Karatsangliou

Archaeological Background

Magoula Karatsagliou is located nearby a seasonal stream. The site has not been subjected to any known antiquarian activity, and the first archaeological studies recorded for the site are field surveys carried out the IG' EPKA during 2007 and 2008. This revealed evidence of habitation in the Later Neolithic (5300 – 4500 BCE.).

Satellite Remote Sensing

A Quickbird image from 15 June 2009 was used for satellite remote sensing at Magoula Karatsangliou. This satellite image has an off-nadir angle of 8.9° and a ground sampling distance (GSD) of 0.63 m (panchromatic) and 2.50 m (multispectral). As one can observe in the satellite imagery, the magoula lies within agricultural fields immediately east of the Athens-Thessaloniki National Highway and next to an industrial plant (Figure 1). The Anchialos Airport is less than 2 km to the southeast and the modern coastline is just over 5 km from the prehistoric settlement toward the east. The landscape around Magoula Karatsangliou is dissected by many rivers and stream beds. One of these rivers passes along the northern side of the magoula forming a deep ravine, while a smaller seasonal stream flows to the south. Today, the area is predominantly used for wheat cultivation, and in the Quickbird satellite image the harvest appears to have recently concluded. Fields further to the southwest are used for grape and olive tree cultivation.

Satellite remote sensing within a 1 km radius around Magoula Karatsangliou produced minimal results. The main area of the habitation mound did not generate any recognizable anomalies that would give any indication of the parameters of the site or its immediate periphery. This was the case in all of the feature enhancement indices (Figure 2). A handful of anomalies related to palaochannels (blue) and agricultural activity (brown) were identified further beyond the settlement mound. For example, PCA clearly shows Anomaly #42 as a palaeochannel. A few other anomalies (yellow) are uncategorized. The possibility that any of these other anomalies are related to prehistoric settlement activity in the region is minimal.

