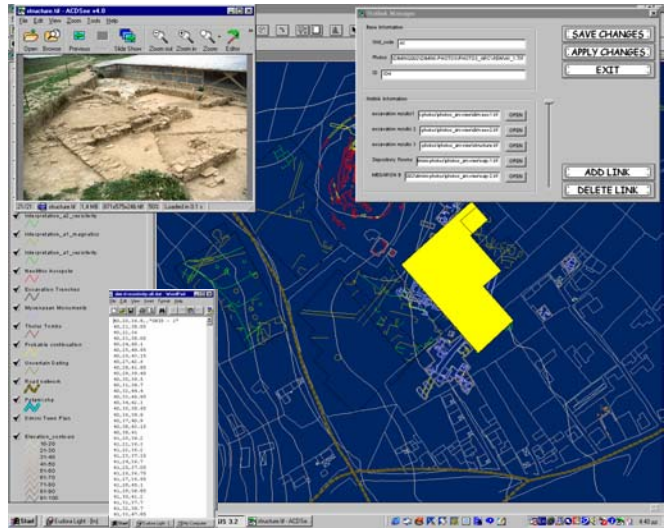


Fig. 10. Functionality of GMI's Hotlink Manager tool, which was used to link the geophysical grids with the corresponding raw data, photos from both the employment of geophysical survey and the excavation results, plans of the architectural remnants, etc.

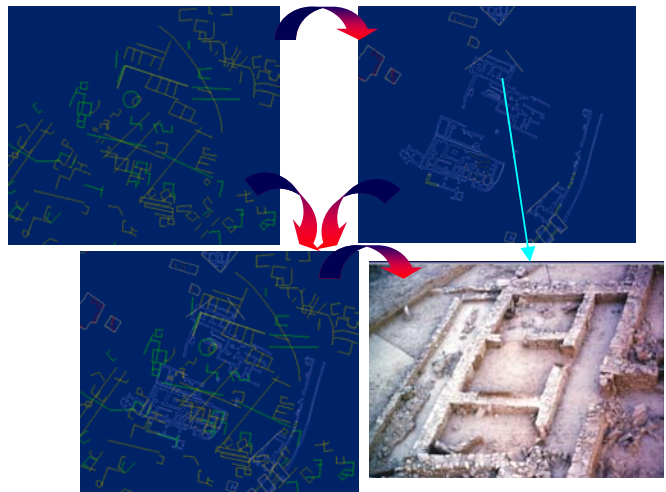


Fig. 11. Comparison of the interpretation of the geophysical maps and the actual results of excavations can lead to the enhancement of the geophysical methods and the creation of a synthetic view of the architectural relics of an archaeological site.

5 Final Remarks

Until today, excavations, based on the results of the geophysical survey, have uncovered two megaron – type monumental buildings (Megaron A and Megaron B) with an open space, perhaps a central court, between them.

Megaron A consists of two parts, connected with a long corridor. The northern part consists of three large residential rooms and a court with columns. The southern part consists of ten small rooms used as workshops and storage rooms. Megaron A (measuring 36,50 x 12,00m) is surrounded by a group of small and large rooms, used for storage purposes. In one of these

storage rooms a large lead pithoid jar along with large clay storage jars was uncovered. In the corridor, which connects the two parts of Megaron A, clay and figurines, metal jewelers, and weapon, stone tools, clay and stone whorls were found, together with six stone molds, used for making jeweler and tools. A stone weight inscribed with Linear B was also uncovered.

A central court connects Megaron A with Megaron B. The latter is also surrounded by a group of storage rooms, within which a sherd inscribed with Linear B was uncovered. Megaron B was destroyed by fire at the end of the 13th cent B.C. and was abandoned. In contrast to Megaron A, there are no traces of re-occupation in Megaron B.

The two Megara (A and B) cover an area of 3.500m². The rooms have been identified as storage areas, workshops, cult areas and residence places. Excavations at Dimini are still in progress. According to the present data, we are dealing with an administrative center that controlled the production, the storage and redistribution of various products. This center reached its peak in the 14th and 13th cent. B.C. and had association not only with the rest of the Greek Mainland, but also with Asia Minor and the Levant.

