Zerelia

Archaeological Background

Magoula Zerelia is located 3.5 km south of the modern town of Almyros and 2 km west of Magoula Almyros 2. The most prominent features around the site are two round-shaped lakes with diameters of 150 m and 250 m.

Archaeological excavations have been carried out on the magoula at various intervals during the last one-hundred years. Most important was the research made by A. Wace and M. Thompson at the very beginning of the twentieth century. According to these excavations, the settlement was first established in the Early Neolithic period and lasted until the Late Bronze Age and into historical times.

Excavations made during the last 10 years by the University of Thessaly in collaboration with the Archaeological Ephorate of Magnesia, confirmed the chronological information about the settlement and focused on a more detailed examination of the habitation phases and the construction of several features.

Satellite Remote Sensing and Historical Aerial Photography Survey

A WorldView-2 image from 4 June 2012 was used for satellite remote sensing at Zerelia (Figure 1). The satellite image has an off-nadir angle of 21.6° and a ground sampling distance (GSD) of 0.55 m (panchromatic) and 2.11 m (multispectral). In addition to the satellite imagery, three aerial photographs were used for remote sensing: (1) 1945 (date unknown) with a scale of 1:42,000; (2) 1960 (date unknown) with a scale of 1:30,000; (3) 1971 (date unknown) with a scale of 1:18,000; and (4) 30 July 2003 with a scale of 1:30,000 (Figure 2).

The landscape around Zerelia is diverse and characterized by semi-hilly terrain within agricultural floodplains. Large river and stream beds produce deep gorges in areas and there are mountains on the southern periphery. Conspicuous in the landscape are the circular twin lakes immediately south of the prehistoric settlement. The modern towns of Almiros and Efxeinoupoli are nearly 3 km to the north of the target area. The topography rises gradually from south to north. The prehistoric settlement of Karatsantagli is only 1 km further to the southwest. The harvest appears to have been recently completed in the 4 June 2012 WorldView-2 and most of the fields around the site have no vegetation. Elevations around the target site range from 140-150 masl.

The aerial photographs show that the landscape around Zerelia has changed between 1945 and 2012. There are still no manmade structures (e.g. farmsteads) even in 2012, but agricultural plots have been altered. Moreover, the aerial photographs from 1945 and 1960 indicate that river beds and streams were more prevalent around the prehistoric tell than they are today. Recent farming activity is probably responsible for this decrease.

Satellite remote sensing within a 1 km radius around Zerelia identified an extensive system of palaeochannels (blue) that once pocketed the terrain (Figures 3-4). High concentrations appear all around the site, but in particular towards the west and southwest. There is a high probability that soil erosion and/or soil accumulation has impacted the region around the archaeological site. Many palaeochannels are now agricultural fields with little evidence of past hydrological activity. Therefore, at some time in the past, the area of Zerelia was active with running sources of water. A few

anomalies relate to agricultural activity (brown) and some are unclassified (yellow). The habitation mound is identified as an oblong anomaly (#115). Other unclassified anomalies, in particular those with circular formations, may be caused by hydrological activity.

Figure 1. Zerelia from a 4 June 2012 WorldView-2 image.

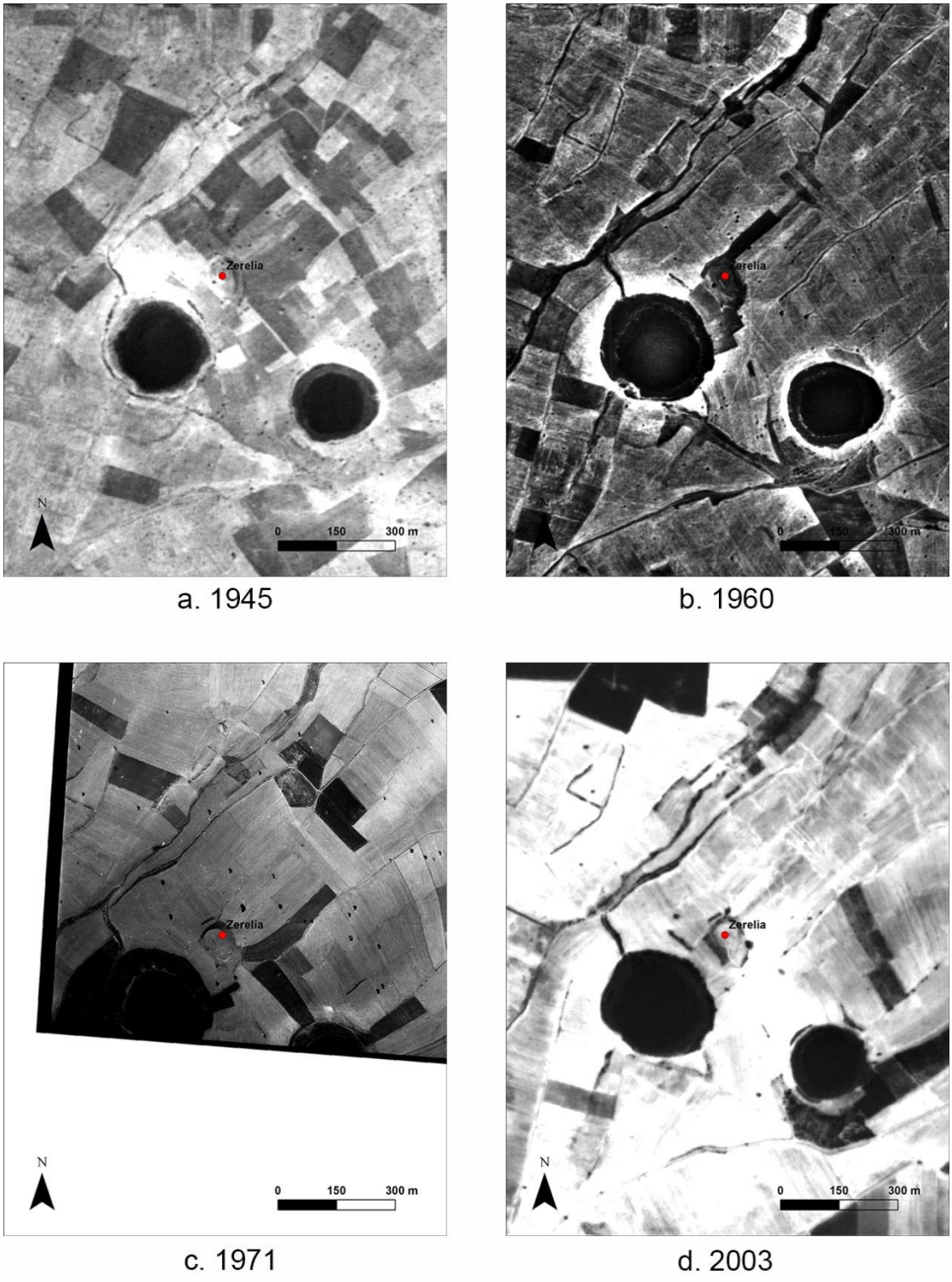


Figure 2. Aerial photographs of Zerelia: (a) 1945; (b) 1960; (c) 1971; (d) 30 July 2003.