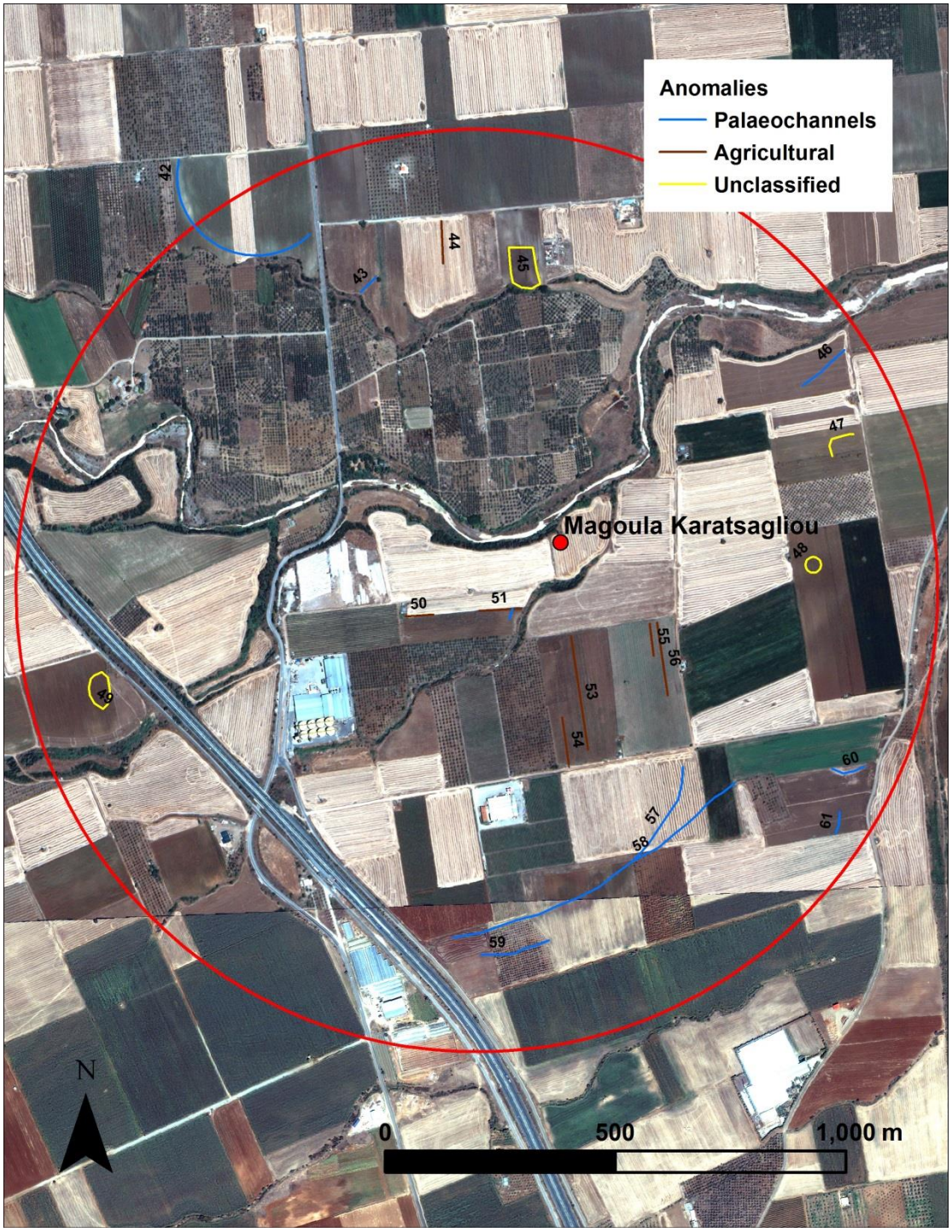


Figure 1: Quickbird image of Magoula Karatsangliou

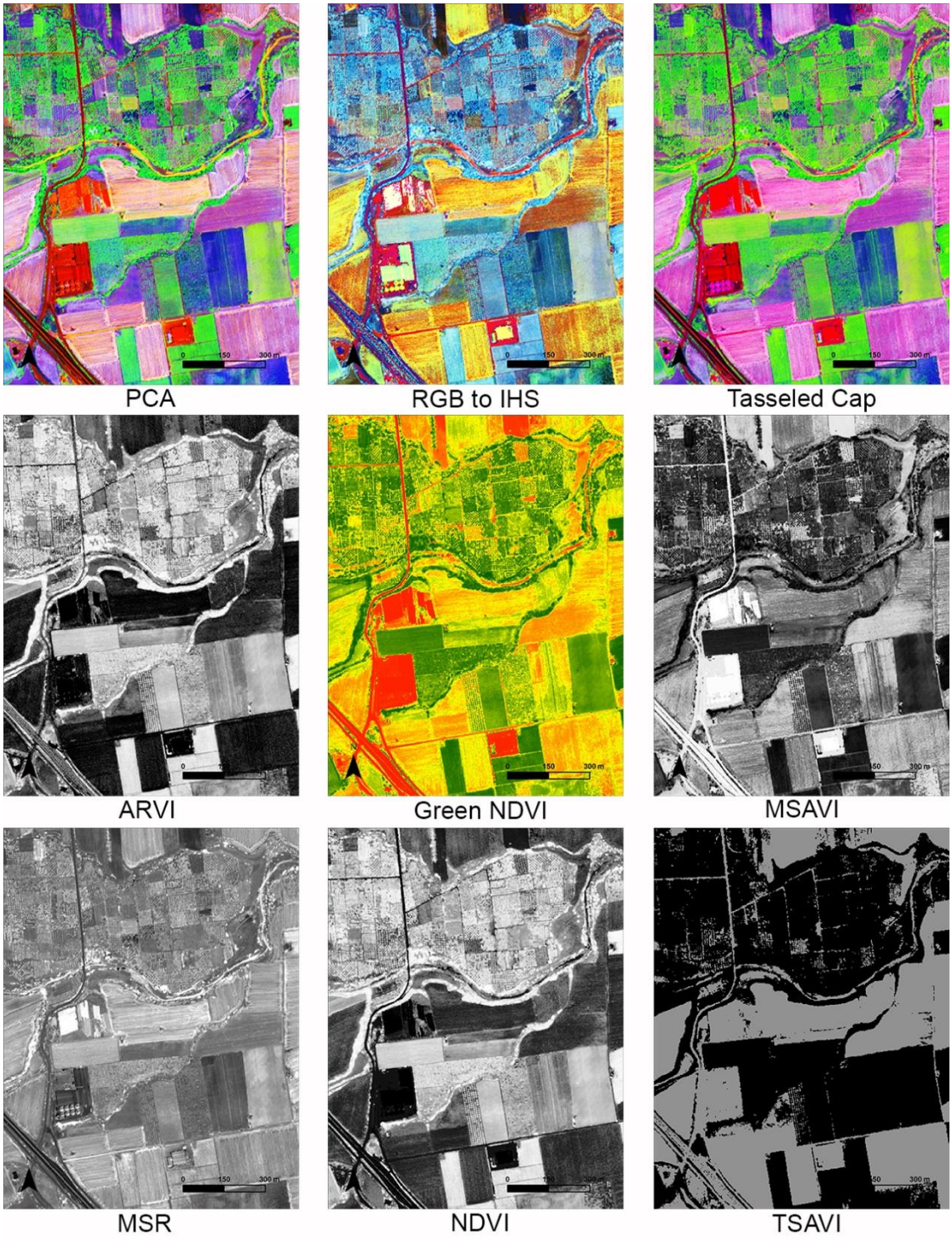


Figure 2: Quickbird enhancement indices for Magoula Karatsangliou

Remotely Piloted Aircraft Systems (RPAS) Survey

The location of Magoula Karatsangliou has been covered with one single flight with Remotely Piloted Aerial System equipped with a regular RGB camera. The camera, a Canon Powershot s100, has a built-in GPS system capable of recording the position of each photograph. Thanks to the CHDK Canon system –which allows for specific parameters to be used for each photograph on an automated base– photographs could be taken at a regular interval (4 seconds lapse). A total of 165 images were collected (during the almost 14 minutes of flight) and almost all of them could be used for photogrammetric restitution. A few frames were excluded because they were too blurry or because they shot on the ground (waiting to take off) or during landing procedures. The average flight altitude was about 150 meters (a.s.l.). A total of about 12 hectares could be photogrammetrically reconstructed.

The images below, show the resulting orthophoto and digital elevation model (Figure 3). The RPAS photographs were taken in November 2013, when fields were already ploughed and no new vegetation was growing. Consequently no vegetation stresses could be analyzed and the potential soil-marks were also compromised by the recent agricultural activities. Only a single discoloration could be located at the edge of the topmost part of the investigated area. The image below shows this circular trace after some color enhancement (Figure 4)

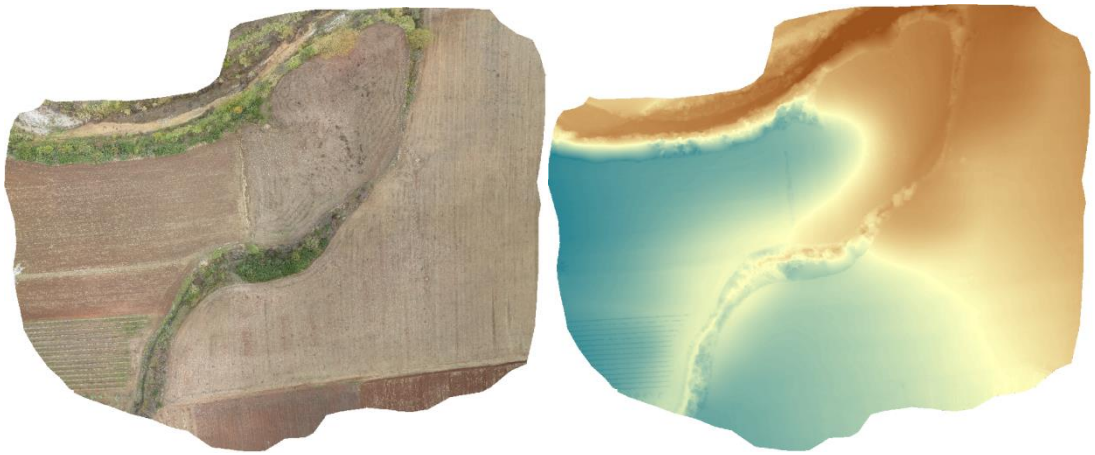


Figure 3: Orthophoto and DEM from photogrammetric processing. Photos of 17.11.2013.


Figure 4 Circular discoloration at the edge of the top-most area of the site.

Considering the general morphology of the area and the apparent absence of structures of that thickness from geophysical prospection (discussed below), it is realistic to consider this discoloration as the result of a lower soil layer, made visible by the erosion on the NE side of the magoula. This layer shows up as being almost parallel with the top-soil, as highlighted in the water level simulation below.

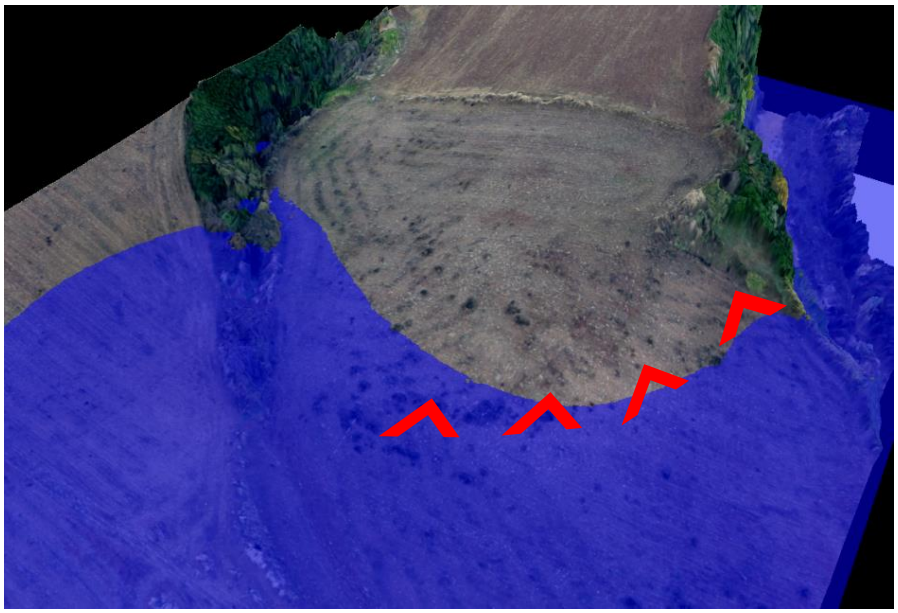


Figure 5: Water level simulation (along the 51 meters contour) looking from NE. The discolouration is clearly not horizontal since it "sinks" towards the left-end side of the image.

