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Ancient Monuments Laboratory
Report 40/99

ABBEY LANDS FARM, WHITBY, NORTH YORKSHIRE, REPORT ON GEOPHYSICAL SURVEY, APRIL 1999

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Summary

A geophysical survey was conducted over part of the Anglian Enclosure to the east of Abbey Lands Farm at Whitby Abbey, Whitby, North Yorkshire. Magnetometry and resistivity surveys were used at a higher resolution than on previous occasions at this site but were nonetheless unable to detect satisfactorily the presence or pattern of the many features predicted by previous trial excavation.

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ABBEY LANDS FARM, Whitby, North Yorkshire.

Report on geophysical survey, April 1999

Introduction

A geophysical survey of approximately 0.45ha was conducted over the recently discovered Anglian enclosure of 7th- to 8th-century AD date to the south of Whitby Abbey, North Yorkshire. The area of investigation (NZ 903 111) lies directly to the east of Abbey Lands Farm (Figure 1) and was partly surveyed by GeoQuest Associates in 1993 using magnetometry and resistivity but without yielding significant archaeological information (Noel and Wright, 1993). However, subsequent trial excavations have revealed dense Anglian age features and inhumations (Wilmott, 1996). The present survey was requested in the hope that higher resolution sampling might improve upon the previous results, prior to the total excavation of the area (Central Archaeology Service, 1999).

The site lies on the shallow crest of a ridge running north-south along the spine of the headland of the East Cliff, Whitby (CAS, 1999). In this area boulder clay lies over limestones and shales of the Upper Lias Ravenscar Formation (Noel and Wright, 1993). At the time of the survey the area was under grass and is bisected by a track to the farm. The boundary with the car park to the south consisted mainly of 7-8m high iron retaining girders which severely affected the magnetometer survey. An adjacent barn and car port of corrugated iron were in the process of being demolished by a large caterpillar digger which was both a logistical and magnetic hindrance during the survey.

Method

Resistivity survey.

Resistivity survey (see Annex 1, note 1) was applied over numbered squares 1-2, 4-6 (Figure 1) to cover the main areas of archaeological features identified by the trial excavation trenches. The grid squares were surveyed using a Geoscan RM15 resistivity meter, an MPX 15 multiplexer and an adjustable PA5 electrode frame. Data was collected from both 0.5m and 1.0m mobile probe spacings over each 30m grid square using 0.5m traverse intervals to collect information at a greater resolution and give some depth information. The survey was hampered on the first day by heavy rain which lowered background soil resistance on subsequent days (see below).

The 0.5m mobile probe spacing dataset is superimposed over a site plan at a scale of 1:666 in Figure 2. Traceplots and linear greyscale plots of the data from both mobile probe spacings are presented in Plan A, plots 1-4, at a scale of 1:1000. Plot A.5 is a greyscale of the data processed to enhance near-surface features (Clark 1996; 156).

Magnetometer survey

Magnetic survey (see Annex 1, note 2) was applied with lowered sensor height, to increase the sensitivity of detection, over grid squares 2-3 and 5-6 using 0.5m spaced traverses. The results of the survey are superimposed over a site plan in Figure 3 at a scale of 1:666. Both a traceplot and linear greyscale of the raw data have been 'de-spiked' (using a median filter to remove single anomalous readings created by ferrous objects) and 'un-bunched' (corrected to zero the median of each instrument traverse to remove heading errors) and are presented in Plan B at a scale of 1:500. Plan B.3 shows a linear greyscale plot of the data, processed using Pratt's crispening operation. The effect of the iron girders across the bottom halves of grid squares 5 and 6 was so great that these sections of the data have been removed in order to minimise their effect on the remainder of the dataset.

It was not possible to survey grid squares 1 and 4 as the mechanical digger was then operating in these areas.

Results

A graphical summary of all significant anomalies discussed in the following text is provided in Plan C.

Resistivity

The main restrictions to the resistance survey were caused by former excavation trenches and the rubble of demolished buildings. Also, the heavy rain at the start of the survey resulted in sharp differences in background resistance. Although most of the these latter effects have been removed by matching the mean values of adjacent grid squares the rain will have reduced the overall resistance contrasts following the first day of fieldwork and so may have eliminated weaker anomalies.

The repetitive, weakly resistant linear anomalies [1] are the result of ridge and furrow cultivation and can be seen over much of grid squares 5 and 6.

The high resistance anomaly [4] is cut by trench E4 (low resistance) and is suggestive of a rubble spread, possibly of Abbey stone used to level this area (as was found in the trench: Busby, *pers comm.*). Another consideration is that there could have been two buildings located here (with the foundations visible as two localised areas of extremely high resistance in Plan A.4.). The nearer-surface responses (Plan A.2) could result from the levelling of these. However, these anomalies, on the edge of the surveyed area, cannot be interpreted with confidence.

