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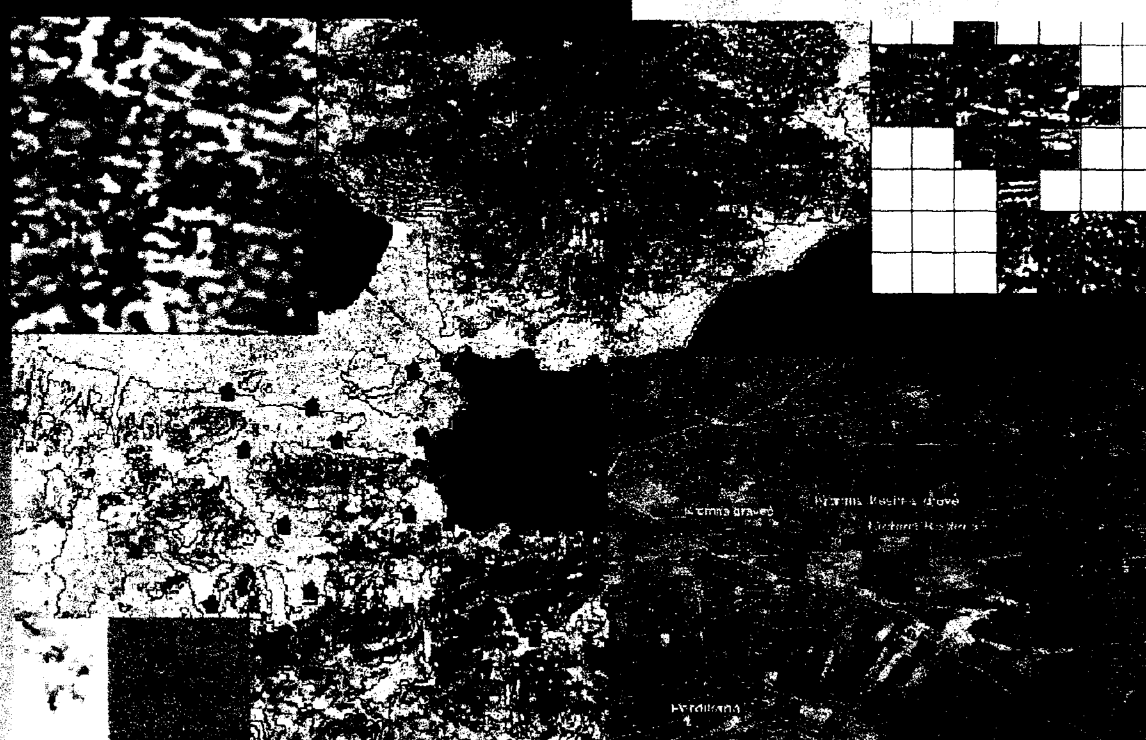
TECHNICAL REPORT

Geophysical Prospection Survey at Kromna-Kesimia & Perdikaria as part of the East Korinthia Archaeological Survey (EKAS - 2002)



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Rethymno, Crete, Greece
January 31, 2003

1. *INTRODUCTION*

Geophysical prospection work was carried out at selected sites that were discovered during the course of the Eastern Korinthia Archaeological Survey (EKAS). The project has been conducted by Ohio State University (Prof. Timothy E. Gregory) and Florida State University (Prof. Daniel J. Pullen). The interdisciplinary project aimed towards the reconstruction of the ancient settlement patterns, emphasizing the role of the past and present environmental settings. The research area was defined by the Examilia and Isthmia basins of the Eastern Korinthia (Fig. 1.1.), where a geomorphological study was carried out and preceded the archaeological investigations.

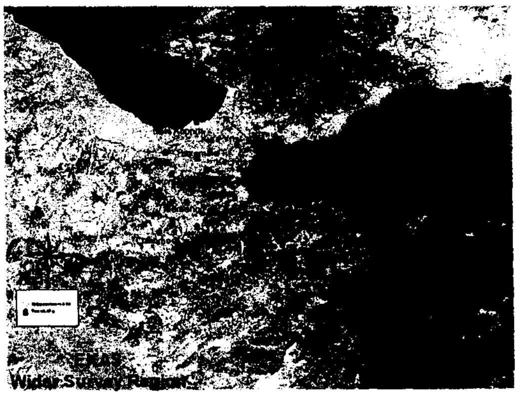

Figure 1.1.: The wider area of interest, as it was covered by the East Korinthia Archaeological Survey (EKAS).

The geophysical surveys were conducted by the Laboratory of Geophysical-Satellite Remote Sensing & Archeo-environment of the Institute for Mediterranean studies/Foundation of Research & Technology, Hellas (F.O.R.T.H.). Geophysical investigations (2002) followed the geomorphological and archaeological studies (1999-2001) and they were focused in the areas of Kromna-Kesimia and Perdikaria (Fig. 1.2.). The geophysical surveys took place during the period of July 9-16, 2002. The goal of the surveys was to map the subsurface architectural relics and provide additional information regarding the extent of the sites and the layout of features across them.

The geophysical surveys were carried out using high-resolution magnetic and soil resistance techniques covering an area of more than 14,000 sq. m. The mosaic of the geophysical grids overlaid on the aerial imagery of the region is shown in Fig. 1.3.

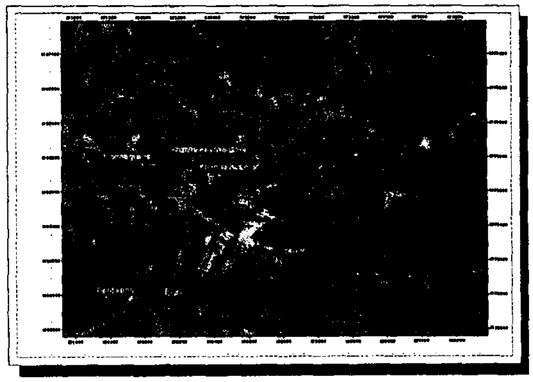

Figure 1.2.: Geophysical investigations were focused in the areas of Kromna-Kesimia and Perdikaria.

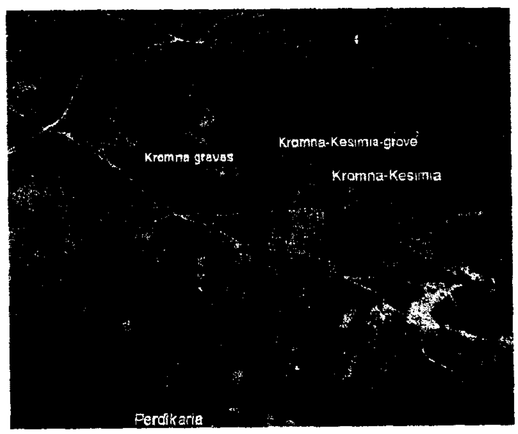

Figure 1.3.: Layout of the geophysical grids.

2. *GEOPHYSICAL PROSPECTION: METHODOLOGY & AREAS OF INTEREST*

The geophysical survey was carried out at 4 different areas (see Fig. 1.2 & 1.3). The first area was Kromna-Kesimia (LOCA 9003), where a number of architectural blocks were found in several fields on the north side of a farm road. About 24 grids were surveyed in the above area using magnetic techniques and a large portion of the site was also covered using soil resistance techniques. Another 20x20m grid (Kromna-Kesimia grove field – DU 1523), was also covered through magnetic techniques. The grid was lying about 150m to the NW of the grid mosaic at Kromna-Kesimia. Two more grids in the area of the tombs (what it is believed to be the cemetery of Kromna) were covered with magnetic techniques. The graves are about 400m to the east from Kromna-Kesimia grids. Finally, both magnetic and soil resistance methods were applied in the prospection of 9 grids at Perdikaria (LOCA 9221), lying about 600m SW from Kromna-Kesimia grids, at the "Plowed Field" site below Rachi Boska.

Geophysical methods can detect various types of subsurface soil features such as pits, building foundations, structural remains, ditches, middens, fire hearths, kilns and concentrations of pottery. These methods are nondestructive and involve measuring the physical properties of soils (such as magnetic susceptibility or electrical resistance) on or below the surface of a site. The soil resistance techniques are best suited for features that contrast with the surrounding soils in porosity, density and water content such as walls, foundations and ditches. The magnetic methods are best suited for features that contrast with the surrounding soils in the concentrations of magnetic minerals they contain, such as pits or ditches filled with topsoils imbedded in sub-soils. In particular, burned soils, kilns, fire hearths, habitation units and ditches filled with organic material enhance the magnetic susceptibility of the soil and thus are good targets for magnetic methods.

Generally, magnetic methods were employed systematically, and they were used for surveying all areas of interest. Soil resistance techniques were used in selected areas of interest to refine the results of the magnetometry and provide complementary information. In the case of the Kromna tombs area, the soil was hard enough to prohibit the use of the frame for soil resistance measurements.

Together with aerial and satellite remote sensing, geophysical prospection has become an integral part of a number of archaeological regional and landscape projects in Greece, providing a general support to the results of archaeological field-walking activities and contributing to the definition and mapping of the occupation areas and the settlement pattern analysis (Sarris 1992:7, Sarris & Jones 2000). Most of these surveys made use of magnetic and resistivity prospection techniques with a high degree of success in mapping the subsurface relics. More specifically, resistivity anomalies in the archaeological survey in Central Boeotia (Bintliff and Snodgrass 1988) were well correlated with the spatial distribution of ceramic scatter and the geochemical survey. Similar results were drawn during the course geophysical (magnetometry and resistivity) and geochemical survey in Laconia (Cavanagh *et al.* 1996: ill. 24.28). Structure foundations and walls (from Late Neolithic to Ottoman period) were generally well defined through the geophysical techniques, especially in areas where environmental conditions and modern activities favored their preservation status.

In other projects (such as Pylos regional survey and Grevena geophysical and geochemical survey), geophysical prospection had a limited level of success in mapping the subsurface relics (mainly due to the environmental conditions of the surveyed sites, such as the proximity of highly resistive bedrock or the presence of olive trees) (Zangger *et al.* 1997:595-613), but it provided valuable information regarding landscape reconstruction, alluvial terrace mapping and paleosols identification (Russell, 1994). In a much more sophisticated way, the Nikopolis project merged geophysical (ground based and coring techniques) and satellite remote sensing to study the diachronic settlement patterns of an 800 km^2 in N.W. Greece (Wiseman 1993). Geological cores suggested that the Holocene marine transgressions extended up to the mountain ridges, geophysical prospection supported the evidence of settlement at sites of higher elevation, such as those in the plain of Grammeno, and satellite imagery was employed to identify several exposed deposits of Plio-Pleistocene sediments associated with Paleolithic sites (Sarris *et al.* 1996).

3. FUNDAMENTAL PROPERTIES OF GEOPHYSICAL PROSPECTION TECHNIQUES

During the geophysical prospection of Kromna-Kesimia and Perdikaria, magnetic and soil resistivity techniques were employed to record the subsurface information at specific areas of the archaeological site. The above geophysical techniques were chosen as the most appropriate for meeting the goals of the project, according to the needs of the research, the geomorphological characteristics of the site and the expected subsurface archaeological targets - with respect to the detection and mapping of them. Emphasis was given to the detailed (high resolution) coverage of the specific areas, using magnetic techniques. A short summary of the properties of the magnetic prospection techniques and the methodology followed in the field is presented in the following paragraphs.

Magnetic Prospection Methods

Magnetic measurements deal with anomalies of the geomagnetic field, which are caused by contrasts of the rock magnetization or by soils rich in magnetic oxides. The magnetization of rocks contains shares of inductive and remnant magnetization: the inductive magnetization originates from the magnetic earth field and depends on its actual strength and direction and on the susceptibility χ of rocks or soils. In contrast, the remnant magnetization is constant and is not changed by alterations of the recent magnetic field.

The remnant magnetization is a long-term effect, which is independent of the recent geomagnetic field. Only iron and ferrimagnetic minerals can be strongly magnetized. The latter are mostly oxides and sulphides of iron. Other materials may be ferro-, para- and diamagnetic. While the similarly strong ferromagnetism is combined with high magnetic susceptibility, the para- and diamagnetism are so weak that they can be ignored in field measurements.

The magnetic effects of magnetic bodies, which can be surveyed on the surface of the earth, are dependent not only on their magnetization, form and size, but also on their depth, because the magnetic field weakens with increasing distance. In archaeological investigations various constructions such as kilns, ovens or fireplaces show increased remnant magnetism thus producing pronounced magnetic anomalies. The task of the interpretation is to separate the results of human activity from the geological variations in subsurface materials.

The measurement of the magnetic field is carried out by proton or caesium magnetometers, which measure the total magnetic field strength, or by gradiometers (proton, caesium or fluxgate), which measure the vertical or the horizontal gradient of the total magnetic field or one of its components, correspondingly (Figure 3.1). The measurements of the first derivative of the vertical component (vertical magnetic gradient) are taken with a fluxgate gradiometer. Fluxgate gradiometers have accuracy of the order of magnitude of 0.1 - 1nT/m. The magnetic field is measured using a sensitive sensor at a constant distance and close to the surface of the ground. Measurements are taken at constant step intervals (usually 0.5-1m depending on the size of the archaeological targets) within rectangular grids of relatively small dimensions (10x10m or 20x20m). Similar is the case of proton or caesium gradiometers, which measure the vertical or horizontal gradient of the total magnetic field intensity.

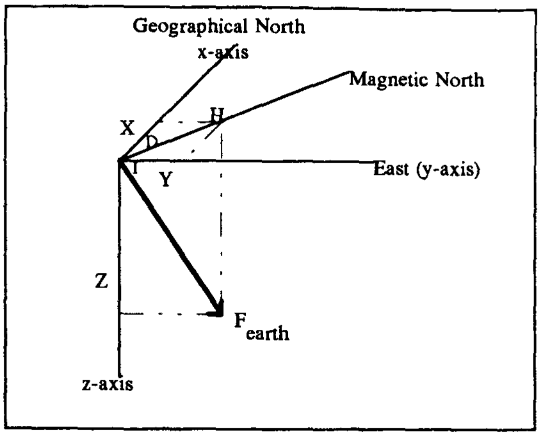

Figure 3.1.: Components of the Earth's magnetic field.

Subsurface targets with magnetic properties different from those of the surrounding soil matrix change the local magnetic field at some large or small degree. This kind of perturbation of the magnetic field is observed as an "anomaly" in the measurements. The disturbance of the upper layers of the soil due to anthropogenic causes can create observable magnetic anomalies.

The magnetic anomalies are directly related to the measurement of the magnetic susceptibility of the soil. Areas with enhanced magnetic susceptibility (with respect to the one of the surrounding soil) are represented as positive anomalies, whereas areas with smaller percentage content in iron oxides (ie. smaller values of the magnetic susceptibility) are represented as negative magnetic anomalies. Both kinds of anomalies are interesting in the process of interpretation of the magnetic data.

Generally, the existence of archaeological relics in the subsoil is characterized by an increase in the magnetic susceptibility levels of the corresponding area, causing a weak magnetic field, which alters the local magnetic field of the earth.

In the prospection of the EKAS sites, the Geoscan FM36 - Fluxgate Gradiometer (Figure 3.2.) was used for the measurement of the vertical gradient of the local magnetic field, namely the difference of the vertical component of the magnetic field at two different heights from the surface. The two sensors of the fluxgate gradiometer consist of two coils, 0.5m apart, emphasizing features within 50-100 cm of the surface. The instrument is able to read the vertical gradient with an accuracy of 0.1nT/m. It is a rapid instrument, which is operated by one person, but it requires readjusting a few times during a day. The readings of the fluxgate gradiometer do not need any corrections for the diurnal variation of the magnetic field since both sensors read simultaneously the vertical component of it. In the same way, measurements are more sensitive in the shallow features due to the smoothing of the deep geological trends.

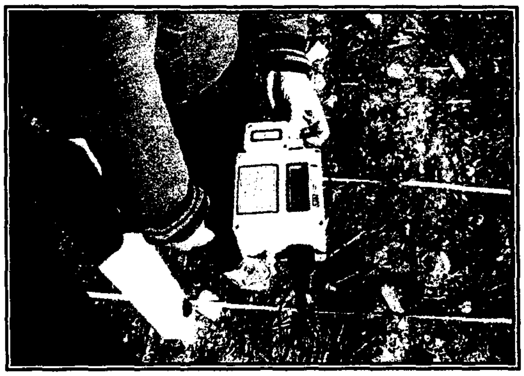

Figure 3.2.: The instrument Geoscan FM36 that was used in the magnetic survey.

Soil Resistance Prospection Methods

Resistivity methods make use of DC or AC fields to measure the electrical potential or potential gradient of the corresponding current. The direct current (DC) method utilizes the resistivity of minerals and rocks. By applying artificial fields of DC (potential fields), the important physical property, the resistivity ρ, is measured in Ohm-m. In geoelectric surveys, a direct current or an alternating current of low frequency (<100 Hz) is fed into the ground by two metallic current electrodes with low stake resistance. This causes a potential field, which is influenced by the distribution of the specific resistivities in the earth. Measurements of differences of the potential field (voltage U [V]) are carried out between two well-grounded, non-polarizable potential electrodes. By applying special evaluation software, information about the distribution of resistivities and the geological structures can be derived.

Geoelectric field data are normally evaluated and presented by the proportion of the voltage U to current I, as measured in the field over inhomogeneous ground. These data are converted into values, which would be valid for a homogeneous half space by considering the actual electrode array. These values are called apparent resistivities and are expressed in [Ohm-m]. Geoelectric DC methods are predominantly used for geoelectric mapping for determination of the horizontal distribution of the resistivity in defined depth horizons.

Lateral differences in apparent resistivities are mapped for a distinct depth level. The data are obtained from a fixed array, which records the potential differences between the potential electrodes and is moved step-by-step along survey lines until the whole survey area is covered. The result is presented as a contour map. Soil resistance anomalies are considered the variations of the electric field or the current density, which are caused by the existence of subsurface targets of different geoelectrical characteristics (resistivity or conductivity). Architectural features, vacuums, caves, wallings and rocky structures appear as strong anomalies of high resistance. Trenches, concentration of organic material and conductive soils appear as weak anomalies of low resistance.

In the prospection of archaeological sites, the Twin Probe configuration is usually employed since in offers a number of advantages such as the mobility of the array, the speed of coverage, the satisfactory spatial resolution and the easy interpretation of the data. The method makes use of two stationary (remote) electrodes (one for the potential and the other for the current) in a distance of about 15m from the surveyed grid and another pair of electrodes which move along transects within the grid. Data are taken every 1m and the spatial resolution and depth range of the array is about 1a and 1-2a correspondingly, where a is the distance between the electrodes of the moving pair. The accuracy of the measurements is about 0.1 Ohms.

The strategy that was followed in prospecting the sites of Kromna-Kesimia and Perdikaria, was to use the fluxgate gradiometer for locating possible anomalies and then use soil resistance techniques in order to verify them or get complementary information about the subsurface relics.

It has to be mentioned that the interpretation of geophysical anomalies depends on past experience and theoretical models and hypotheses. The results of the interpretation process cannot be considered always irrefutable. They may be related to geological or surface characteristics or other environmental parameters. The refinement of the interpretation of the geophysical maps can be achieved with the cooperation of both archaeologists and geophysicists and the confirmation of a selected number of candidate targets (Aitken, 1974, Weymouth, 1986, Sarris, 1997).

4. *METHODOLOGY*

Instrumentation

In the geophysical survey, a Geoscan FM36 fluxgate gradiometer and a Geoscan Resitivity meter RM15 were used for measuring the vertical magnetic gradient and the soil resistance with an effective investigation depth of about 1-1.5m. The goal of the geophysical prospection campaign was the detection and mapping of the subsurface archaeological remnants at the specific areas of interest.