Geophysical Prospection

For the investigation of Magoula Karatsangliou, magnetic prospection (SENSYS-MX), GPR (NOGGIN), and electromagnetic induction (GEM-2) were used. The coverage per methodology and the total coverage are:

Methodology	*Coverage*
Magnetic	3.00 hectares
GPR	0.20 hectares
EM	1.20 hectares
Total	4.40 hectares

Geomagnetic Survey

Figure 6: Geomagnetic prospection results

Magnetic data at Karatsangliou cover two main areas. Survey coverage was determined based on surface pottery distributions. The larger area to the north has wider coverage and is separated from the southern portion with ditch which has been incised by a seasonal creek (See Aerial and Satellite Remote Sensing sections above).

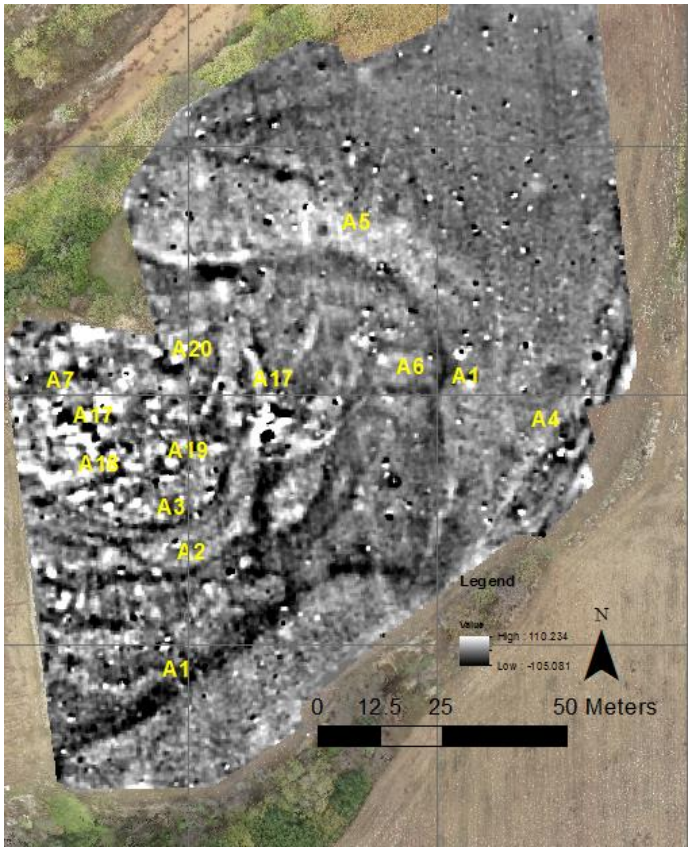


Figure 7 Geomagnetic prospection results at the core of the settlement

The northern area can be further classified into two sections based on magnetic readings. The inner core has higher data heterogeneity and is magnetically busier. A contiguous curvilinear anomaly (A1) separates these natural and cultural deposits from quieter areas to the east and south. The magnetic signature of this anomaly drops towards the east. The core of the magoula seems to be confined within the almost circular shape of anomaly A3 that has a diameter that spans from about 41 to 47m. A number of features are evident within the core of the magoula (A17, A18, A19 and A20). All of these anomalies indicate extreme values of the vertical magnetic gradient but their lack of a clear outline indicates poor preservation conditions of the causative features. To the east and west, the magnetic data suggest some interruptions (A7 and A17) to the inner enclosure of the magoula, which may be correlated to entrances. Specifically, to the west of A7 a linear anomaly (A14) extents for more than 72m and arrives at A13. Feature A2 is magnetically similar. It is possible that A1, A2 and A3 constitute 3 enclosures of the magoula, with the outer one (A1) also constituting defensive construction against periodic flooding from the nearby meanders that extend to the north, east and west of the magoula.

Anomaly A5, extending to the north of A1, does not have a distinct geometric shape, but instead it represents a fuzzy area of increased magnetic values, probably resulting from the concentration of organic material due to the flooding of the meanders. Another magnetic feature (A6) runs perpendicular to A1 and it may represent an outer entrance to the magoula as it is oriented to the same direction to A17. Outside of the outer enclosure (A1), a few anomalies appear. That at A4 may indicate residues of the flooding zone by the SE meander.