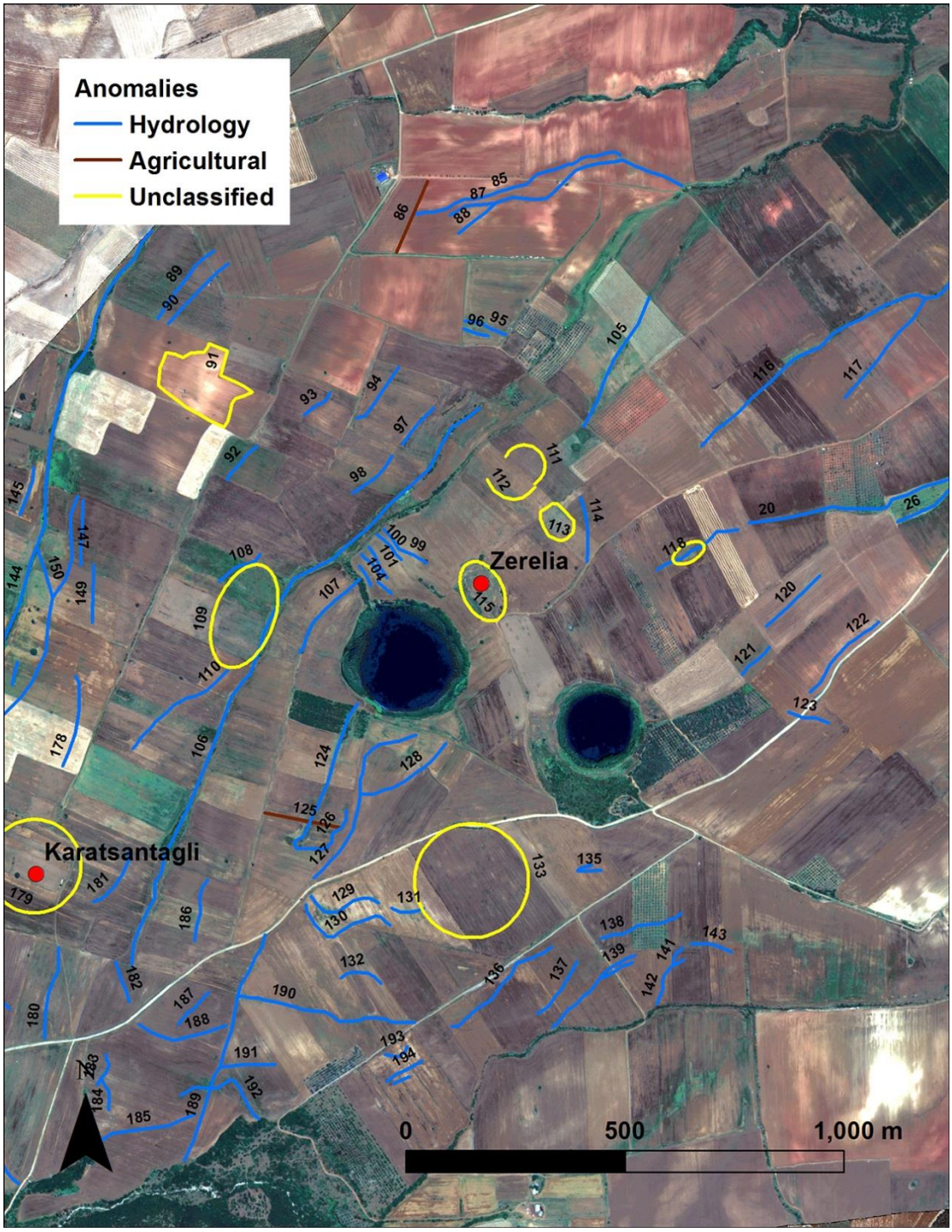


Figure 3. Surface anomalies from the 4 June 2012 WorldView-2 image within a 1 km radius around Zerelia.

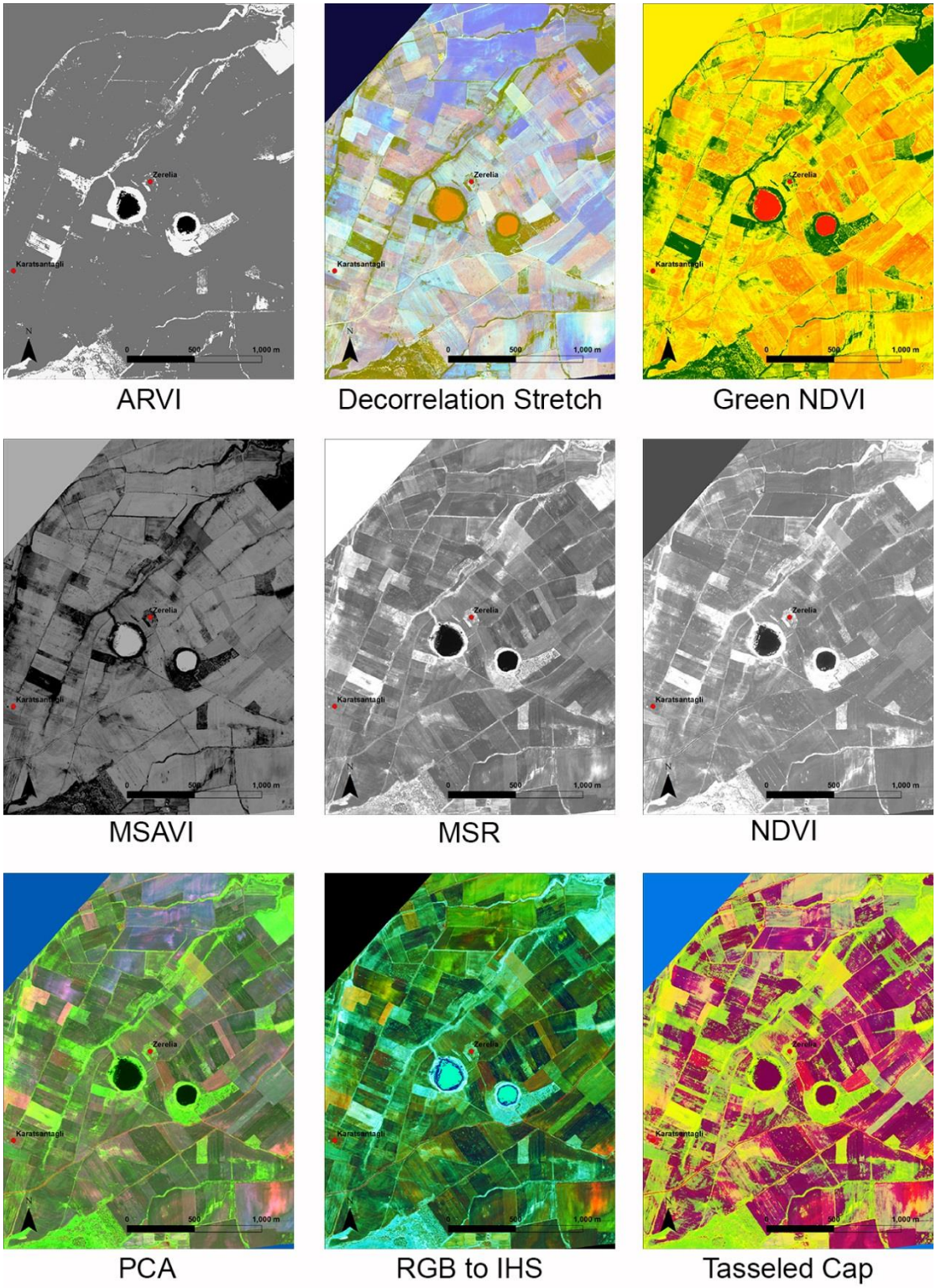


Figure 4. Spectral filters and vegetation indices applied to the 4 June 2012 WorldView-2 image around Zerelia

