KAMARA

Archaeological Background

"Kamara" is a low magoula located in the southern part of the Almyros plain. It was discovered during the public works for the construction of the National Road "Athens–Thessaloniki" (1999-2000). The archaeological excavations conducted there revealed that it is a settlement of the Middle Neolithic period, which consists of two main building phases. Being a settlement with habitation limited to a specific period of time, it is a good example for the study of settlement patterns using geophysical methods and, of course, further excavation.

Satellite Remote Sensing and Historical Aerial Photography Survey

A WorldView-2 image from 19 September 2013 was used for satellite remote sensing at Kamara (Figure 1). The satellite image has an off-nadir angle of 4.1° and a ground sampling distance (GSD) of 0.50 m (panchromatic) and 1.87 m (multispectral). In addition to the satellite imagery, two aerial photographs were used for remote sensing: (1) 1971 (date unknown) with a scale of 1:20,000; and (2) 8 June 1982 with a scale of 1:30,000 (Figure 2).

Kamara lies in the Sourpi Plain, approximately 3-4 km wide and enclosed by high mountains. Rivers and streambeds pocket the region, and the National Road crosses from south to north. The highway stands only meters from the prehistoric settlement, and during its construction the eastern zone of the site was impacted negatively. The village of Drimonas lies on the western side of the valley, while Agia Triada and Sourpi are at the northeast. The majority of the agricultural fields appear to be used for wheat cultivation, but there are also olive and/or citrus orchards. Elevations around the target site range from 50-80 masl.

The aerial photographs show that the landscape around Kamara has changed dramatically since the 1970s (Figure 3). A major reorganization of agricultural land altered the valley in the late 1970s and early 1980s. Agricultural fields in the 1971 aerial photograph are small and do not follow a consistent orientation. The National Highway also does not impact the valley to the degree that it does today. The 1982 aerial photograph shows the culmination of land reorganization. Fields are much larger and share common orientations. Moreover, many rivers and streams have been filled up or diverted into canals. Palaeochannels are still visible even in the 19 September 2013 WorldView-2 satellite image. Cultivation in fields at Kamara is predominately focused on olive groves. However, the 1971 aerial photograph shows that other crops (apparently wheat) were planted here 40 years ago.

Satellite remote sensing within a 1 km radius around Kamara identified an extensive system of palaeochannels (blue) that once pocketed the terrain (Figures 4-5). High concentrations of palaeochannels are located all around the prehistoric tell and flow from west to east. It is noteworthy that one palaeochannel passes directly north of the settlement in a field that was mapped by geophysics (the field north of the olive grove) (Figure 6). Magnetics and electromagnetics found few anomalies here, probably as a result of the hydrological activity noted in the satellite imagery and even the historical aerial photographs. At any rate, at some time in the past, the area of Kamara was very active with running sources of water. Only one anomaly likely relates to the prehistoric settlement (yellow). A fuzzy (and incomplete) circular anomaly approximately 120 m in diameter was identified around the eastern portion of the site. No other anomalies in the target area appear to be from obvious archaeological features.