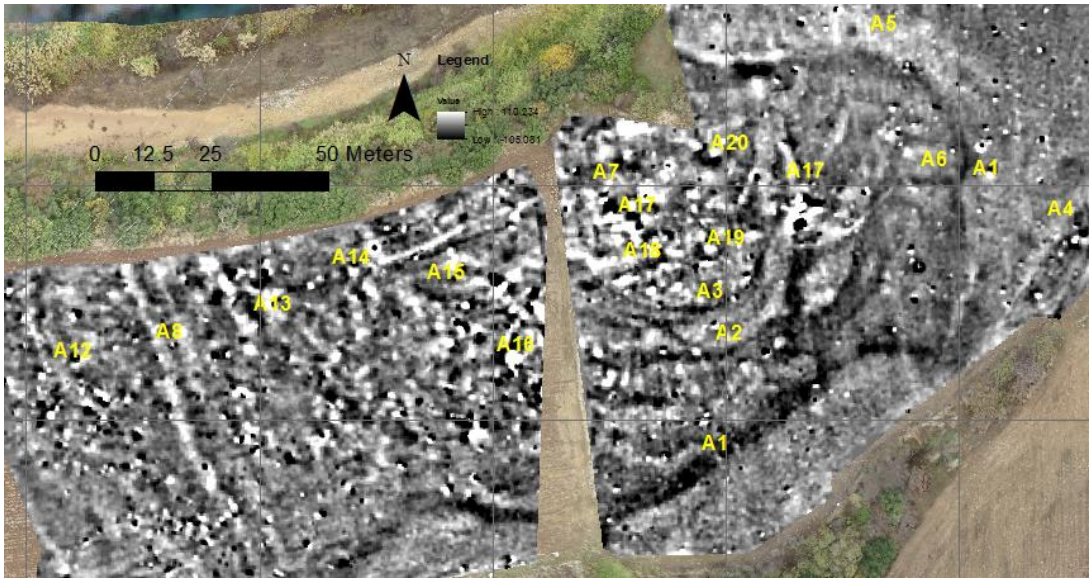


Figure 8: Geomagnetic results extending to the west

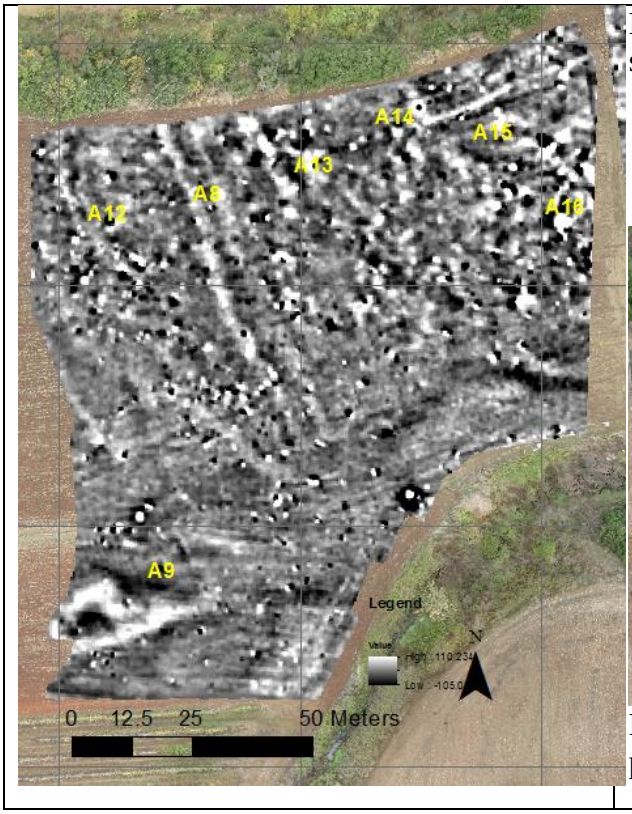


Figure 9: A focus on the western section

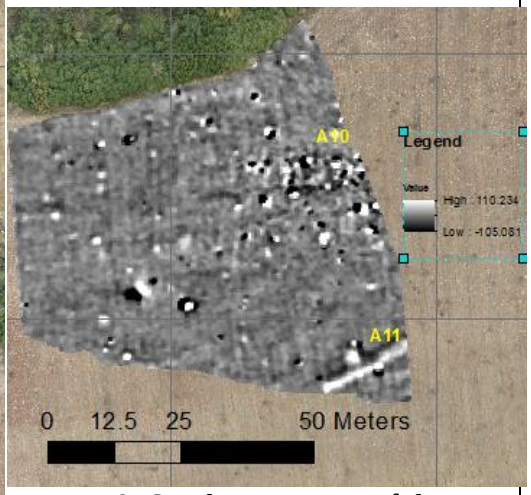


Figure 10: Southern portion of the prospection

Anomaly A8 to the west consists of two highly magnetic linear responses running in parallel (6 meter apart) which may have been caused by recent activities. Anomaly A9 to the SW has large dimensions (~15m by ~9m) with an extension towards east for another ~10 meters. There is not enough contextual information to fully decipher Anomaly A9, but its rectangular shape immediately suggests it is of anthropogenic origin.

The southern area is devoid of architectural anomalies. A rectangular feature (Anomaly A10) is located at a distance of about 70m from the outer enclosure of the magoula (A1) and even further to the south another linear feature (A11) becomes visible. There is not enough contextual information for these anomalies as they are far away from the magoula. The rest of the region to the south is relatively quiet, with no further evidence of habitation.

Electromagnetic Induction Survey

We used the GEM-2 from Geophex with 1 m profile spacing. Electromagnetic data in Karatsangliou reveal anomalies akin to magnetic prospection. The seasonal creek is perhaps responsible for the high conductivity responses on the sides of the: these could be fluvial deposits. The higher conductivities correlate with some of the linear magnetic features (A1 and A5), and thus they might be being caused by the fluvial material having different magnetic susceptibilities than the rest of the soils on site.

The magnetic susceptibility results are not very clear but the dataset provides some new information. For example, Anomaly A4 which corresponds also to an anomaly of higher magnetic susceptibility, maybe a ditch, unlike Anomaly A1 which looks like a boundary between two layers with different magnetic susceptibility. On the top of the magoula, there are a lot of high susceptibility anomalies that are smaller in size. These probably relate to archaeological remains, but they do not give us a clear spatial organization for the interior of the Magoula. Anomalies A2 and A3 look more like ditches than boundaries of area with specific magnetic susceptibility. Unlike the magnetometry, the EM data does not extend to the south part of the site. Some linear anomalies, perpendicular to the EM boundaries, are induced by the merging of different grids during the processing.

