anomaly is outlined at the center of this suggested courtyard. To the north side of the courtyard, a long corridor is recognizable. This is not the case for the southern side of the complex, where its limits are not easily distinguished. Three internal divisions (rooms) are identified between the courtyard and the northern corridor, mainly from the GPR and the soil resistance measurements. Another elongated room is suggested on the eastern side of the complex.

FINAL REMARKS

Having a good responce from the surface surveying techniques, geophysical approaches proved extremely efficient in identifying a number of architectural structures most probably related to villas, farmsteads and agricultural installations. The geophysical survey proved a successful addition to the archaeological field survey of the territory of the Roman town of Aesernia to enhance the understanding of surface scatters of archaeological material, and the importance of the usage of multiple geophysical techniques (manifold approach, Sarris 2013) was clearly demonstrated. In some cases, such as site A232, the complementarity of the various techniques could be exploited in order to produce primitive 3D reconstructions of the various architectural compounds. In the next phase of the "Landscapes of Early Roman Colonization" project, a selection of sites in the research area around Aesernia (including the three examples given here) will be subject to a detailed intra-site study, using a high-resolution, gridded point sampling technique, in order to enhance the chronological and functional interpretation of the sites and to identify possible areas of internal functional zoning.

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Towards an integrated remote-sensing strategy for revealing the urban details of the Hellenistic-Roman city of Demetrias, central Greece

Apostolos Sarris[a], Jamieson Donati[a], Tuna Kalayci[a], Carmen Cuenca García[a], François-Xavier Simon[a, c], Meropi Manataki[a] and Pegky Triantafylopoulou[b]

KEY-WORDS: integrated geophysical survey, EM, GPR, magnetics, Hellenistic–Roman, Demetrias, urban, Greece

INTRODUCTION

The ancient city of Demetrias is located on a small promontory on the Pagasetic Gulf just south of the modern city of Volos. It was established by the Macedonian king Demetrios in 294 BC and became the royal residence of the Antigonid dynasty of Macedonian kings. The city flourished as a political center and as a stronghold for the Macedonian naval fleet. After the Romans defeated the Macedonians in 168 BC, a prolonged state of decline befell the city, but it continued to be inhabited until the 6th century AD. Organized along the lines of the Macedonian kingdom cities, Demetrias was a major strategic settlement in the region, as attested by its large extent, the expansive fortification walls that enclose a large area in the region, and its monumental architecture. A reconstruction of the city plan of Demetrias has been produced based on past excavations of the 1960s and 1970s by D. Theocharis and a group of German archaeologists (Milojić 1974; Milojić and Theocharis 1976; 1978; Milojčić *et al.* 1980; Einwanger 1981; Bakhuizen *et al.* 1987).

GEOPHYSICAL APPROACHES

Previous geophysical work in the area covered the region of the ancient theater which is well preserved (Sarris *et al.* 2013). The aim of our current research involved an expansion of investigation to other sections of the site and the creation of a best-practices approach to geophysical prospection.

High-resolution multispectral satellite images were employed together with excavation plans in order to reconstruct the layout and plan of the city. Based on this, various segments of the city were explored, via magnetic, soil resistance, electromagnetic (EM) and ground penetrating radar (GPR) techniques. In total, about 10 ha of the ancient city were covered, out of which about 5 ha was new coverage without overlap from the different methodologies. Depending on the accessibility and the vegetation of the areas, measurements of the magnetic field were carried out by both Bartington G601 (with sampling of 1 m x 12.5 cm) and a multi-sensor

[a] Laboratory of Geophysical–Satellite Remote Sensing and Archaeoenvironment (GeoSat ReSeArch Lab), Institute for Mediterranean Studies, Foundation for Research and Technology, Hellas (F.O.R.T.H.), Rethymno, Crete, Greece
[b] Archaeological Ephorate of Magnesia, Greek Ministry of Culture, Volos, Greece
[c] Plateforme Intelespace, Maison des Sciences de l'Homme, Clermont-Ferrand, France

