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REPORT ON THE GEOPHYSICAL SURVEY AT CROWLINK ROUND BARROW, EAST SUSSEX, APRIL 1998

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Summary

A geophysical survey was conducted over the location of a suspected Bronze Age round barrow at Crowlink, E. Sussex threatened by coastal erosion of the chalk cliff on which it sits. Magnetic survey of the site successfully revealed a series of significant anomalies related to associated barrows to the N and a two-phase pattern of field systems. Unfortunately, the response in the immediate vicinity of the threatened barrow was obscured by the presence of intense magnetic disturbance possibly related to wartime activity at the site. A more limited earth resistance survey was also undertaken and revealed additional anomalies apparently related to the raised mound of the barrow.

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CROWLINK ROUND BARROW, E. SUSSEX
Report on geophysical survey, April 1998.

Introduction

Following an archaeological survey conducted by the Field Archaeology Unit, University College London (FAU) between Seaford Head and Beachy Head, E. Sussex, a suspected Bronze Age round barrow on Baily's Hill was identified as being under imminent threat through coastal erosion (Holgate 1986). Given the proximity of the barrow to the cliff edge and current rates of erosion it seems likely that the barrow will be destroyed within the next few years. A programme of archaeological evaluation has therefore been proposed by the County Archaeologist to record the monument prior to its eventual destruction through a project design commissioned by English Heritage (Greatorex 1998). The project is to be jointly funded by Sussex County Council, English Heritage and The National Trust, who own the land on which the barrow stands.

The monument (SAM No. East Sussex 342), subsequently referred to as "Barrow A", is believed to represent a bowl barrow dating to the period *circa* 2500 to 1500 BC, although a number of other similar mounds excavated in Sussex have revealed Saxon burials in primary contexts (Drewett *et al* 1988). A second topographic feature 75m NE of Barrow A has also been identified as a bowl barrow and is included with in the same SAM designation. The aim of the geophysical survey was to place Barrow A in the context of the surrounding landscape and more specifically, to confirm the presence of an encircling ditch around Barrow A and provide evidence for any additional archaeological activity associated with the monument.

The site (centred on TV 5445 9660) is located on a shallow layer of well drained calcareous silty soil of the Andover 1 Association (Soil Survey of England and Wales 1983) developed over a substrate of undivided Upper and Middle Chalk (Institute of Geological Sciences 1971). It is included within the Sussex Downs Area of Outstanding Natural Beauty and is designated as a Site of Special Scientific Interest (SSSI) due to the downland flora and associated insects that it supports. The monument survives as an approximately oval raised mound with a diameter 15.5m EW and 13.5m NS standing to a recorded height of 0.5m situated 7.5m from the current cliff edge.

Method

Due to the success of magnetic survey over similar monuments and geology (*eg* Caburn Bottom, Glynde, E. Sussex; AML archive), this technique was adopted to cover an area of approximately 2.5ha surrounding Barrow A. A 30m grid was established over the site (Figure 1) and two permanent survey markers inserted along the baseline. Unfortunately, due to instrument failure it was not possible to establish the precise NGR coordinates of the survey grid for this report. Therefore Figures 1 and 2 provide only an approximate location and field measurements should be made with reference to the permanent survey markers established at the site.

Data was collected from each 30m grid square using a Geoscan FM36 fluxgate gradiometer along N-S traverses following the standard method outlined in note 2 of Annex 1. In addition, an earth resistance survey was conducted over a more limited area but encompassing both scheduled monuments identified at the site (Figure 1); this technique has ed successful in locating the encircling ditches of a bowl barrow at Bullock Down, Beachy Head, E. Sussex, (Hackmann 1976). The earth resistance survey was conducted at a 1m x 1m sample interval over an area of approximately 0.6ha with a Geoscan RM15 resistivity meter utilising a twin-electrode array and mobile probe spacing of 0.5m (note 1 of Annex 1).

More detailed resistivity survey was conducted over an off-set 30m x 30m square centred on Barrow A (see Plan B for location). This latter survey utilised a Geoscan MPX 15 multiplexer and adjustable PA5 electrode array to simultaneously collect 0.5m and 1.0m mobile probe separation data. The greater separation of the mobile probe electrodes forces the applied current to penetrate further into the ground and can often detect anomalies arising from more deeply buried features (Scollar 1990, 321-4, Linford 1993). In this case, the sample interval was 0.5m (NS) x 1.0m (EW) for the 0.5m mobile electrode array and 1.0m x 1.0m for the deeper penetrating 1.0m mobile probe spacing array.

Plan A shows a greytone image and X-Y traceplot of the magnetometer data after statistical processing of each survey line to provide a zero-centred mean. This process eliminates offsets between adjacent survey lines that may occur due to the directional sensitivity of fluxgate gradiometers when data is collected from alternate "zig-zag" traverses and considerably improves the presentation and interpretation of the resulting data. Plan B1 and B2 show a traceplot and greytone image of the raw resistivity respectively. An enhanced greytone image of the data is presented in Plan B3 after processing with a high-pass Gaussian filter (radius = 5m). Results from the detailed resistivity survey over Barrow A are presented in Plans B4 and B5 together with residual near surface anomalies enhanced by subtracting the deeper penetrating data set from the shallow readings (Plan B6). The latter data was collected with the remote electrode pair separated to a distance at which their contribution to the recorded reading became negligible. Under these conditions measurements recorded with the twin-electrode array multiplied by a factor of $2\pi r$ (where r = mobile probe separation) express the apparent resistivity of the volume of ground immediately below the mobile electrodes in units of Ωm.