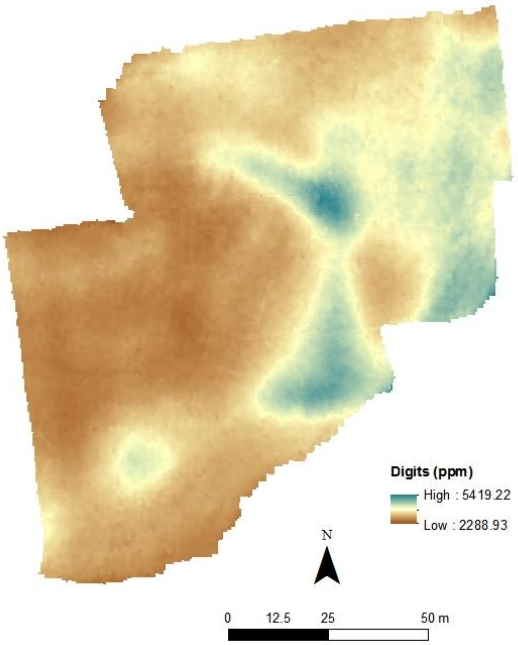


Figure 11: Electrical conductivity (GEM2 – HCP) for 0-2.5 m depth

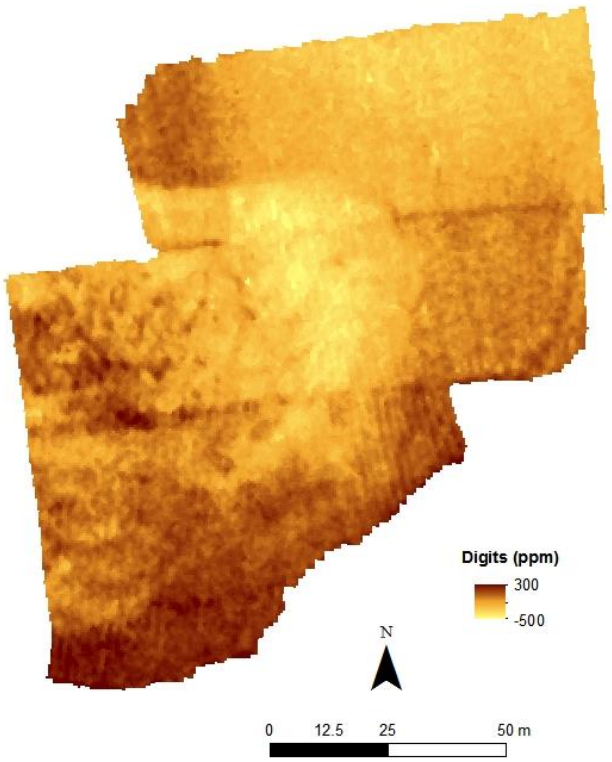
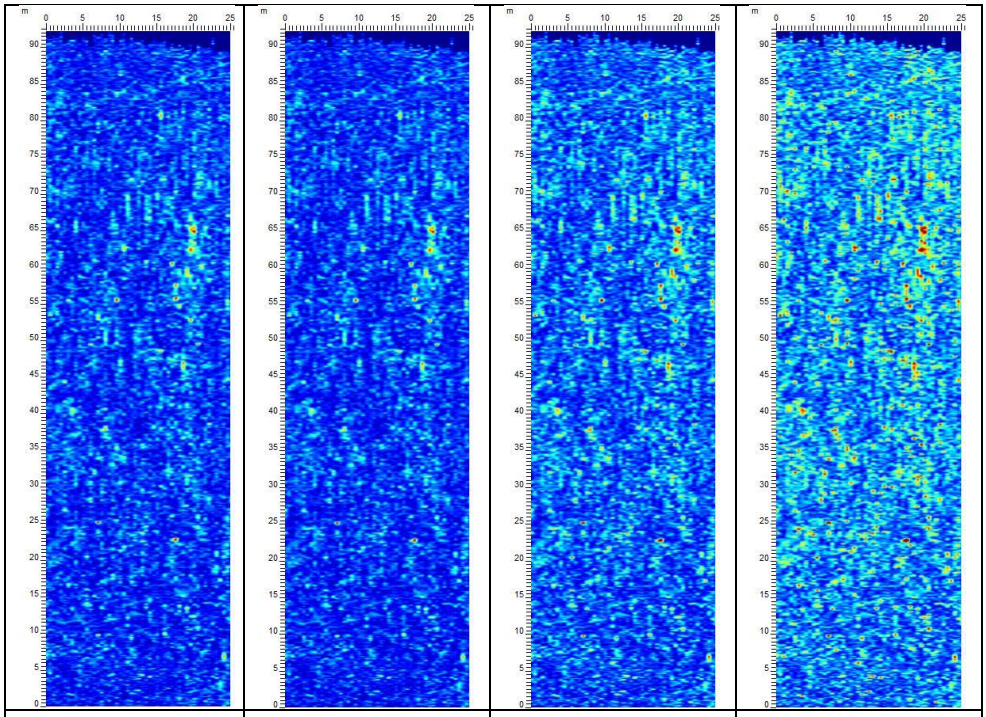


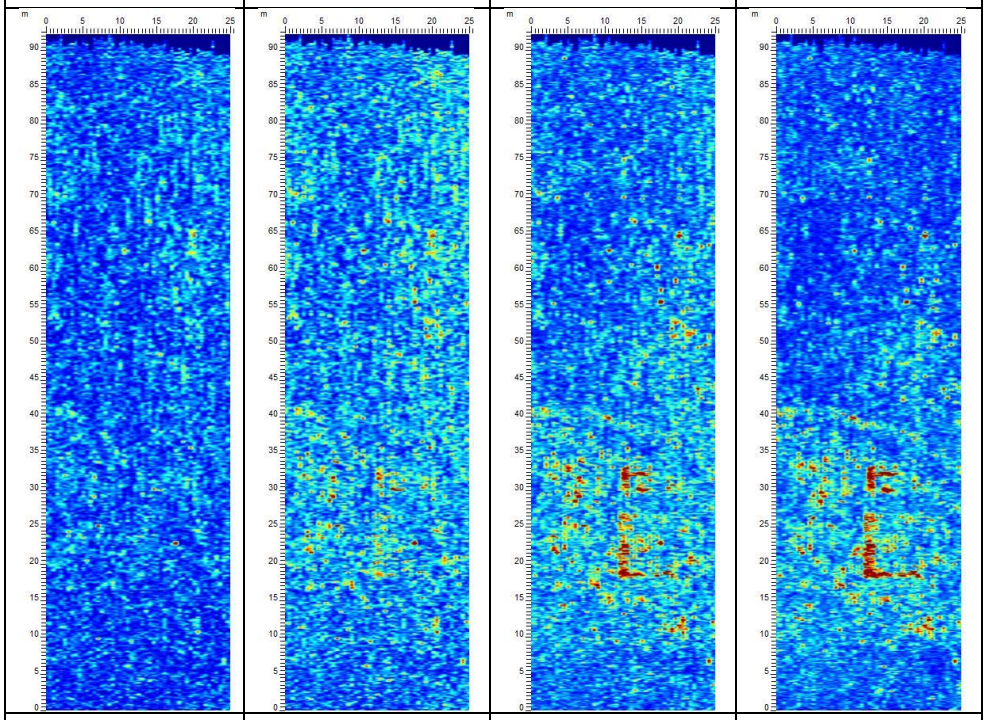
Figure 12: Magnetic susceptibility (GEM2 – HCP) for 0-1.7 m depth