Measurement Strategies

The geophysical techniques were used in a systematic way. Measurements were carried out with sampling interval of Δx & Δy=1m in magnetic surveys for both East and North directions. In the area of the tombs at Kromna-Kesimia, magnetic surveys were carried out with sampling interval of Δx=1m & Δy=0.5m to achieve a higher resolution. Soil resistance measurements were taken every 1m, along transects 1m apart. The coverage of the areas of interest was carried out by moving along transects in a S-N direction.

Processing Procedure

Due to the nature of the magnetic measurements, the magnetic data did not need any corrections for the diurnal variations of the earth's magnetic field. On the other hand, all data were characterized by a constant shift of the average value within each surveyed grid due to differences in balancing the instrument and the shifting of the base/reference stations. For this reason, pre-processing of the data was needed in order to create a common base level for all grids (rectification of images).

The raw magnetic data were entered in a portable PC right after fieldwork. Magnetic data were dumped into a portable PC through an RS232 serial cable. Each data set was coded after a grid number. Data sets were given the appropriate coordinates according to the position of the adjacent grids. A specific (random) map coordinate system was chosen, following the topographic layout of the excavation/survey grids. Statistical analysis of both the common rows and the calculation of the average level of adjacent grids were carried out in order to provide a correction factor for each grid. Both the change of coordinates and the correction factors were able to create the mosaic of the grids in each area. In this way processing of the adjacent grids was conducted simultaneously.

Most data sets were processed with a specific methodology. Kriging interpolation was used for gridding the data. In some cases, selective despiking techniques were used to isolate the extreme values that masked the anomalies of interest. Selective compression of the dynamic range of values was also employed to isolate anomalies close to the background level. A mask file was created to isolate the area that was not surveyed.

Other filters such as high-pass filters (gradient) or the calculation of first horizontal derivatives have been helpful in emphasizing the high frequency components of the geophysical maps. Finally, interpretation maps (in a simplified diagrammatic form) were produced based on the features that were identified during the different processing steps.

Colour and grey scale geophysical maps were produced: Hot colours (reddish colours) in colour maps and light (white) colours in grey scale maps represent high magnitude measurements. Cold colours (bluish colours) in colour maps and dark (black) colours in grey scale maps represent low intensity anomalies.

5. *RESULTS*

LOCA 9003: KROMNA-KESIMIA (1528-1531, 1542-1544)

The area of research was covered by young olives to south of the dirt road and older olives to the north. Wheat was also cultivated towards the northeast part of the region. Part of the area to the north of the dirt road was also transformed to a vineyard. Several architectural blocks were lying across the site, some of which were considered to be *in situ*. Most of the blocks were at the limits of the different property fields and owners claimed that they were coming from the nearby fields. According to the preliminary archaeological survey report, among the finds discovered in the corresponding Dus were Mycenaean fine wares (Late Helladic), terracotta figurines (at least two of which are Late Helladic), and much fine ware of the Geometric and Archaic periods as well as of the Classical and Hellenistic periods. Preliminary study of a mall portion of the latter material by Martha Risser indicated that the specific finds could be considered as evidence for the existence of a shrine or sanctuary of the Archaic and Classical periods.

About 24 grids were investigated in the particular region. 23 grids had dimensions of 20x20m, whereas one grid (to the north) had dimensions 20x15m. Eight of the grids were lying south of the dirt road. The mosaic of the geophysical grids measured with sampling of Δx=1m and Δy=1m, shows some variability of the magnetic signals, which indicate a systematic drift especially evident in the northern and southern grids (Fig. 5.1). At the same time, some strong anomalies (linear and isolated) are present at various sections of the investigated area. In order to better define the subsurface magnetic anomalies and isolate the signals originating from the surface features, a systematic recording of the surface features was performed during the survey of each grid. Surface anomalies were overlaid on the map of the magnetic anomalies (Fig. 5.2.). In an effort to balance the signal's level differences originating from various balance procedures of the instrument, data were rectified to a common level base line (Fig. 5.3.). In this way, it was possible to smooth out differences originating by the different levels of the magnetic signals within the individual grids. Together with the compression of the dynamic range of the grey scale of the magnetic values, the resulting map shows a number of features, some of which are not related to the surface characteristics of the terrain.

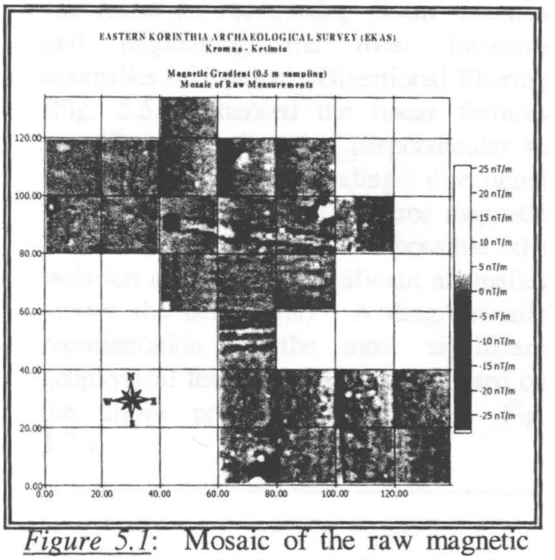

Figure 5.1: Mosaic of the raw magnetic measurements with 1m sampling interval.

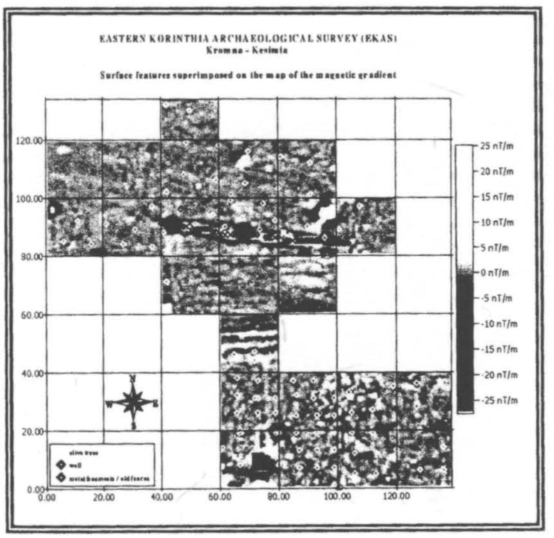

Figure 5.2: Overlay of the surface features on the rectified map of the magnetic data. The correlation of some strong anomalies with the existence of old fences, metal fragments and trees is obvious.

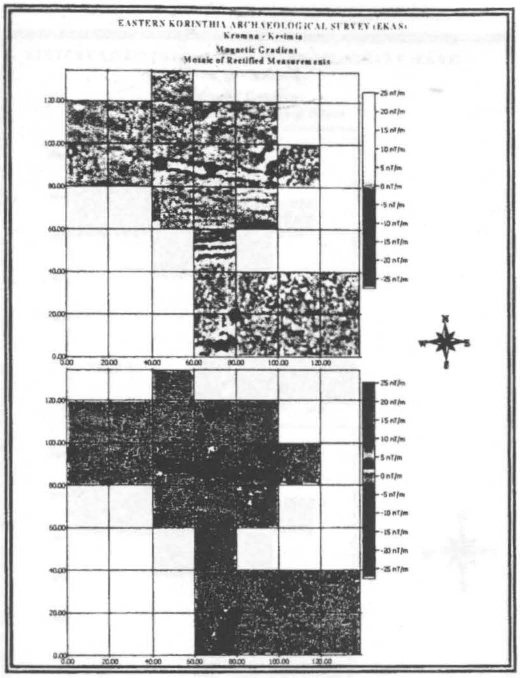

Figure 5.3: Rectification of magnetic measurements to a common level base line. Grey scale and color maps.

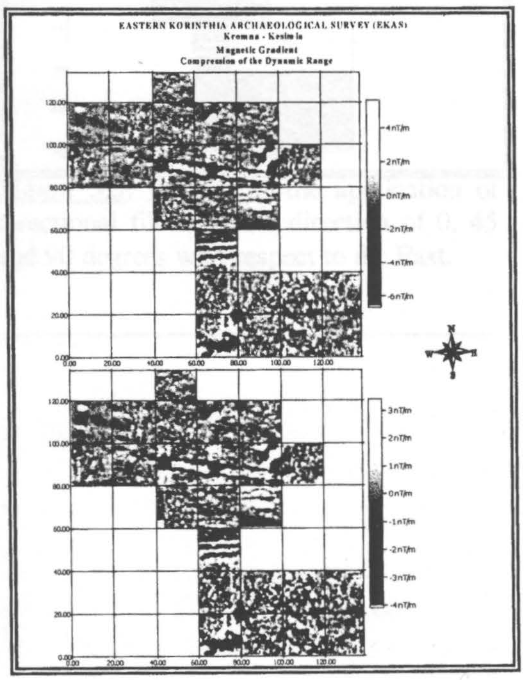

Figure 5.4. Grey scale maps resulting from the compression of the dynamic range of the magnetic values.

Initial values of the magnetic measurements included also values in the upper and lower limits of the gradiometer range (+/-204.7 nT/m). The compression of the dynamic range of the magnetic values (Fig. 5.4.) was applied for different ranges (namely –6 to 5nT/m and –4 to 3 nT/m) in order to highlight anomalies lying close to the background level. The particular method was able to smooth the extreme anomalies originating from metal fragments in favor of the weaker anomalies. Processing of the data was successful in recognizing linear features and pinpointing the most intensive anomalies of interest. Directional filtering (Fig. 5.5.) enhanced the linear features extending in a direction perpendicular to that of the corresponding directional filters. Mapping of the extreme magnetic values (Fig. 5.6.) made possible the isolation of the most significant anomalies (above the base level). A diagrammatic representation of the most significant geophysical features was created, based on the above processing procedures (Fig. 5.7.).

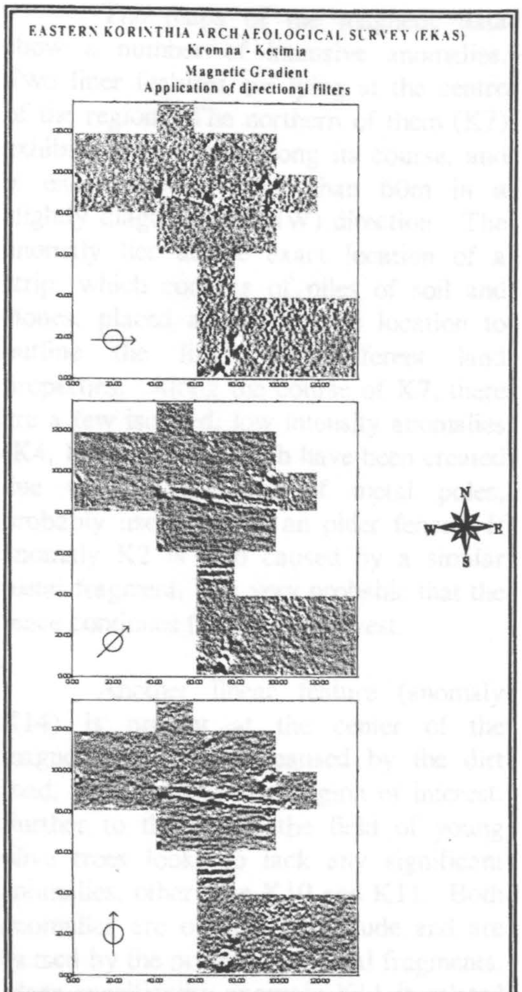

Figure 5.5: Results of the application of directional filters in the direction of 0, 45 and 90 degrees with respect to the East.

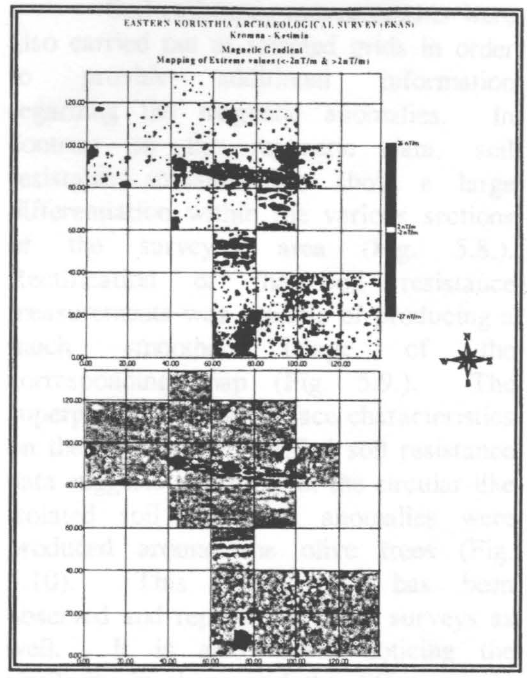

Figure 5.6: Mapping of the extreme values (lows and highs) of the magnetic data.

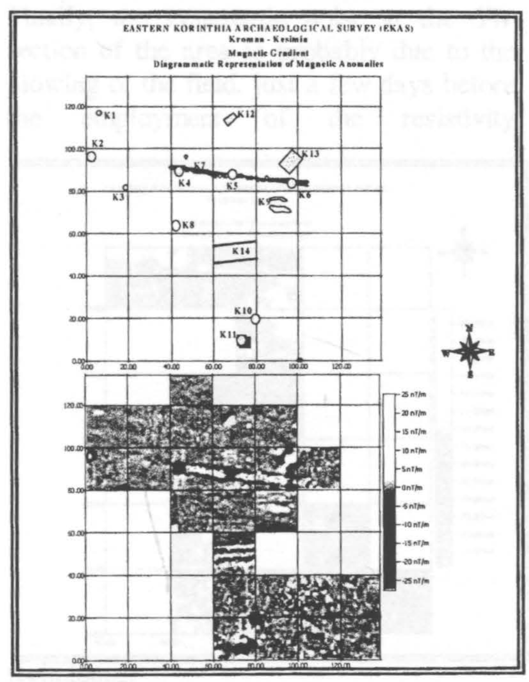

Figure 5.7: Diagrammatic representation and coding of the magnetic anomalies.

The maps of the magnetic data show a number of intensive anomalies. Two liner features are lying at the centre of the region. The northern of them (K7) exhibits high values along its course, and is extending for more than 60m in a slightly diagonal (SE-NW) direction. The anomaly lies at the exact location of a strip, which consists of piles of soil and stones, placed at the specific location to outline the limits of different land properties. Along the course of K7, there are a few isolated, low intensity anomalies (K4, K5 and K6), which have been created due to the existence of metal poles, probably used to hold an older fence. If anomaly K2 is also caused by a similar metal fragment, it is very probable that the fence continues further to the west.

Another linear feature (anomaly K14) is present at the center of the magnetogram and is caused by the dirt road, which crosses the region of interest. Further to the south, the field of young olive trees looks to lack any significant anomalies, other than K10 and K11. Both anomalies are of high magnitude and are caused by the presence of metal fragments. More specifically, anomaly K11 is related to a modern well and anomaly K10 is caused by a metal stake that supports an olive tree. Anomalies K1, K3 and K8, at the northern field, seem to be of similar nature.

The most significant anomalies of the region can be identified with K12 and K13. They are of dipole nature and their axis of symmetry lies at a NW-SE direction. They extend over a region of 3x3 m and 6x6 m for K12 and K13 respectively. Their original intensity (+/- 25nT/m) does not justify the presence of metal fragments. It can be suggested that both of the above anomalies may be related to the presence of kilns.

Finally, anomaly K9 corresponds to 2 slight depressions in the terrain. Due to the lack of any geometric characteristics, it is not certain if the particular anomaly can be related to architectural relics.

Soil resistance measurements were also carried out at selected grids in order to provide additional information regarding the magnetic anomalies. In contrast to the magnetic data, soil resistance measurements show a large differentiation within the various sections of the surveyed area (Fig. 5.8.). Rectification of the soil resistance measurements was capable of producing a much smoother image of the corresponding map (Fig. 5.9.). The superposition of the surface characteristics on the map of the rectified soil resistance data suggests that most of the circular-like isolated soil resistance anomalies were produced around the olive trees (Fig. 5.10). This phenomenon has been observed and reported in other surveys as well. It is also worth noticing the similarity in shape and the differences in magnitude and dimensions of the soil resistance measurements produced around the young (to the southern part) and the older (to the northern section) olive trees. Finally, the systematic noise at the SW section of the area is probably due to the plowing of the field, just a few days before the employment of the resistivity techniques.

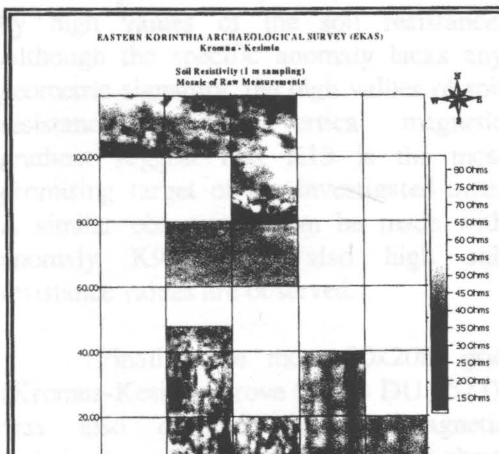

Figure 5.8: Mosaic of the initial soil resistance measurements at Kromna-Kesimia.

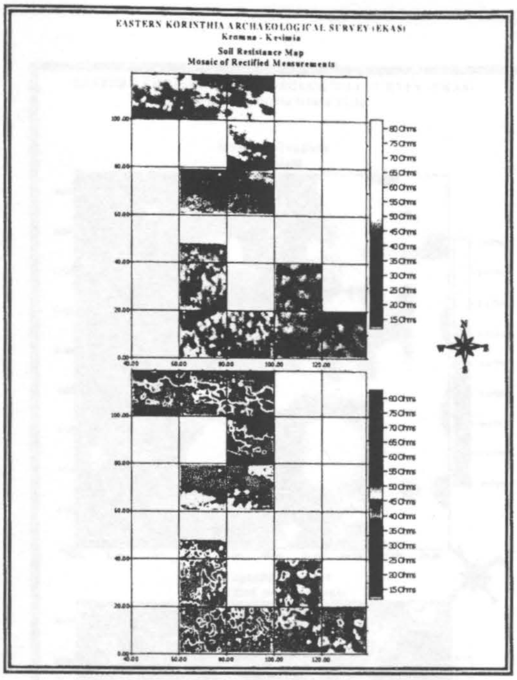

Figure 5.9: Mosaic of the rectified soil resistance measurements at Kromna-Kesimia.

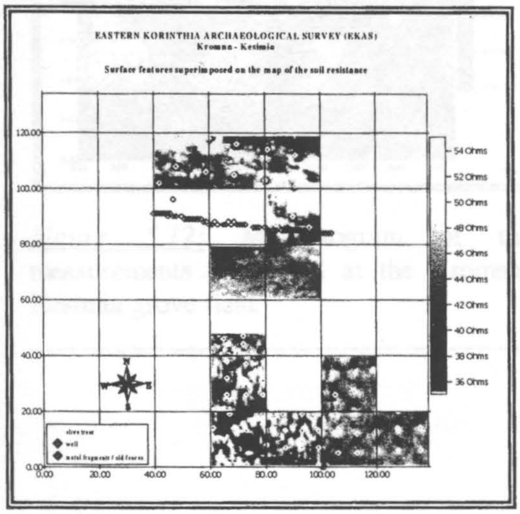

Figure 5.10: Overlay of the surface features on the map of the soil resistance measurements at Kromna-Kesimia.