The high resistance readings at [5] are probably responses to shallow stoney features and are strongest in the 0.5m data. They partially disguise the linear low resistance anomaly [6] which is most likely to be a ditch. This is deeply cut as it appears wider in the 1.0m mobile probe data and, due to its apparent depth, may predate [5].

The large area of high resistance at [7], cut by the track to the farm, is most probably on the line of the later medieval monastic boundary and seems to include at least two linear elements. Parallel and to the north of the track is a distinct linear edge which might correspond with a wall

(Plan A.4); another parallel anomaly is visible just to the south of the track (Plan A.2). The more generalised high resistance values, which widen out to the east, may possibly represent the rubble from the boundary or perhaps from buildings speculated to have existed along this southern stretch of the boundary (Busby, *pers comm.*).

An area of slightly raised values [8] may correspond with boulders noted in the eastern end of trench E3 (Batchelor *pers comm.*) but the effect is too diffuse to allow a pattern to be determined.

The high resistance anomalies at [9] were adjacent to the car port demolished during the survey where there was much surface rubble already present. However, the stronger readings concentrate in the 1.0m mobile probe spacing data, and suggest a greater depth than would be expected just from surface rubble. Two similar responses at [10] were also detected in the previous survey and interpreted as 'stony areas' (Noel and Wright, 1993). The northerly and more resistant of the two appears to have been partially cut by trench (E2) but no causative feature was apparent. Both anomalies lie on the alignment of ridge and furrow detected to the west of the farm (Noel and Wright, 1994) and could therefore be a continuation of this. East and perpendicular to the anomalies at [10] are two slightly high resistance areas [11] that may be an extension of the adjacent ridge and furrow system to the east [1].

There is an area of low resistance at [12], bounded on the east by a near-surface linear response. The previous interpretation of the linear anomaly as a drain (Noel and Wright, 1993) concurs with the lowered, boggy topography of this area. The low resistance adjacent to this could include the projected continuation of a pathway previously recorded in the area of the new car park (Noel and Wright 1993). The low resistance linear anomaly [13] corresponds to a recent field boundary (*ibid.*) that has since been removed.

The weak and amorphous high resistance anomaly at [14] appears to be centred on a small area of rather higher readings from which a linear anomaly extends to the north. A further linear anomaly may be present running north-east, south-west from the central area (Plan A.5).

<u>Magnetometry</u>

The magnetic data is characterised by concentrations of extreme anomalies which are all likely to be of relatively recent origin (eg [2], the metalled farm track); between these are areas of bland response in which nothing of significance has been detected.

In grid squares 5 and 6 a 15m wide strip of readings [3] was severely disturbed due to the large ferrous girders at the edge of the site.

The linear anomaly [15], with both positive and negative responses, could represent a ceramic drain or a former fence line. It appears to join the strongly magnetic readings at [16]. This latter anomaly has produced a similar response to that of [17], and both these coincide with the highest area of resistance at [7]. Such magnetic anomalies are likely to be recent in origin but it is a remote possibility that they may be associated with (?industrial) structures on the monastic boundary [2].

The negative magnetic anomalies [18] and [19], both adjacent to the track [2], are also probably responses to ferrous debris - as is [20] which is mostly obscured by the disturbed readings [3]. The strongly magnetic anomalies at [21] and [22] are also probably responses to ferrous material. The smaller disturbances at [23] - [25] are possibly connected by a tentative linear anomaly [26]. [23] is on the same alignment as the end of the low resistance linear anomaly [13] and could be associated with this former boundary feature. Anomaly [25] partially coincides with the high resistance anomaly [8]; both could be the responses to infilling of trench E3.

Conclusions

Although the recent surveys have identified several anomalies that could relate to archaeological activity they have failed to elucidate the density or detail of the buried features which are known to be present.

Apart from the severe problems associated with adjacent building works and demolition, this disappointing result can be broadly explained by a lack of physical contrasts presented by the features, exacerbated by the masking effects of the medieval and post-medieval activity. There is little congruence between known archaeological features and geophysical anomalies, and there are some inconsistencies. For instance, in trenches C4 and the southern and northern parts of E3 no archaeological features were recorded (CAS 1999, Fig 5) although the geophysical evidence suggests the presence of rubble; on the other hand features found in trenches E2 and C1 produced little geophysical response (although inhumations would not be expected to be detectable here).

It is noted that rather better results, though still difficult to interpret, have been recorded over similar geologies at Scarborough Castle (Bray and David 1998) and Lanercost Priory (Payne 1998) where features are perhaps greater in scale and better preserved.

Despite the detailed ground resolution of the recent surveys at Abbey Lands, the generally poor response suggests that further geophysical work at this site, even if undertaken at a different time of the year, would be unlikely to yield a significant increase in archaeological information.

Surveyed by: A Payne
L Martin

Date of survey: 19 - 23/4/99

Reported by: L Martin

Date of report: 21/6/99

Archaeometry Branch,
Ancient Monuments Laboratory,
English Heritage.