A series of ~ 100g topsoil samples were also collected at 15m intervals along the survey base line (Figure 1) to assess the variation in magnetic susceptibility over the site (Figure 3).

Results

Significant anomalies discussed in the following text are numbered and can be identified by reference to Plan C.

Magnetic data

The most obvious magnetic anomaly **[1]** is found over the location of the second monument immediately NE of Barrow A. This takes the form of a circular, ditch-type response of diameter 12m that appears to contain two central pit-type anomalies. Such a response would be expected from a bowl barrow with an *in situ* encircling ditch and confirms the suitability of magnetic survey for the location of such monuments at the site. Similar responses, (**[2]**, **[3]** and **[4]**) were recorded in squares 1-4 to either side of the walkers' path which appears to have created a detectable anomaly **[5]** along both edges through the erosion of topsoil along its course. Whilst **[2]**, **[3]** and **[4]** can not be identified as the response to barrows the area did contain a number of topographic features with similar dimensions to both Barrow A and the tumulus at **[1]**.

Additional positive anomalies **[6]** and **[7]** visible in this area may also represent significant archaeological activity, perhaps a pair of large pits.

A series of linear anomalies cross the entire survey area and appear to represent two phases of a relict field or enclosure system. The two systems can be distinguished both by their orientation and their relative response with regard to the zero mean of the combined data set. The first pattern **[8]** forms a single rectilinear enclosure with a largely negative response and can be attributed to a series of extant linear impressions observed in the field. The negative response would appear to arise from the lack of magnetic topsoil (see *Topsoil susceptibility* below) in the open ditches and is contrary to the positive anomalies normally produced by the magnetically enhanced fill expected from buried ditches.

The second pattern of ditches **[9]** does exhibit a positive response which appears to run as a "zig-zag" NS across the site. However, it is possible that the magnetometer has only detected part of a more extensive enclosure system suggested by a number of incomplete linear anomalies (*eg* in grid squares 12 and 28) which, if extended would form a pattern of rectilinear enclosures over the crown of the hill. It seems reasonable to assume that **[9]** predates **[8]** on the grounds that it is still partially extant and passes through **[1]** suggesting that the ditch system was constructed long after the monument ceased to be respected as part of the surrounding landscape and may, perhaps, be quite recent in origin.

It is of interest to note the variation in magnitude of response demonstrated by **[9]** which is greatest through squares 1 and 3 and may, perhaps, be indicative of increased anthropogenic activity in this area enhancing the magnetic susceptibility of the topsoil in-filling cut features. To the south a single section of parallel ditches is found in squares 7 and 11 and a distinct pit-type response **[10]** is visible in square 15.

Additional linear anomalies **[11]**, **[12]** and **[13]** may well also represent parts of a relict field system. However, they appear to be on a different alignment again to patterns identified monument do exhibit anomalous values of $\kappa_{FD\%}$ $<6\%$ in comparison to values $>10\%$ demonstrated by the rest of the data (Figure 3B).

The magnitude of $\kappa_{FD\%}$ is related to the grain-size population of the magnetic particles present in the sample (Thompson and Oldfield 1986; pp54-56) with values of $\kappa_{FD\%}$ exceeding 10% equating to the majority of particles present being ferrimagnets in the superparamagnetic range. This suggests that topsoil in the vicinity of Barrow A contains either (i) a high concentration of larger single/multi domain particles or (ii) increased grain-grain interactions between the superparamagnetic particles present. To investigate this further additional mineral magnetic measurements were performed on two samples 60S and 225S both before (wet) and after (dry) air-drying. These measurements included:

Partial Anhysteretic Remanent Magnetisation (pARM) determined by applying a 0.05mT steady field through incremental 5mT windows during AF demagnetisation in a peak 200mT field. ARM for the sample was subsequently measured after applying the steady field throughout the entire AF demagnetisation (Figure 3C and 3D).

Isothermal Remanent Magnetisation (IRM) acquired through exposure to pulse magnetic fields to a maximum of 1000mT (Figure 3E and 3F).

AF demagnetisation of $IRM_{(1000mT)}$ subsequent demagnetisation of $IRM_{(1000mT)}$ with incremental peak AF fields from 1mT - 200mT (Figure 3E and 3F).

Results of the pARM measurements demonstrate the low coercivity of the magnetic minerals present in the samples. Approximately 90% of the ARM is acquired by particles with a coercivity <40mT indicating either the presence of large multi-domain grains or an assembly of very fine interacting superparamagnetic grains. Sample 225S demonstrates a consistently lower pARM response than sample 60S suggesting an apparent shift of the grain-size population towards larger SD particles. The results of the IRM acquisition curves (Figure 3E and 3F) confirm this shift in the coercivity envelope and show that the majority of IRM is acquired in fields <100mT. Demagnetisation of IRM acquired in a 1000mT field (Figure 3E and 3F) indicates a much greater similarity between the two samples (both wet and dry) than was found for the IRM acquisition curves. This again suggests the greater influence of grain-grain interactions in sample 225S as the additional magnetic fields generated between particles will act to oppose the creation of IRM and aid its demagnetisation.