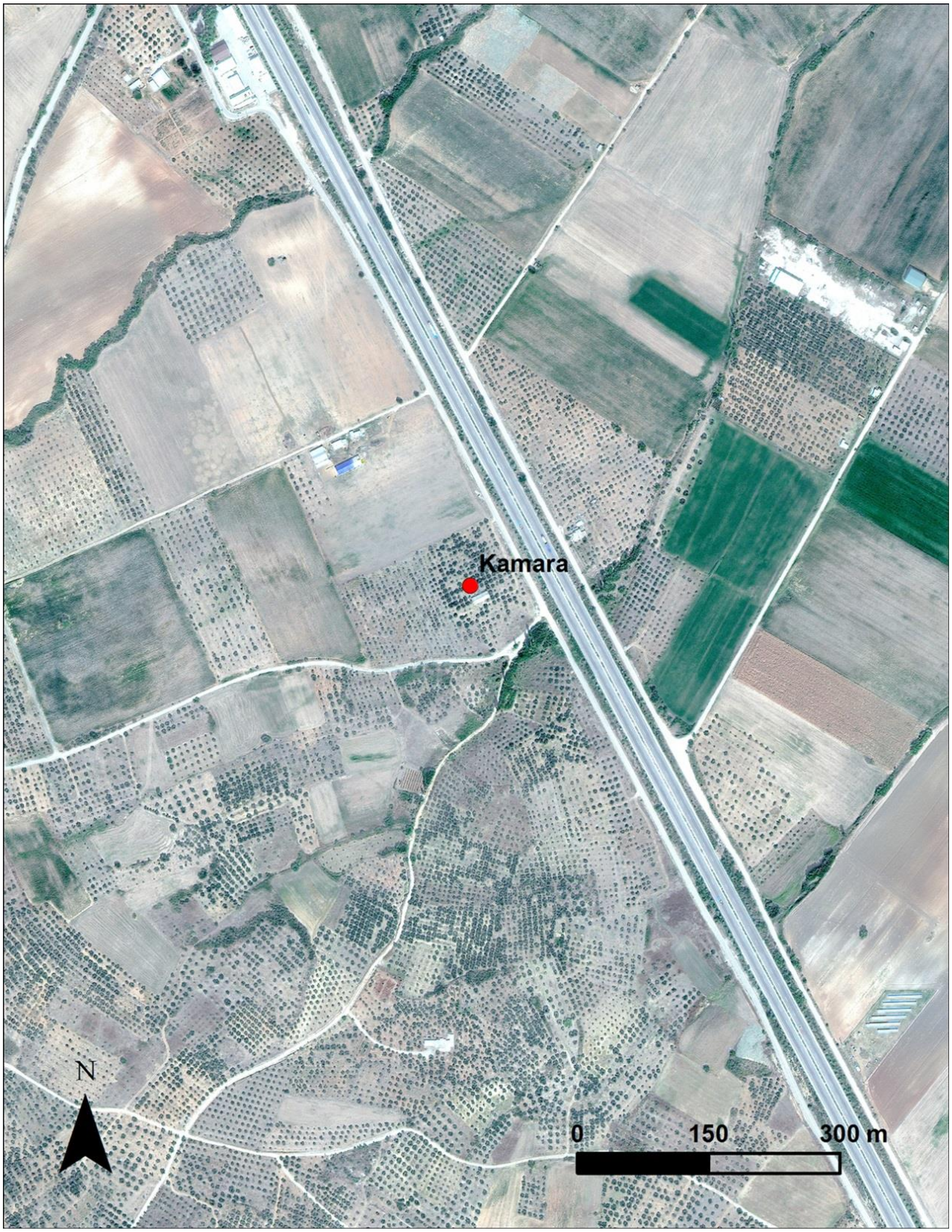


Figure 1: Kamara from a 19 September 2013 WorldView-2 image

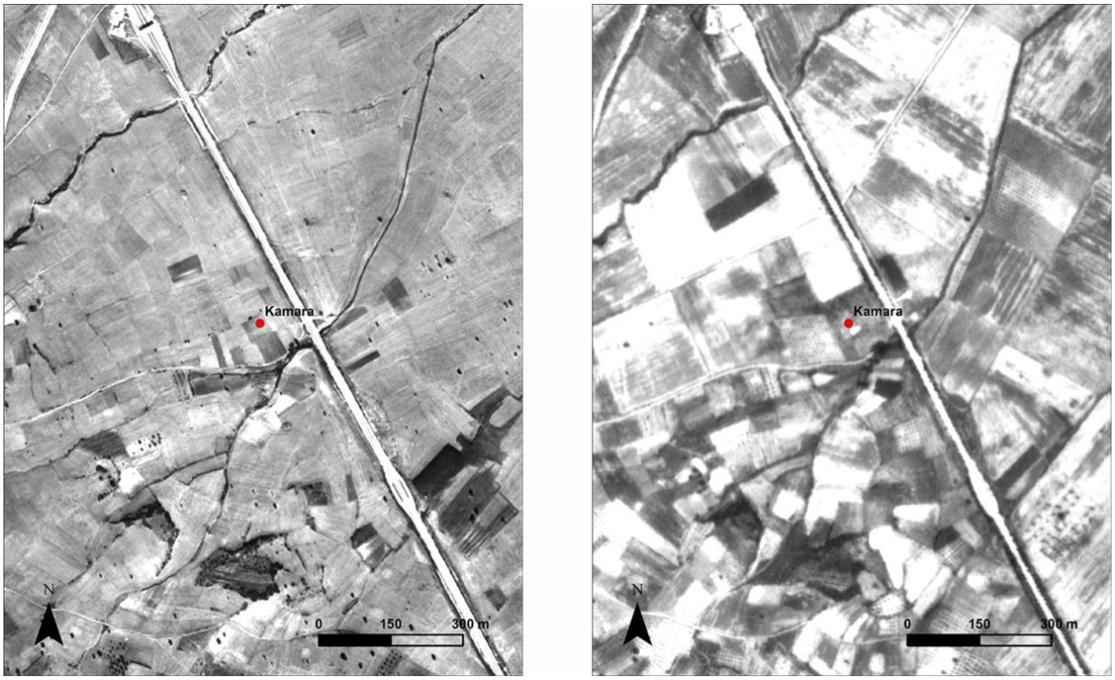


Figure 2: Aerial photographs of Kamara: (l) 1971; (r) 8 June 1982

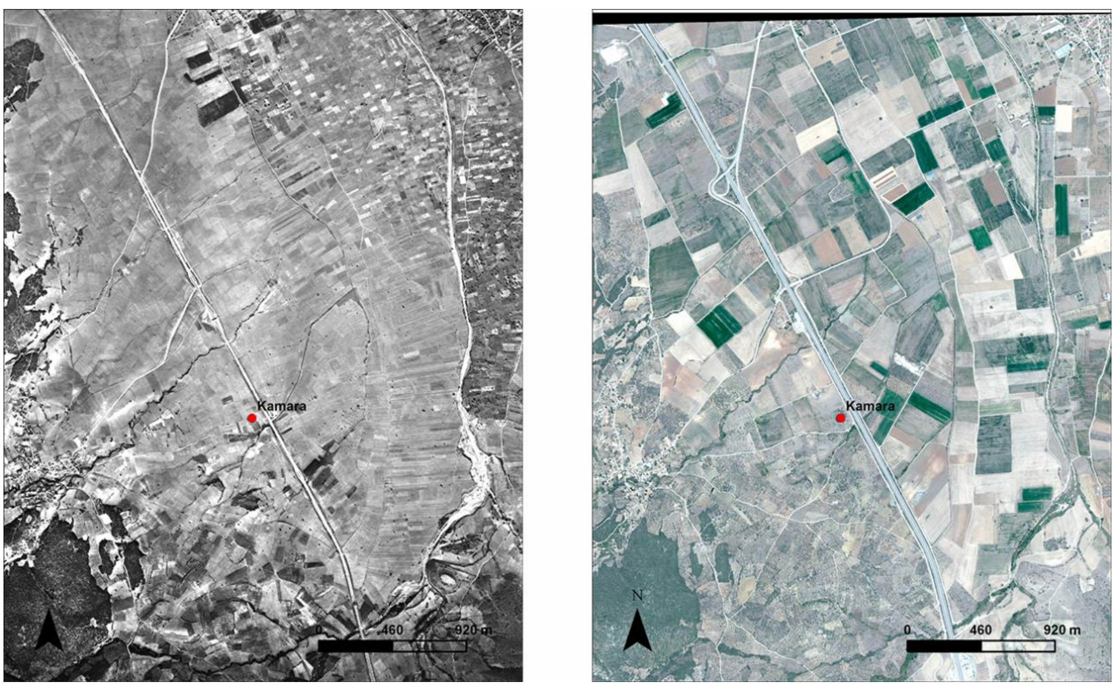


Figure 3: Kamara: (l) 1971 aerial photograph; (r) 19 September 2013 WorldView-2