Acknowledgments

Vince Griffin is thanked for supplying the base maps for the figures; and Peter Busby, David Batchelor and Marie-Clare are thanked for use of office facilities, advice and assistance on site.

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List of enclosed figures and plans:

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.

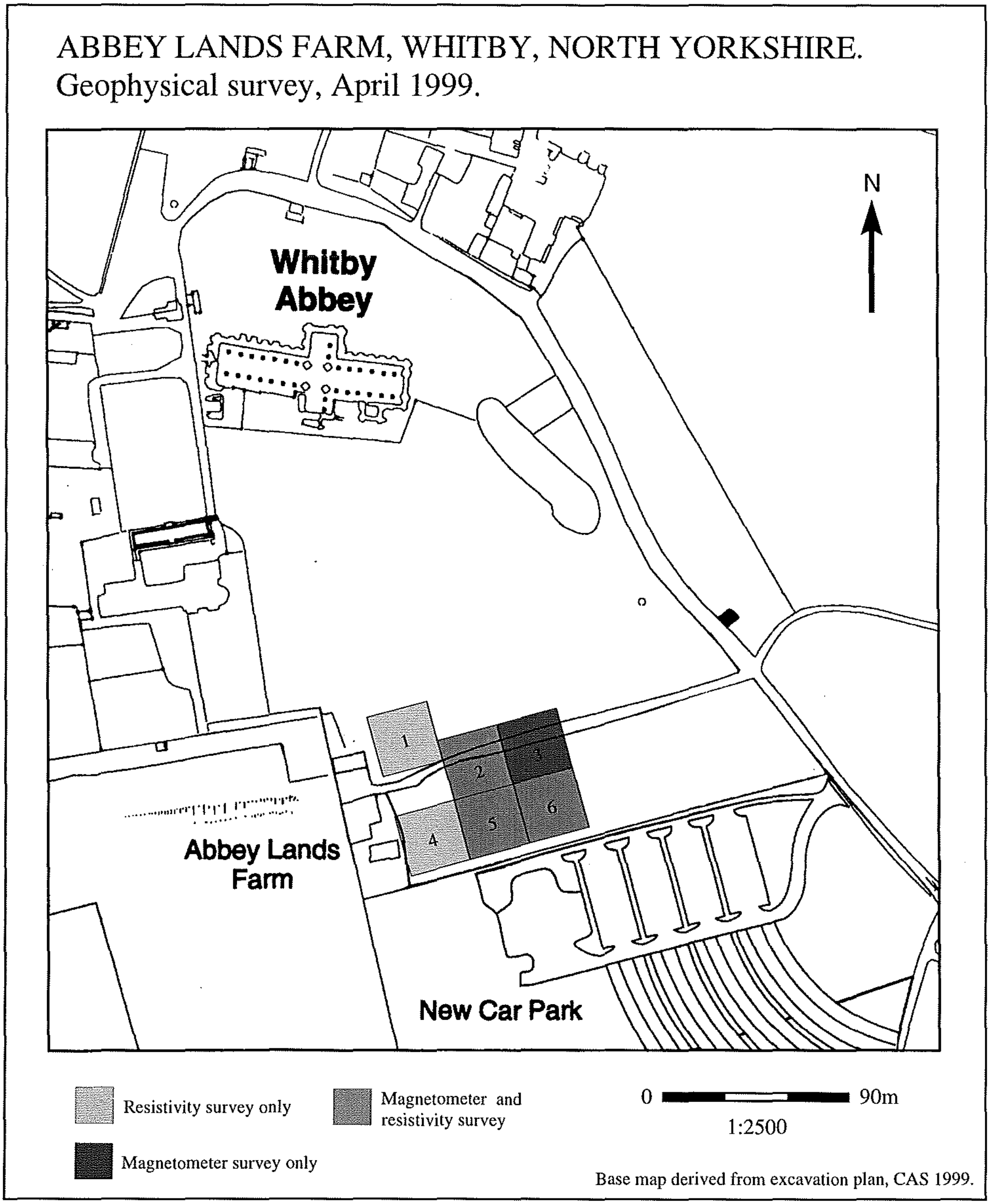


Figure 1; Abbey Lands Farm, Whitby, North Yorkshire, *Location of geophysical survey April 1999.*