Both samples 60S and 225S appear to have a very similar grain-size distribution which may be attributed to the dominance of a low coercivity mineral such as magnetite or maghaemite. From consideration of the high values of $\kappa_{FD\%}$ it would appear that the majority of particles are superparamagnetic with considerable grain-grain interactions accounting for the observed remanence behaviour after exposure to laboratory fields. Whilst much larger multidomain particles may also demonstrate a similar low coercivity and offset between acquisition and demagnetisation curves, due to internal demagnetising fields, no frequency dependence would be expected. Sample 225S demonstrates a much greater grain-grain interaction than 60S that may indicate either a variation in the pedogenic enhancement of topsoil towards the cliff edge or an anthropogenic modification, such as the localised action of fire.

Conclusion

Magnetic survey at this site has revealed a number of significant anomalies apparently related to a group of prehistoric burial mounds. Additional linear anomalies suggest the presence of a two-phase ditched enclosure system which appears unrelated to the funerary activity at the site. However, results in the vicinity of the threatened monument, Barrow A, have been hampered by the presence of unexpected magnetic disturbance related, perhaps, to war-time activity. In particular, the presence of a magnetic anomaly related to a palisade or ditch encircling Barrow A has not been detected although a similar anomaly does surround the location of the other recorded tumulus covered by the survey area.

Resistivity survey failed to detect a ditch-type anomaly around either monument but did reveal the presence of a high-resistance anomaly associated with the mound of Barrow A. Thus if Barrow A does indeed represent a funerary monument it would appear to take the form of a raised mound without the presence of any obvious encircling ditch.

Anomalous topsoil susceptibility results in the vicinity of Barrow A suggest the pedogenic enhancement of magnetic minerals has been modified through the action of fire at some point. Whilst this may be due to a natural fire the location of a coincident enhanced magnetic anomaly **[17]** and a shallow low resistance response **[25]** adjacent to the monument on a prominent cliff-top suggests the site of a deliberate beacon or fire.

Subsequent excavation of Barrow A should be extended to confirm the nature of the magnetic disturbance surrounding the monument and also investigate the adjacent anomaly to the SE tentatively identified above as a burnt feature of indeterminate age. Wider evaluation of the surrounding area is also recommended with particular regard to the recording of topographic anomalies N of Barrow A.

Surveyed by: E. Bray
P. Cottrell
N. Linford
A. Payne

Date of survey: 27-28/4/98

Reported by: N. Linford

Date of report: 15/5/98

Archaeometry Branch,
Ancient Monuments Laboratory,
English Heritage.

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Enclosed Figures and plans

Figure 1	Location of the geophysical surveys (1:2500).
Figure 2	Greytone image of raw magnetometer data superimposed on the OS map (1:2500).
Figure 3	Topsoil magnetic susceptibility results and mineral magnetic measurements.
Plan A	(1) X-Y traceplot of despiked magnetometer data, (2) linear greytone image of despiked magnetometer data (1:1000).
Plan B	(1) X-Y traceplot of raw earth resistance data, (2) Equal area greytone image of raw earth resistance data, (3) linear greytone of enhanced earth resistance data (1:1000), (4) equal area greytone of 0.5m mobile-probe spacing detailed resistivity survey, (5) equal area greytone of 1.0m mobile-probe spacing detailed resistivity survey, (6) linear greytone of near surface residual anomalies (1:500).
Plan C	(1) Summary of magnetic anomalies, (2) summary of earth resistance anomalies (1:2500).

Annex 1: Notes on standard procedures

1) **Resistivity Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all aligned parallel to one pair of the square's edges, and each separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metres from the nearest parallel square edge. Readings are taken along each traverse at 1 metre intervals, the first and last readings being 0.5 metres from the nearest square edge.

   Unless otherwise stated the measurements are made with a Geoscan RM15 earth resistance meter incorporating a built-in data logger, using the twin electrode configuration with a 0.5 metre mobile electrode separation. As it is usually only relative changes in resistivity that are of interest in archaeological prospecting, no attempt is made to correct these measurements for the geometry of the twin electrode array to produce an estimate of the true apparent resistivity. Thus, the readings presented in plots will be the actual values of earth resistance recorded by the meter, measured in Ohms (Ω). Where correction to apparent resistivity has been made, for comparison with other electrical prospecting techniques, the results are quoted in the units of apparent resistivity, Ohm-m (Ωm).

   Measurements are recorded digitally by the RM15 meter and subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Ancient Monuments Laboratory using desktop workstations.

2) **Magnetometer Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all parallel to that pair of square edges most closely aligned with the direction of magnetic North. Each traverse is separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metre from the nearest parallel square edge. Readings are taken along each traverse at 0.25 metre intervals, the first and last readings being 0.125 metre from the nearest square edge.

   These traverses are walked in so called 'zig-zag' fashion, in which the direction of travel alternates between adjacent traverses to maximise survey speed. However, the magnetometer is always kept facing in the same direction, regardless of the direction of travel, to minimise heading error.

   Unless otherwise stated the measurements are made with a Geoscan FM36 fluxgate gradiometer which incorporates two vertically aligned fluxgates, one situated 0.5 metres above the other; the bottom fluxgate is carried at a height of approximately 0.2 metres above the ground surface. The FM36 incorporates a built-in data logger that records measurements digitally; these are subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Ancient Monuments Laboratory using desktop workstations.