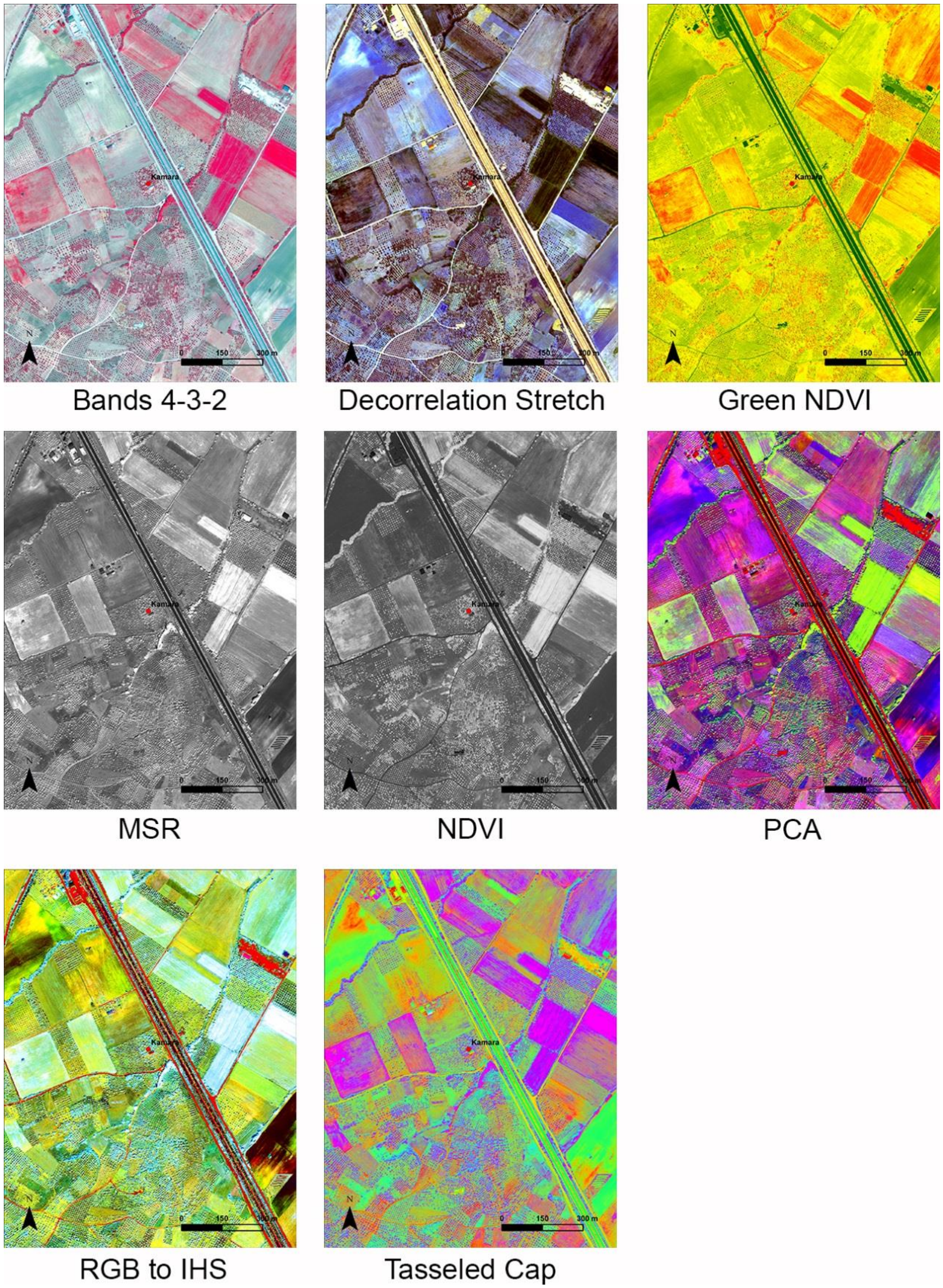


Figure 4: Spectral filters and vegetation indices applied to the 19 September 2013 WorldView-2 image around Kamara

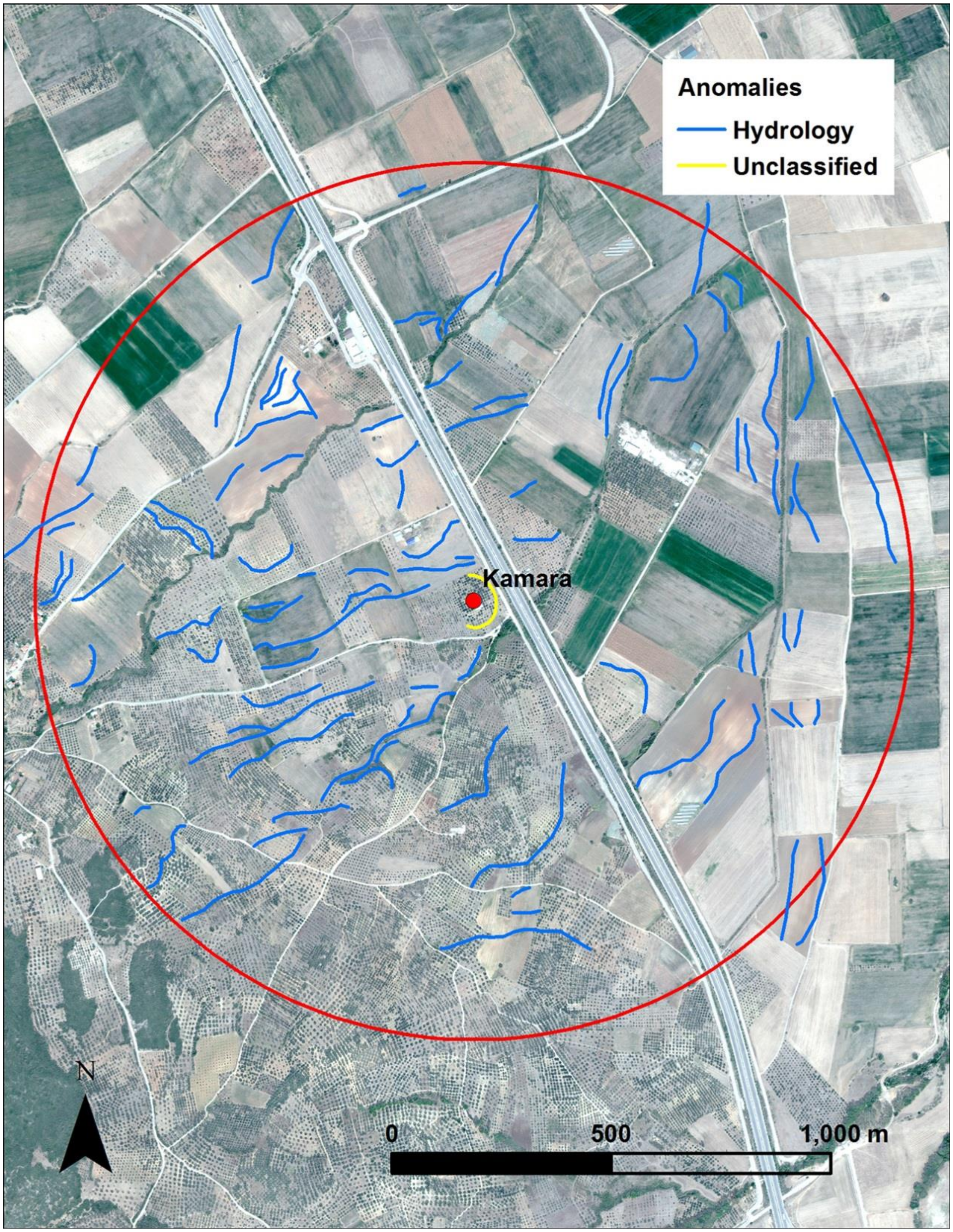


Figure 5: Surface anomalies from the 19 September 2013 WorldView-2 image within a 1 km radius around Kamara