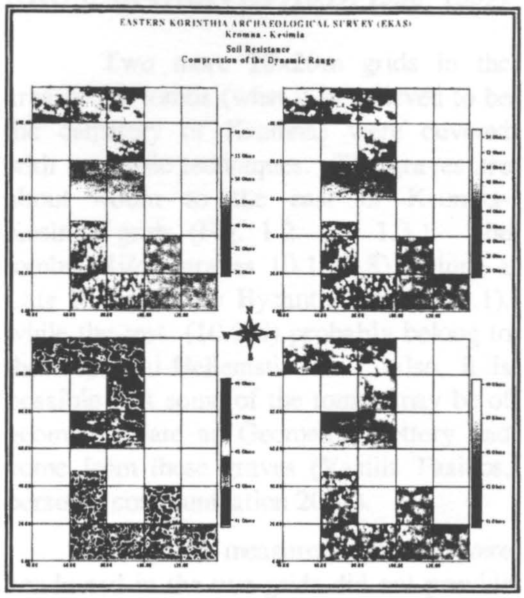

Figure 5.11: Compression of the dynamic range of the soil resistance data taken at Kromna-Kesimia.

A close comparison between the magnetic anomalies (Fig. 5.7.) and the maps derived by the compression of the dynamic range of the soil resistance data (Fig. 5. 11.) shows a good correlation in the vicinity of anomaly K13, characterized by high values of the soil resistance. Although the specific anomaly lacks any geometric signature, the high values of soil resistance and of vertical magnetic gradient suggest that K13 is the most promising target of the investigated area. A similar observation can be made with anomaly K9, where also high soil resistance values are observed.

Finally, one more 20x20m grid (Kromna-Kesimia grove field – DU 1523), was also covered through magnetic techniques. The grid was lying about 150m to the NW of the grid mosaic at Kromna-Kesimia. Magnetic measurements did not produce sufficient evidence for any subsurface targets of archaeological significance (Fig. 5.12).

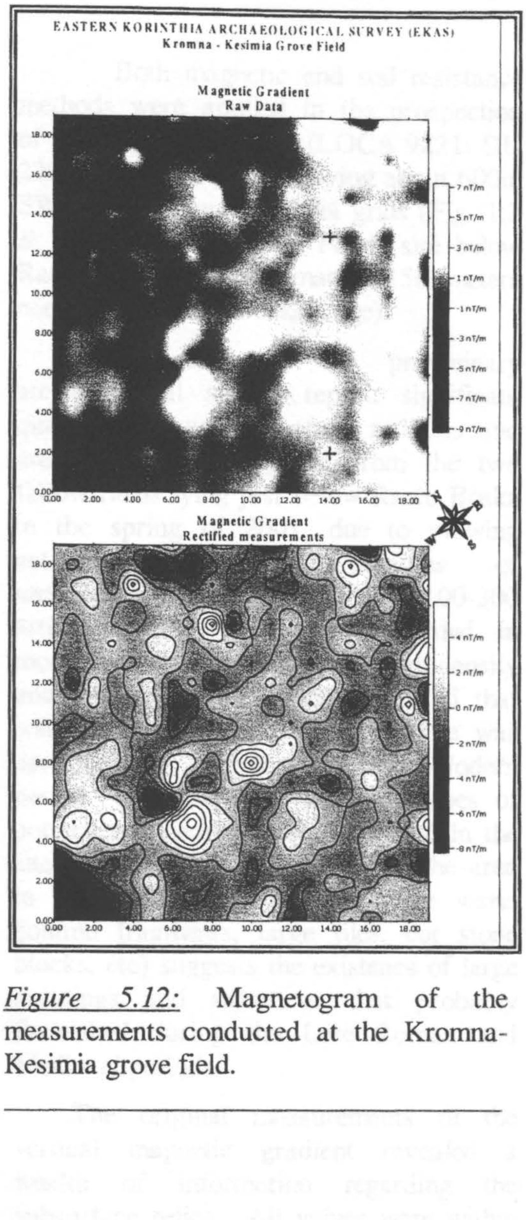

Figure 5.12: Magnetogram of the measurements conducted at the Kromna-Kesimia grove field.

KROMNA-GRAVES (1039, 1558, 1559)

Two more 20x20m grids in the area of the tombs (what it is believed to be the cemetery of Kromna) were covered with magnetic techniques. The graves are about 400m to the east of Kromna-Kesimia grids (Fig. 1.2. and 1.3.). The tombs (Rife's graves 10.1-10.8) include a Late Roman-Early Byzantine tomb (10.1), while the rest (10.2-8) probably belong to the Classical-Hellenistic era. Also, it is possible that some of the tombs may be of geometric date as Geometric pottery had come from these graves (Vasilis Tasinos, personal communication 2002).

Magnetic measurements that were conducted in the two grids did not provide sufficient evidence to support the existence of more tombs in the area of the investigations. In the resulting magnetogram (Fig. 5.13), a few weak anomalies are present but it is very hard to correlate them with tombs (maybe with the exception of an anomaly at x=4-6E, y=12-15N in Grid-2). Finally, no signs of architectural relics or structures are shown in the magnetic maps.

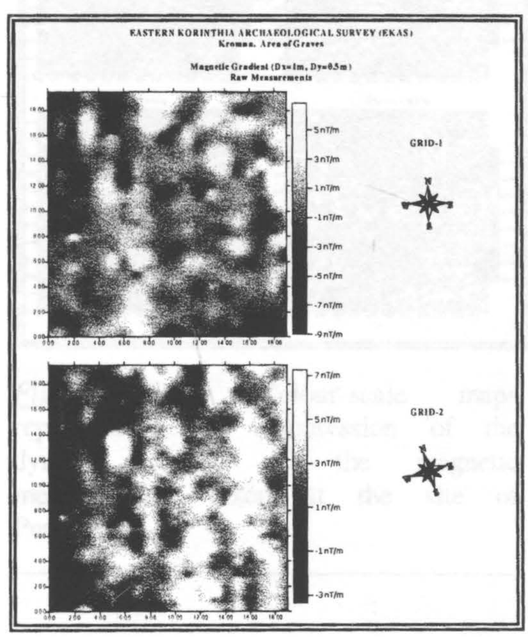

Figure 5.13: Magnetogram of the measurements conducted in the area of the graves at Kromna-Kesimia.

LOCA 9221: PERDIKARIA (2228-2233)

Both magnetic and soil resistance methods were applied in the prospection of 9 grids at Perdikaria (LOCA 9221: DU 2209-2210, 2228-2233), lying about 600m SW from Kromna-Kesimia grids (Fig. 1.2 & 1.3), at the "Plowed Field" site below Rachi Boska (approximately 150 meters north of the Rachi Boska ridge).

According to the preliminary archaeological survey report, significant quantities of well-preserved artifacts and architecture was exposed from the two fallow fields lying just below Rachi Boska in the spring of 2001, due to plowing activities. Large densities of archaeological material (100-300 artifacts/survey unit) were recorded in most sections of the site. The high density and variety of the cultural material that was recorded suggests that the site was used from the Archaic to the Early Modern period. Although the different types of pottery and ceramic material found in the site indicates an intensive use of the area in antiquity, most evidence (fine ware, column fragments, large tiles, cut stone blocks, etc) suggests the existence of large buildings and structures that probably flourished during the Late Roman and Medieval periods.

The original measurements of the vertical magnetic gradient revealed a wealth of information regarding the subsurface relics. All values were within the range of about +/-17 nT/m. The mosaic of the magnetic grids showed a number of linear anomalies, probably originating from architectural relics. The compression of the dynamic range of the magnetic measurements (Fig. 5.14. and 5.15. corresponding to the grey scale and color-scale maps) and the application of directional filters (Fig. 5.16) emphasized the linear features, which are probably related to the outline of an architectural complex, in agreement to the indications of the surface survey data.

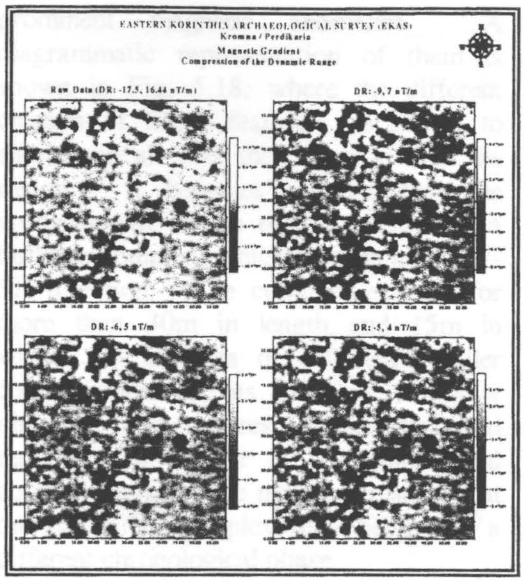

Figure 5.14: Grey-scale maps representing the compression of the dynamic range of the magnetic measurements taken at the site of Perdikaria.

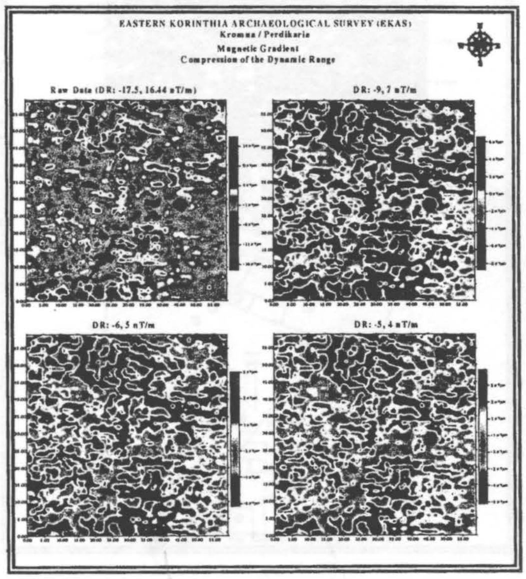

Figure 5.15: Colour-scale maps representing the compression of the dynamic range of the magnetic measurements taken at the site of Perdikaria.

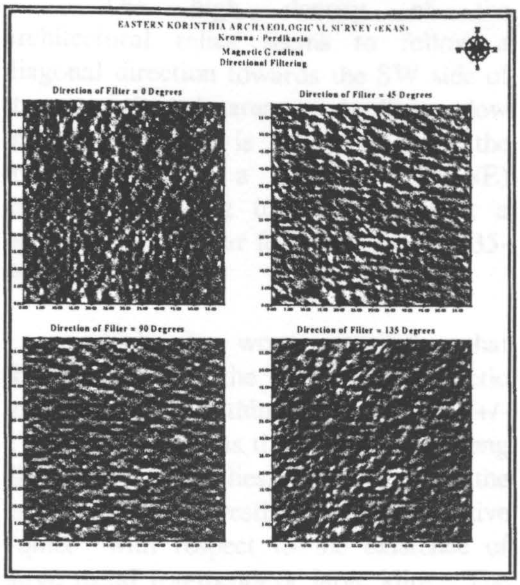

Figure 5.16: The application of directional derivatives (in 4 different directions) emphasized a number of linear features in the magnetic map.

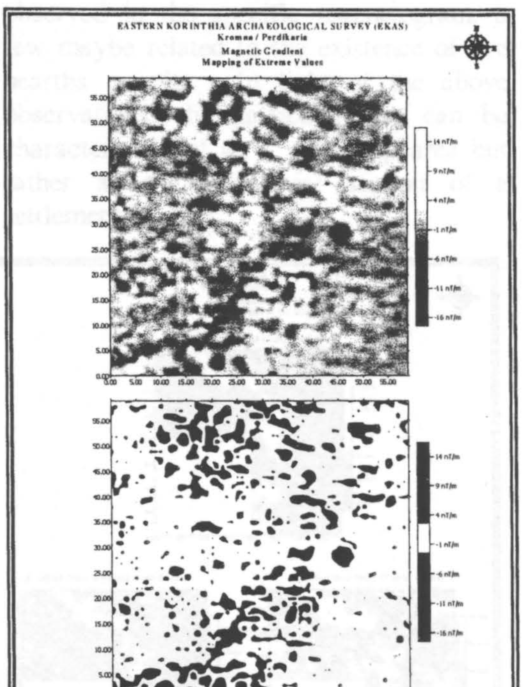

Figure 5.17: Mapping of the extreme values of the magnetic measurements (low values in blue and high values in red).

The application of a high-pass filter and the mapping of the extreme values of the magnetic measurements (Fig. 5.17.) were capable in isolating the most prominent magnetic anomalies. A diagrammatic representation of them is shown in Fig. 5.18, where the different clusters of linear features are shown to spread out all over the central part of the region. It becomes obvious that the northern part of the region consists of a building complex, which extends in a NW-SE direction. The complex extends for more than 30m in length and 15m in width. It consists of different smaller compartments and its direction is slightly different from the rest of the structural remains that appear in the central and southern parts of the map, suggesting that the particular complex may belong to a different chronological phase.

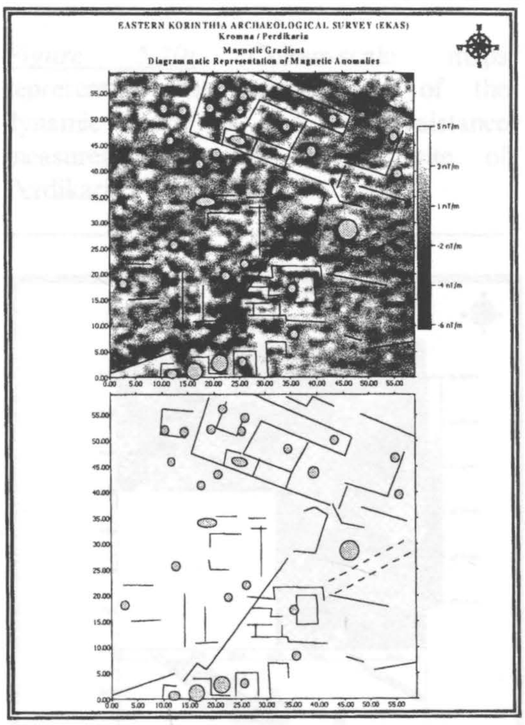

Figure 5.18: Diagrammatic representation of the magnetic anomalies, which have been identified at the site of Perdikaria.

A few signs of structural remains appear in the central region of the map. The density of architectural relics seems to increase towards the southern side of the investigated area. Again, the outline of a well-preserved building is shown to extend in the area x=25-40E and y=10-20N. A number of internal characteristics indicate that the particular feature consists of different compartments.

The high density of the architectural relics seems to follow a diagonal direction towards the SW side of the investigated area. A linear low intensity anomaly is shown to cross the magnetogram in a diagonal (SW-NE) direction, reaching to an end (?) at a probable rectangular feature lying at x=35-40E, y=28-36N.

It is also worth mentioning that the range of the original magnetic measurements (within the range of +/-17nT/m), as well as the lack of any strong dipole-like anomalies, suggest that the area of the investigations is relative "quiet" with respect to the existence of large metal fragments or large kilns. The higher values are located in the SW section of the region, whereas the rest of the magnetic measurements are lying within the range of +/-11nT/m. Of the monopole-like anomalies that can be observed in the specific magnetogram, a few maybe related to the existence of fire hearths or pits. In light of the above observations, the particular site can be characterized not as a workshop area but rather as the residential section of a settlement.

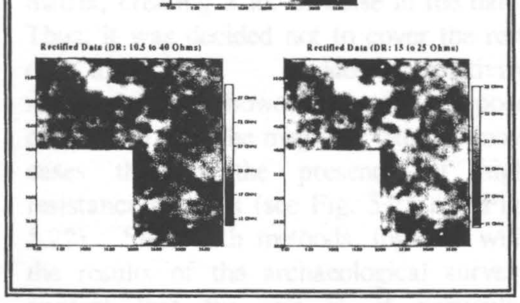

Figure 5.19: Grey-scale maps representing the compression of the dynamic range of the soil resistance measurements taken at the site of Perdikaria.

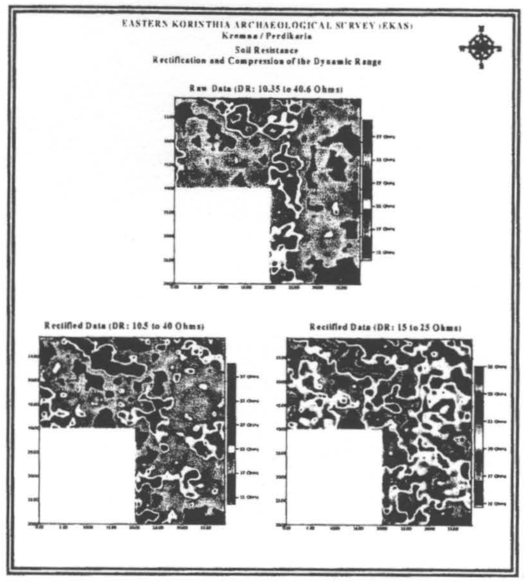

Figure 5.20: Colour-scale maps representing the compression of the dynamic range of the soil resistance measurements taken at the site of Perdikaria.

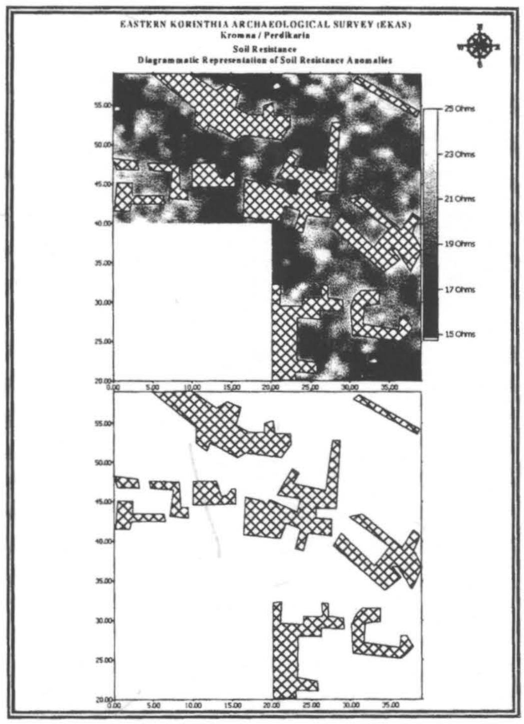

Figure 5.21: Diagrammatic representation of the soil resistance anomalies, which have been identified at the site of Perdikaria.

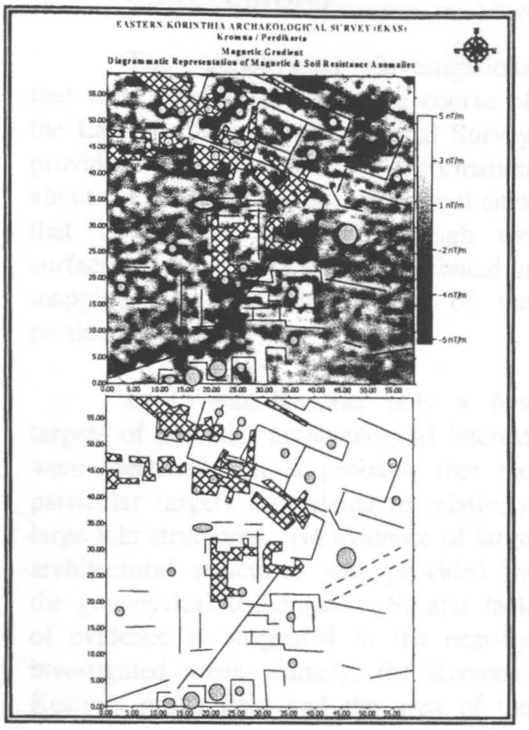

Figure 5.22: Synthetic map representing the outline of both the soil resistance and magnetic anomalies, which have been identified during the course of the geophysical investigations at the site of Perdikaria.