It is the opinion of the manufacturer of the Geoscan instrument that two sensors placed 0.5 metres apart cannot produce a true estimate of vertical magnetic gradient unless the bottom sensor is far removed from the ground surface. Hence, when results are presented, the difference between the field intensity measured by the top and bottom sensors is quoted in units of nano-Tesla (nT) rather than in the units of magnetic gradient, nano-Tesla per metre (nT/m).

3) **Resistivity Profiling:** This technique measures the electrical resistivity of the subsurface in a similar manner to the standard resistivity mapping method outlined in note 1. However, instead of mapping changes in the near surface resistivity over an area, it produces a vertical section, illustrating how resistivity varies with increasing depth. This is possible because the resistivity meter becomes sensitive to more deeply buried anomalies as the separation between the measurement electrodes is increased. Hence, instead of using a single, fixed electrode separation as in resistivity mapping, readings are repeated over the same point with increasing separations to investigate the resistivity at greater depths. It should be noted that the relationship between electrode separation and depth sensitivity is complex so the vertical scale quoted for the section is only approximate. Furthermore, as depth of investigation increases the size of the smallest anomaly that can be resolved also increases.

Typically a line of 25 electrodes is laid out separated by 1 or 0.5 metre intervals. The resistivity of a vertical section is measured by selecting successive four electrode subsets at increasing separations and making a resistivity measurement with each. Several different schemes may be employed to determine which electrode subsets to use, of which the Wenner and Dipole-Dipole are typical examples. A Campus Geopulse earth resistance meter, with built in multiplexer, is used to make the measurements and the Campus Imager software is used to automate reading collection and construct a resistivity section from the results.

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Provisional location of geophysical survey, April 1998.

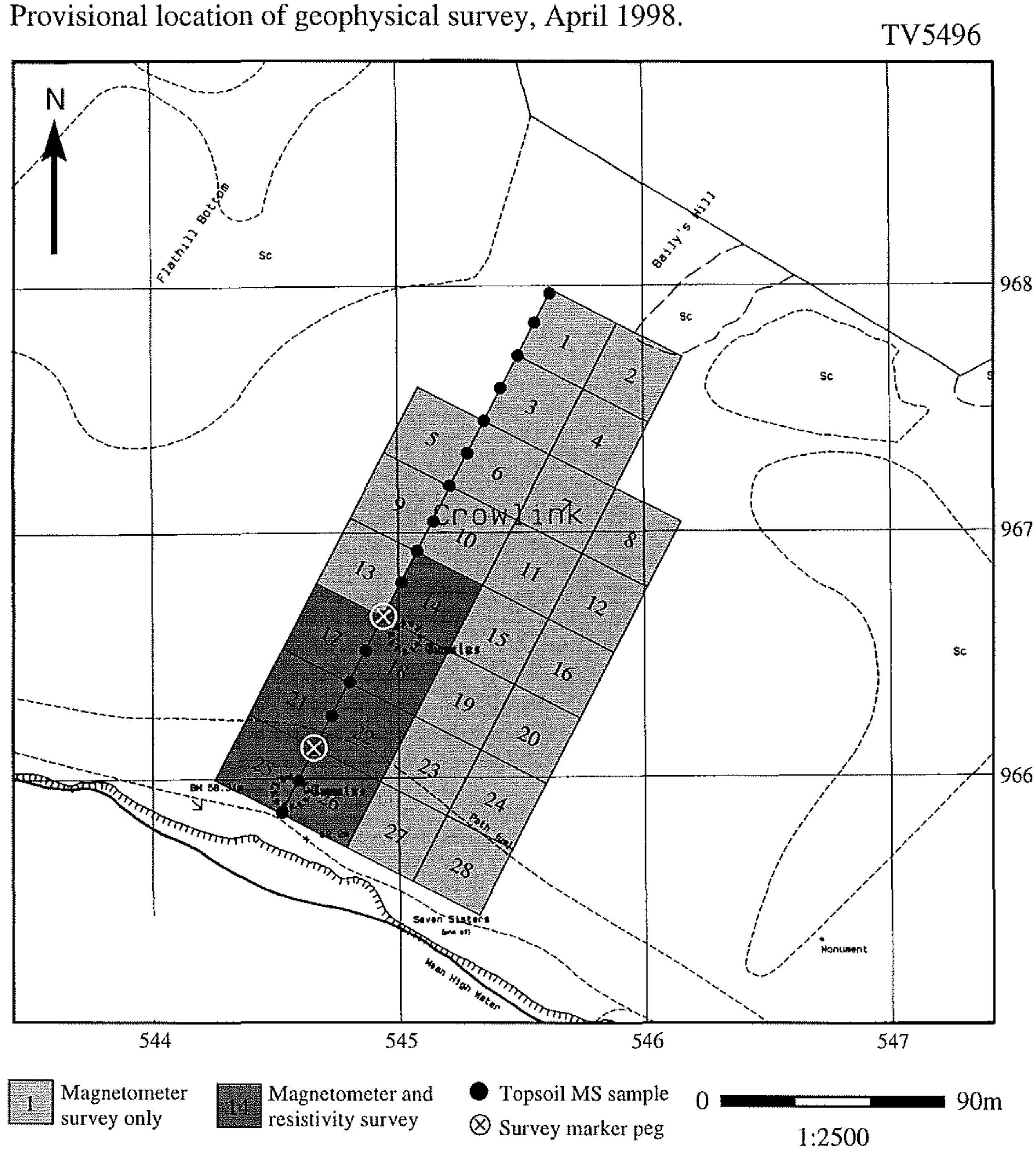


Figure 1; Crowlink Round Barrow, East Sussex, Location of geophysical survey.