Remotely Piloted Aircraft Systems (RPAS) Survey

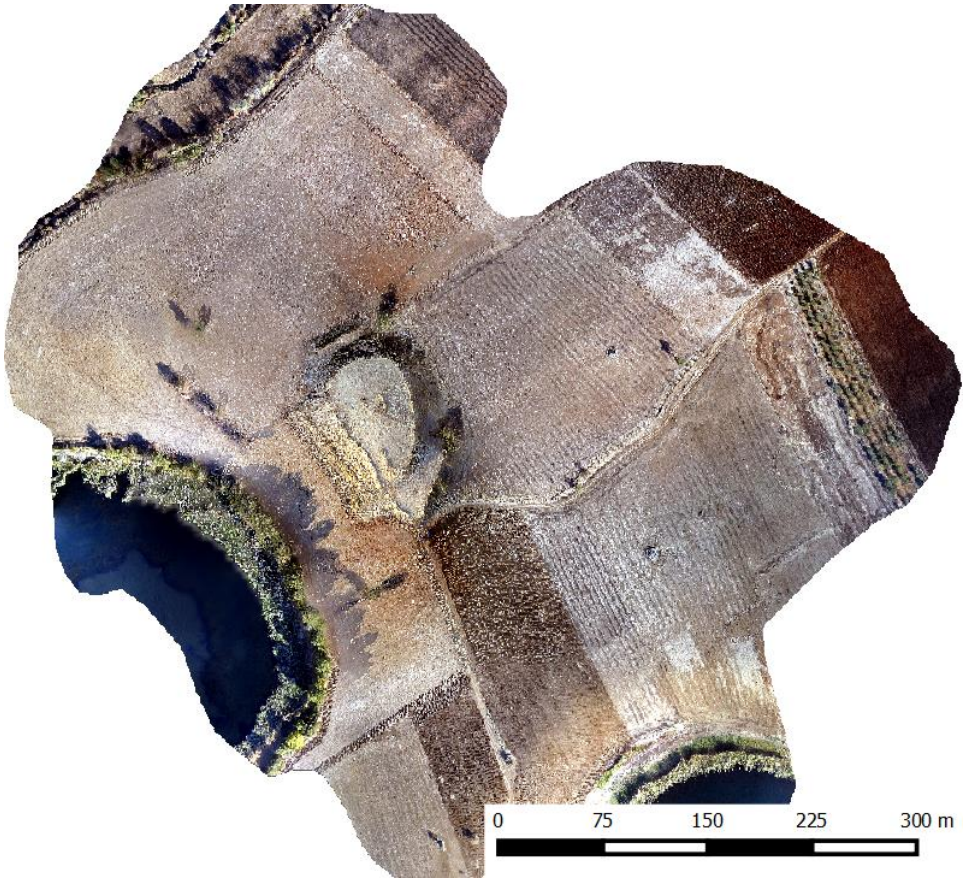


Figure 5: RPAS data from Zerelia

The aerial coverage around Zerelia was quite large, reaching more than 400 m around the center of the main hilltop. Low altitude photographs have been collected during the period of November 2013, when crops have been cut and only partially collected. This makes any air-photo-interpretation difficult since no traces of vegetation stress could be visible and any potential geological marks are hidden by the completed phenological cycle.

Geophysical Prospection

Combined Geomagnetic and Electromagnetic Induction Surveys

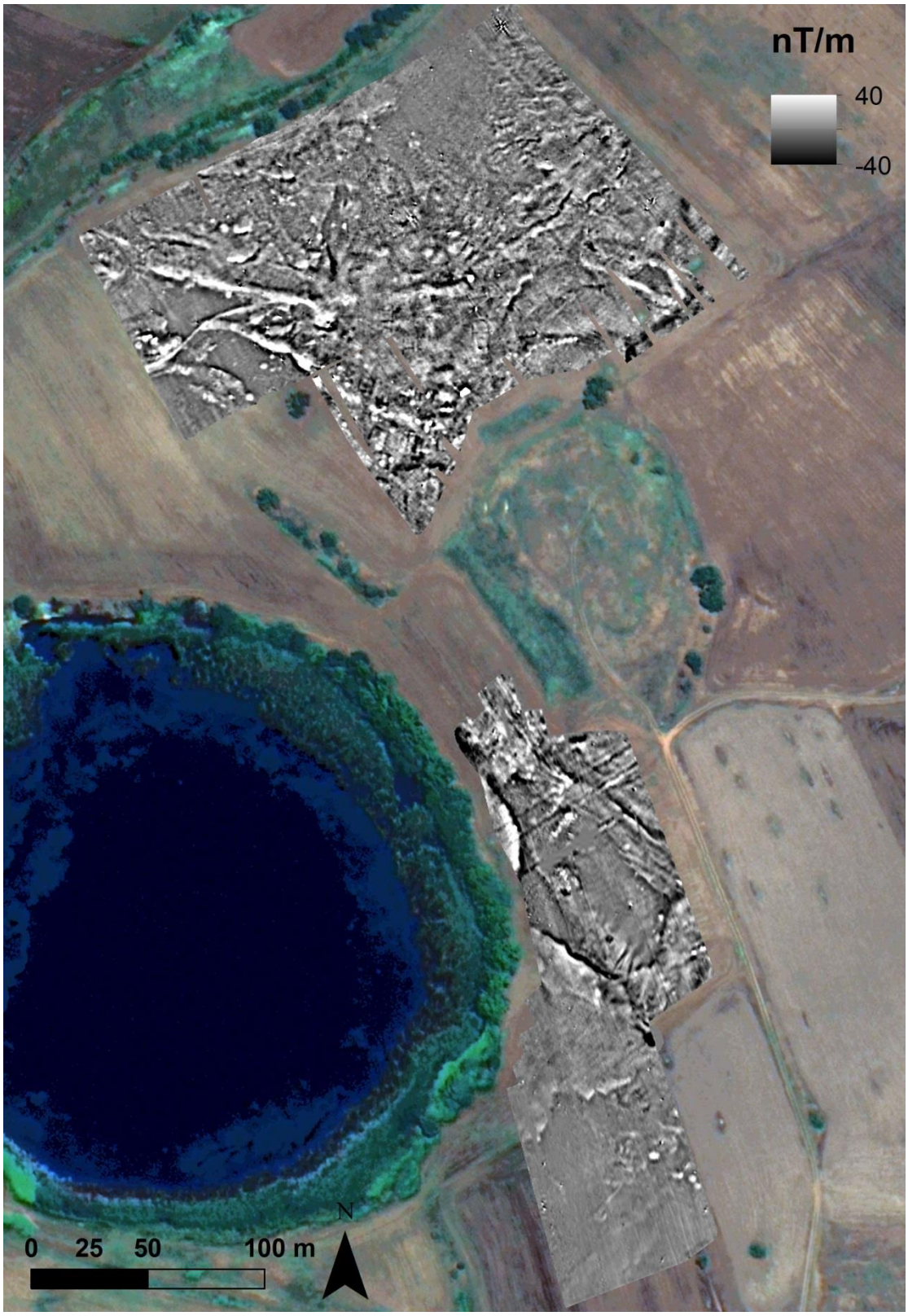


Figure 6: Geomagnetic results from Zerelia

Geomagnetic and electromagnetic data at Zerelia are characterized by a large number of anomalies which represent non-anthropogenic processes. Various lineaments at various lengths cross cut areas both to the north and to the south of the magoula.

Among these, Anomaly X calls for more attention. High magnetic linear anomalies run in parallel for at least 100 m and bisect a narrower anomaly in northeast-southwest direction. Following this further, one reaches another lineament running in the same direction, but also leaning towards the magoula itself (Anomaly Y). Considering this spatial behavior, it can be suggested that Anomaly X forms a palaeochannel in relation to Anomaly Y, which might have been in use during the occupation of magoula.

The geomagnetic data also provide evidence for features which are most likely architectural elements made of diamagnetic materials. These are quite few in number and concentrated to the northwest of the magoula. Another cultural feature is located at the southern portion of the survey zone. A road, most likely dated to modern periods, is detected running in an almost east-west direction.