Soil resistivity measurements were conducted only in three out of the nine grids that were surveyed with magnetic techniques (Fig. 5.19 & Fig. 5.20). The surface soil layer was heavily disturbed due to plowing activities and the electrodes of the RM15 frame did not made a good contact with the loose soil matrix, creating a lot of noise in the data. Thus, it was decided not to cover the rest of the site. Indeed, resistivity measurements showed a relative poor correlation with the magnetic data, in most cases through the presence of high resistance sections (see Fig. 5.21 and Fig. 5.22). Still, both methods, together with the results of the archaeological survey, suggest that the site is of particular interest, bearing a number of subsurface targets – probably well-preserved architectural relics of a multi-period settlement.

6. CONCLUSIONS

The geophysical investigations that were conducted during the course of the East Korinthia Archaeological Survey provided complementary information about the nature of the archaeological sites that have been identified through the surface survey activities and contributed in mapping the subsurface relics of the particular sites.

In Cromna-Kesimia only a few targets of potential archaeological interest were identified. It is probable that the particular targets are related to relatively large kiln structures. No evidence of large architectural structures was provided by the geophysical techniques. Similar lack of evidence is suggested in the near-by investigated areas, namely, the Kromna-Kesimia grove field and the area of the graves.

In contrast, the site of the "Plowed Field" at Perdikaria looks more promising. The large densities of archaeological material that were recognized during the surface survey are well related to the evidence provided by the geophysical techniques, which suggests the existence of a number of architectural remains within a depth of about 1-1.5m below the surface. The architectural relics are well presented in the geophysical data, especially in the magnetic measurements, suggesting a relatively good preservation status of them. The different orientation of the structural remains suggests different occupation phases. Among the most prominent features, which were identified through the magnetic survey, are two large structural complexes (one to the north and the other to the center of the surveyed region), consisting of different compartments. Finally, no extreme values were observed in the magnetic data, suggesting that the specific section is related to the residential segment of a settlement.

Future excavations will allow a better correlation of the geophysical features with the actual archaeological relics of the sites.

References

Aitken, M., *Physics and Archaelogy*, 2nd ed., Oxford, 1974.

Bintliff J. L. and A. M. Snodgrass, Mediterranean survey and the city. *Antiquity* 62: 57-71, 1988.

Cavanagh, W., R. Jones and A. E. Sarris, The phosphate and geophysical surveys, in W. Cavanagh, J. Crouwel, R.W.V. Catling and G. Shipley (eds.), *Continuity and Change in a Greek Rural Landscape: The Laconia Survey II*, 235-62. London: British School at Athens supp. Vol. 27, 1996.

Russell, E., Reconstruction of topography at archaeological sites in Grevena, Greece. *Proceedings of the 7th Keck Research Symposium in Geology*, 160-163, Trinity University, San Antonio, Texas, U.S.A., 1994.

Sarris, A., *Shallow Depth Geophysical Investigation Through the Application of Magnetic and Electric Resistance Techniques*. A published Ph.D. Dissertation, U. of Nebraska-Lincoln, Dept. of Physics and Astronomy, Lincoln, U.S.A., 1992.

Sarris, A., J. Weymouth, B. Cullen, C. Stein & J. Wiseman, The Nikopolis Project - integration of geophysical prospection, satellite remote sensing, and GIS techniques in the study of Epirus, Greece. *International Symposium on Archaeometry' 96*, Urbana, Illinois, U.S.A., 1996.

Sarris, A. & Jones, R., "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.

Weymouth, J., Geophysical Methods of Archaeological Site Surveying, in *Advances in Archaeological Method & Theory*, v. 9, ed. by M. B. Schiffer, Academic Press, 1986.

Wiseman, J., Harbors, towns, and prehistory: survey and field school in Greece, *CONTEXT* 11 (Nos 1-2): 1-4, 1993.

Zangger, E., M.E. Timpson, S.B. Yazveno, F. Kuhnke and J. Knaust, The Pylos Regional Archaeological Project, Part II: Landscape evolution and site preservation. *Hesperia* 66(4): 549-642, 1997.

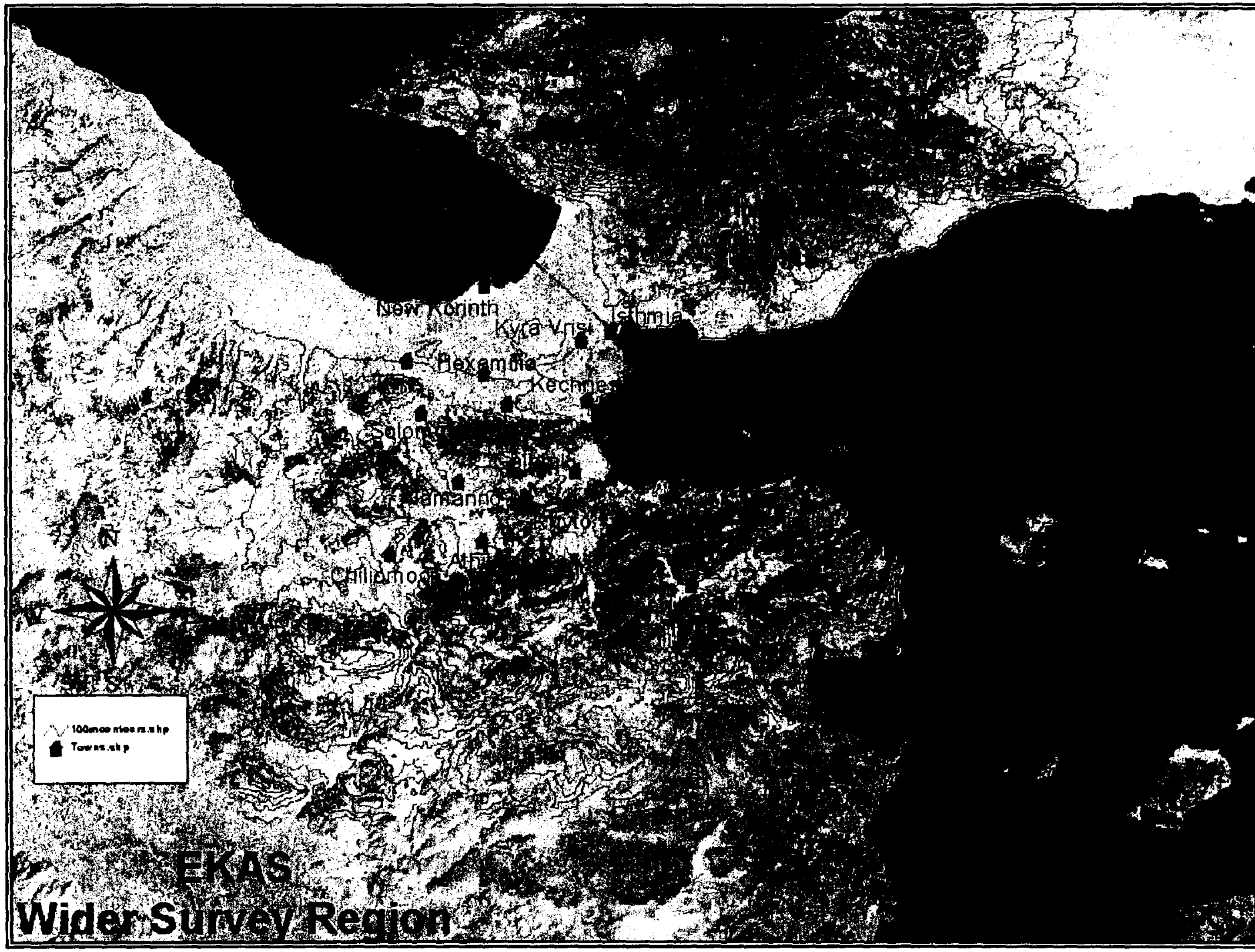

Figure 1.1.: The wider area of interest, as it was covered by the East Korinthia Archaeological Survey (EKAS).

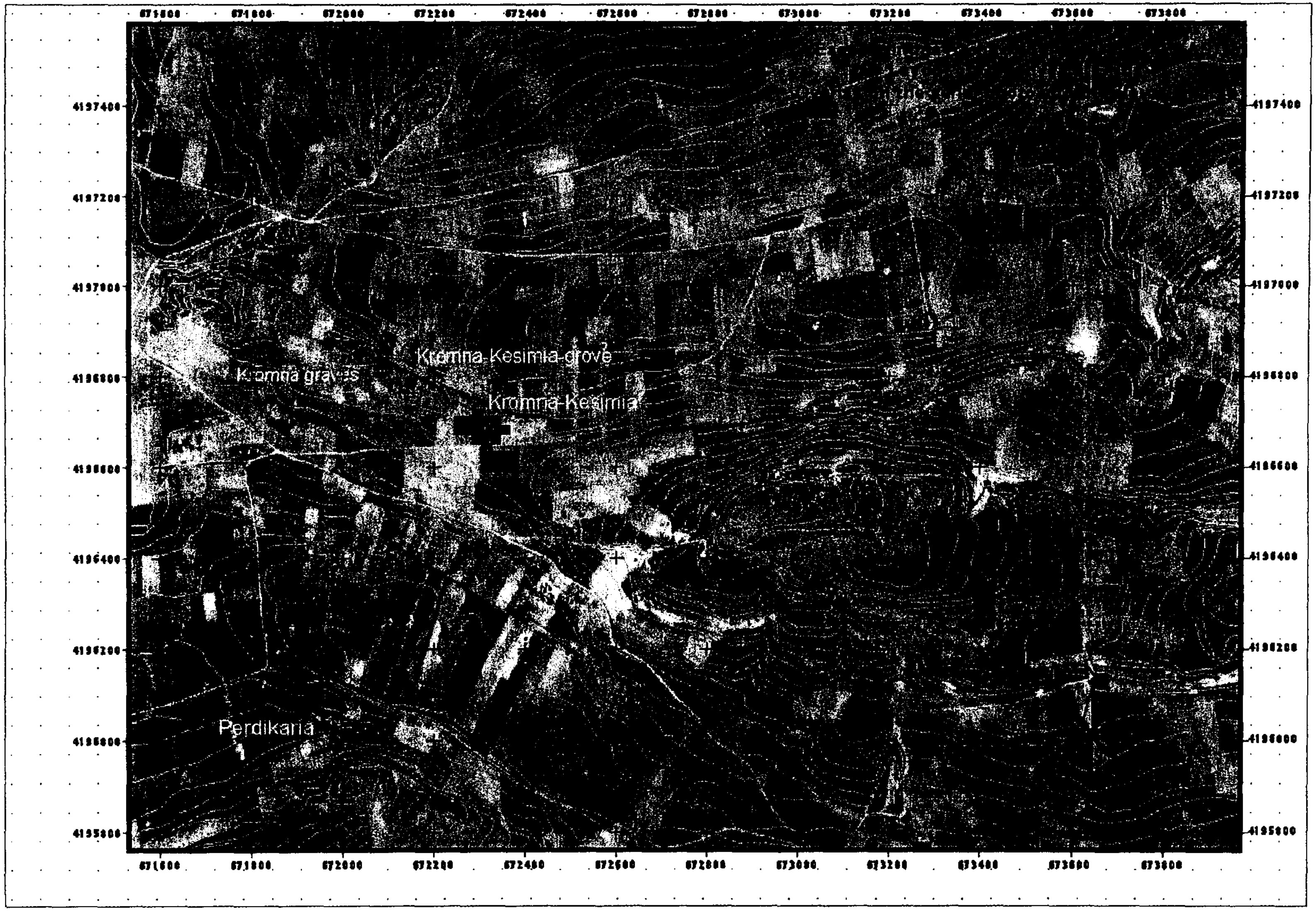

Figure 1.2.: Geophysical investigations were focused in the areas of Kromna-Kesimia and Perdikaria.

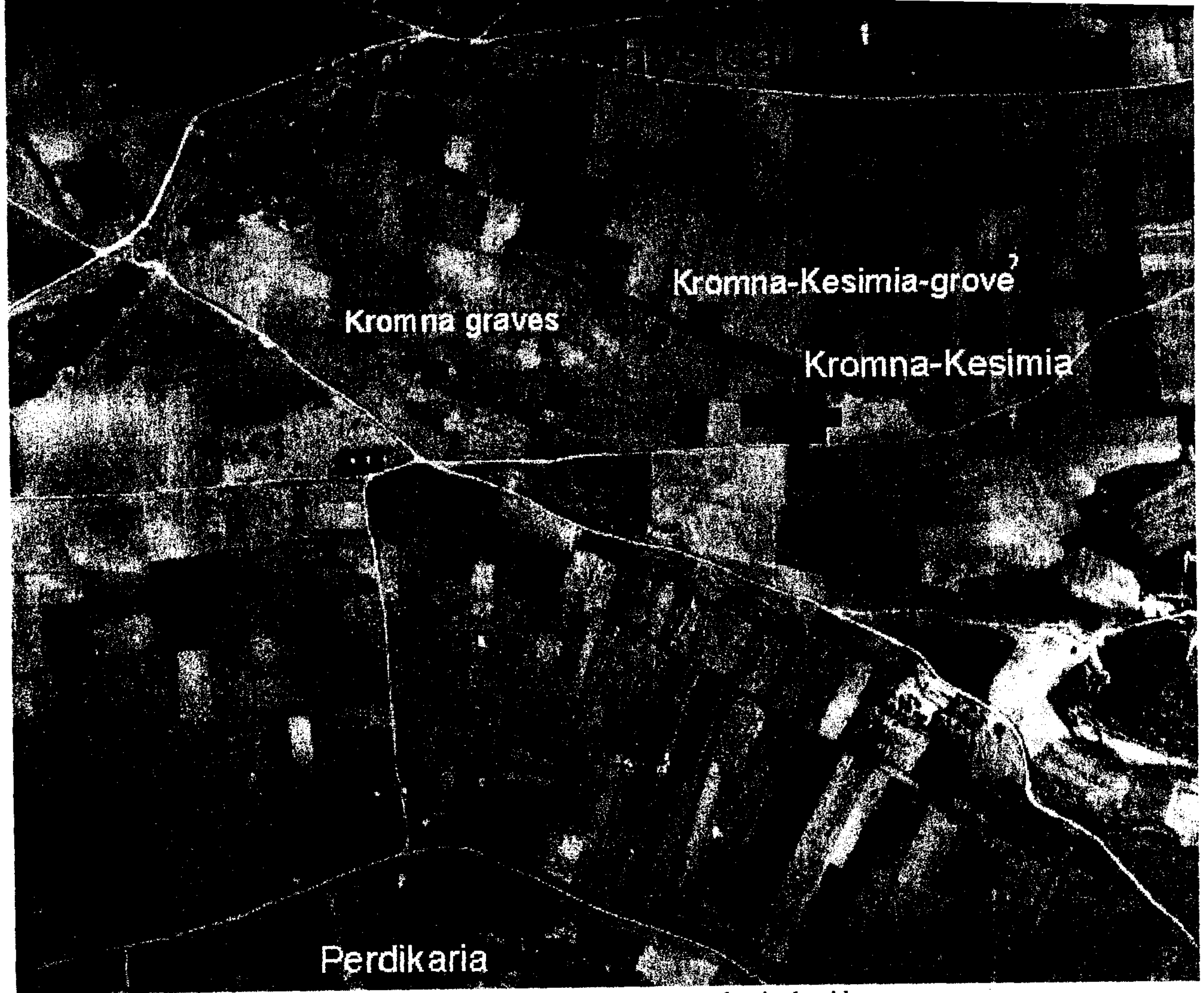

Figure 1.3.: Layout of the geophysical grids.

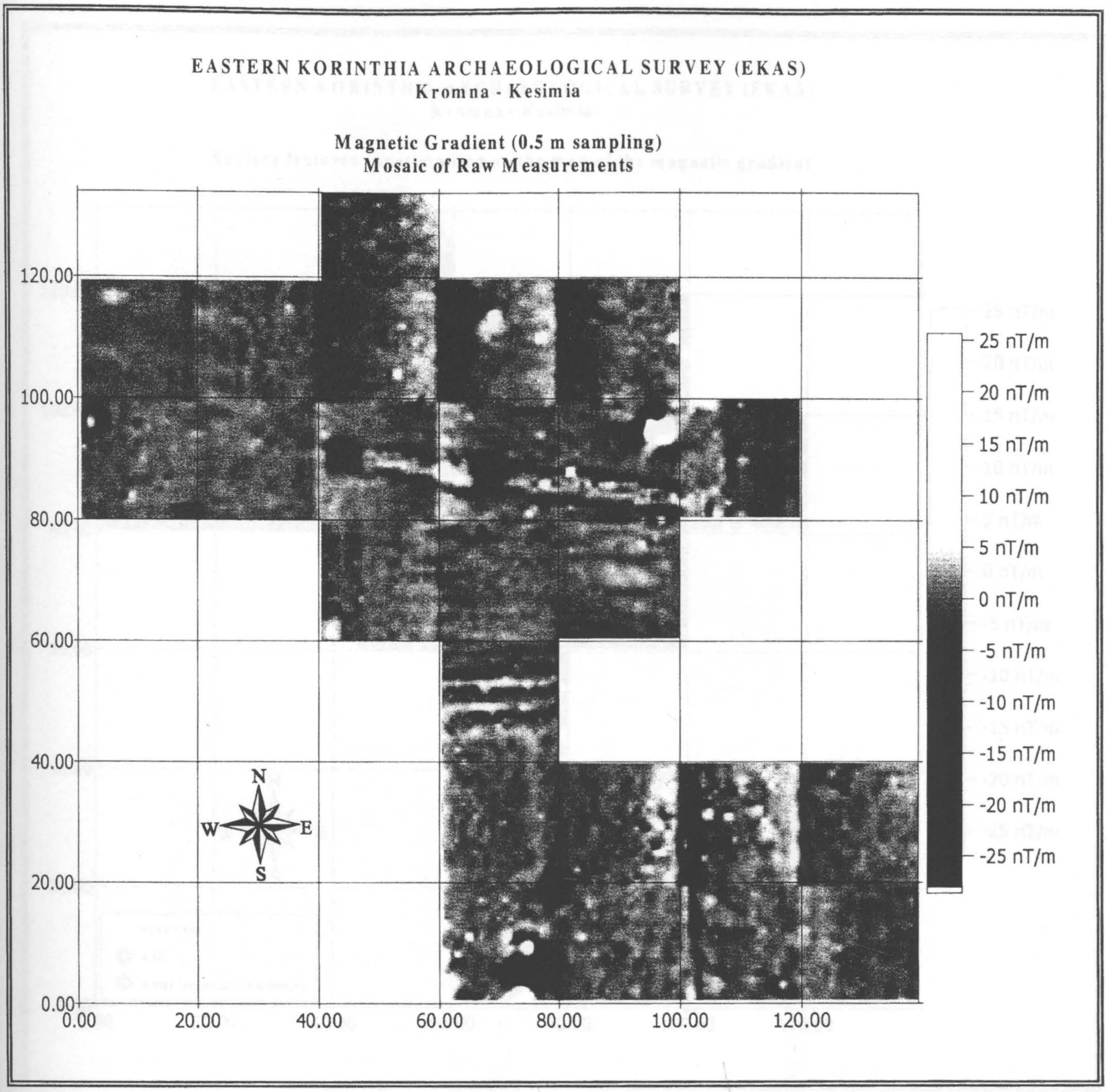

Figure 5.1: Mosaic of the raw magnetic measurements with 1m sampling interval.