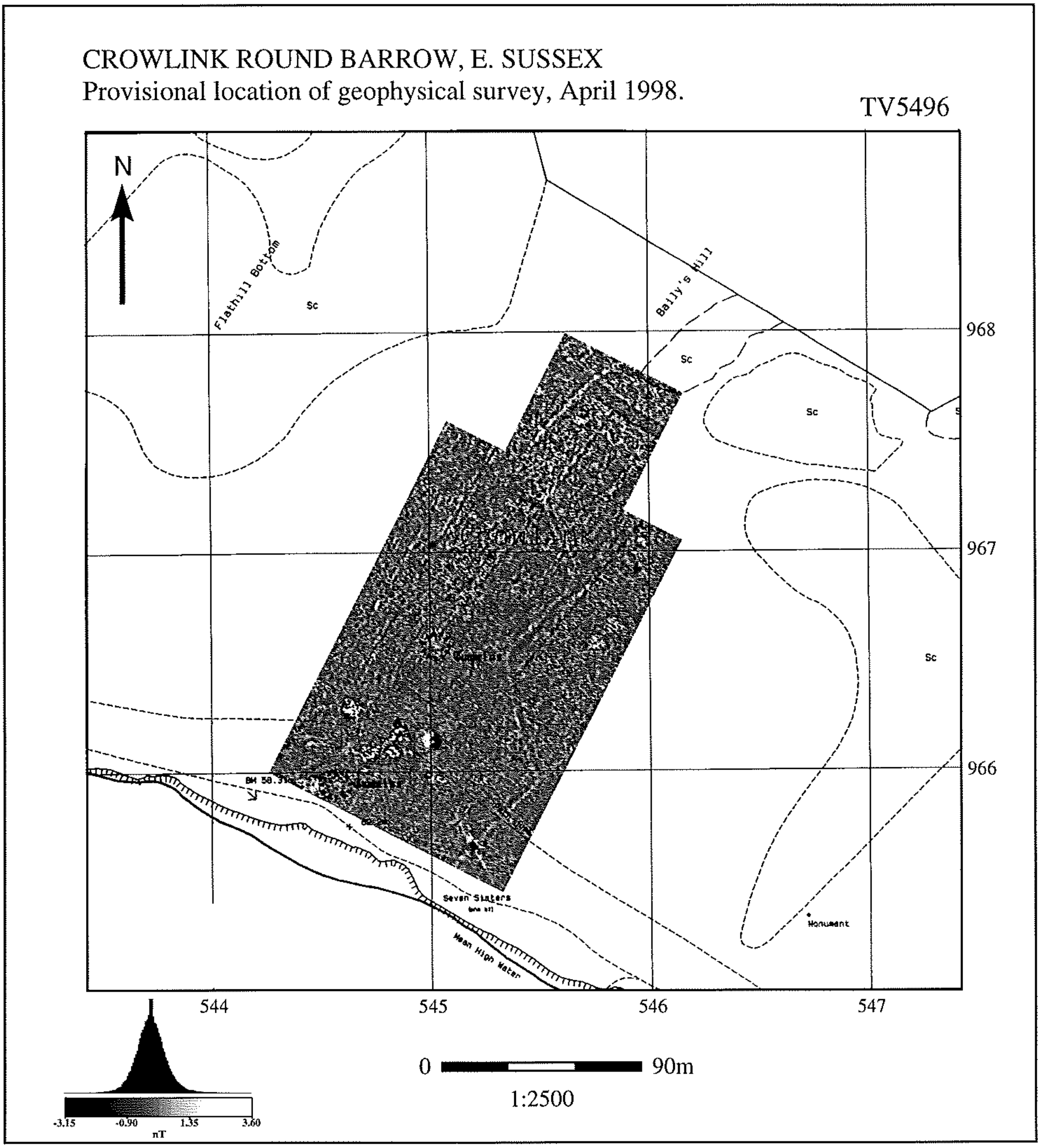


Figure 2; Crowlink Round Barrow, East Sussex, *Greytone of geophysical survey superimposed over base OS map.*