Electrical conductivity does not show clearly the same channel, which does not necessarily disprove its inexistence. But we can conclude that the filling is almost the same as the soil material with a different magnetic susceptibility. Spatial distribution of electrical conductivity does not look well organized, even from a geomorphological point of view for both areas surveyed with the GEM-2.

Two anomalies of low conductivity can be pinpointed in the area: The first one is situated at the extreme northern part of the surveyed area. The very low conductivity value shows a different filling. This part of the site is close to a small stream. It is possible that the ancient route of this stream was closer to the site during the Neolithic, and thus, might have been fully exploited. The second one is localized to the central south region, above a linear anomaly of high magnetic values.

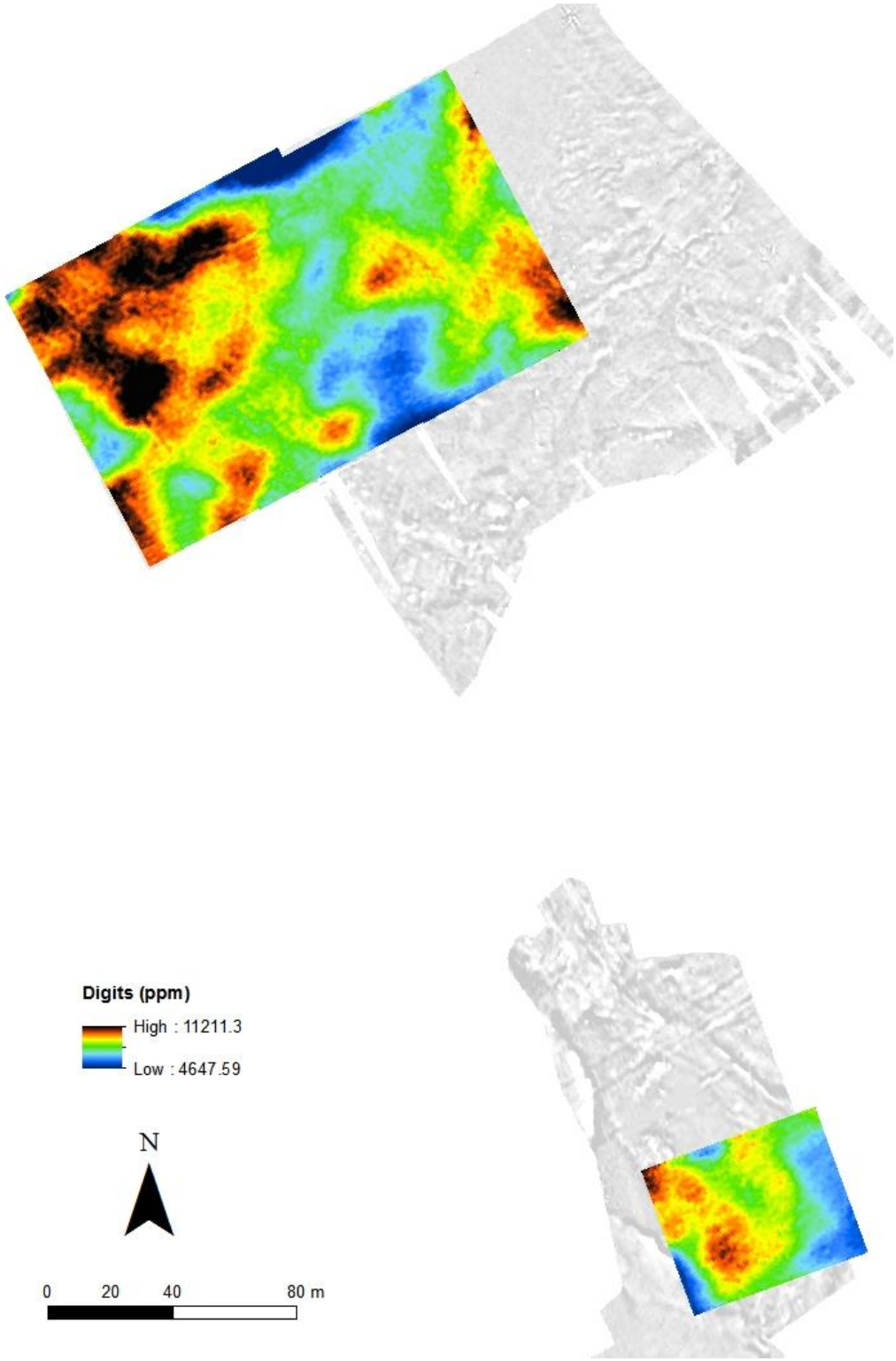


Figure 7: Electrical conductivity (GEM2 – HCP) for 0-2.5 m depth

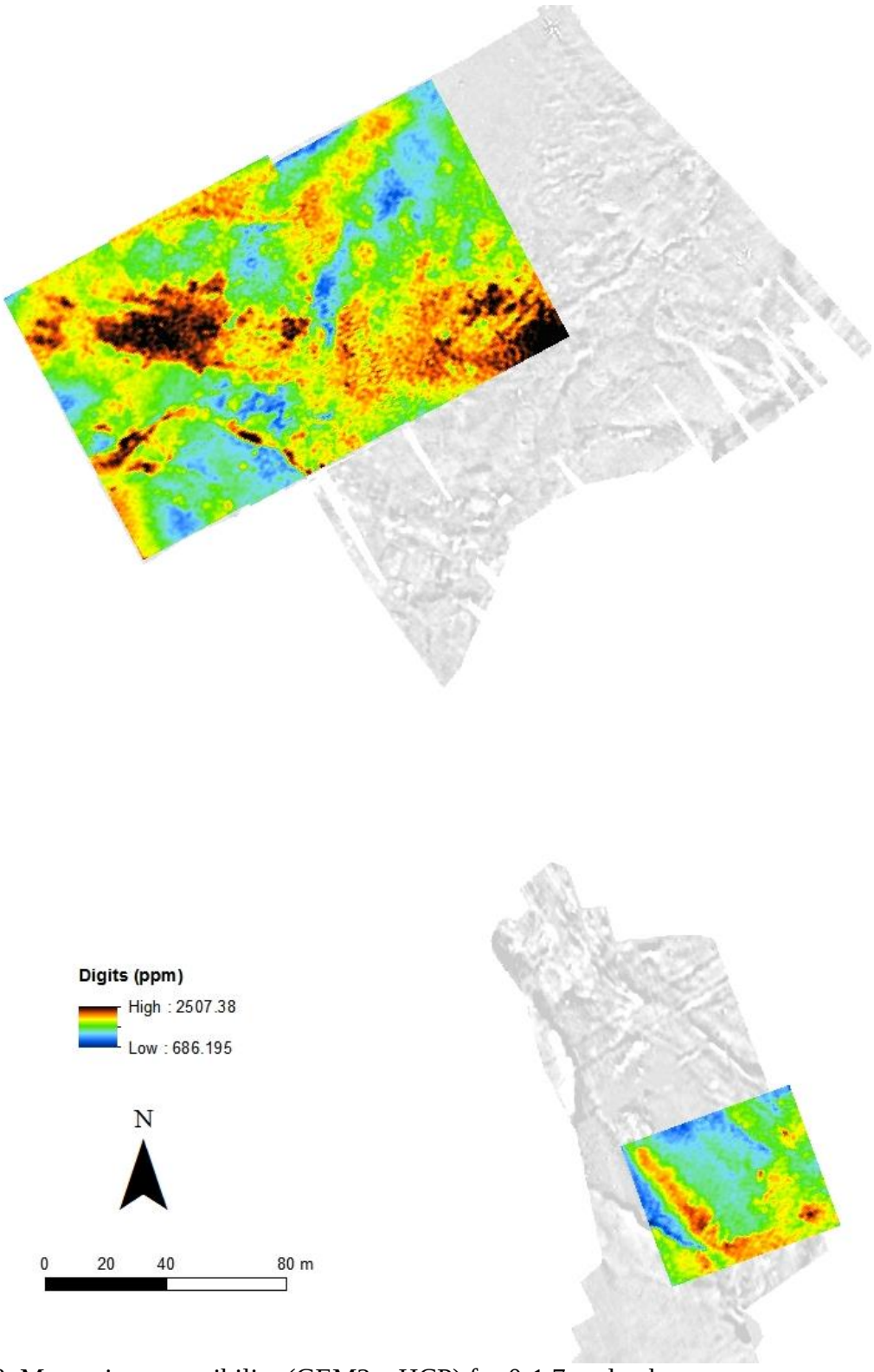


Figure 8: Magnetic susceptibility (GEM2 – HCP) for 0-1.7 m depth

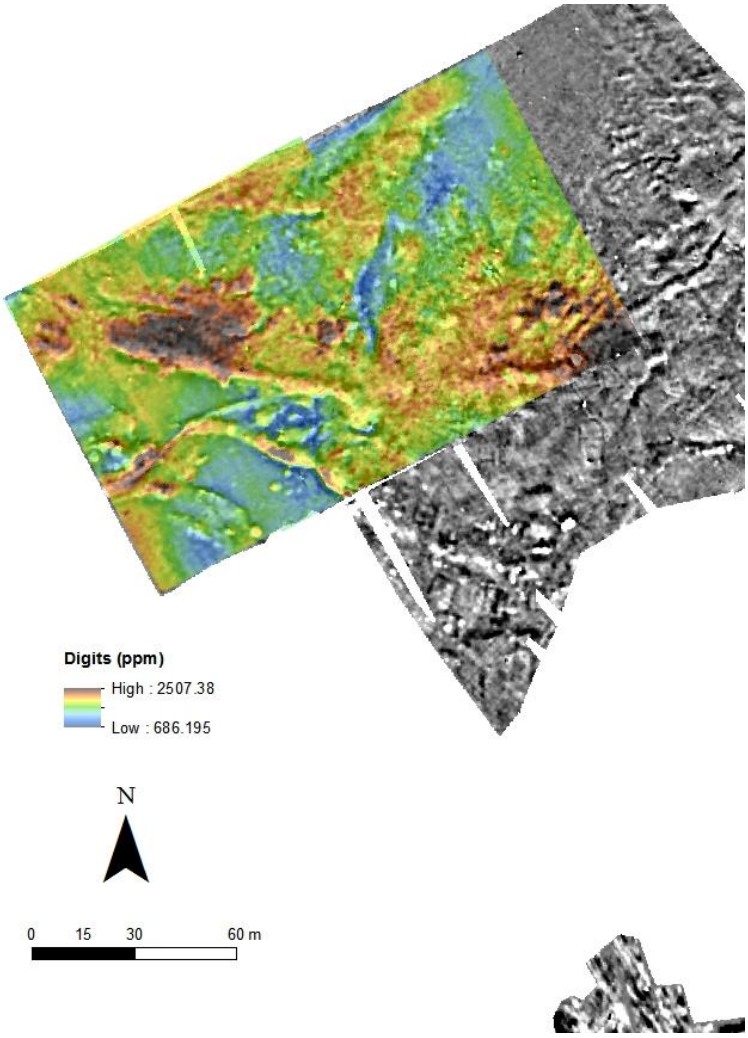


Figure 9: Overlapping of the magnetic susceptibility from EM instrument and magnetic anomalies of magnetic prospection