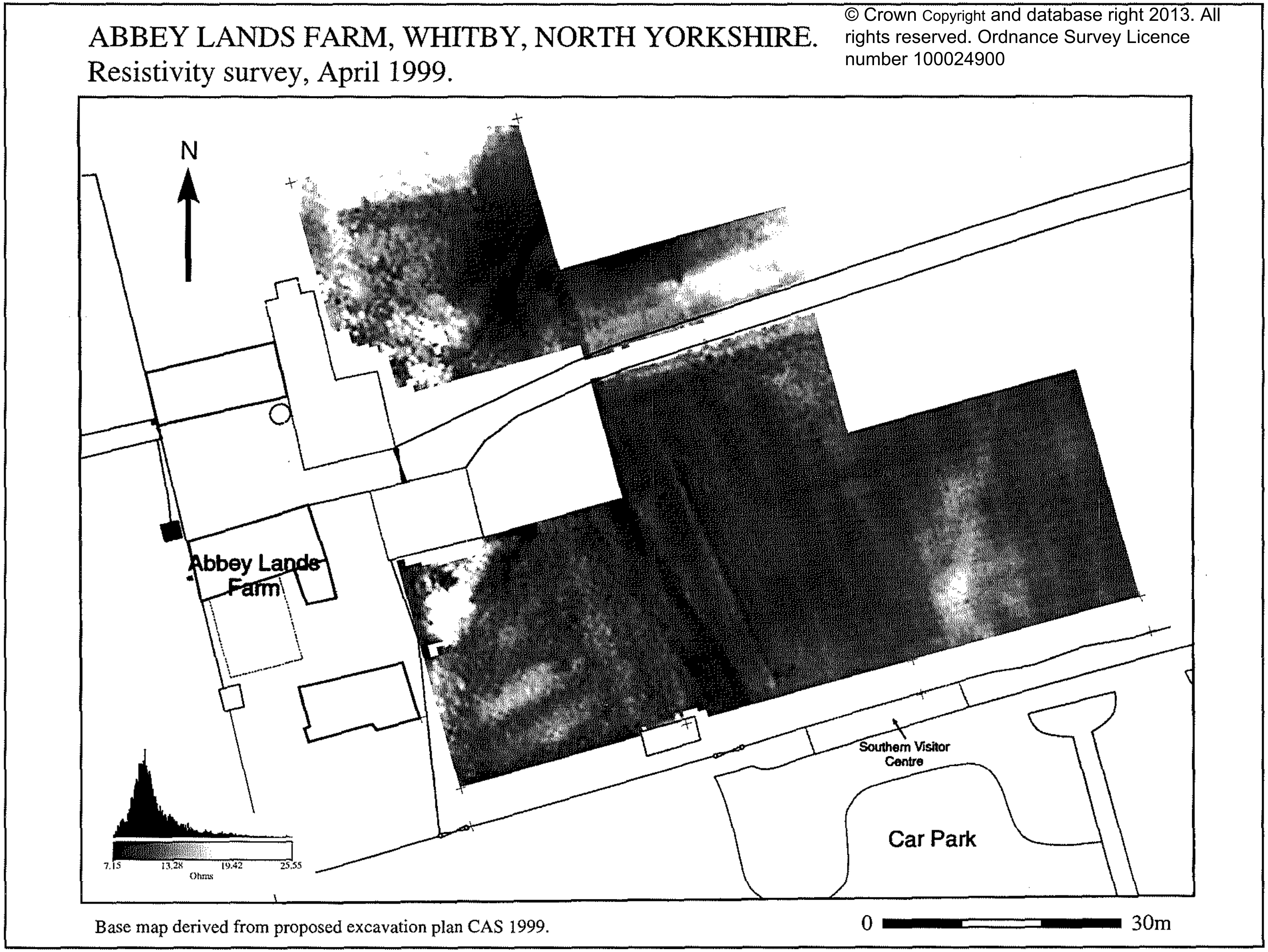


Figure 2; Abbey Lands Farm, Whitby, North Yorkshire, *Greyscale of 0.5m mobile probe spacing resistivity data superimposed over site plan.*