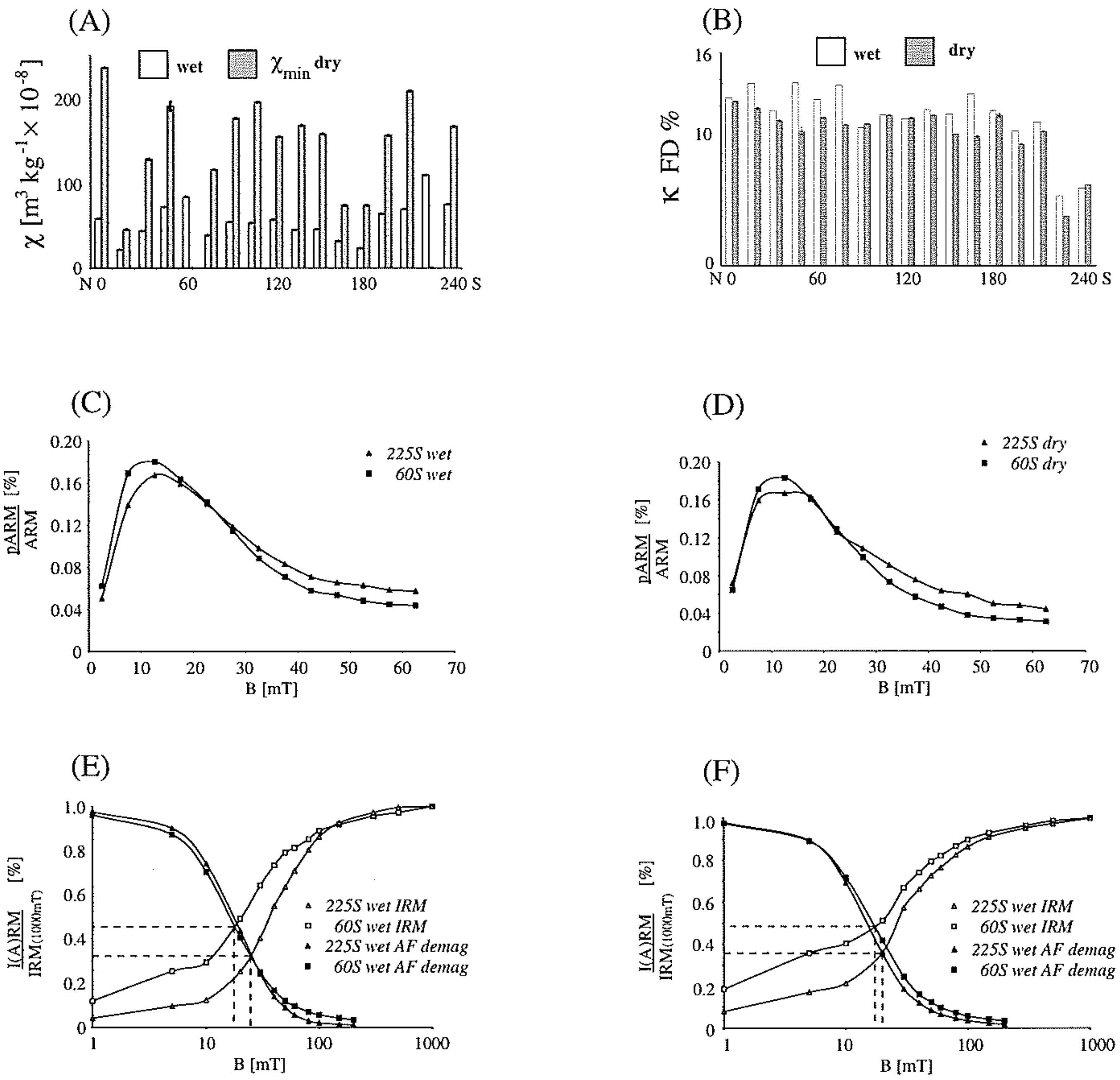
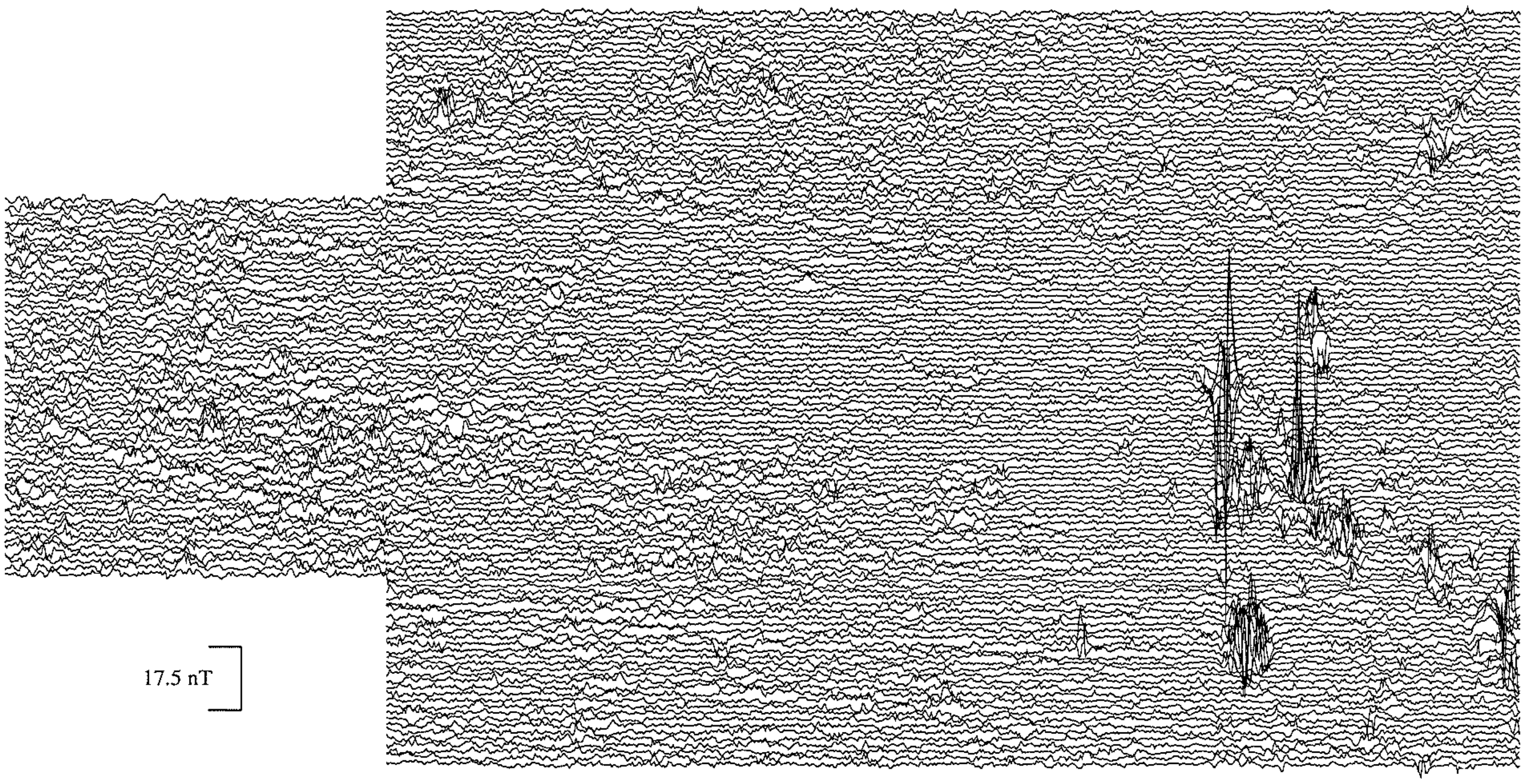