As we can see on the overlapping of magnetic susceptibility and magnetic anomalies, both information are very close (Figure 9). Nevertheless, the magnetic survey only gives boundaries of the channel, while magnetic susceptibility shows the filling of the paleaochannel. This information is interesting because one can distinguish between ditches, such as anomaly X, and a channel, such as anomaly Y. The magnetic susceptibility does not give any clear information about architecture.

On the second overlapping (Figure 10) one can also distinguish a similarity of information. Magnetic linear anomalies show boundaries of the different level of magnetic susceptibility. Any information related to human activity or occupation is visible.

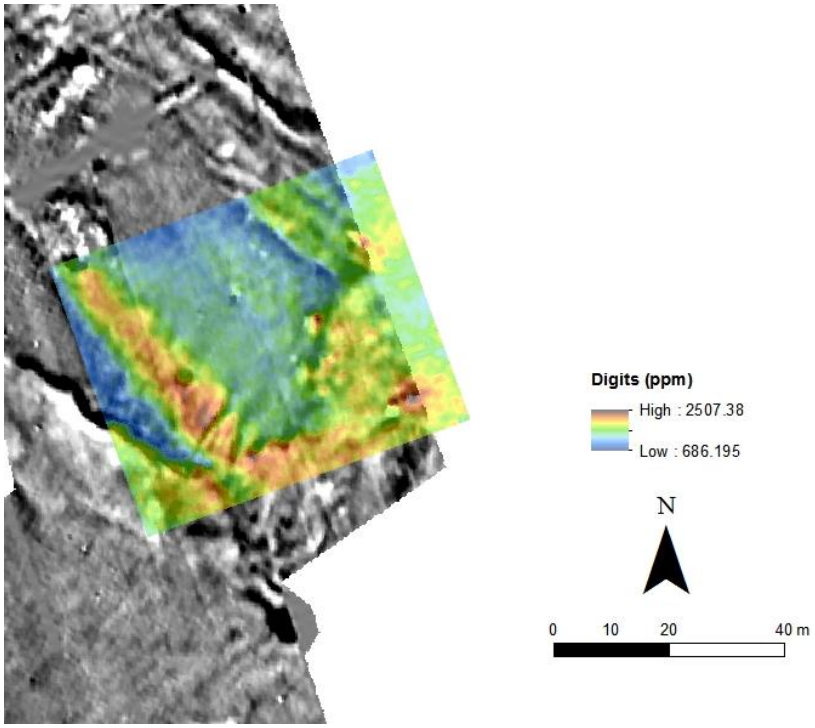


Figure 10: Overlapping of the magnetic susceptibility from the EM instrument and the magnetic anomalies

Ground Penetrating Radar Survey

The total area covered with Noggin GPR at magoula Zerelia is 3000 m^2 and consists of two survey grids (Figure 11). The first grid was positioned southeast of the main hill of the magoula and the collected data were processed as follows: Trace reposition, Repick first break (5%), Dewow, Lowpass filter (f=20 % Nyquist). The results are presented in Table 1. The signal penetration is limited due to attenuation and did not return any useful information below 100 cm depth. Besides the limited penetration, the results were extremely noisy due to the rocky terrain and the plowing lines. A few scatter anomalies are visible within the range 80-100 cm.