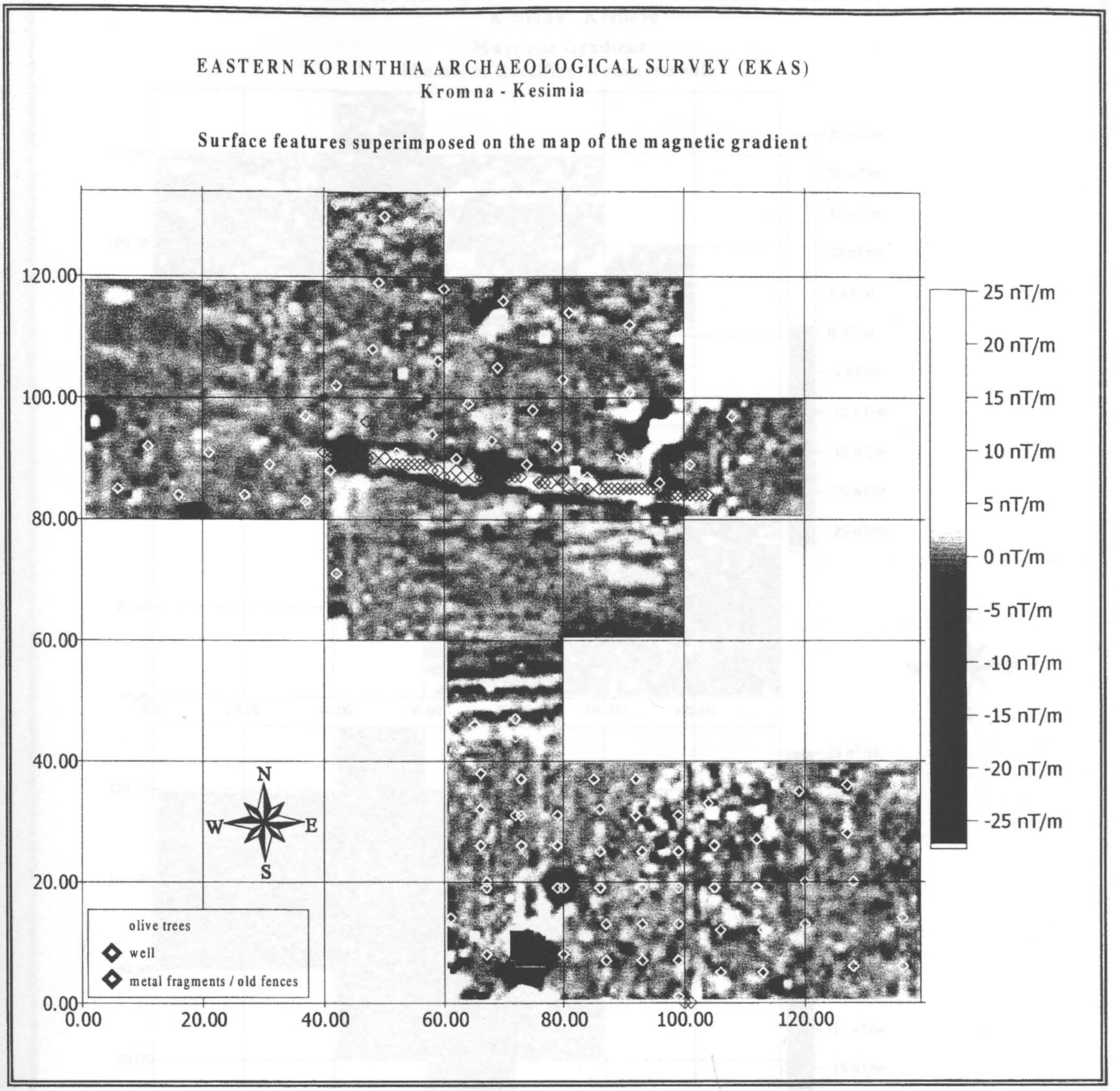

Figure 5.2: Overlay of the surface features on the rectified map of the magnetic data. The correlation of some strong anomalies with the existence of old fences, metal fragments and trees is obvious.

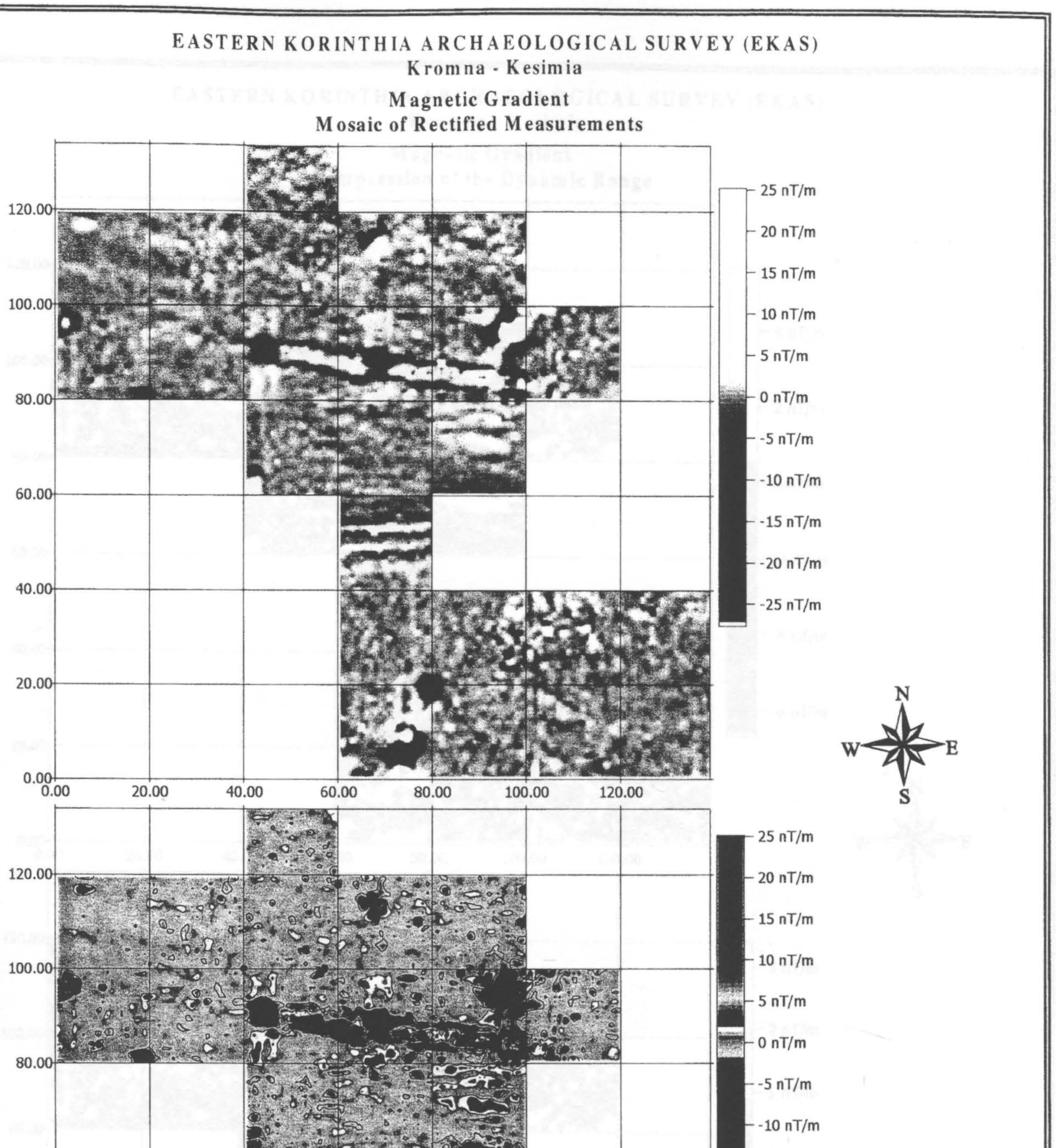

Figure 5.3: Rectification of magnetic measurements to a common level base line. Grey scale and colour scale maps.

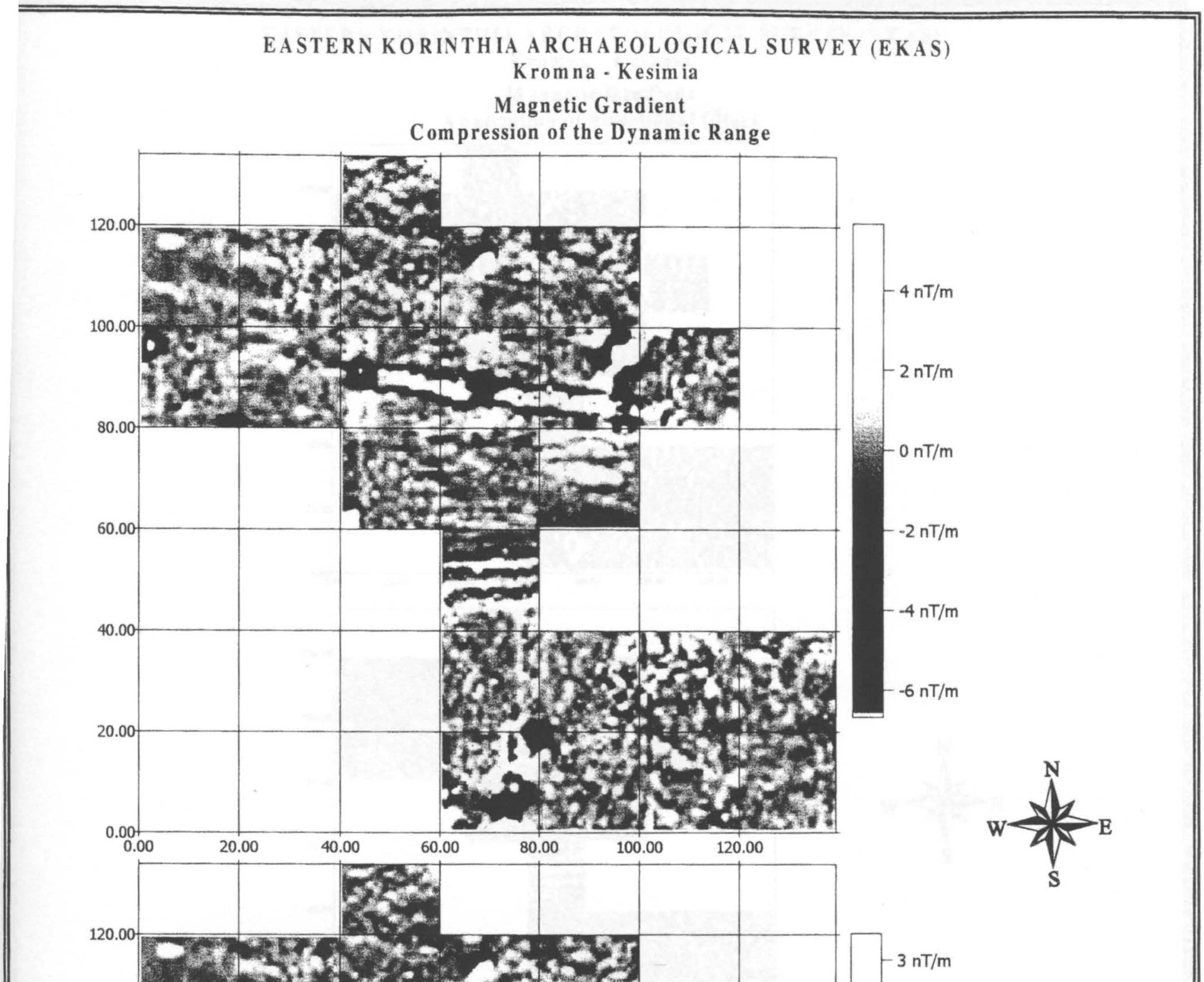

Figure 5.4. Grey scale maps resulting from the compression of the dynamic range of the magnetic values.

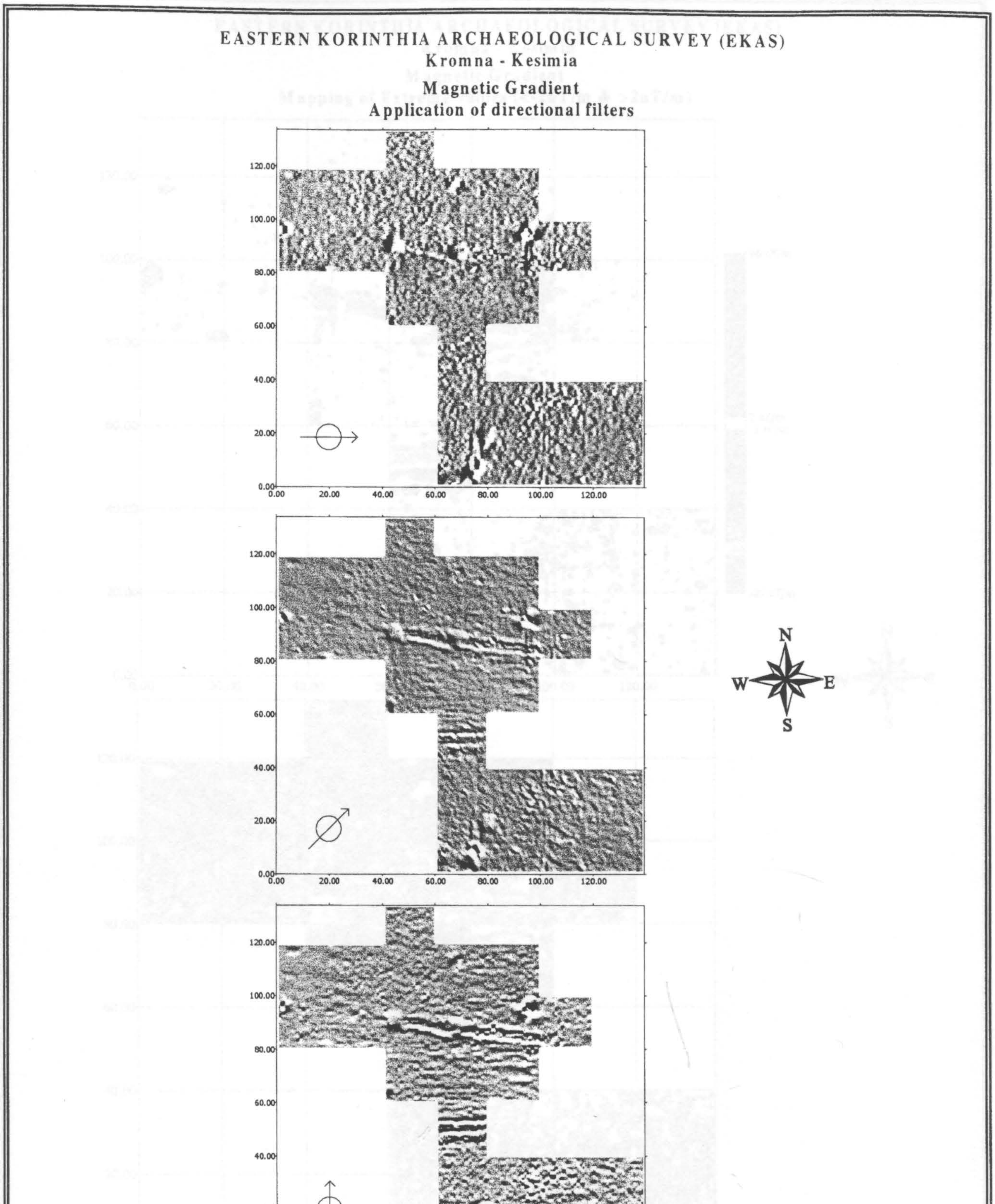

Figure 5.5: Results of the application of directional filters in the direction of 0, 45 and 90 degrees with respect to the East.

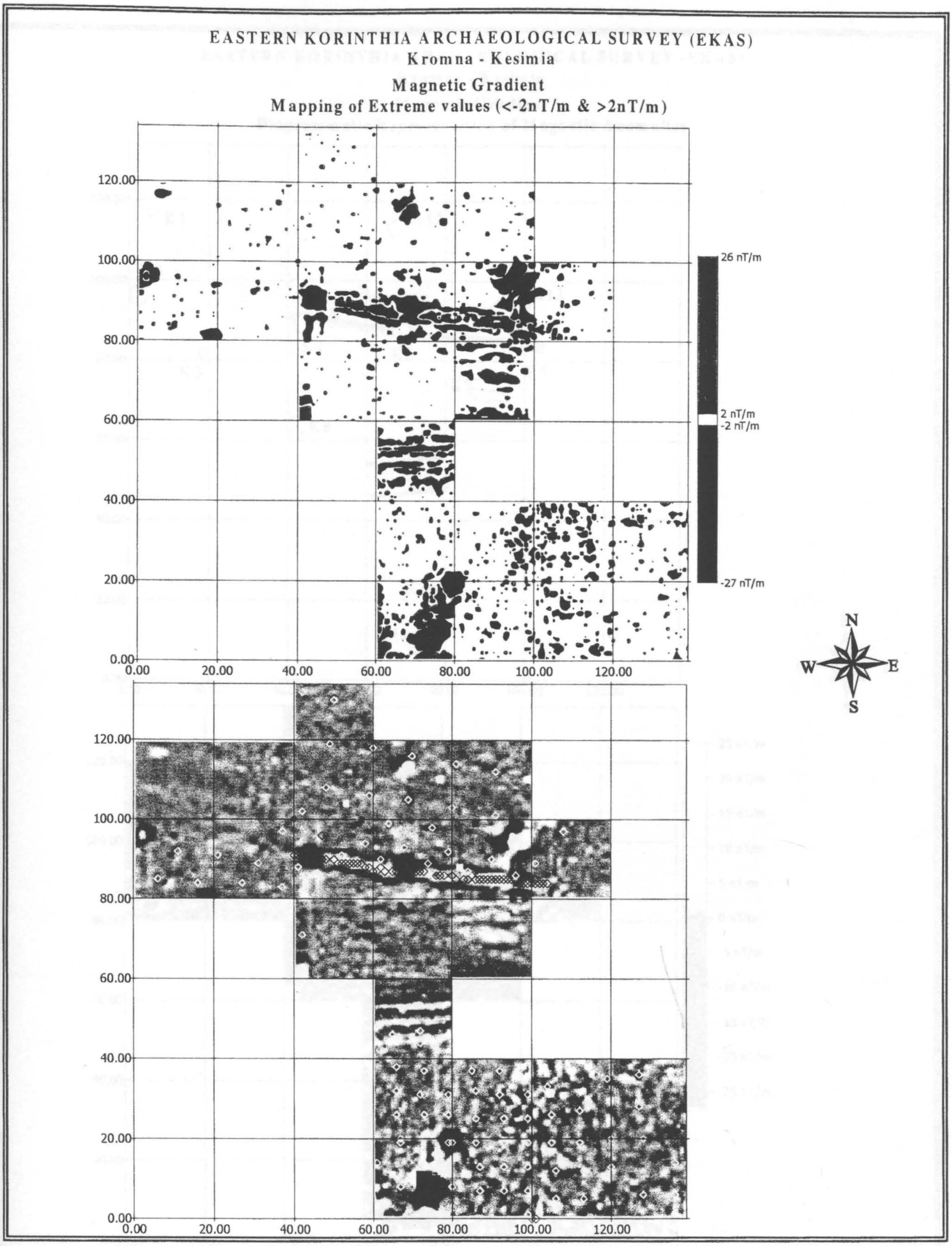

Figure 5.6: Mapping of the extreme values (lows and highs) of the magnetic data.