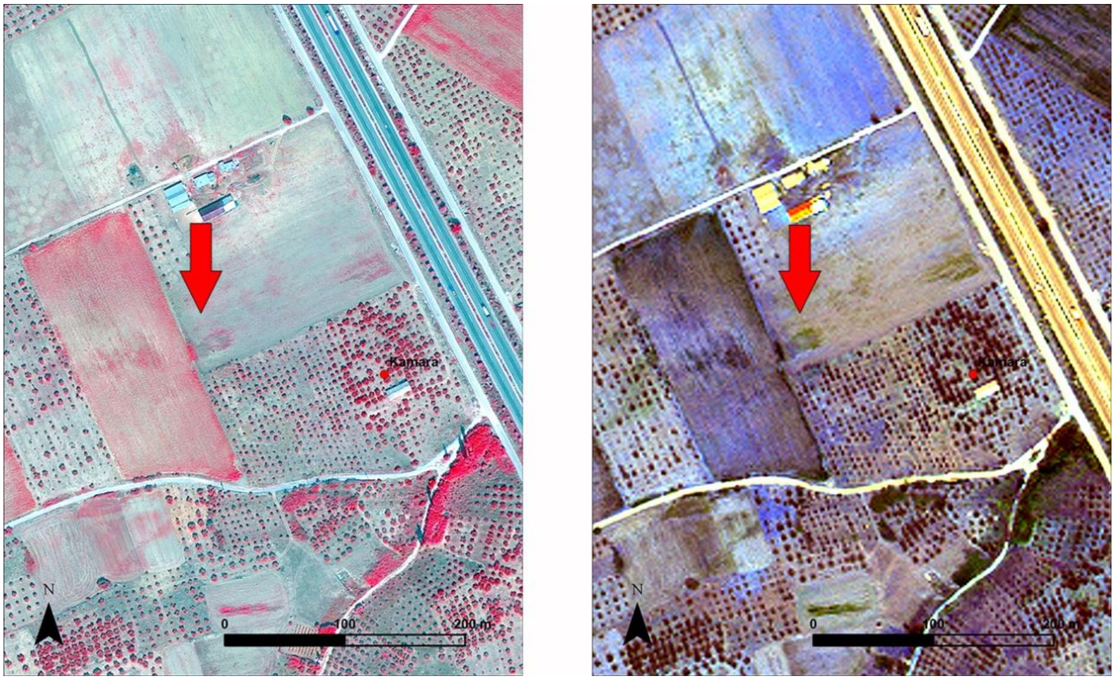


Figure 6: Palaeochannels visible in the field immediately north of Kamara from the 19 September 2013 WorldView-2 image: (l) Bands 4-3-2; (r) Decorrelation stretch

Geophysical Prospection

Geomagnetic Survey

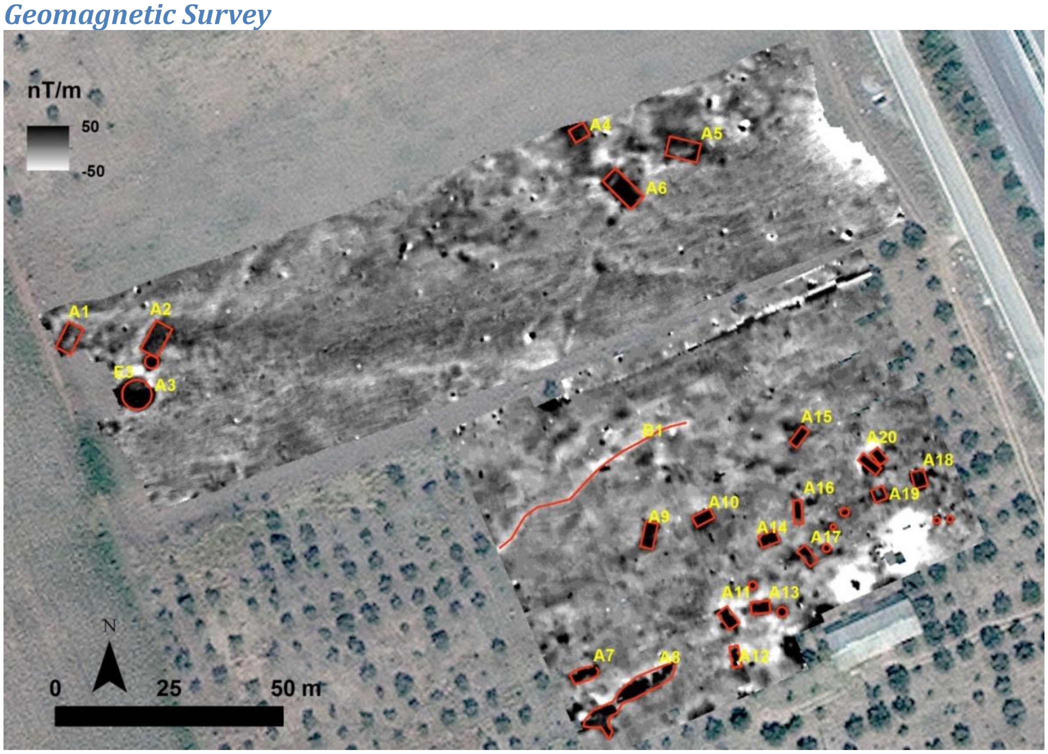


Figure 7: Results of the geomagnetic prospection

Geomagnetic survey was performed using a SENSYS multisensor system (northern section) and Bartington Grad601 gradiometers (southern section). Gridded survey was performed due to the infeasibility of using the large multisensor array in the orchard. Regardless, both instruments provided satisfactory results and complement each other. The interpretation below is provided independent of the system.

In the northern section, at least six positive magnetic anomalies are detected. Shapes of these anomalies are not clear, but they mostly appear to have rectangular bounds, other than A3. The wide gap in between these magnetic anomalies suggests past destruction of the site, further deposition after the abandonment, settlement shift by time, or selective land use.

The southern sector is richer in terms of the occurrence of magnetic anomalies, suggesting denser occupation in this area—assuming identical taphonomic processes in both areas. Results from the southern zone suggest modern vegetation has little impact on magnetic readings—other than survey logistics. A11, A12, and A13 together form a cluster and might be considered as the "core" of Kamara. Other anomalies are concentrated to the northeast of this "core", albeit without a decipherable settlement pattern. Another interpretation would be to consider A11, A12, A14, A16, and A20 as the anomalies at the border of the settlement even though there is no visible enclosure at the settlement. If this interpretation is correct, then the modern building sits at the center of the ancient settlement and Kamara further extends to the south of this building.

Electromagnetic Induction Survey

EM survey was conducted with the GEM2 from Geophex using 5 frequencies. We did a profile each 1 meter with a GPS positioning. Data acquisition was done on the north part of the olive field. The data were processed in order to map the electrical conductivity and the magnetic susceptibility. Results are presented in Figures 8 and 9.

The map of magnetic susceptibility shows two kind of information. First, there is a global variation in the direction of the palaeochannel as it is observed in the satellite images. As expected, the border of the channel presents a higher magnetic susceptibility than the center of the channel. This difference comes probably from the finest grain which is deposited on the side of the main stream.

The second kind of anomaly looks like the ones also observed on the magnetic map. The high value of magnetic susceptibility for such anomalies probably corresponds to archaeological remains. Nevertheless, they do not present a clear organization in this peripheral area, in contrast with what we observed under the olive trees through the magnetic measurement.

The electrical conductivity map does not show any clear archaeological features. On the east side of the map, we observe an area with strong noise. This could be explained by the proximity of the road (i.e. being a preferential area to dispose of construction waste from the road), or by the proximity of a power line. The value of the electrical conductivity is low (closer to 10 mS/m). These low values are probably induced by a dry clay soil close to the ground surface. Only regional variation of conductivity is visible. These variations are close to the magnetic susceptibility variation. They probably come from the palaeochannel and different sedimentary fillings.