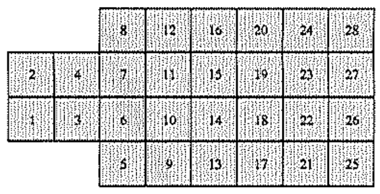
Figure 3; Crowlink Round Barrow, East Sussex, *Topsoil magnetic susceptibility results and mineral magnetic measurements.*

CROWLINK ROUND BARROW, E. SUSSEX **PLAN A**

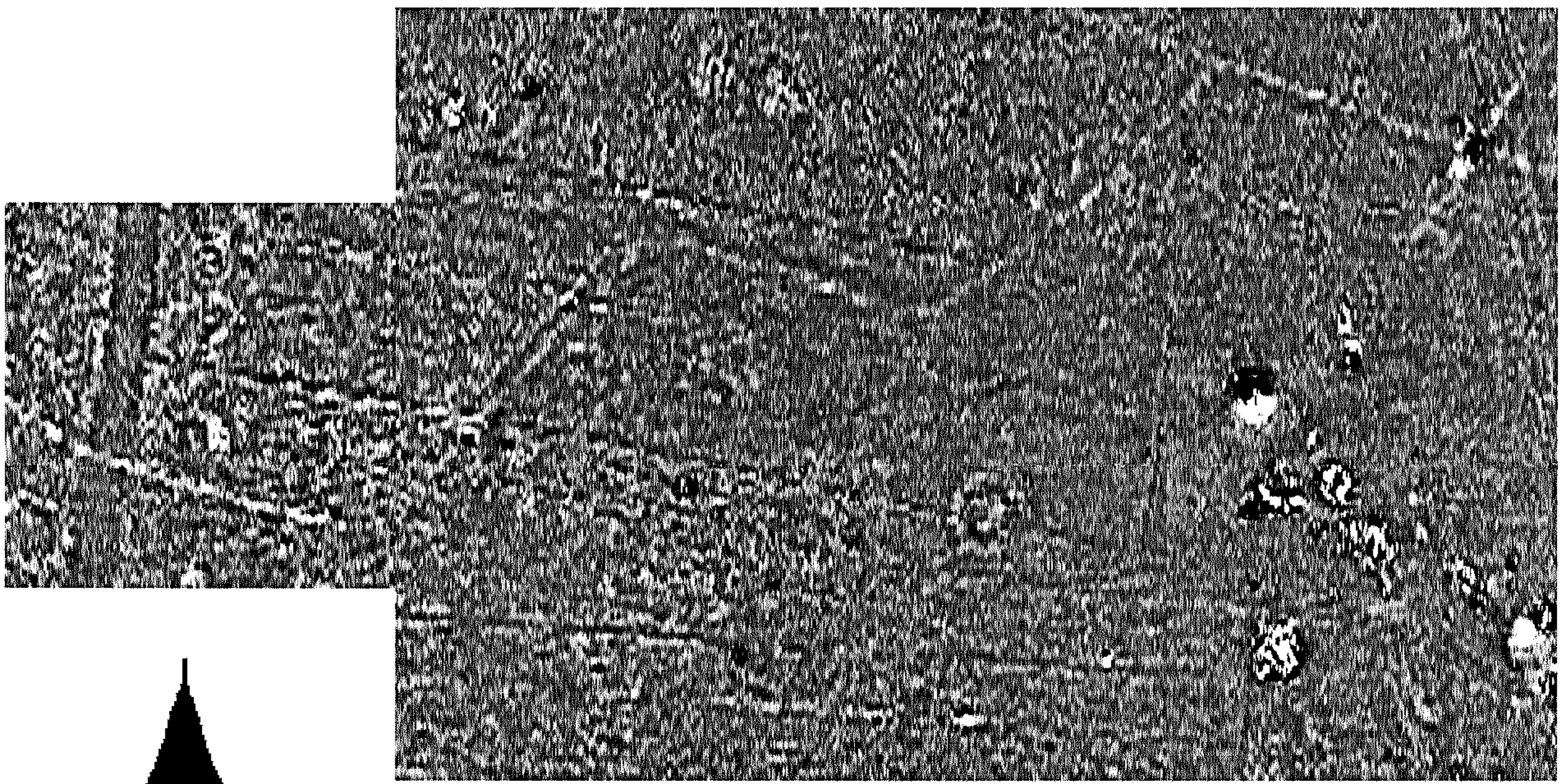
Magnetometer survey, April 1998.