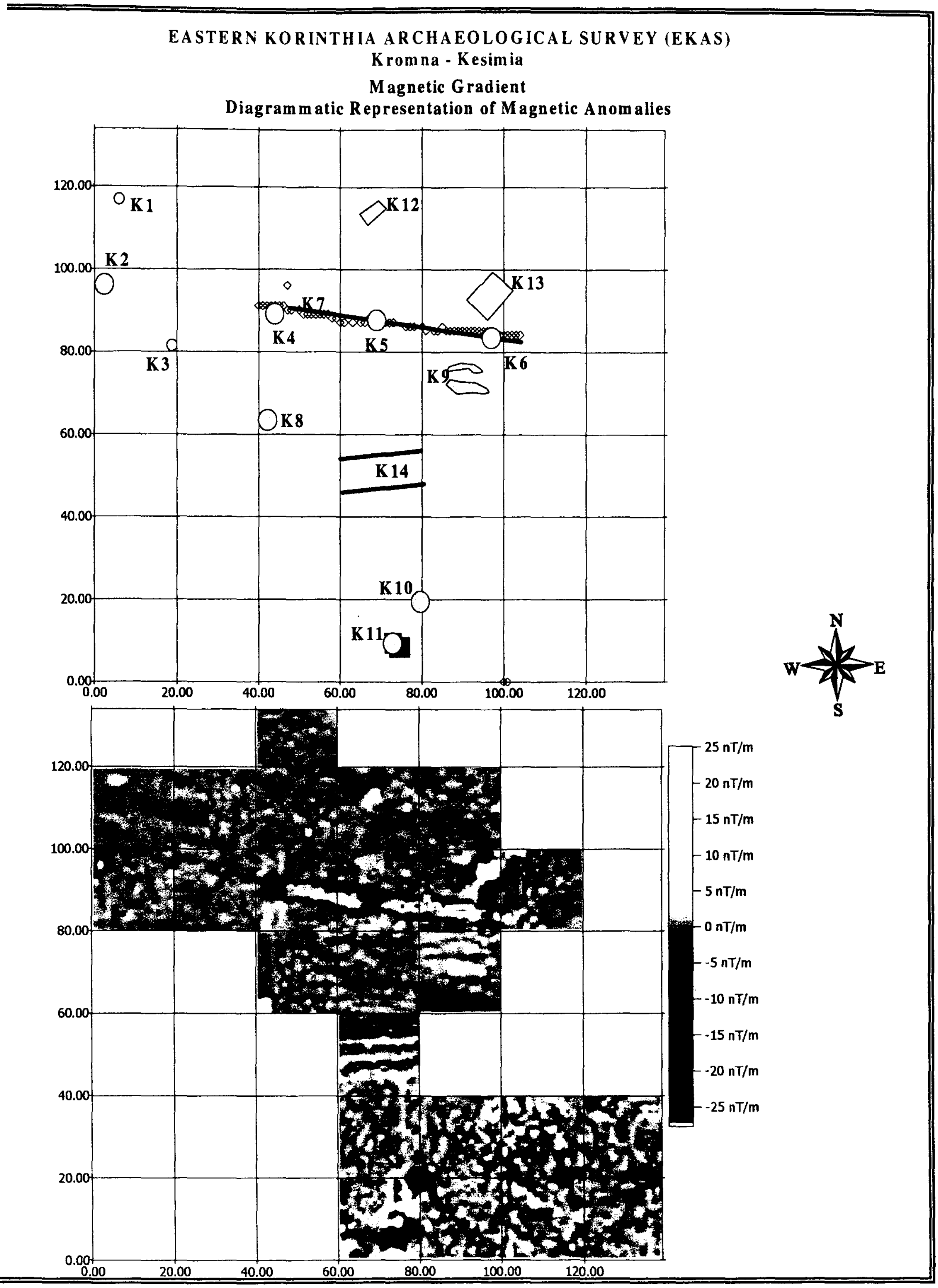

Figure 5.7: Diagrammatic representation and coding of the magnetic anomalies.

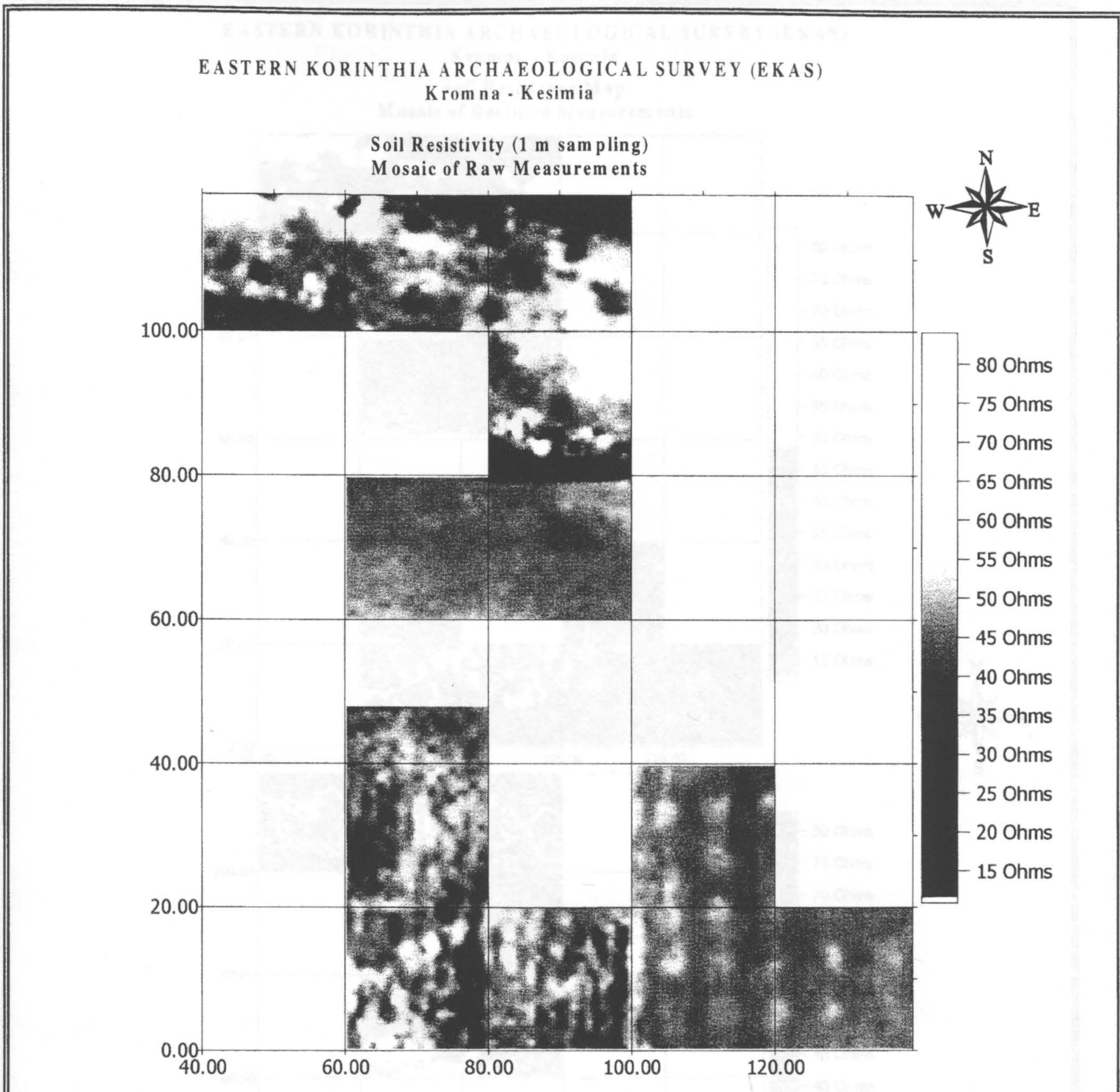

Figure 5.8: Mosaic of the initial soil resistance measurements at Kromna-Kesimia.

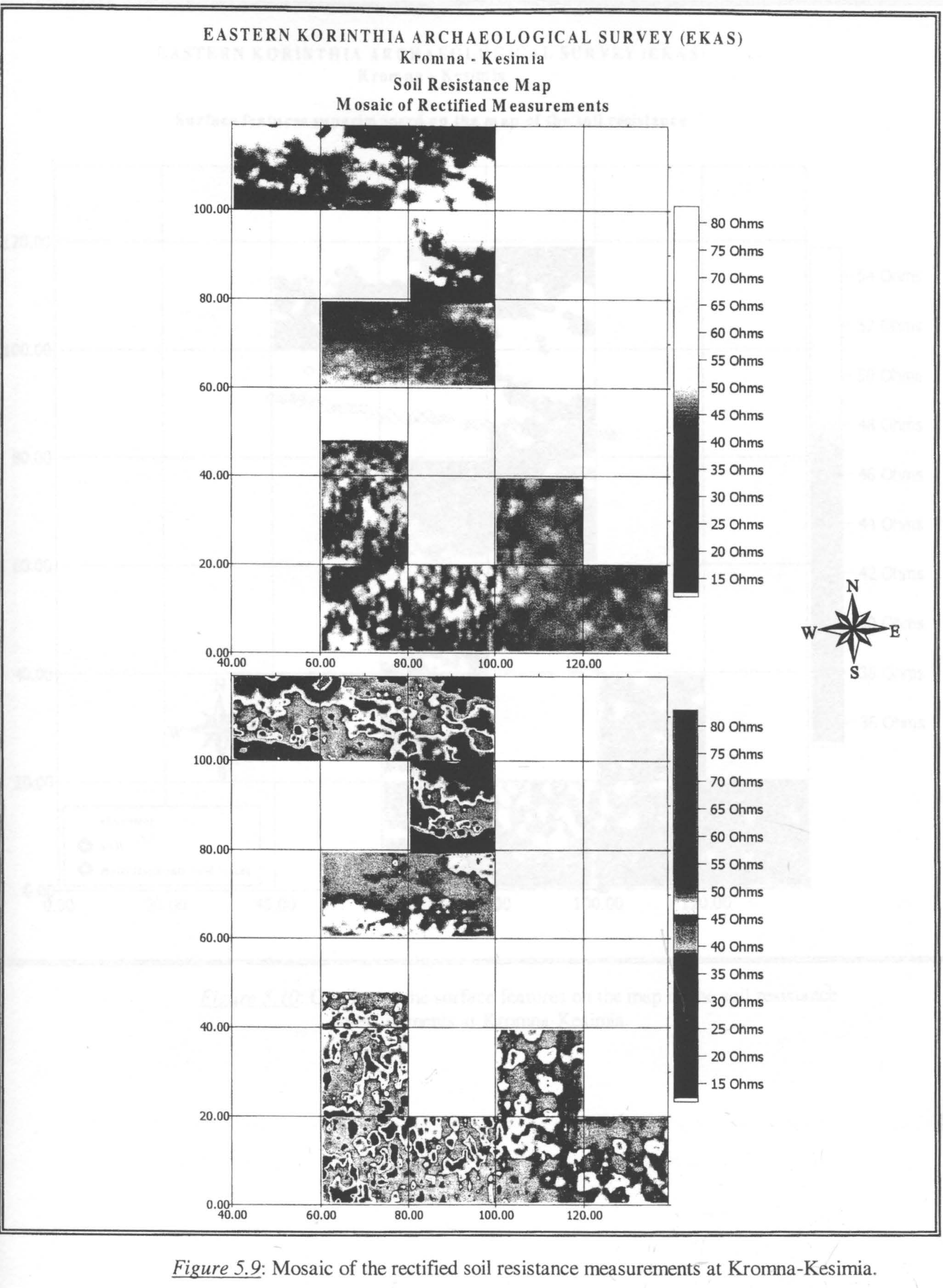

Figure 5.9: Mosaic of the rectified soil resistance measurements at Kromna-Kesimia.

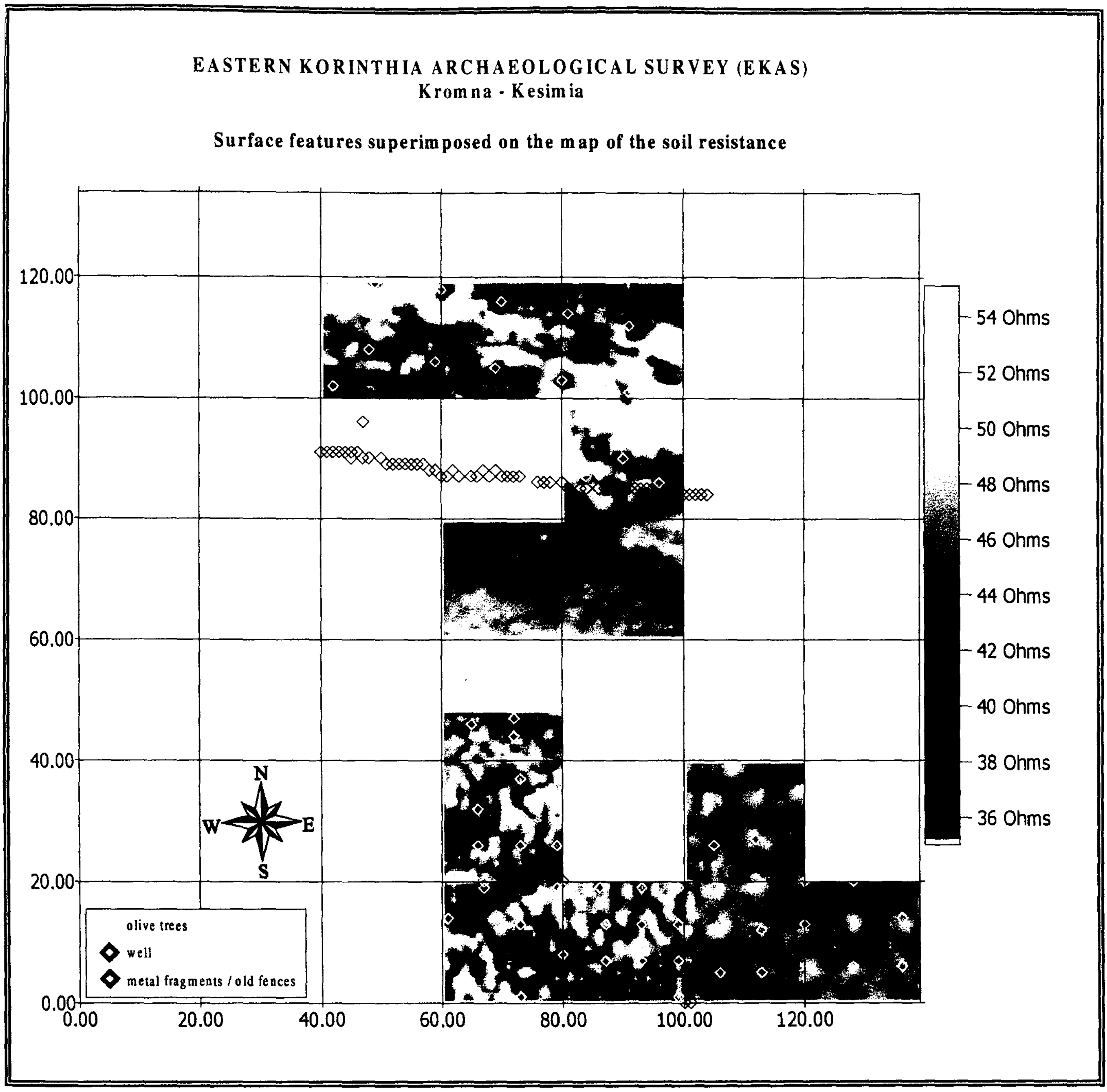

Figure 5.10: Overlay of the surface features on the map of the soil resistance measurements at Kromna-Kesimia.

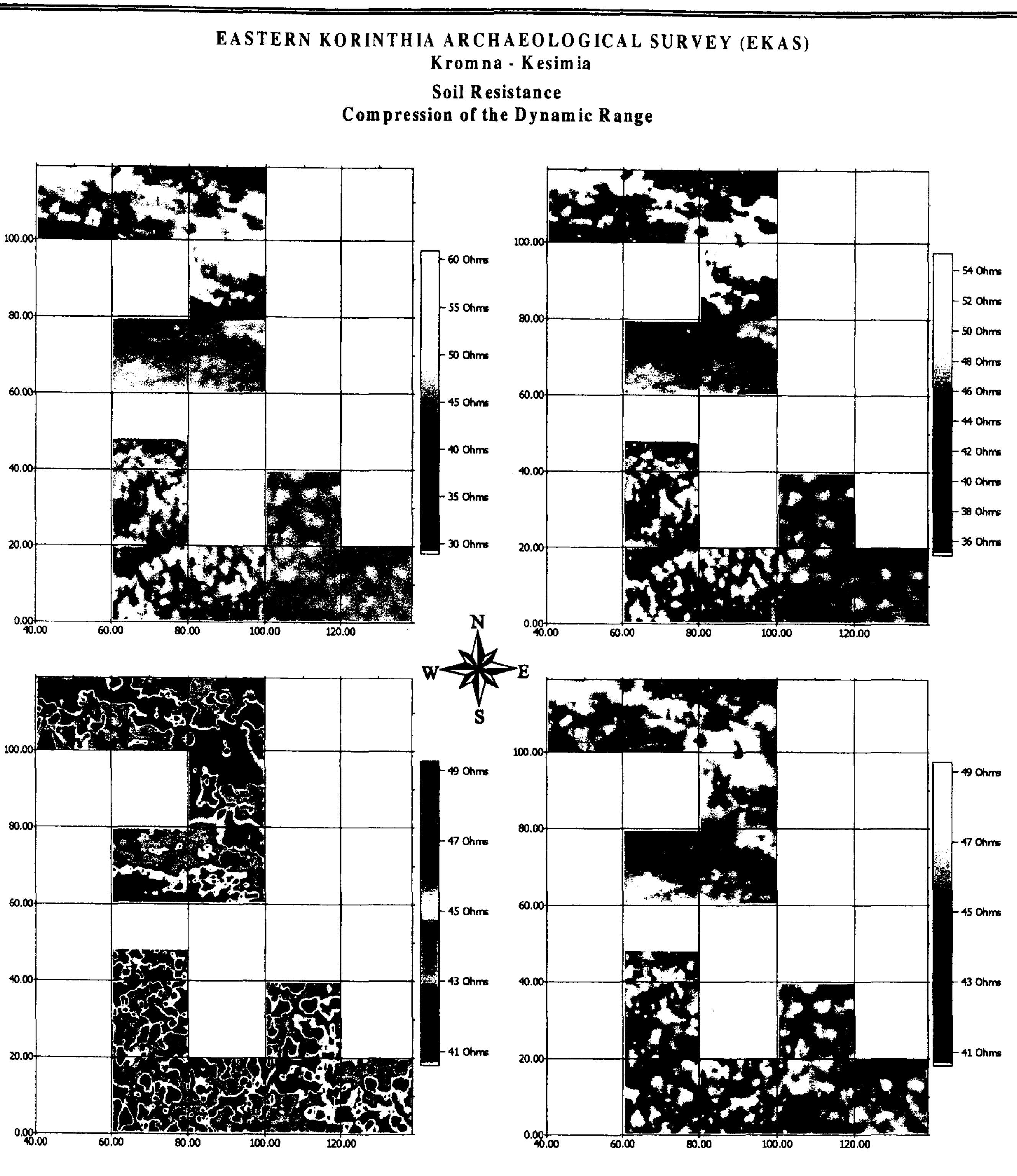

Figure 5.11: Compression of the dynamic range of the soil resistance data taken at Kromna-Kesimia.