Figure 8: Results of the magnetic susceptibility

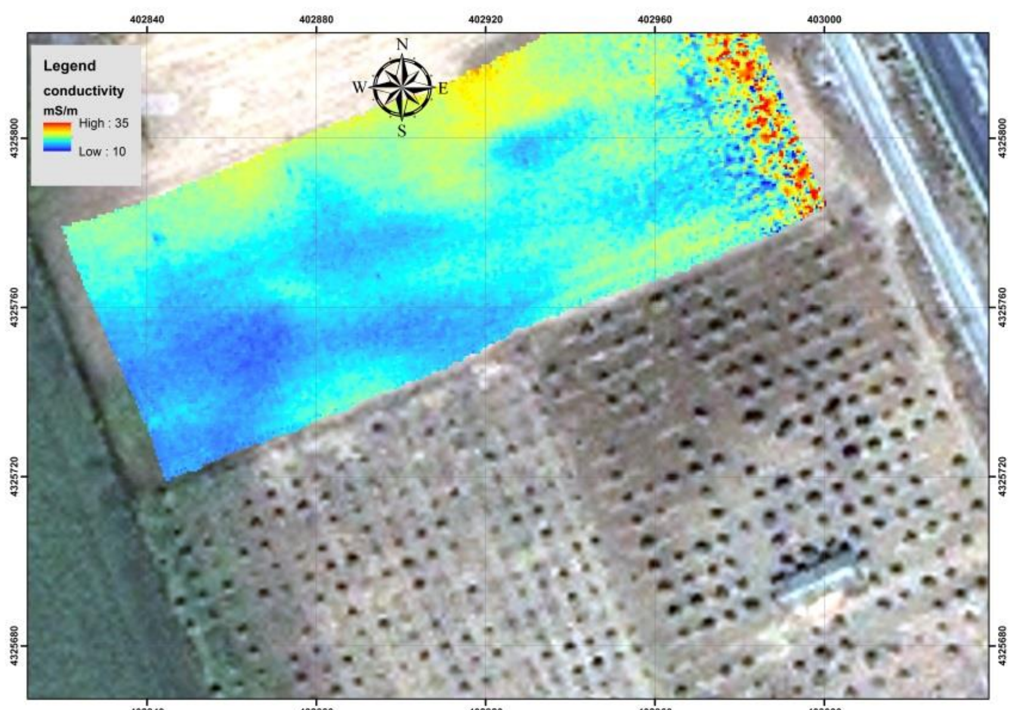


Figure 9: Conductivity map from Kamara

Ground Penetrating Radar Survey

The area covered by GPR at Magoula Kamara is 1000m^2 and presented in Figure 7. The resulting slices are summarized in Table 1. The processing flow that applied at the collected data is: Trace Reposition, Repick first break (5%), Dewow, Sec2 (Atn=25.83 dB_m, StrtG=5,MaxG=985), Background Average Subtraction, Bandpass filter (Fc1=40 % Freq, Fp1=80 % Freq, Fp2=160 % Freq, Fc2=200 % Freq), Lowpass(f=50 % Nyquist), Highpass filter (f=30 % Nyquist). In contrast with other methods, such as magnetics, the GPR results in this area are not clear, as the visible reflections have small dimensions and are located irregularly in space. Thus, the interpretation of the GPR results was done regarding the magnetic results.

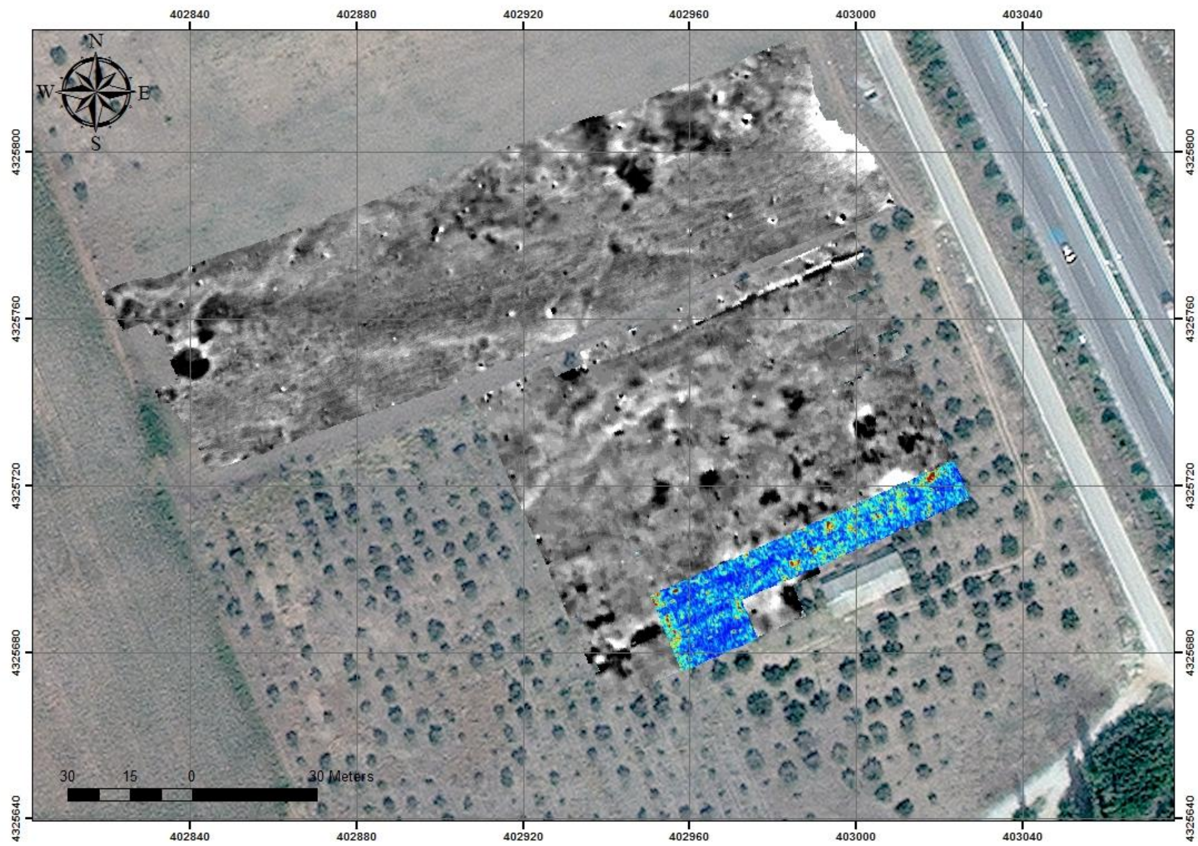
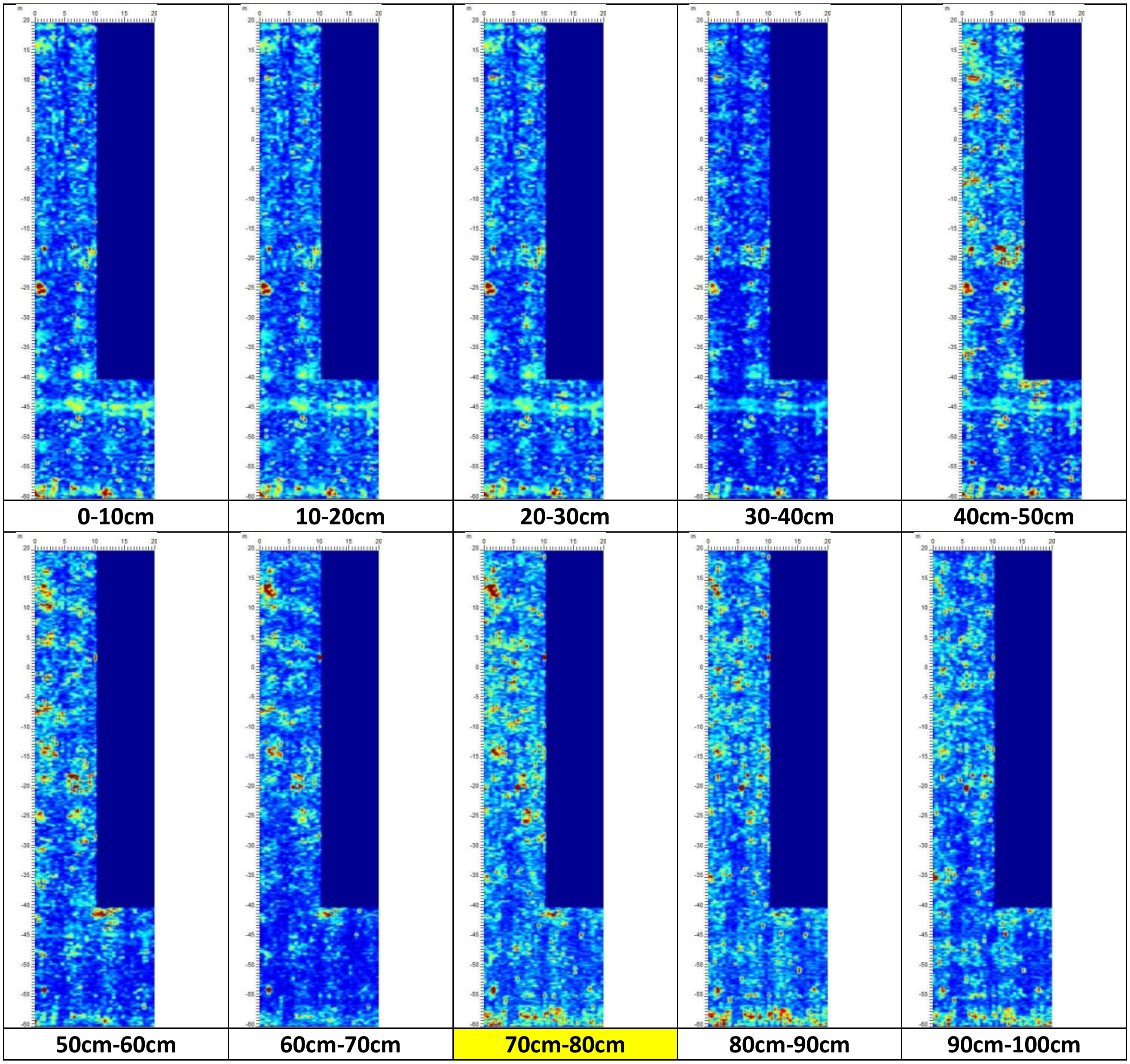