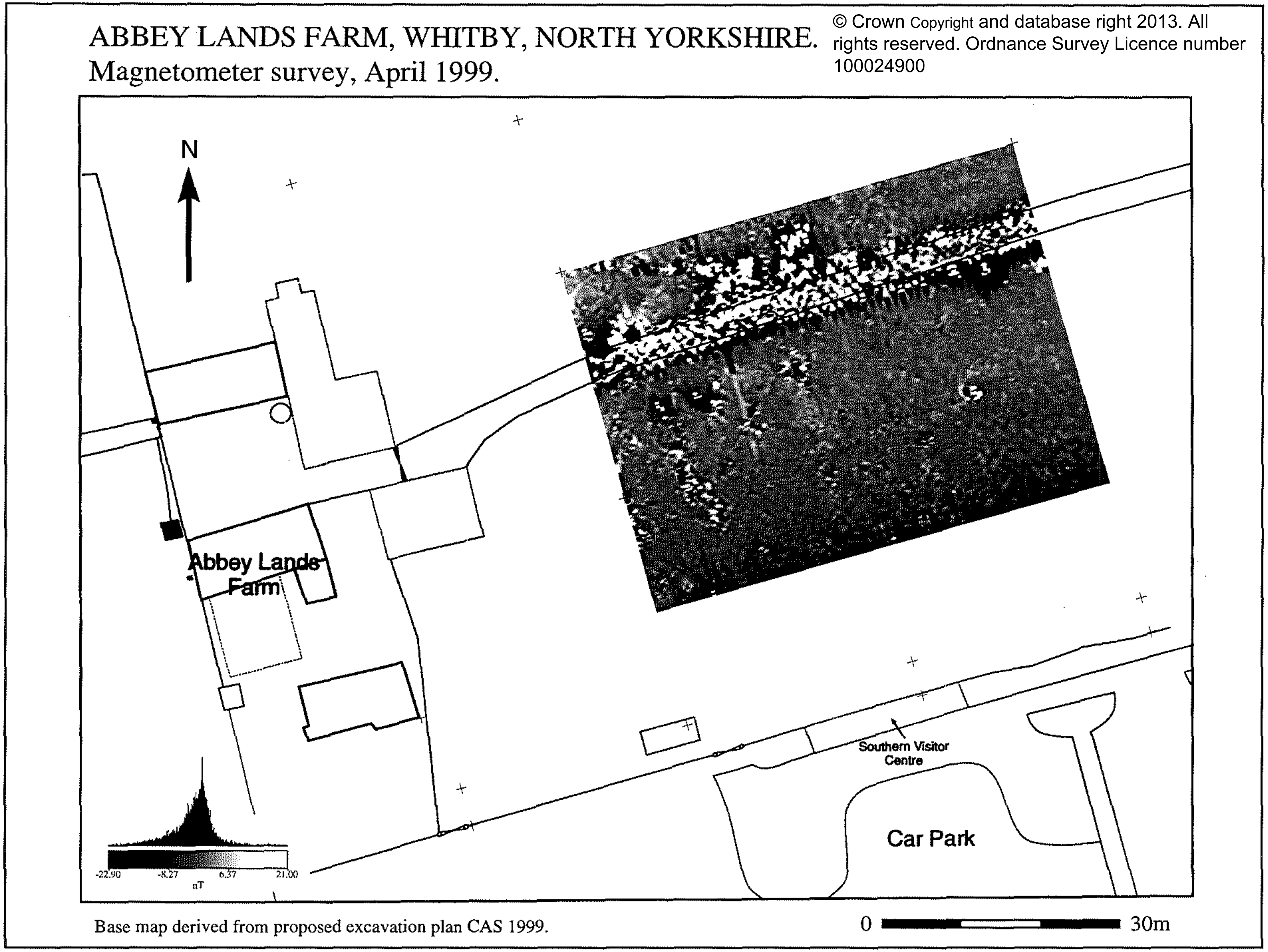
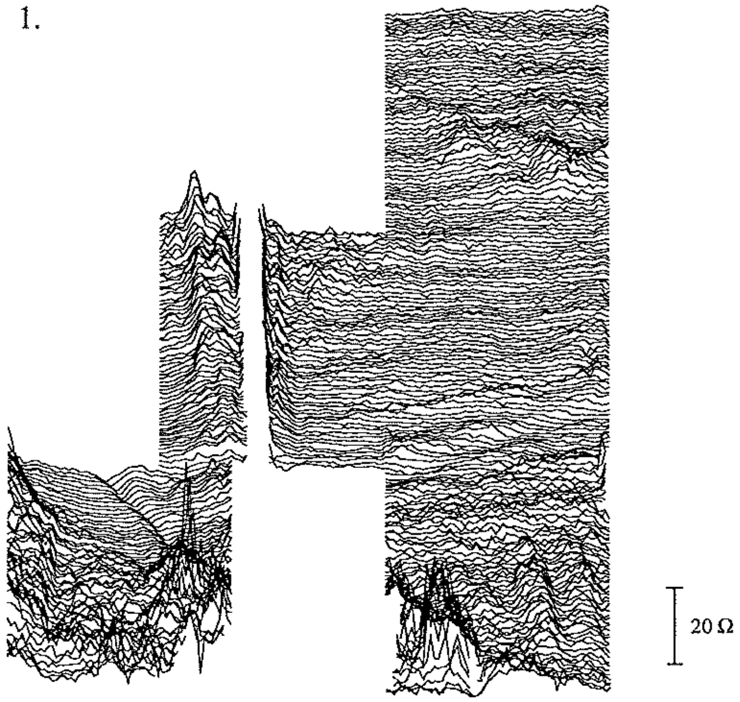


Figure 3; Abbey Lands Farm, Whitby, North Yorkshire, *Greyscale of magnetometer data superimposed over site plan.*