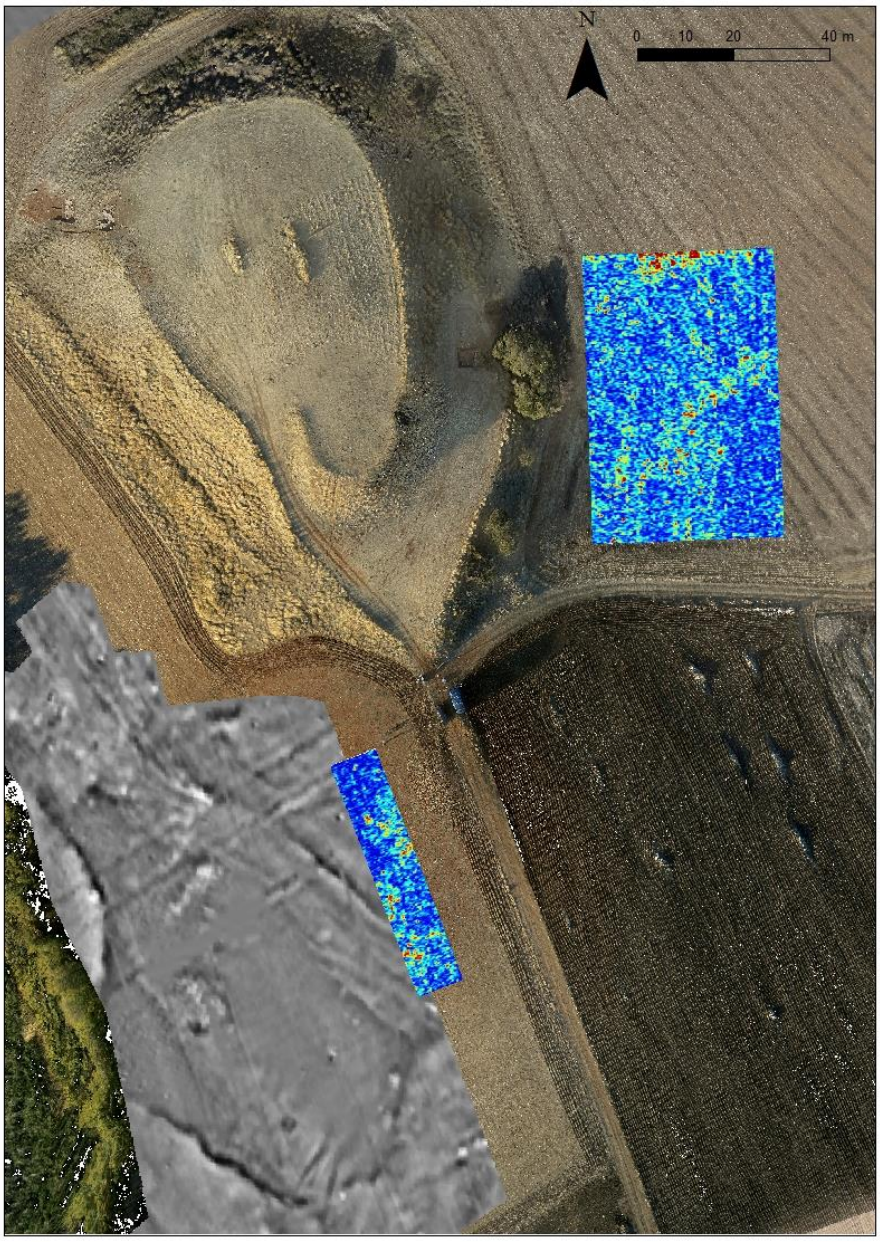
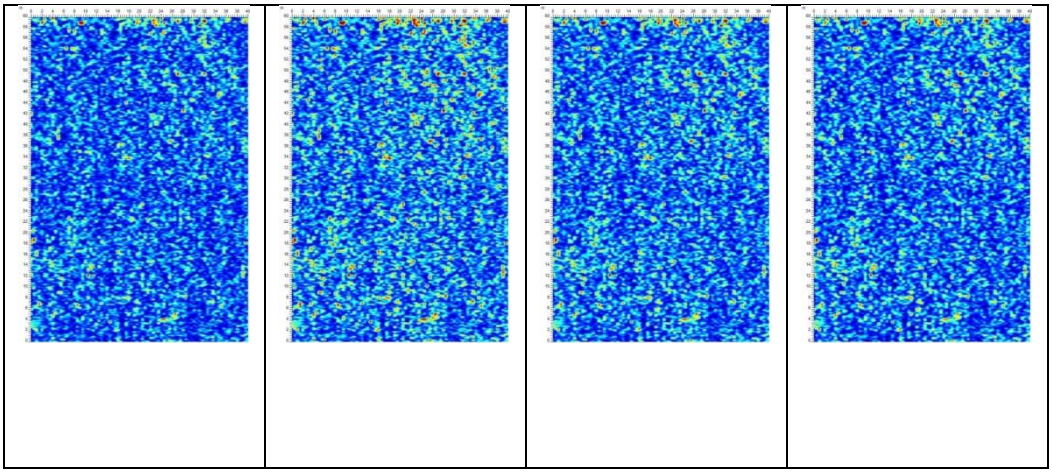
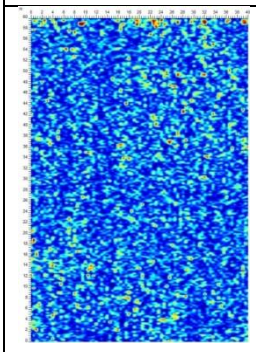
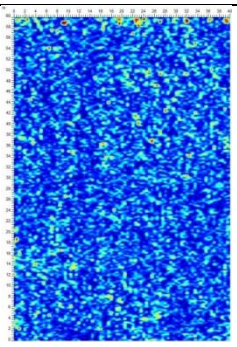
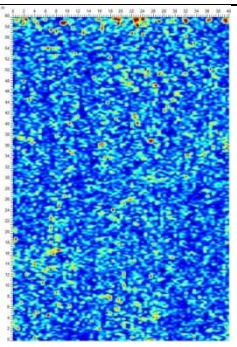
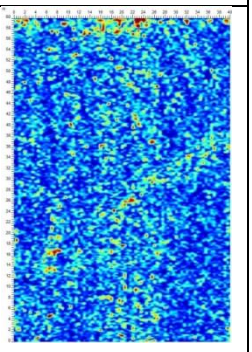
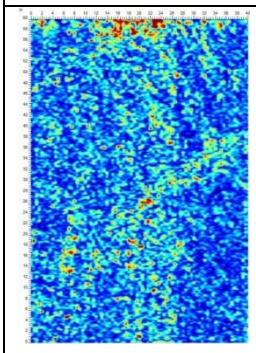
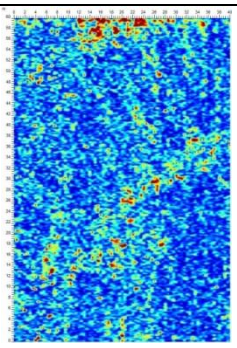
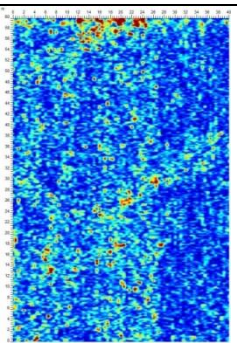
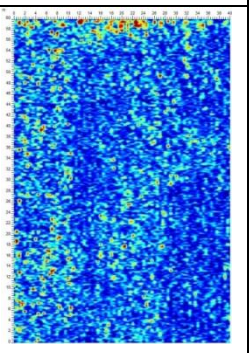
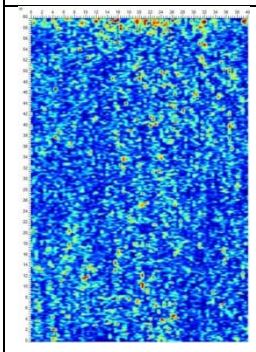
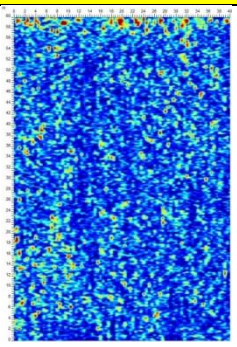
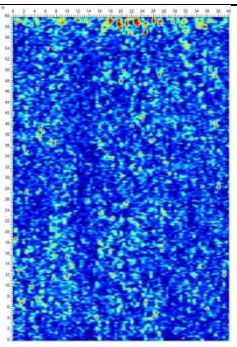
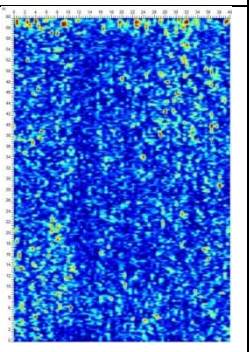


Figure 11: Noggin GPR grids location along with magnetics results at Magoula Zerelia.