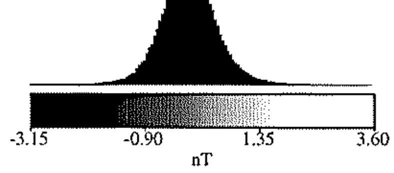
(1) *Traceplot of despiked magnetometer data*





(2) *Linear greytone of despiked magnetometer data*





0 90m

1:1000

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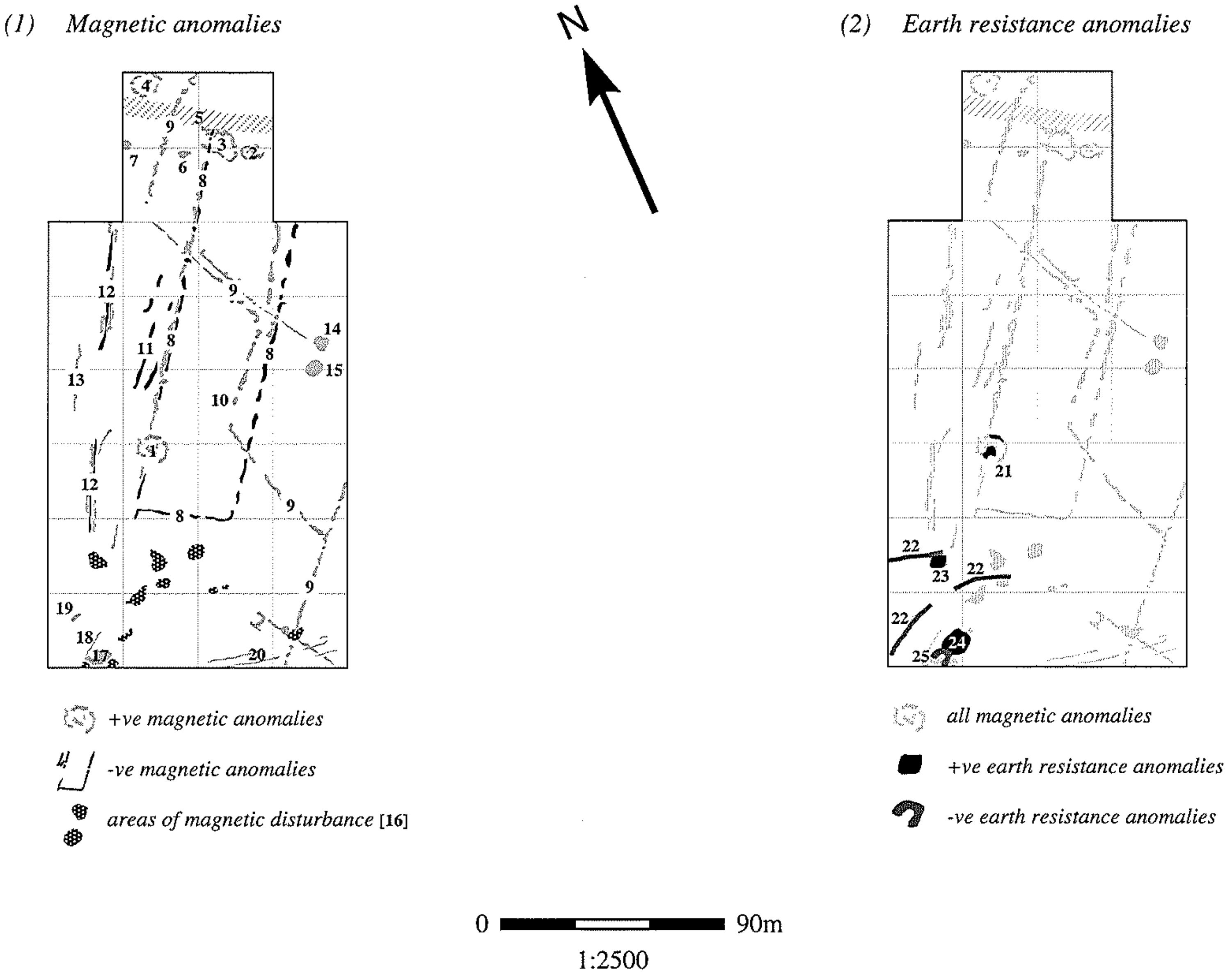
Summary of significant geophysical anomalies

PLAN C



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