Ground Penetrating Radar Survey

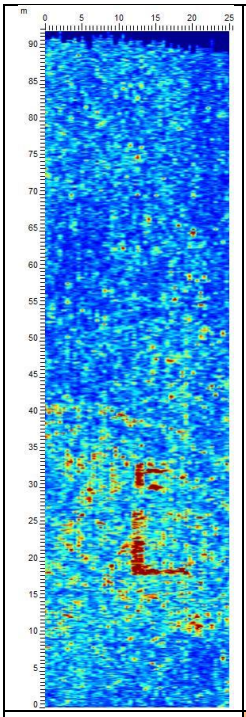
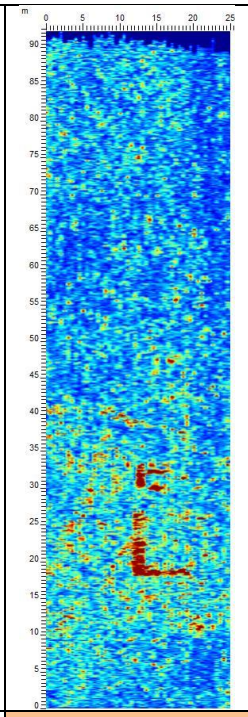
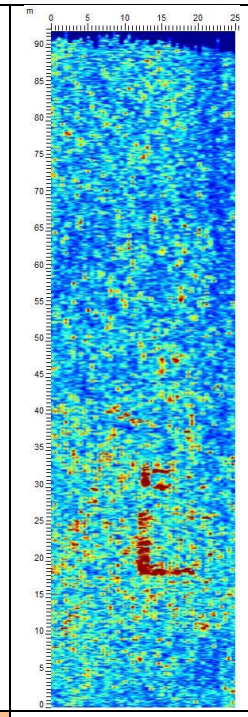
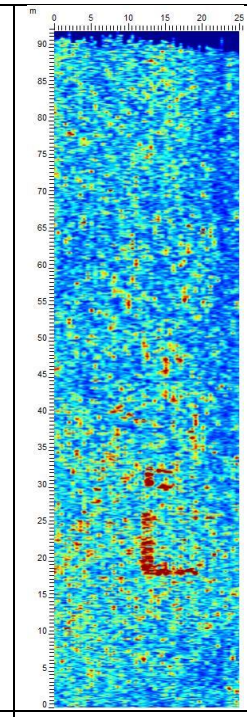
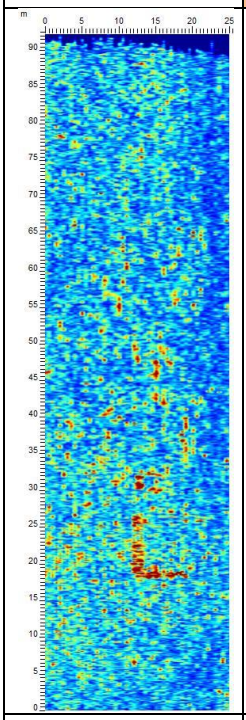
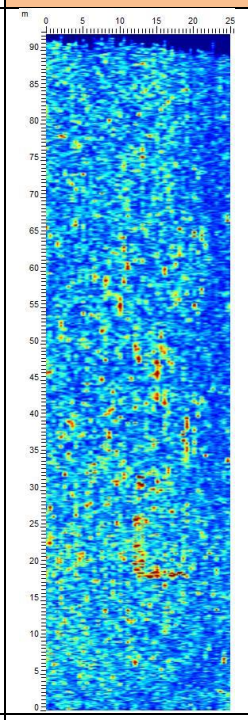
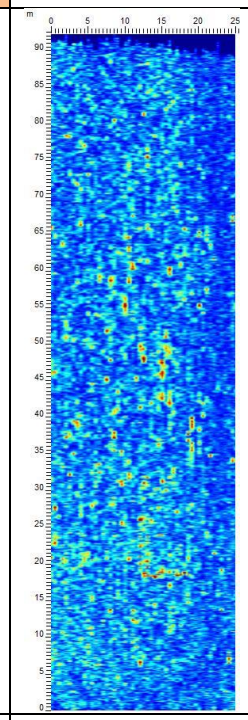
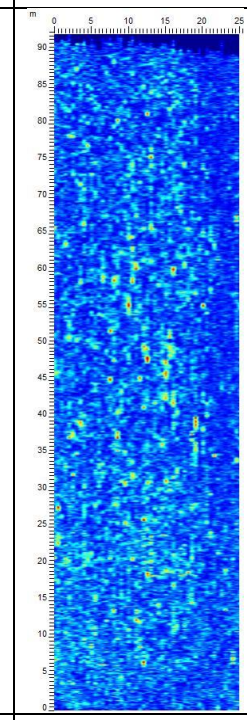
An area of 25.0x90.0m was covered with NOGGIN GPR equipped with a 250MHz antenna. The grid was set on the top of the magoula in accordance with the known pottery distribution and data were collected in parallel transects. Due to the rough terrain and the steep slopes present, the usage of GPR was limited and the data were noisy with low signal penetration. In order to enhance the recorded signals the following corrections and filters were applied in order: Time zero ±30%, Dewow, SEC gain, Background noise removal (global) and frequency filtering (bandpass filter). Then, depth slices were extracted with 10cm thickness from the surface and up to 2.00m. The results are summarized into the following images.



0-10cm	10-20cm	20-30cm	30-40cm



40cm-50cm	50cm-60cm	60cm-70cm	70cm-80cm

			
80cm-90cm	90cm-100cm	100cm-110cm	110cm-120cm
			
120cm-130cm	130cm-140cm	140cm-150cm	150cm-160cm

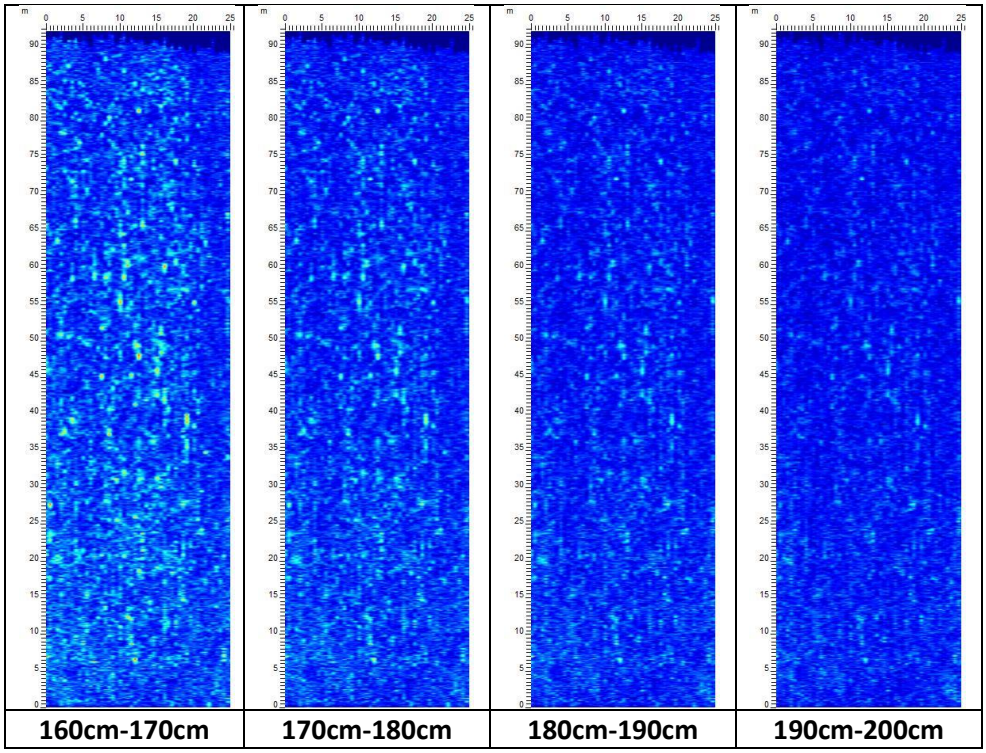
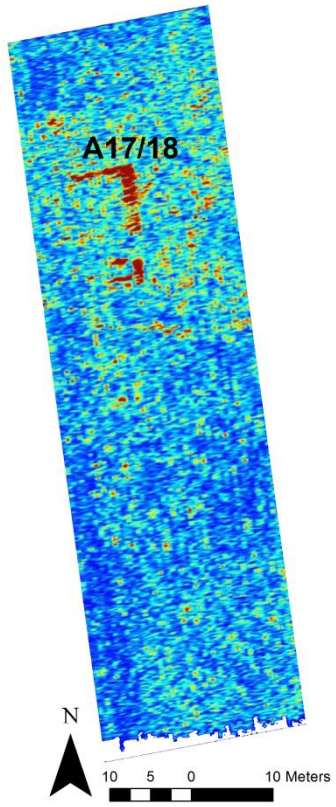


Table 1: GPR depth slices with 10cm thickness

The GPR results don't exhibit any particular information apart from noise within the range of 0-50cm and 140-200cm depth. A strong anomaly (A17/A18) is revealed at 60cm depth and extends up to 130cm that is possibly related to a manmade structure due to the geometry that it exhibits. A17/A18 consists of two features. The first one is a reverse "L" shape structure located at the northern part of the grid that extends 7.0m horizontally (from west to south) and 8.0 vertically (north to south), while the second one is a rectangular structure 3.0x4.0m. It is not clear if the two structures are related to each other.