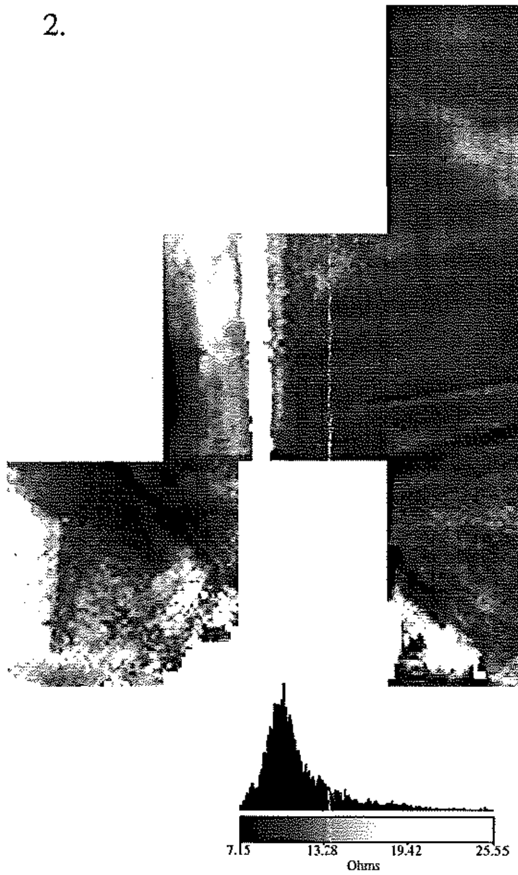
WHITBY ABBEY, NORTH YORKSHIRE.
Resistivity survey April 1999.

PLAN A.

1.



2.



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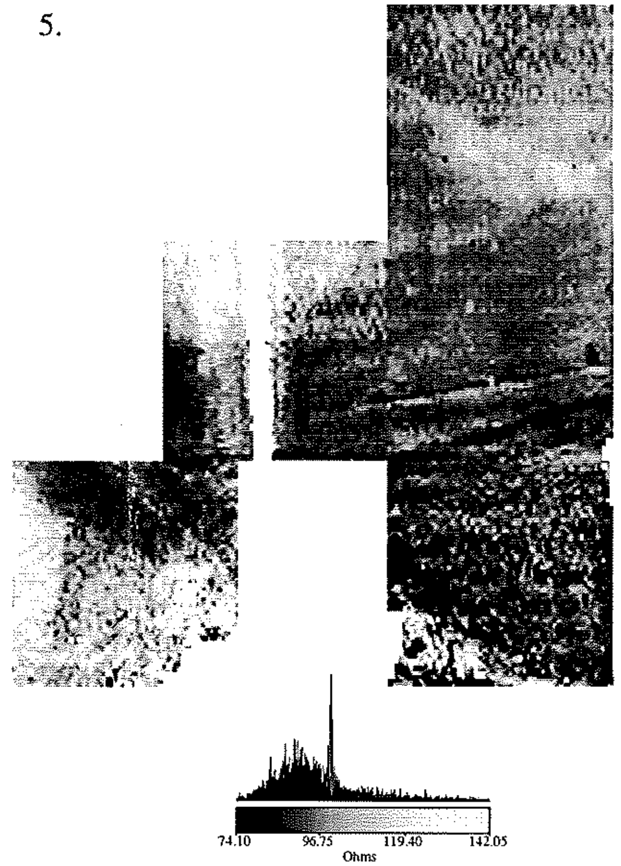
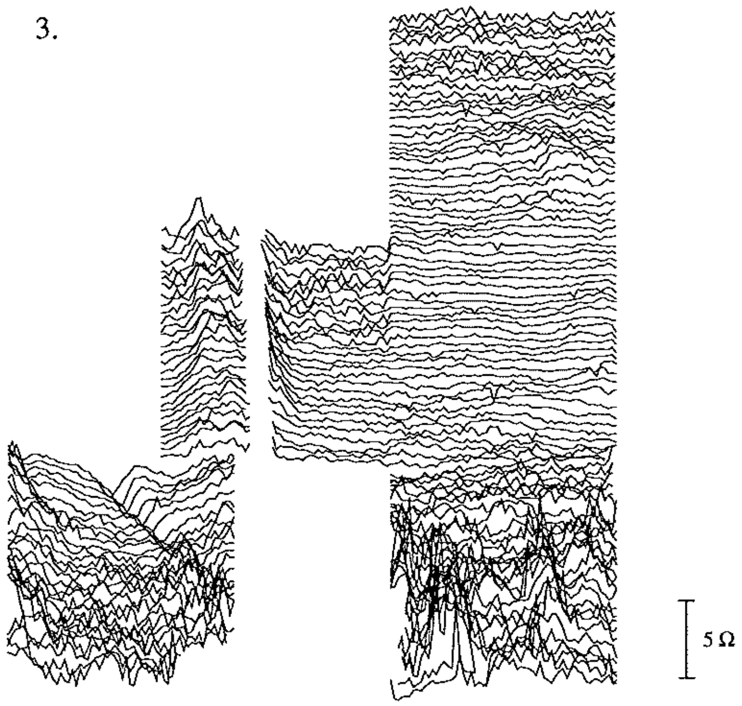
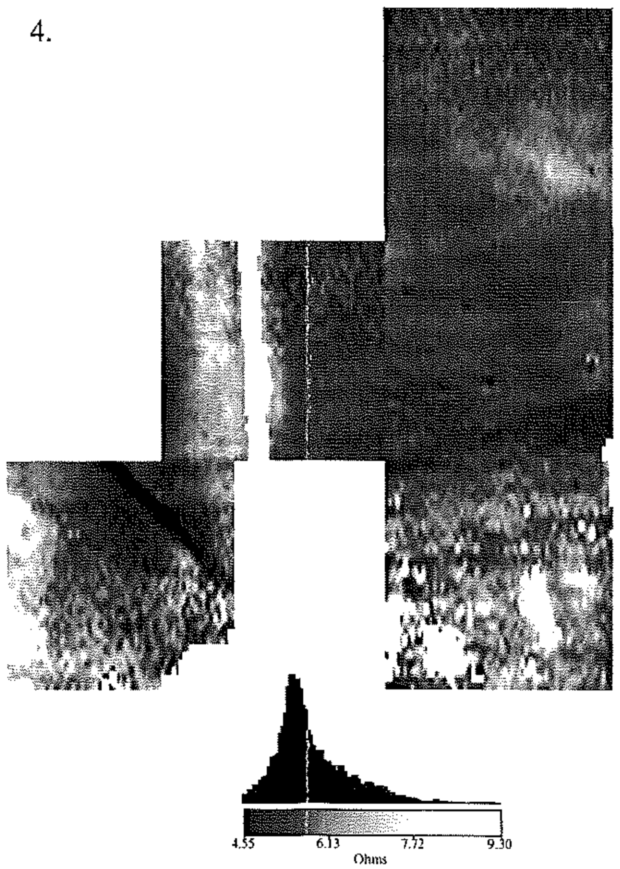