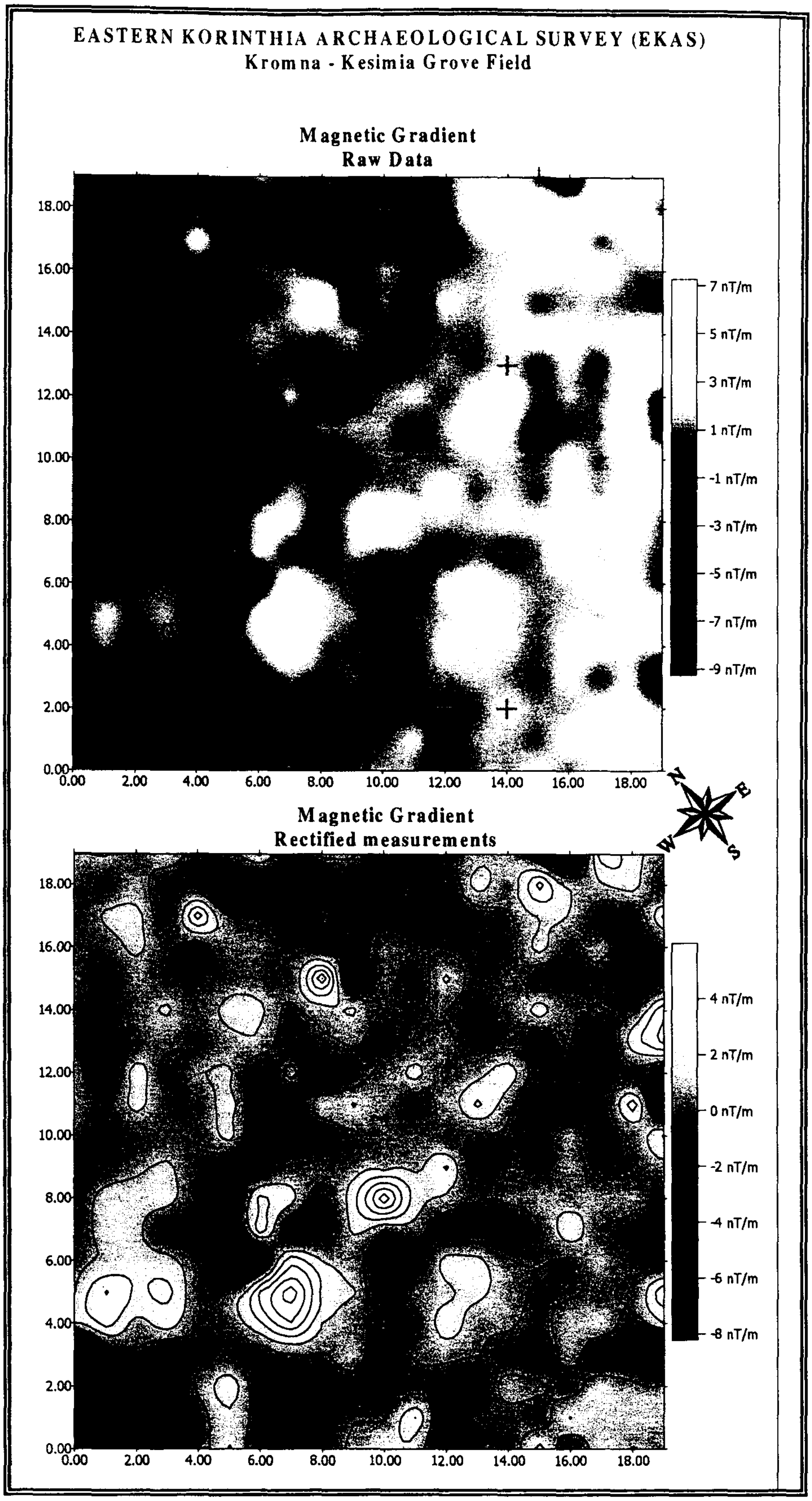

Figure 5.12: Magnetogram of the measurements conducted at the Kromna-Kesimia grove field.

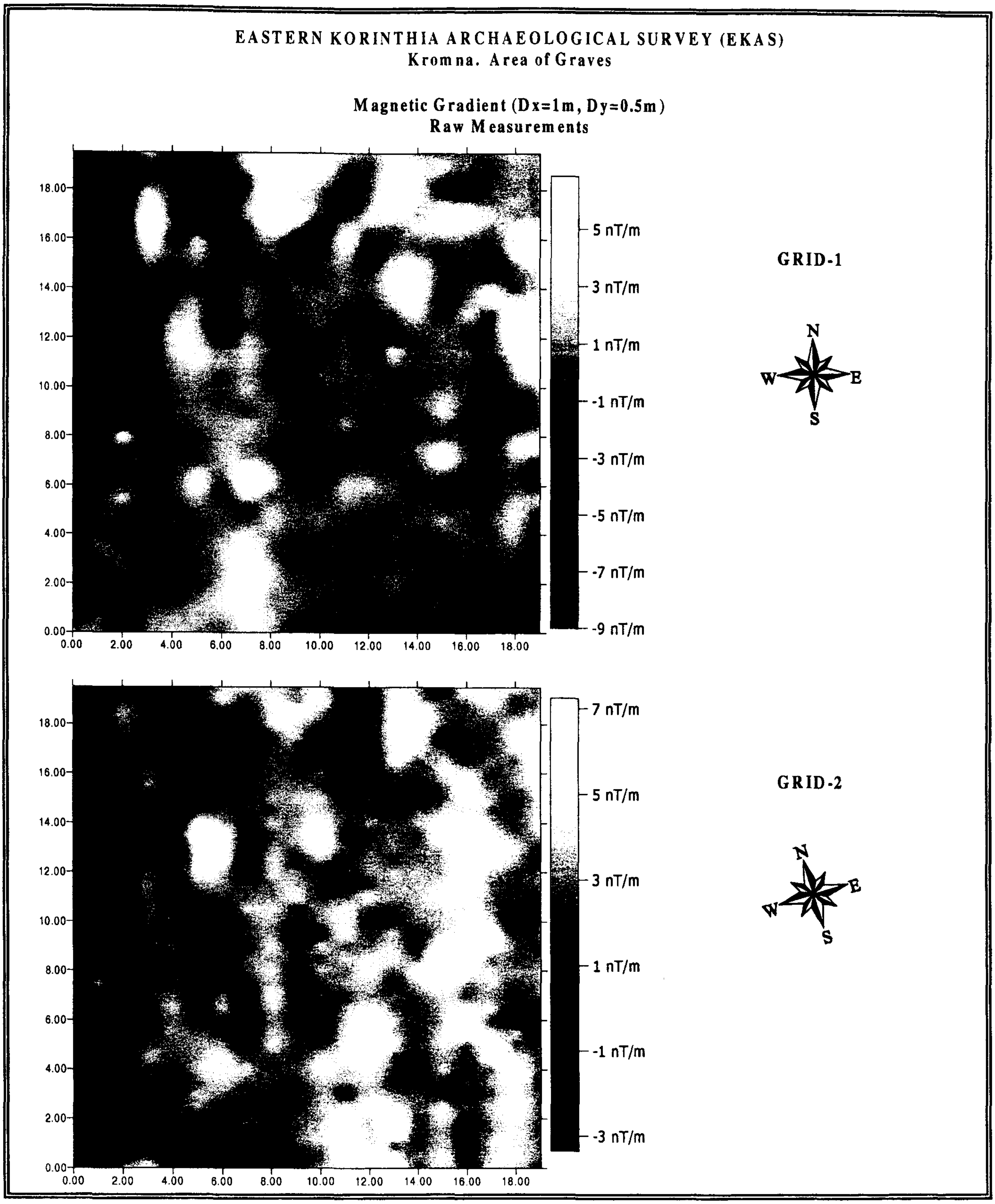

Figure 5.13: Magnetogram of the measurements conducted in the area of the graves at Kromna-Kesimia.

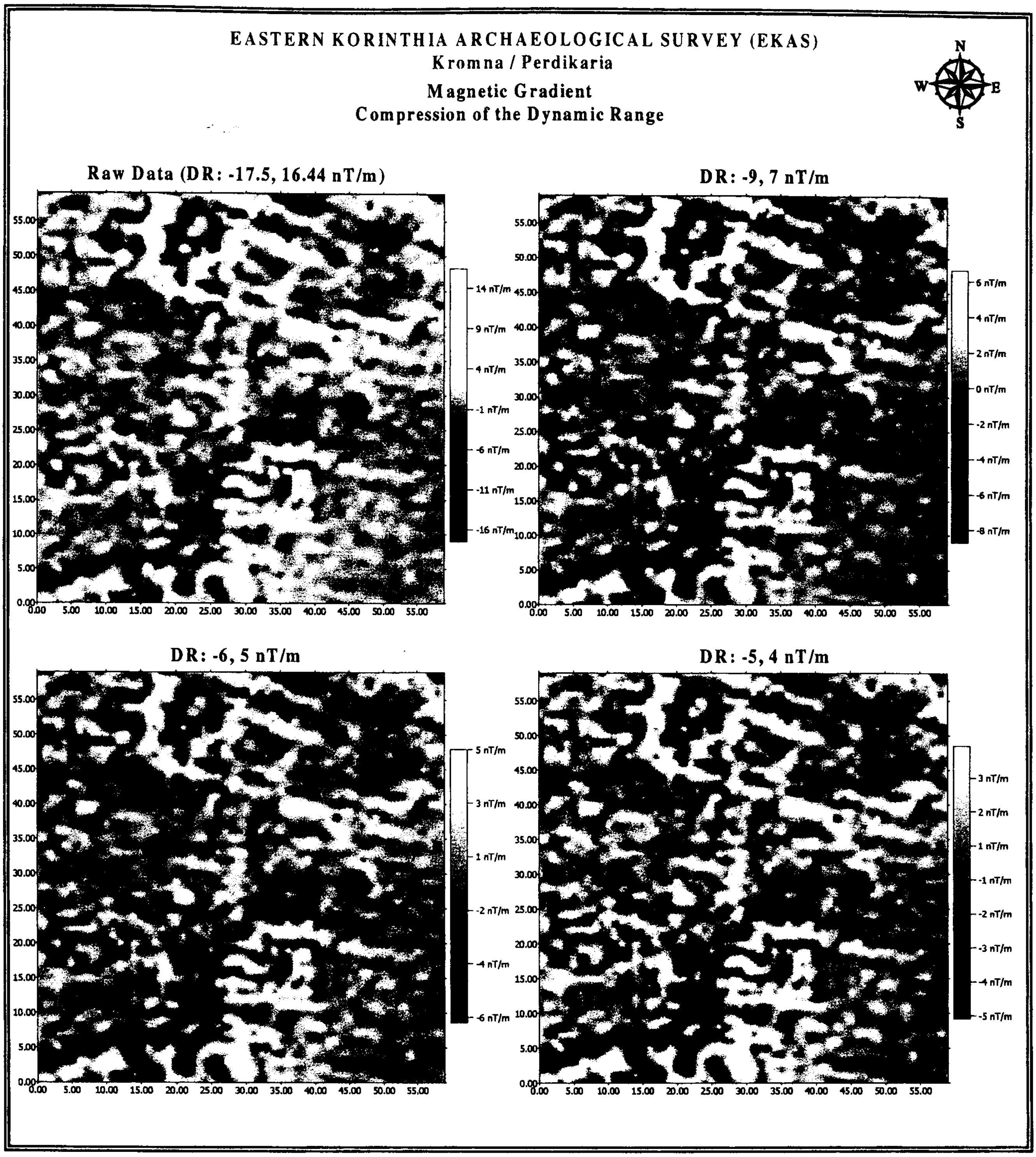

Figure 5.14: Grey-scale maps representing the compression of the dynamic range of the magnetic measurements taken at the site of Perdikaria.

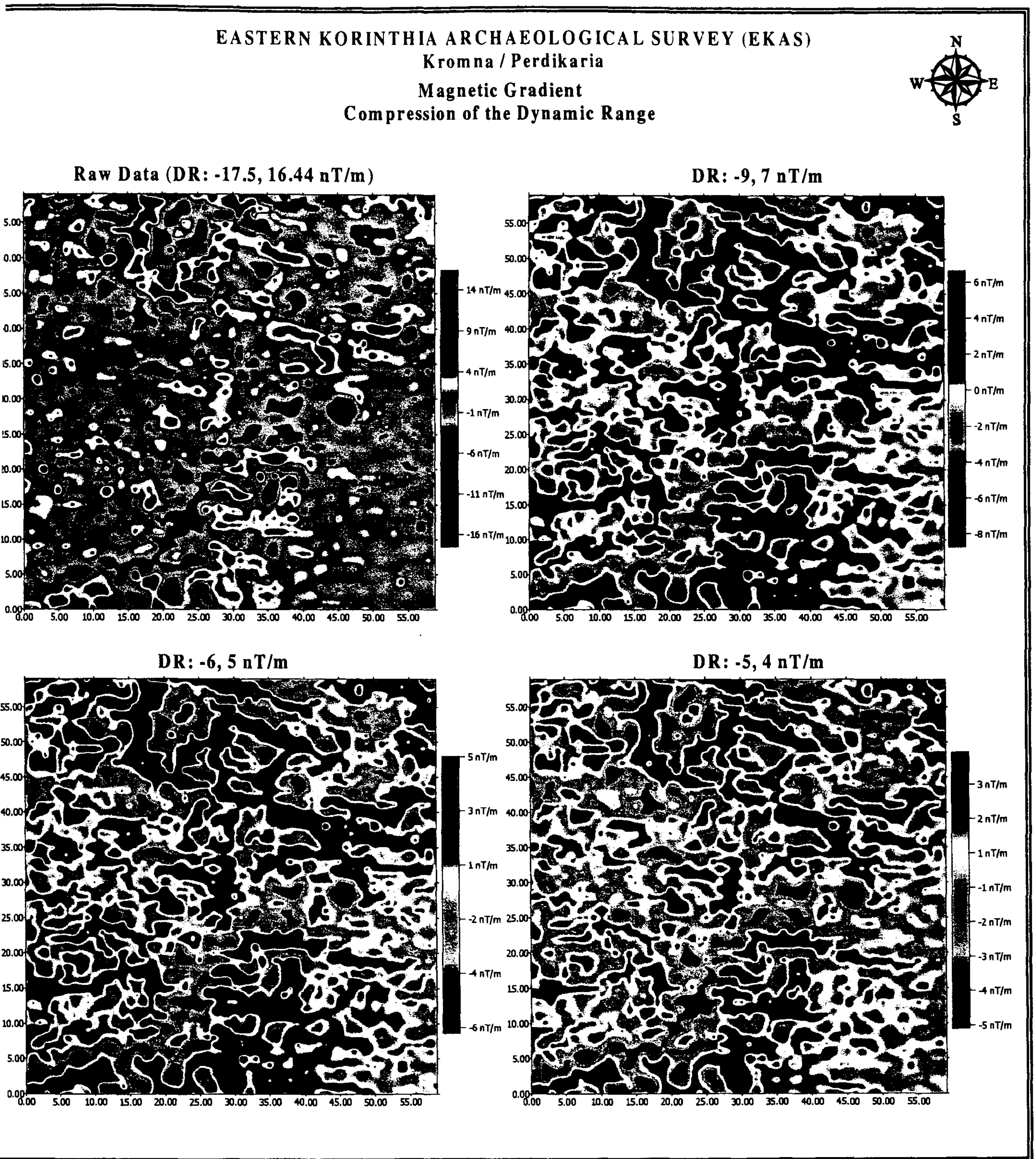

Figure 5.15: Colour-scale maps representing the compression of the dynamic range of the magnetic measurements taken at the site of Perdikaria.

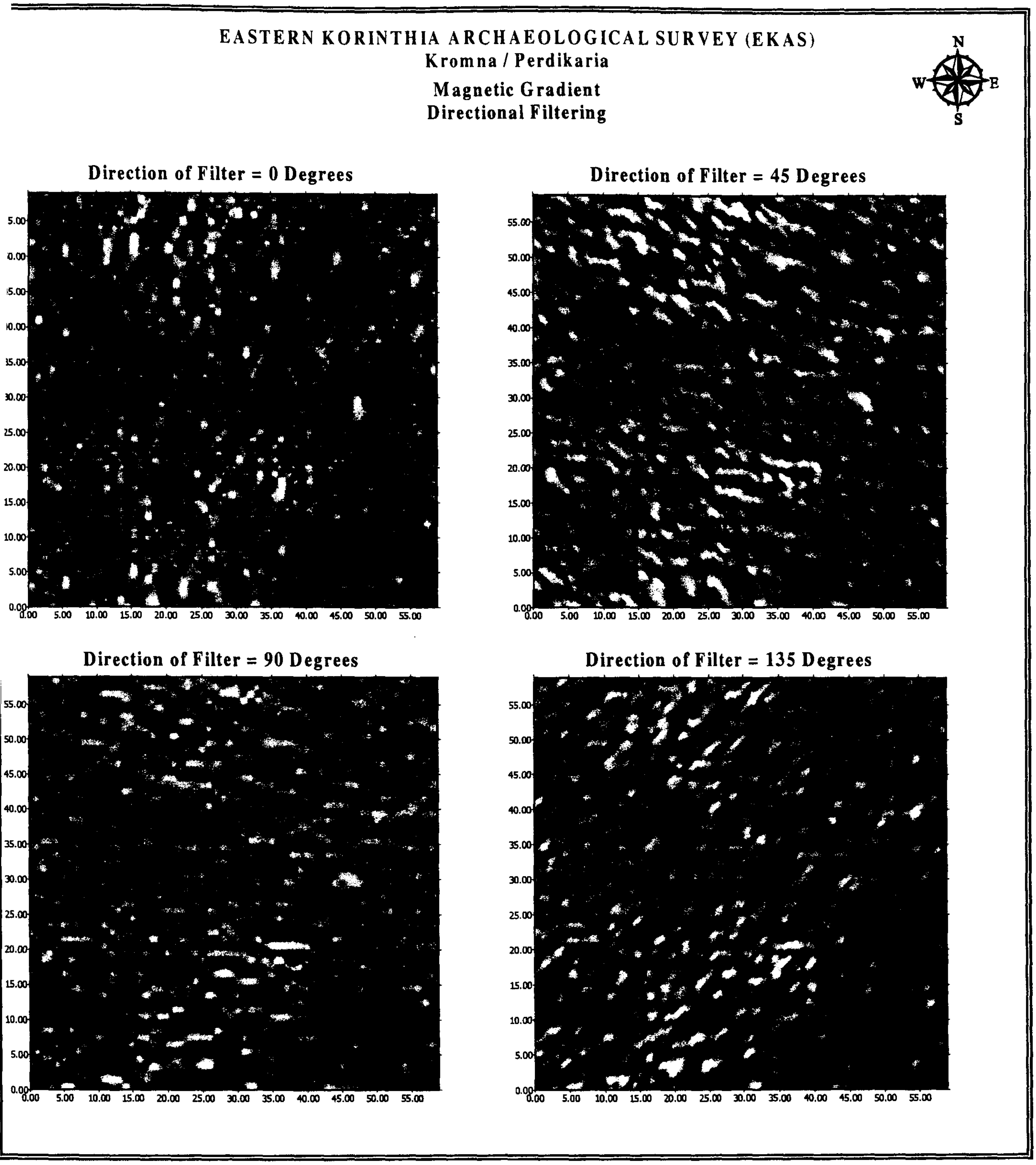

Figure 5.16: The application of directional derivatives (in 4 different directions) emphasized a number of linear features in the magnetic map.