Additionally, the grid covered with GPR overlapped with magnetic and EM survey. The anomaly A17 doesn't appear clearly in magnetic data due to noise while it is not detected at all in the EM data. One possible explanation for this behavior is the structure's building material having greater contrast in the electrical properties (and therefore perhaps a stone built structure?) than in magnetics, thus it is easier to map with GPR than with methods that rely on a magnetic contrast.



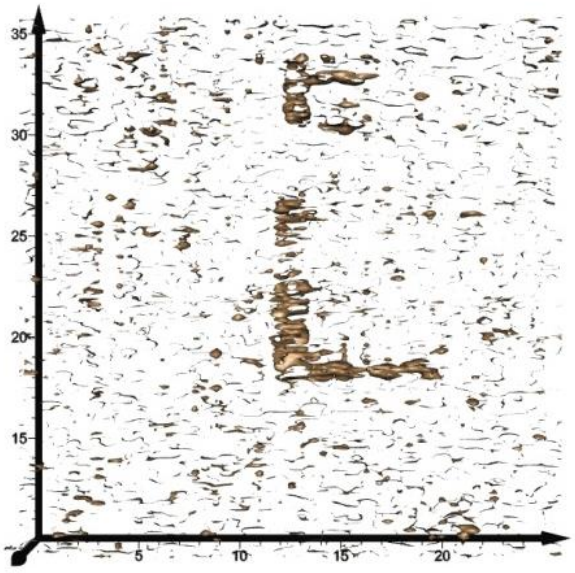
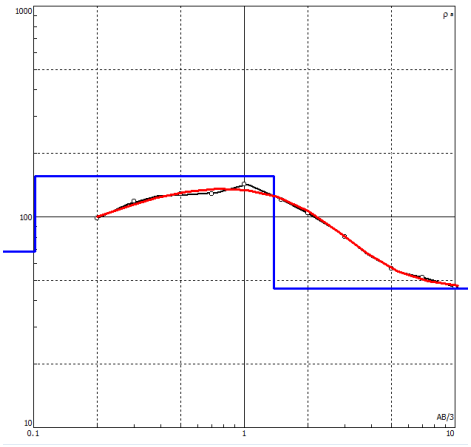


Figure 13: A 3D depiction of Anomaly A17/18

Figure 14: The slice for Anomaly A17/18

Vertical Electric Sounding



The VES shows a three depth layers. It was conducted on the top of the magoula, showing in this case the anthropogenic material making up the magoula. The topsoil shows a medium value of conductivity. The lowest is close to the resistivity of a clay soil. Between the topsoil and this lower part a more resistive part shows the anthropogenic material of the mound of the magoula. Note that the RMS error is very low so the experimental data fit very well with the model suggested after inversion.

Rau1=68.4	e1=0.101
Rau2=156	e2=1.28
Rau3=45.5	RMS = 2.64 %

Integration of Geophysical Results

The geophysical survey at magoula Karatsangliou employed magnetic (SENSYS-MX), EM (GEM-2) and GPR (Noggin Plus 250MHz) techniques covering a total region of about 3ha, 1.2ha and 0.2ha respectively. The geophysical survey focused on the top of the tell and expanded towards the east, south and west, as the abrupt slope to the north did not allow any survey over that specific section of the site. Survey coverage was determined based on known surface pottery distributions. Two main areas were covered, the larger of which to the north is separated from the southern section by a long running ditch which is engraved by a seasonal creek.

The northern area can be further classified into two sections based on magnetic readings. A contiguous curvilinear anomaly (A1) separates the natural and cultural deposits, the latter showing higher data heterogeneity and higher values of the vertical magnetic gradient (Figure 15). The magnetic signature of A1, which has a maximum width of about 3.8m and is probably correlated to a ditch, fades away towards the east, especially in the area A5, which represents a fuzzy zone of increased magnetic values, probably resulting from the concentration of organic material due to the erosion from the upper strata or the flooding of the meanders. This observation is in agreement with the RPAS photographs which were taken in November 2013, when fields were already ploughed. GEM2 readings of the soil conductivity indicate higher values of the conductivity to the east section of the site as well. Flooding simulation based on the recent DTM (created by the RPAS survey) has been also supportive of the above assumption, as the virtual 1-2m flooding front coming from the southern meander seems to match completely with the eastern and south-eastern outline of A1 (Fig. 16). Indeed to the NE of A5, most of the region is relatively quiet with an almost complete absence of anomalies.

The core of the magoula seems to be confined within the almost circular shape of anomaly A3 that has a diameter that spans from about 41 to 47m. The weak reflections originating from the GPR indicate that the particular feature represents a 1m wide fortification wall. The VES measurements that were carried out at the top of the magoula indicated three depth layers, with the cultural layer confined between 10cm to 130cm and having a resistivity of 156 Ohm-m. A number of magnetic features are evident within the core of the magoula (A17, A18, A19 and A20) and seem to expand to cover most of the 1520 square meters areal extent of the main core of it. All of these anomalies indicate extreme values of the vertical magnetic gradient, which may suggest residues of burning, but they lack a clear outlines which indicates a poor state of preservation. In contrast, at the position of A17 and A18, strong reflection signals from the GPR outlined linear segments of structural remains that consist most probably of stone. The larger section expands at the location of A17 and consists of two perpendicular walls (8 and 9m each), oriented almost in a N-S direction. A smaller structure (A18) of dimensions 4.5x2.5m is located further to the south. GPR slices indicated that the particular architectural relics are located within a depth of 60-130cm below the surface (in agreement with the VES measurements for the depth of the anthropogenic layer).

Towards the east and west directions, magnetic data suggest some interruptions (A7 and A17) to the inner enclosure of the magoula, that may be correlated to entrances. Another magnetic feature (A6) runs perpendicular to A1 and may represent an outer

entrance to the magoula as it is oriented to the same direction to A17. Magnetically similar to A3 is the feature A2, which may represent another fortification wall. GEM2 readings also indicated that the most resistive strata of the region are confined within the enclosure A2. In contrast, A1 is much wider and more homogeneous in terms of its magnetic signature (absence of small dipole anomalies) and it is more suggestive of an outer ditch. Indeed, the in-phase GEM2 measurements indicate that A1 looks like a boundary between two layers with different magnetic susceptibility. Most probably, A1, A2 and A3 constitute 3 enclosures of the magoula, with the outer one (A1) to have been raised as a defensive construction against periodic flooding from the nearby meanders and especially from the one that runs to the south of the magoula, since the elevation difference between it and A1 is less than 2m.

Outside of the outer enclosure (A1), a few anomalies appear. The one at A4 may represent the natural bank of the SE meander. Anomaly A8 to the west consists of two highly magnetic linear responses running in parallel (6 metres apart) which may have been caused by recent activities. Feature A12 has a similar curvature to the outer enclosure (A1) but it does not seem to continue further. Anomaly A9 to the SW has large dimensions (~15m by ~9m) with an extension towards east for another ~10 meters. There is not enough contextual information to fully decipher Anomaly A9, but its rectangular shape immediately suggests it is of anthropogenic origin. The southern area is devoid of architectural anomalies, with the exception of 2 worth mentioning anomalies. A rectangular feature (Anomaly A10) is located at a distance of about 70m from the outer ditch of the magoula (A1) and even further to the south another linear feature (A11) becomes visible. There is not enough contextual information for these anomalies as they are far away from the magoula. The rest of the region to the south is relatively quiet, with no further evidence of habitation.