Figure 10: GPR grids position regarding the area covered with magnetics at Magoula Kamara.



0-10cm
10-20cm
20-30cm
30-40cm
40cm-50cm
50cm-60cm
60cm-70cm
70cm-80cm
80cm-90cm
90cm-100cm

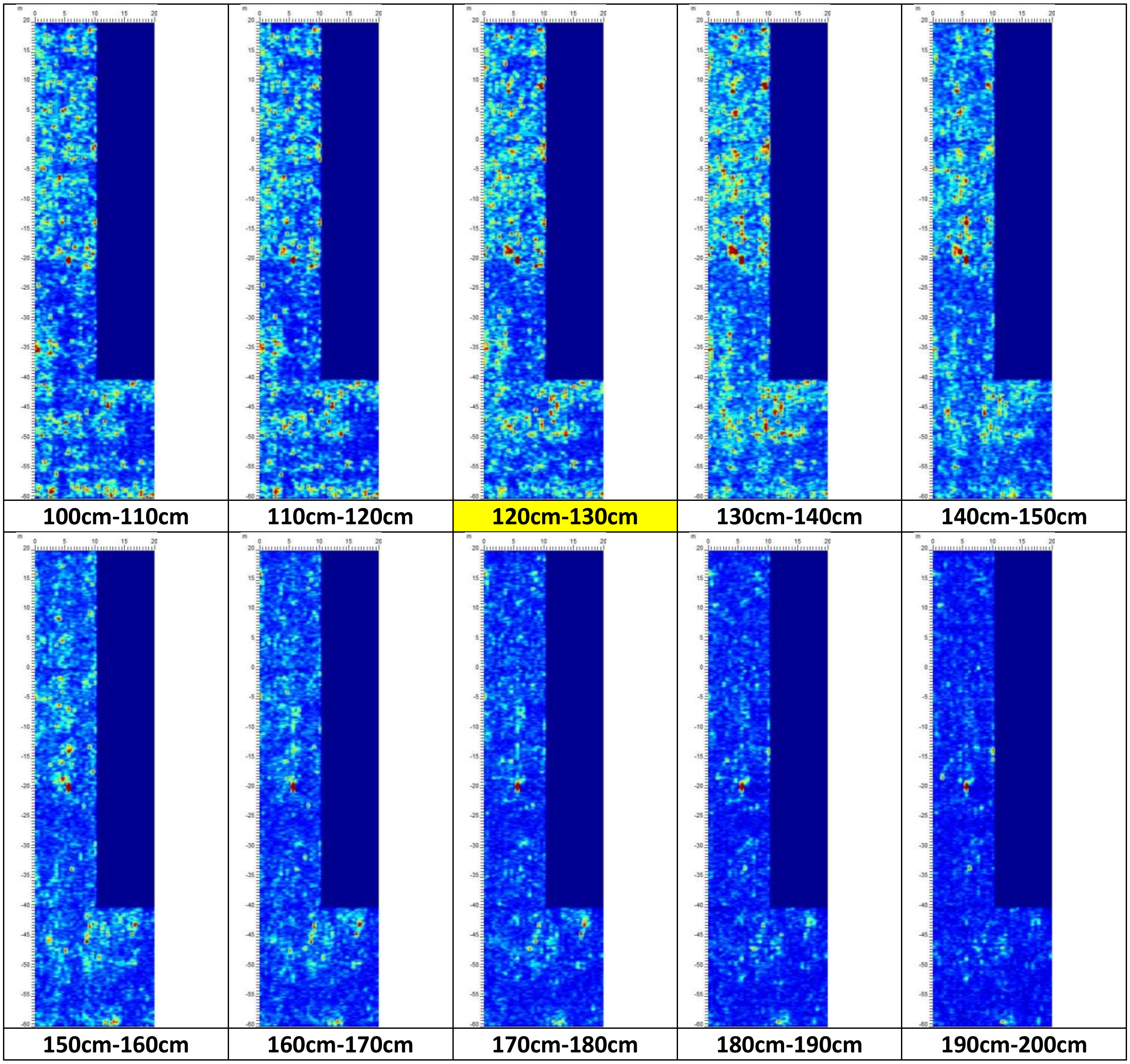


Table 1: GPR depth slices for the grids with code names M1, M5, M9, and M13 at Kamara with 10cm thickness.