3.



4.



1. Traceplot of despiked resistivity data at 0.5m mobile probe spacing.

2. Linear greyscale of despiked resistivity data at 0.5m mobile probe spacing.

3. Traceplot of despiked resistivity data at 1.0m mobile probe spacing.

4. Linear greyscale of despiked resistivity data at 1.0m mobile probe spacing.

5. 0.5m mobile probe spacing data divided by 1.0m data to accentuate near surface features.

0 60m

1:1000

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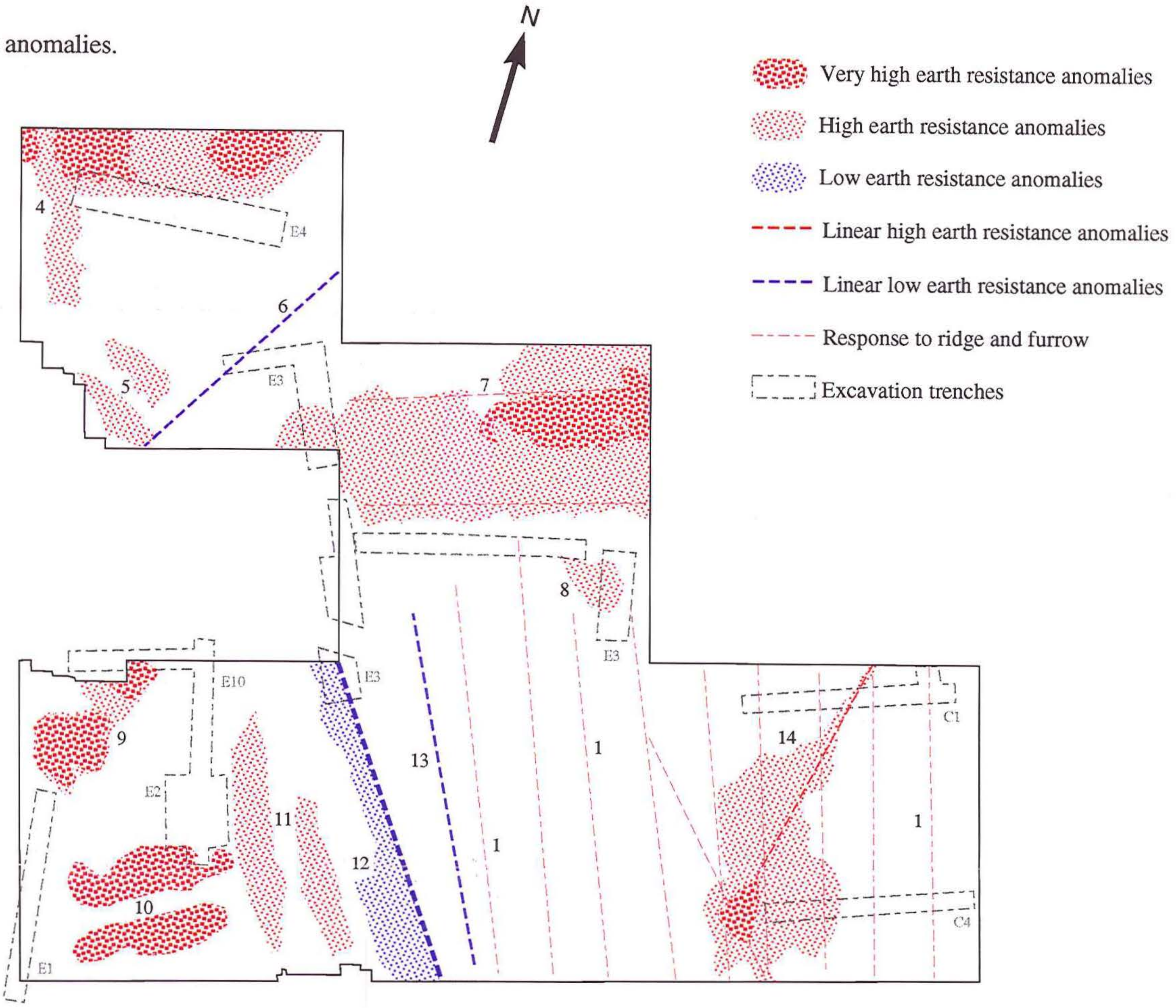
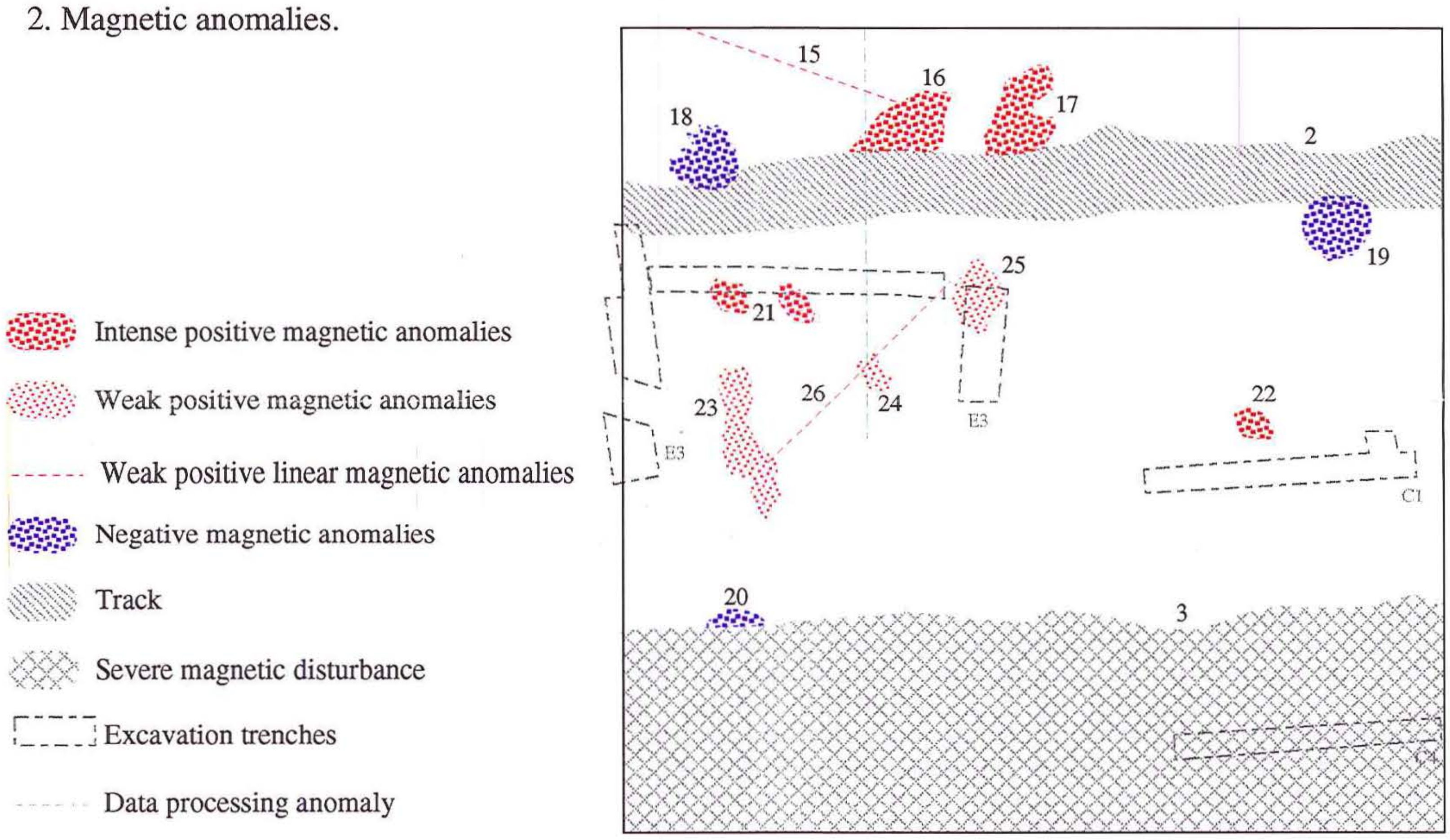
PLAN C.

Summary of significant geophysical anomalies.

1. Resistance anomalies.



2. Magnetic anomalies.



0 30m

1:500

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