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

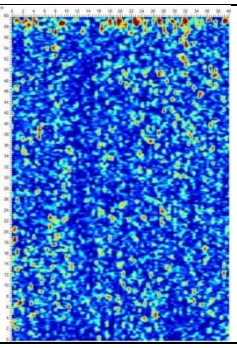
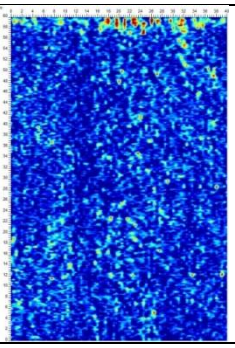
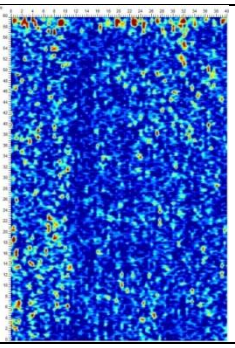
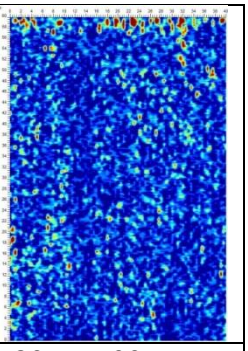
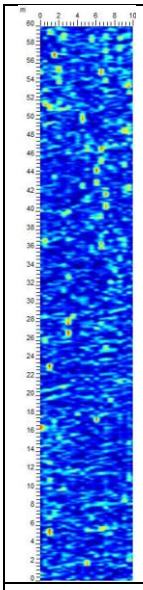
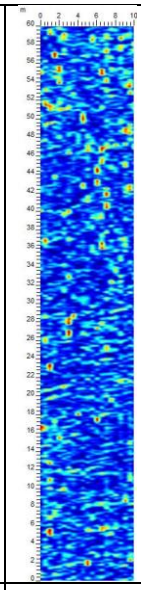
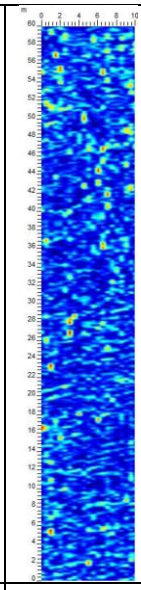
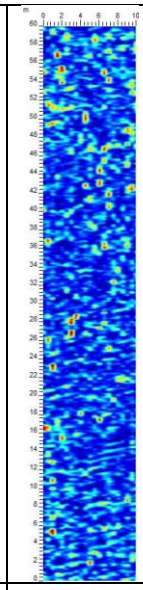
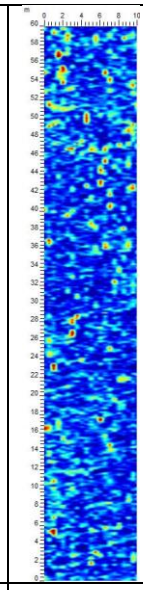
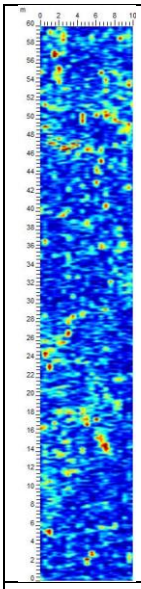
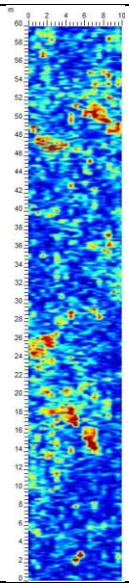
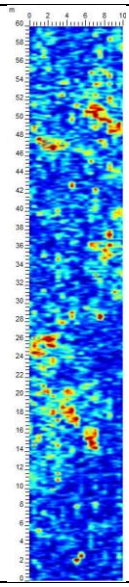
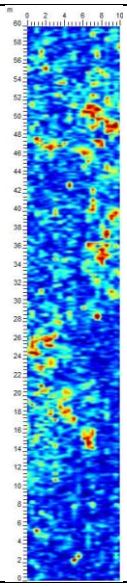
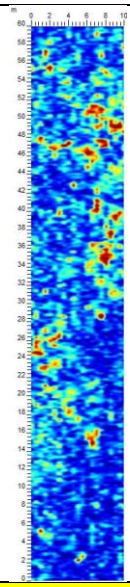
			
160cm-170cm	170cm-180cm	180cm-190cm	190cm-200cm

Table 1: GPR depth slices for the grid with code name East_Zerelia, at Magoula Zerelia with 10 cm thickness

The second grid is located south of the settlement's center as indicates Figure 11. The filters and corrections applied to the collected scans are: Trace reposition, Repick first break (10%), Dewow, SEC2(Atn=33.35 dB_m,StrtG=3.98,MaxG=516), Background average subtraction, Bandpass filter (Fc1=40 % Freq,Fp1=80 % Freq,Fp2=120 % Freq,Fc2=160 % Freq), while the results are presented in Table 2. The strongest anomalies appear within the range 60cm-130cm from the surface and have irregular shape. Below that depth the signals are attenuated returning no information.

				
0cm-10cm	10cm-20cm	20cm-30cm	30cm-40cm	40cm-50cm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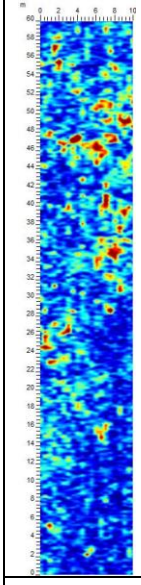
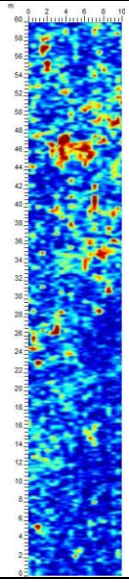
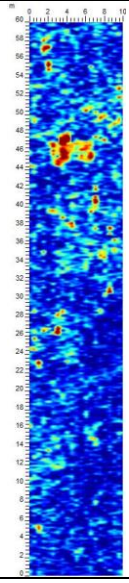
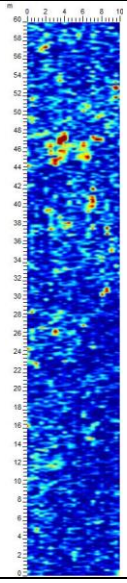
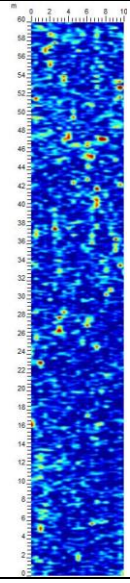
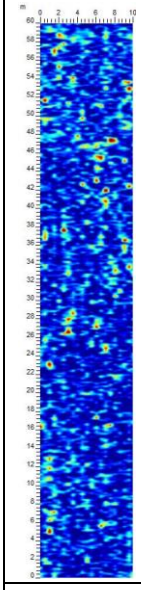
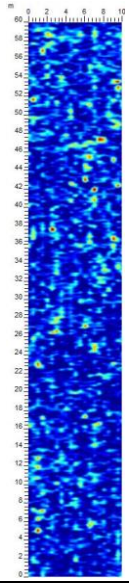
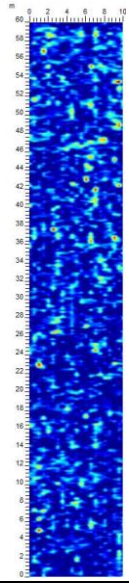
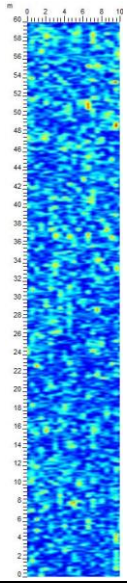
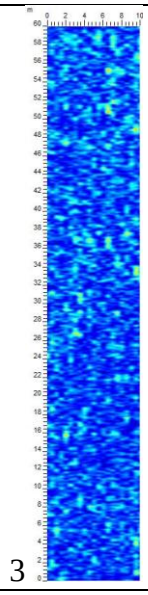
				