In Figure 11, the georeferenced GPR slice at 70-80cm depth is presented, along with the magnetic results and their interpretation (red color). Two GPR reflections are identified with the magnetic results: A12 and A21. The anomaly A12 has an irregular shape and is visible within the range 40-80cm. This anomaly is placed in the same position as a strong rectangular magnetic anomaly, which could be assigned to structural remains. The strong reflection A21 shows up within the range 40-90cm, has irregular shape, and appears also in the magnetic results as a weak anomaly of similar shape.

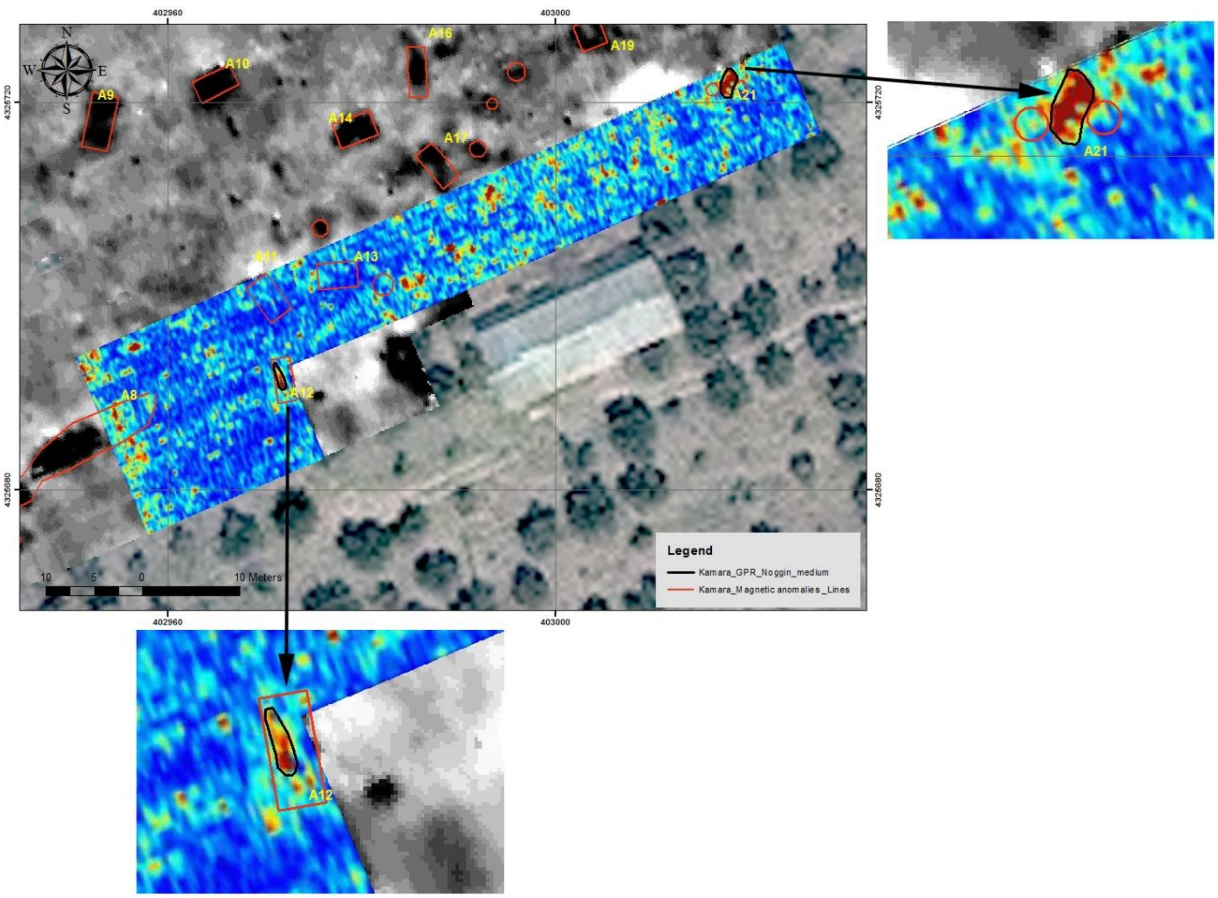


Figure 11: Georeferenced GPR slice at 70-80 cm depth along with the magnetic interpretation.

Resistance Survey

Due to limited coverage, resistance survey at Kamara does not provide substantial evidence in terms of settlement organization and distribution of anomalies. However, it is valuable for its comparison with the geomagnetic results. The high-resistance anomaly aligned at the southern boundary of the grid appears to be the continuation of linear magnetic anomaly B1. The resistance values increase to the north and focalize at the center of the grid, but are more pronounced at the northeast corner in two blobs. In these high resistance areas, geomagnetic survey is not homogenous, but quiet in terms of the occurrence of anomalies.