Excavations were able to identify Mycenaean Dimini with ancient Iolkos. Together with the results of the geophysical survey and GIS it is possible to have a much more synthetic picture of the extent of the site and its environs. Moving a step further, a virtual reconstruction of the settlement is possible (Fig. 12), allowing researchers and visitors to obtain a more realistic view of the site as reflected in the myth of the Argonauts.

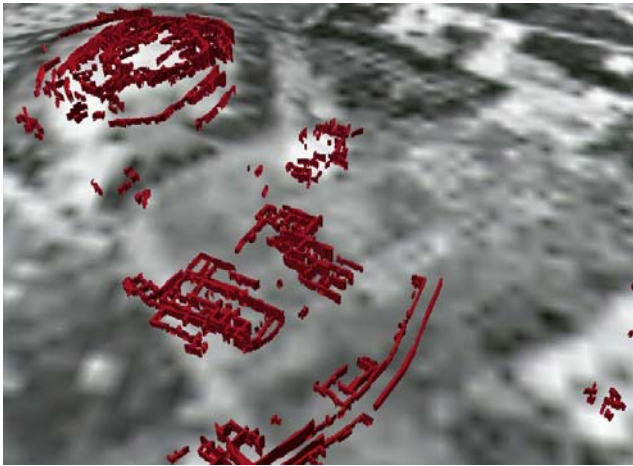


Fig. 12. Construction of a virtual reality model of the Mycenaean Dimini (ancient Iolkos).

Appendix A. Software: Processing of geophysical data was carried out with Geoplot and Surfer, while the GIS module of the project was achieved through the use of ArcView 3.2. Digitization of topographic maps was performed using Acad2000. Processing of the digitized data, together with the VR design and virtual flight component, was carried out using TNTMips software package.

References

- ADRIMI-SISMANI, V., 1992, O Mykenaikos Oikismos sto Dimini, in Proceedings of an International Conference for Ancient Thessaly to the memory of D. R. Theochari (Athens), 271-78.
- ADRIMI-SISMANI, V., 1994, H Mykinaiki Poli sto Dimini. Neotera Dedomena gia tin Archea Iolko, Proceedings of the meeting with title "Neotera Dedomena ton Erevnon gia tin Archea Iolko", May 12, 1993, Volos, p.17-45.
- ADRIMI-SISMANI, V., 1996, The Mycenaean town at Dimini: new data about Ancient Iolkos, *Incunabula Graeca* XCVIII3, 1295-1309.
- JOHNSON, A. C., SARRIS A., AMZA-PREIN M. E., 1999, "A New Interactive FFT-Based Grid Saturing Technique Applied to Ground Geophysical Surveys in Greece", *2nd Balkan Geophysical Congress and Exhibition*, Instabul, July 5-9, 1999.
- JONES, R & SARRIS, A., 2001, "Electronic Databanks for Mediterranean Geophysical Surveys: Expectations and Deliverables for Practitioners & Archaeologists", *4th Int. Conf. on Archaeological Prospection*, Austrian Academy of Sciences, Vienna, September 19-23, 2001.
- SARRIS, A., 1998, "Geophysical Issues in Archaeological Research: Paradigms, Uncertainties & Inferences", *invited talk at the International Symposium on Remote Sensing in Archaeology*, Boston University, Boston, U.S.A., 16-19 April, 1998.
- SARRIS, A. & JONES, R., 2000, "Geophysical and Related Techniques Applied to Archaeological Survey in the Mediterranean: A Review", *Journal of Mediterranean Archaeology (JMA)*, v.13, no.1, pp. 3-75, June 2000.
- SARRIS, A, ADRIMI-SISMANI, V., TOPOUZI, S., SOETENS, S., TRIANTAFYLLIDIS, F., KEVGAS, V., KARATHANASIS, CH., GIOUROU, A., TZANETEAS, K., MAVROUDIS, TH. , KARIMALIS, K., KARIMALI, E., PAPADAKI, A. & G. KRITIKAKIS, 2001, "Geophysical Prospection in Mycenaean Dimini, Magnesia (Greece)", *4th Int. Conf. on Archaeological Prospection*, Austrian Academy of Sciences, Vienna, September 19-23, 2001.