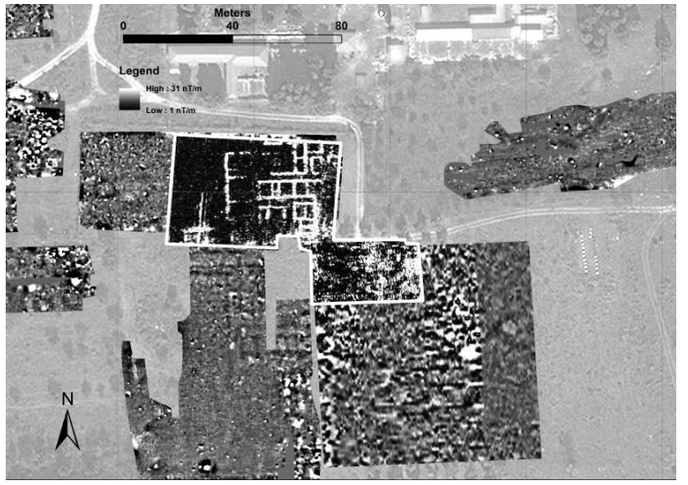

Fig. 1. Superposition of the GPR Noggin Plus 250MHz 0.8 m depth slice on the magnetic data acquired from the area to the south of the Hellenistic Palace of Demetrias. Data are overlaid on a WorldView 2 satellite image. The Hellenistic palace is shown in the upper right corner of the image.

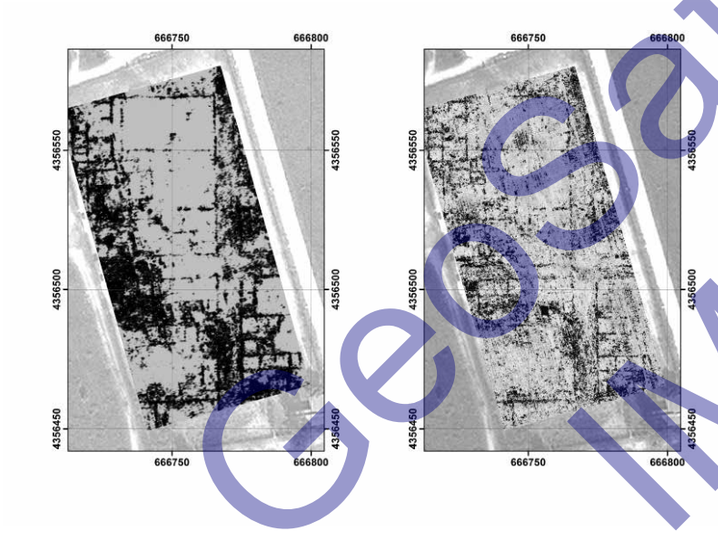

Fig. 2. Demetrias, area of the soccer field. Left: Depth slice of 0.8 m from the Noggin Plus 250MHz GPR unit. Right: Depth slice of 0.8 m from the MALÅ Imaging Radar Array 400MHz GPR unit. Dark colours indicate the most intense reflectors.

SENSYS Magnetometer MX system consisting of eight fluxgate gradiometers (with sampling of about 0.5 m x 10 cm) and a GPS rover unit. A single channel Sensors and Software NOGGIN Plus-Smart Cart system with a 250 MHz antenna and a MALÅ Imaging Radar Array with nine 400MHz antennas were widely employed within a number of flat sections, especially parking lots and soccer fields. Spatial sampling resolution was 0.5 m x 2.5 cm and 10 cm x 8 cm correspondingly for the above GPR units. Soil conductivity and magnetic susceptibility information were acquired via a GEM-2 multi-frequency and a CMD multi-coils spacing electro-magnetometer units (with sampling of 1 m x 1 m). Small sections were also investigated through a twin-probe-array Geoscan RM85 resistivity meter.

MAPPING OF THE URBAN STRUCTURE OF THE ANCIENT CITY

Due to recent activities in the area, deposition of modern debris increased levels of noise for magnetic measurements and vegetation density prevented the implementation of all techniques, especially GPR. On the other hand, multiple techniques were implemented in the better preserved areas. The geophysical results through the amalgamation of the various techniques have been extremely revealing in confirming the accuracy of the German city plan, providing evidence for new streets not included on the plan and identifying clusters of subsurface buildings, both large public and smaller private constructions, with great clarity.

Despite the surface distribution of metal and garbage debris, a number of linear anomalies became apparent from both magnetics and GPR to the west and south of the central excavated site, where the Hellenistic palace complex and agora are located (Fig. 1). Most notable is the group of structures located to the south of the palace, which consists of square and rectilinear rooms of various dimensions and long corridors. The western boundary of the complex has clear definition from a north–south wall identified in GPR and to a lesser extent with magnetics. The structural remains continue further to the west with a similar density, in contrast to any significant features found within the agora itself.

An even higher density of structural remains was found in the region east of the agora and southeast of the Hellenistic palace. Almost all methods (EM, magnetics and GPR) applied in the specific area where a dirt soccer field is presently located produced comparable outcomes with the most clarity and details resulting from the higher-resolution GPR surveys (Fig. 2). The data indicate that the region could have been a dense residential and commercial quarter of the ancient city, where structures were confined in blocks of about 50 m x 100 m and crossed by N–S and E–W streets of about 8.2 m in width. Within the city blocks, structural complexes seem to consist of various clusters of rooms and corridors with or without open yards. This kind of architectural arrangement is typical of Hellenistic and Roman urban houses with courtyards or gardens in the back and shared partition walls between houses (Rumscheid 1998; Zanker 1998).