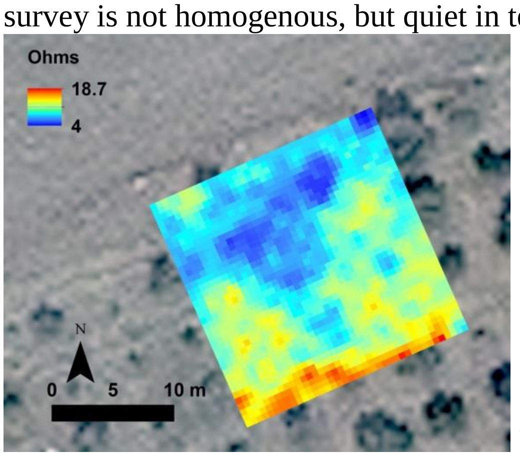


Figure 12: Results from the single resistance survey grid

Vertical Electric Sounding

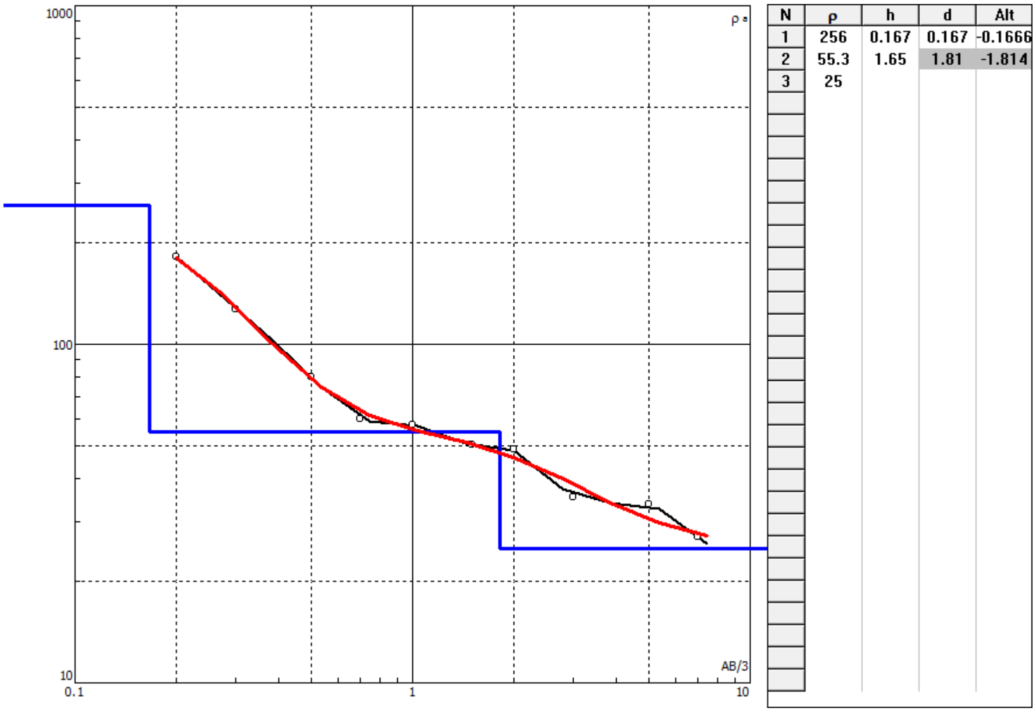


Figure 13: VES results from Kamara

The vertical electrical sounding can be explained by a three-layer model with a decrease of resistivity with depth. The first layer presents a high resistivity, probably coming from the dry clay soil, and then the resistivity decreases to reach a very low value of 25. This distribution could correspond to a clay soil with different water content.

Integration of Geophysical Results

Magoula Kamara is located on the southeast border of the Thessalian plains, close to the village of Drimonas. As is indicated by the surface sherds, the site has been most probably divided by the course of the national road that leads from Paralia Pelasgias to Mikrothives. The geophysical survey of the site was carried out in the section west of the national road, which was slightly elevated and covered by an olive grove. Part of the site to the north was cultivated.

The geophysical investigations at Magoula Kamara made use of magnetic (SENSYS and Bartington G601), soil conductivity/magnetic susceptibility (EM GEM2), and GPR (Noggin Plus 250MHz) techniques. A 20x20 m grid was also covered via soil resistance (Geoscan Research RM85, Twin Probe, a=1 m) methods. The largest coverage of the site was accomplished though the magnetic survey that scanned more than 15,000 square meters. Only the north section of the site was covered with EM techniques. The south section, where the olive grove was extended, was covered mainly with the Bartington 601 fluxgate gradiometer and a few sections close to the modern concrete structures to the south with the NogginPlus GPR unit.

Soil magnetic susceptibility, soil conductivity, soil resistivity, and GPR were not that successful in producing significant subsurface features. Soil magnetic susceptibility data derived from the

GEM2 unit indicated a few areas of increased values towards the northwest section of the surveyed region (E1, E2, E3, and E4), a few which coincided with magnetic anomalies (A1, A2, and A3), which may be indicative of human habitation. Similar kinds of features were suggested from the magnetic data of the northeast side of the surveyed field (A4, A5, and A6). Interestingly enough, there is a complete absence of features in both the EM and magnetic data between these two clusters of anomalies. The highest density of magnetic features has been indicated to the south section of the site, where the higher elevation and density of sherds are encountered. Most of these features (A9-A20) seem to represent daub-made structures, probably burnt, and oriented in a random direction. In general, these structures have similar magnetic signatures to those to the north, but they are of smaller dimensions (~5x3 m). Considering the semi-oval layout of the structures, it seems that the image we have obtained has captured half of the core of the magoula. The rest of it probably extends further to the south, where some modern structures have been built.

A few other intense anomalies to the southwest (A7 and A8) do not have any geometric shape, and it is not certain if they are of anthropogenic origin. An elongated feature (B1) running for more than 50 m in an east-west direction to the north of this dense cluster of structures is also obvious in the magnetic data, even though its traces are lost as we move further to the east.

Taking into account the acquired anomalies of the site, we may suggest that the particular site consists of the core settlement to the south and some possible neighborhoods to the north. It is also worth mentioning that to the north and south of the settlement, two channels seem to cut through (in a southwest-northeast direction) at a distance of 400 m and 50 m, respectively.

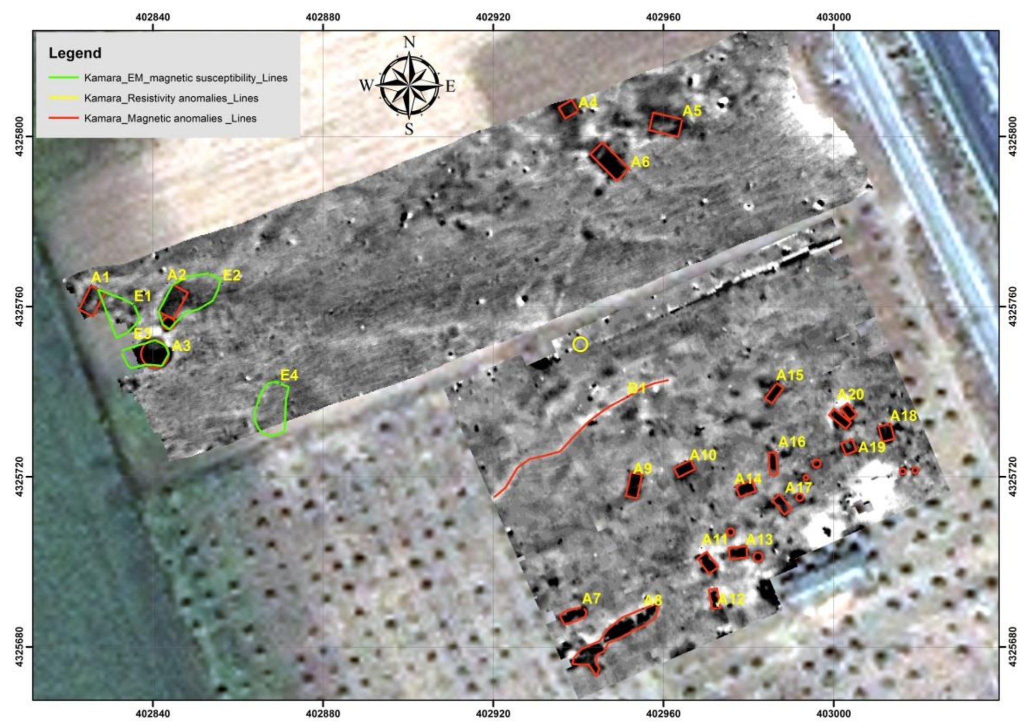


Figure 14: Anomalies from different geophysical methods

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