100cm-110cm	110cm-120cm	120cm-130cm	130cm-140cm	140cm-150cm
				 3
150cm-160cm	160cm-170m	170cm-180cm	180cm-190cm	190cm-200cm

Table 2: GPR depth slices for the grid with code name South_Zerelia, at magoula Zerelia with 10 cm thickness.

The interpretation of the results in the case of the Zerelia_east grid is not an easy task as they exhibit a lot of scatter anomalies of medium and strong intensity (Figure 12a). Three areas are identified as possible geological features due to their shape and intensity as described by A1, A2, and A3. The results in the case of the grid that is located south of the magoula presents less noise and a few strong anomalies of irregular shape, as indicated by A4, A5, A6, A7, and A8 in Figure 12b. These anomalies seem to be related with geological features. Among them, A7 seems to be a continuation of the geological feature visible in the magnetic results while A8 follows the same trend as A7.

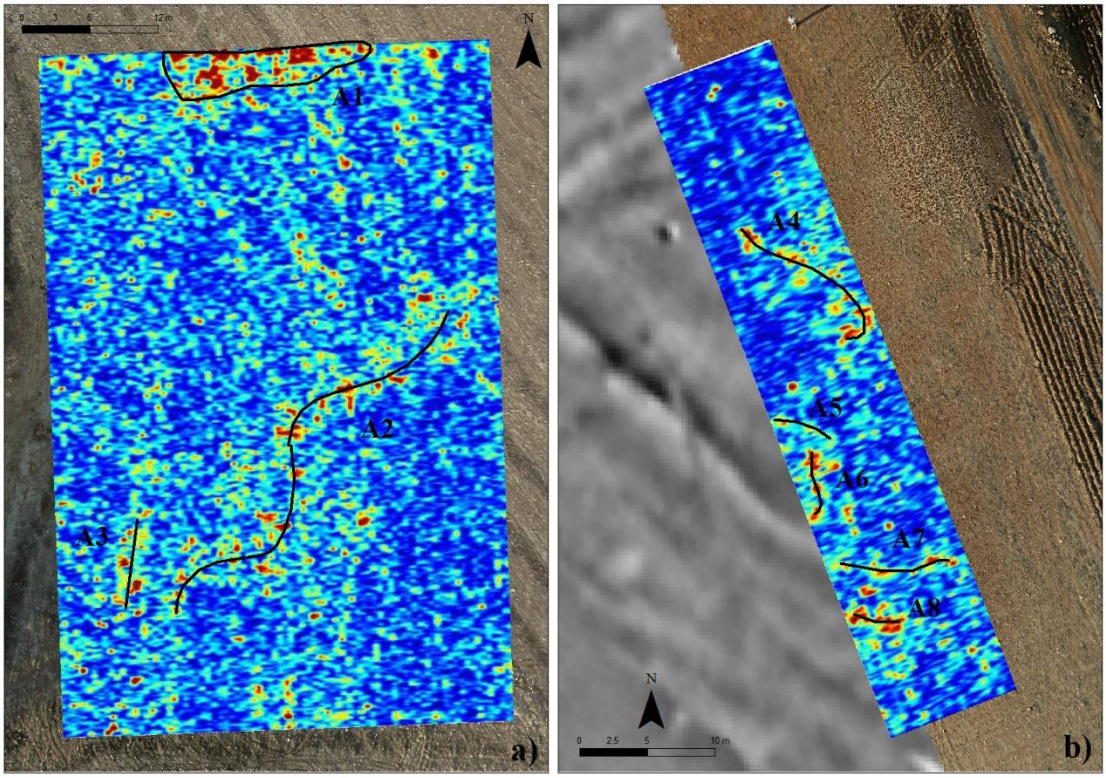
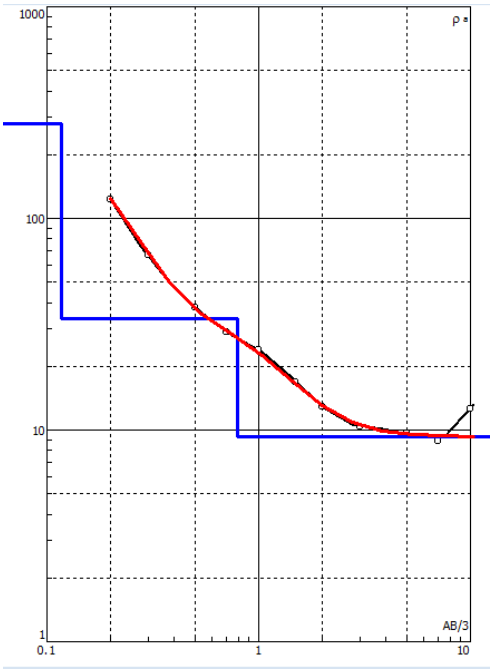


Figure 12: GPR results at Magoulia Zerelia where a) is the georeferenced slice from the grid east of the Magoula at 90-100 cm depth with the corresponding interpretation and b) is the georeferenced slice from the grid south of the Magoula at 90-100 cm depth with the corresponding interpretation.

Vertical Electric Sounding

We proceed to two vertical electrical soundings at Zerelia. Both of them were taken below the magoula. The first one was situated on the ridge between the two lakes, while the second one was on the south point of the big grid in the northern part.

VES 1 : 

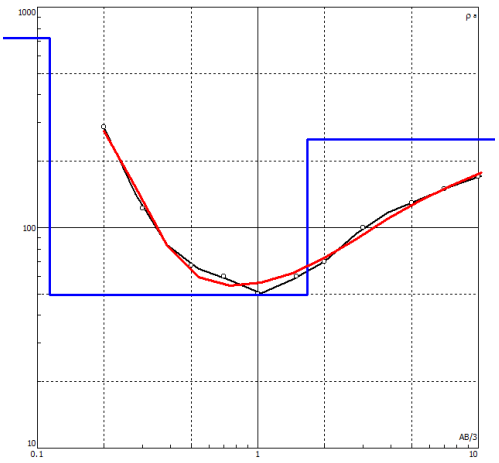
Rau1=281 e1=0.117

Rau2=33.5 e2=0.68

Rau3=9.27

RMS = 9.74 %

The first electrical sounding reveals a very low resistivity. High resistivity values for the top layer result from the heterogeneity and dryness of the clay. Then the resistivity decreases to reach 10 ohm.m. This very low value probably reveals the geological formation while the second one is probably affected by pedological process.

VES 2 : 

Rau1=726 e1=0.113

Rau2=49.5 e2=1.57

Rau3=251

RMS = 5.98 %

For the second electrical sounding we observe the same value for the topsoil and the second layer, also probably affected by pedological process on a deep soils, this time (1.7m) then the resistivity increase to reach 250 ohm.m. In this case the lower layer is not a clay formation or we have a very deep soil, with some other parent material.

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