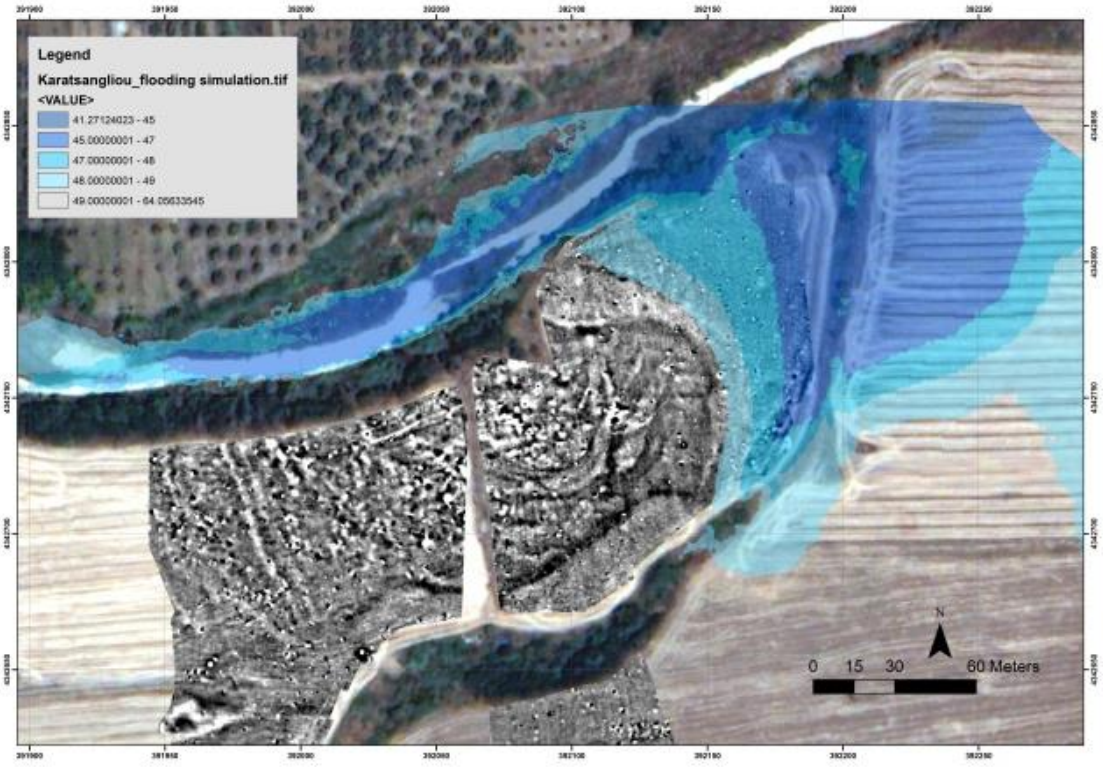


Figure 15: Flooding simulation results around the settlement

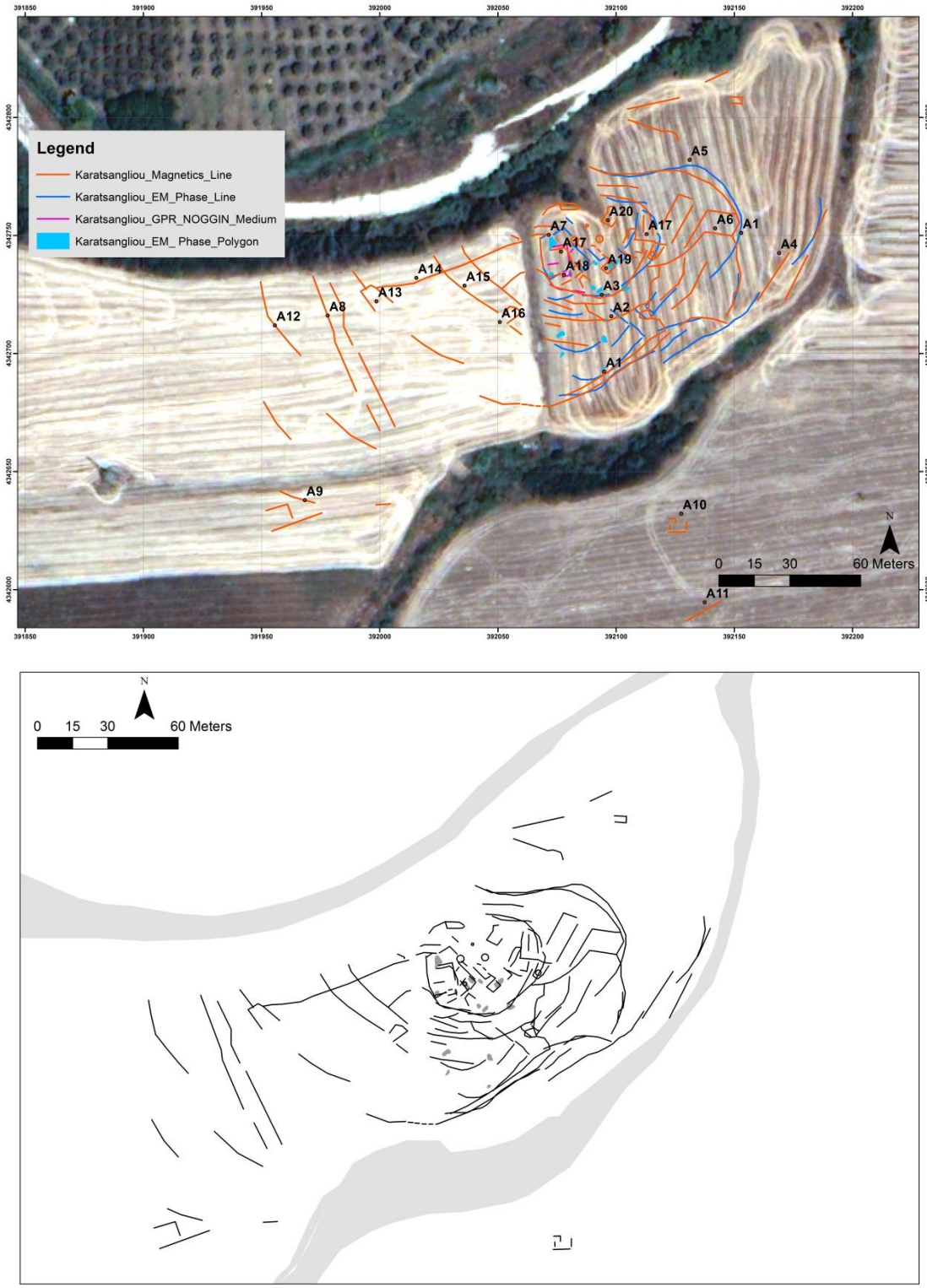


Figure 16: Depiction of anomalies from different methodologies

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