Moving away (~400 m) from the center of the city and close to the modern shoreline in the northern region of Demetrias, geophysical data discovered the partial ruins of a large buried structure following the same alignment as the rest of the city plan. The structure consists of a semicircular (20–25 m radius) western half that is connected to a rectilinear (about 45 m in length) complex with individual rooms (Fig. 3). The semicircular exterior of the building has a corresponding semicircular feature 7–8 m inside. The southern end of the rectilinear complex

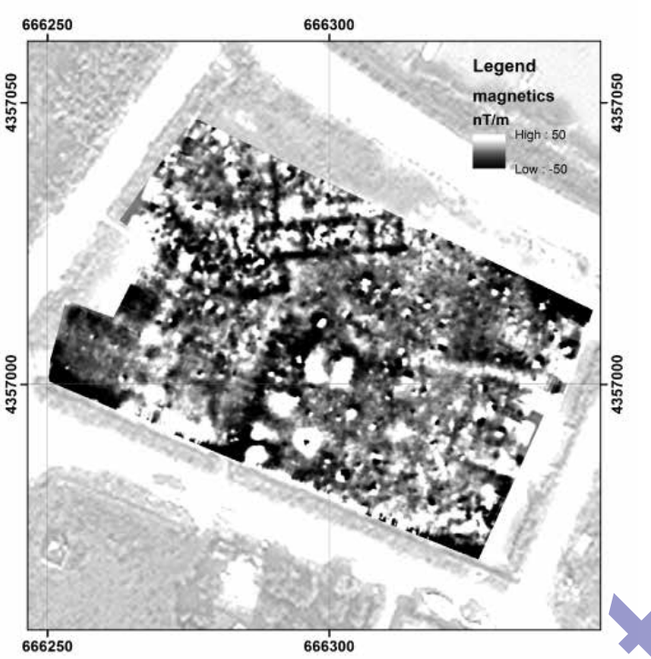

Fig. 3. Results of the SENSYS magnetic prospection from the field close to the shoreline

is subdivided into four rooms. The western room appears to have an apsidal end. North of these rooms, a large square area (courtyard?) appears in the geophysical data. The plan of the particular monument is suggestive either of a small theater with an attached portico or of a covered odeion, although a bath complex cannot be ruled out.

Overall, geophysical survey in Demetrias was more than revealing. It confirmed sections of the older German plan, identified various new features, blocks and roads, provided accurate details of the internal structural planning of the city blocks, and indicated the expansion of the city plan in areas that were completely unexplored. The resulting maps have contributed significantly to an understanding of the usage of the urban space in the Hellenistic and Roman periods, allowing comparisons with other similar cities in the Greek mainland.

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Cultural variations of the Neolithic landscape of Thessaly

Apostolos Sarris[a], Tuna Kalayci[a], François-Xavier Simon[a, d], Jamieson Donati[a], Carmen C. García[a], Meropi Manataki[a], Gianluca Cantoro[a], Georgia Karampatsou[a], Evita Kalogiropoulou[a], Nassos Argyriou[a], Sylviane Dederix[a], Cristina Manzetti[a], Nikos Nikas[a], Konstantinos Vouzaxakis[c], Vasso Rondiri[b], Polyxeni Arachoviti[b], Kaliopi Almatzi[b], Despina Efstathiou[b] and Evangelia Stamelou[b]

KEY-WORDS: geophysical survey, multisensor magnetic survey, EM, GPR, RM, satellite remote sensing, UAV, magnetic susceptibility

INTRODUCTION

The Neolithic period in Europe (6800–2000 BC) is widely considered a key epoch in the evolving relationship of human beings and their inhabitable environment. Groups of hunters and gatherers gave way to more sedentary agrarian societies involved with animal husbandry and the cultivation of subsistence crops. Various interdisciplinary studies have focused on

[a] Laboratory of Geophysical - Satellite Remote Sensing and Archaeoenvironment (GeoSat ReSeArch Lab), Institute for Mediterranean Studies, Foundation for Research and Technology, Hellas (F.O.R.T.H.), Rethymno, Crete, Greece
[b] Archaeological Ephorate of Magnesia, Greek Ministry of Culture, Volos, Greece
[c] Archaeological Ephorate of Karditsa, Greek Ministry of Culture, Karditsa, Greece
[d] Plateforme Intelespace, Maison des Sciences de l'Homme, Clermont-Ferrand, France