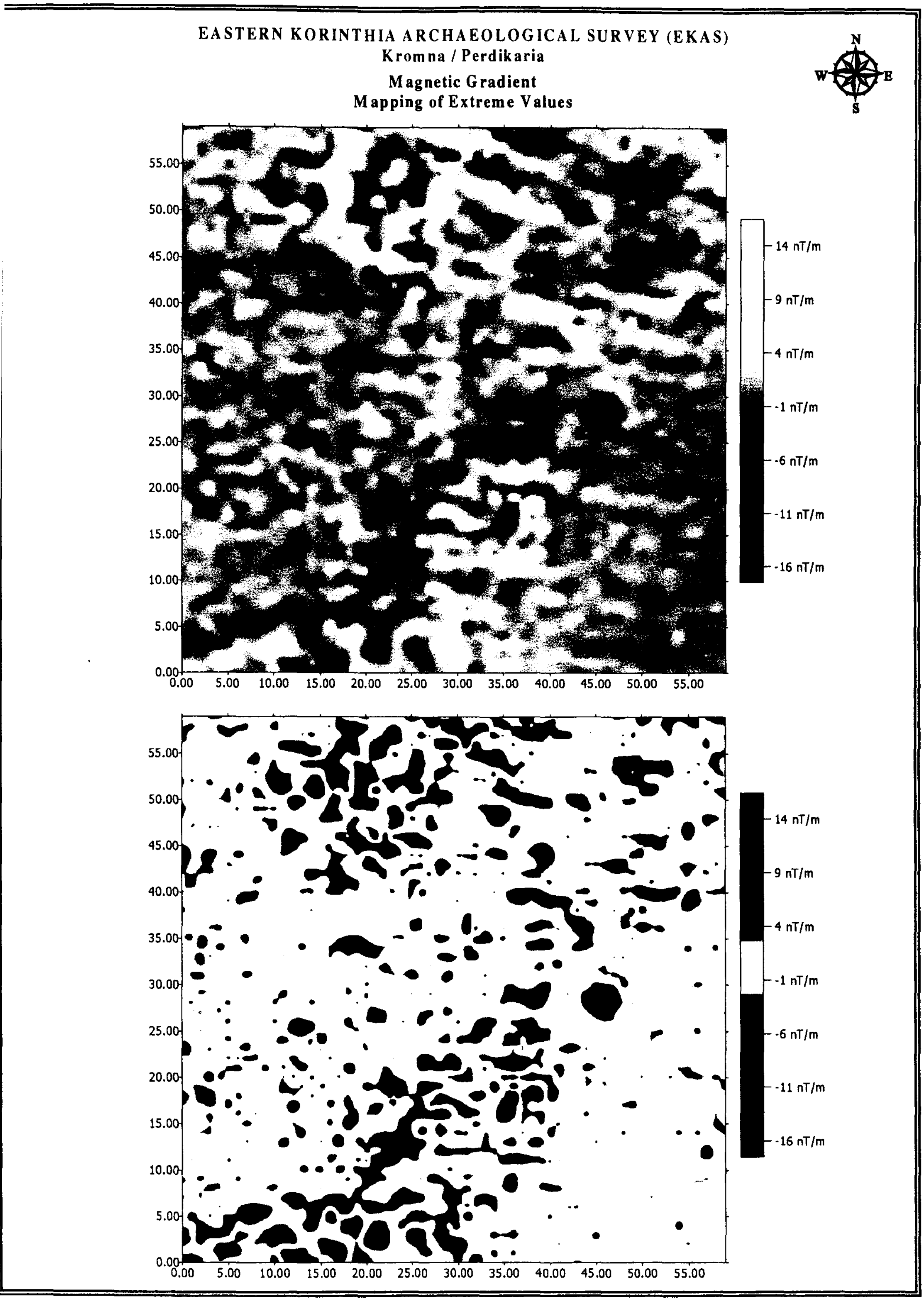

Figure 5.17: Mapping of the extreme values of the magnetic measurements (low values in blue and high values in red).

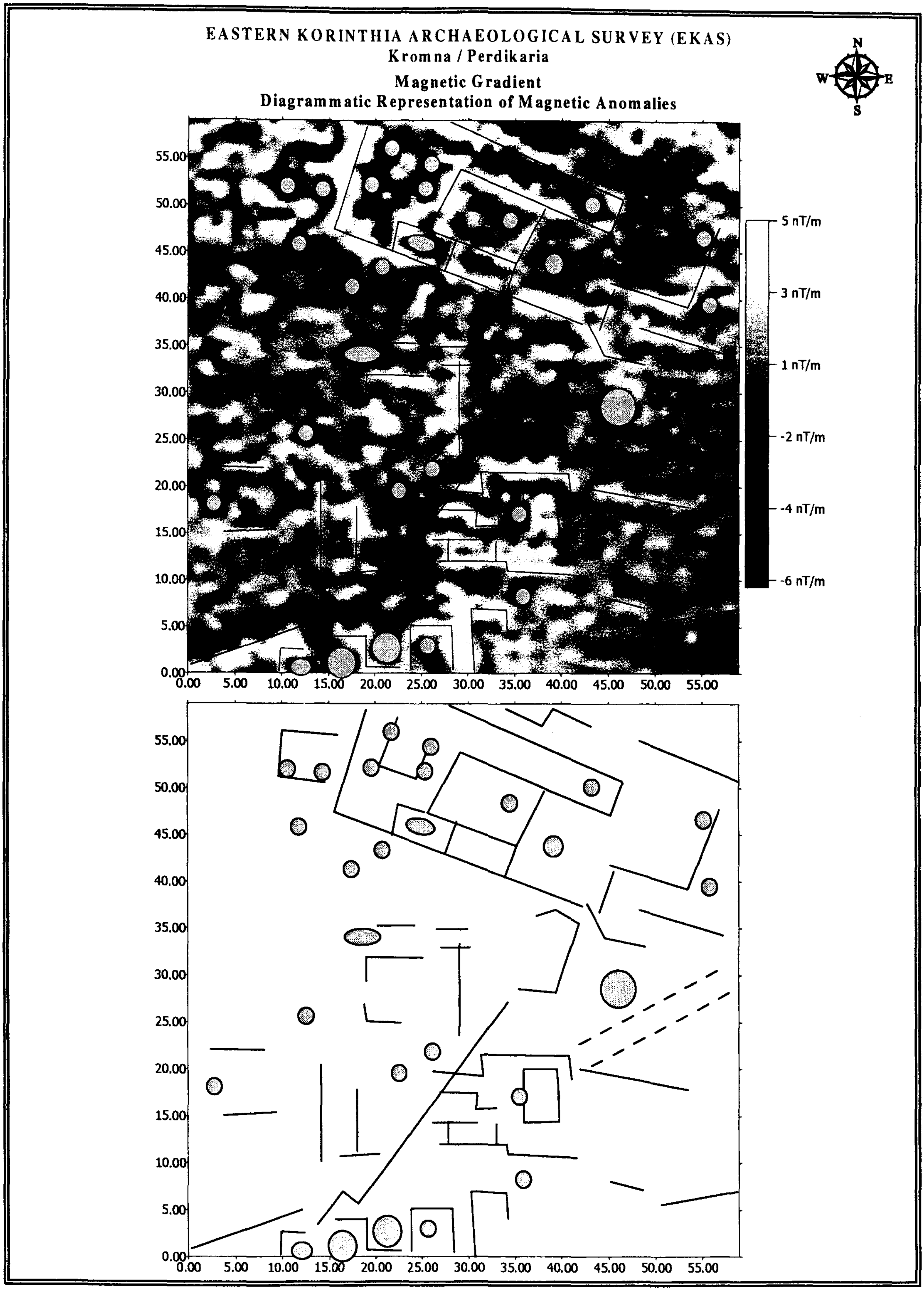

Figure 5.18: Diagrammatic representation of the magnetic anomalies, which have been identified at the site of Perdikaria.

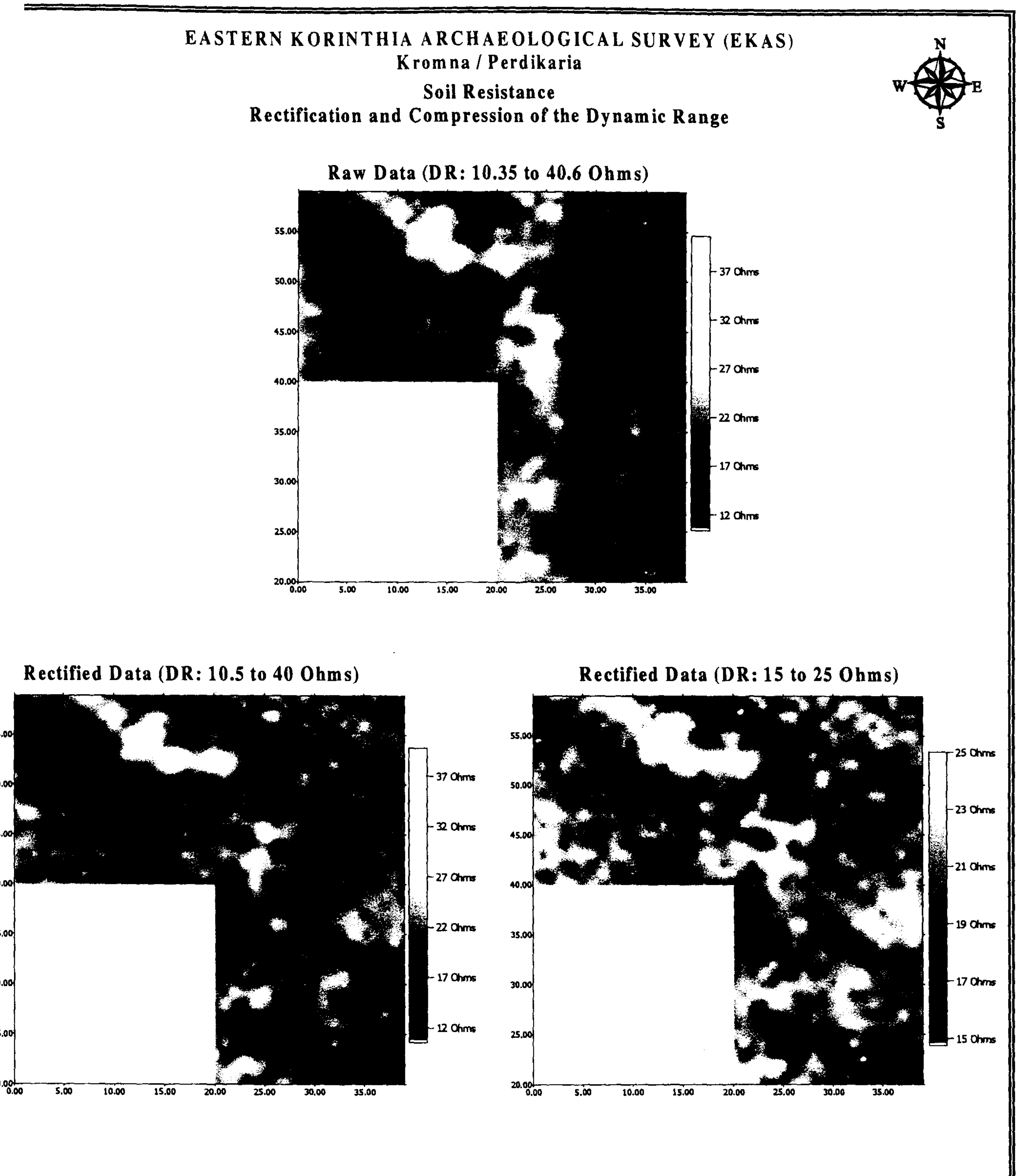

Figure 5.19: Grey-scale maps representing the compression of the dynamic range of the soil resistance measurements taken at the site of Perdikaria.

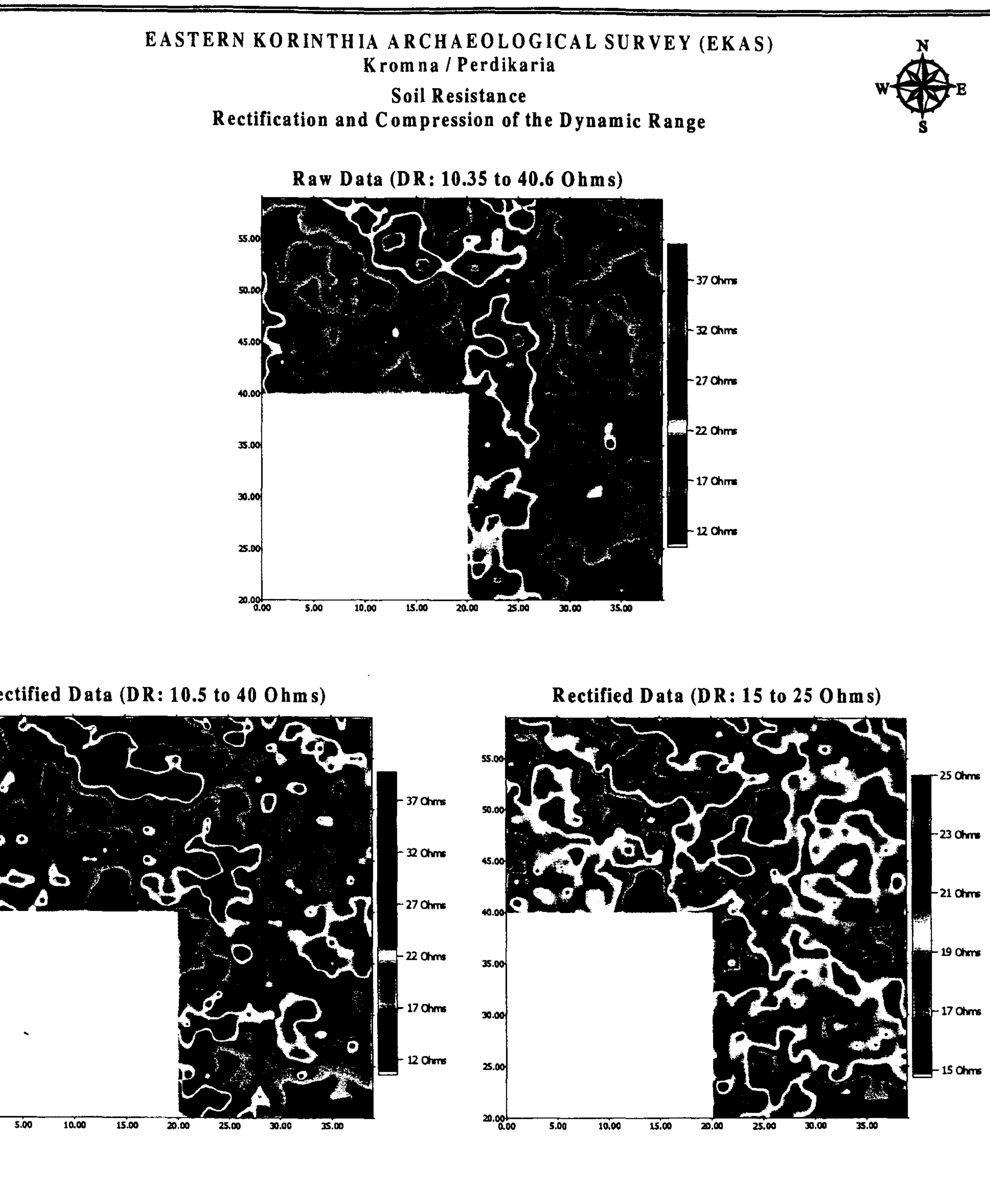

Figure 5.20: Colour-scale maps representing the compression of the dynamic range of the soil resistance measurements taken at the site of Perdikaria.

Figure 5.21: Diagrammatic representation of the soil resistance anomalies, which have been identified at the site of Perdikaria.

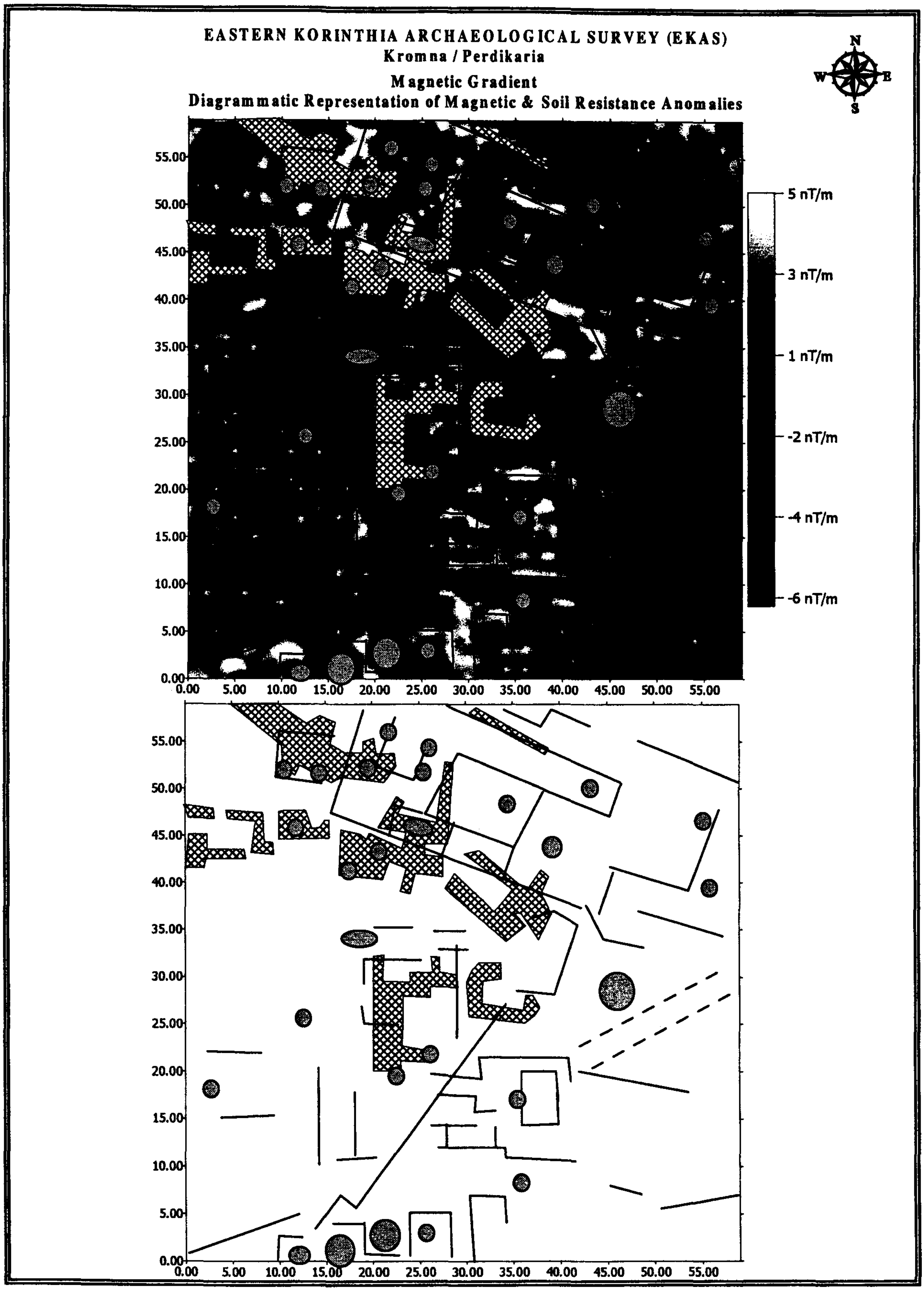

Figure 5.22: Synthetic map representing the outline of both the soil resistance and magnetic anomalies, which have been identified during the course of the geophysical investigations at the site of Perdikaria.