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Ancient Monuments Laboratory
Report No. 57/98

TEWITFIELD, N. LANCASHIRE
REPORT ON GEOPHYSICAL SURVEY, FEBRUARY/MARCH 1998

E. Bray, N. Linford, P. Linford

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Summary

A geophysical survey was conducted over a site at Tewitfield, Lancashire, where finds of Viking hack silver had been found by metal detector. The aim was to determine whether there was any anomaly in the vicinity of the finds which might be related to them. Magnetometry, resistivity, magnetic susceptibility, vertical electrical sounding and ground probing radar methods were applied. A large elongated resistivity anomaly was located adjacent to the find positions, and estimated to extend to a depth of between 0.8m and 1.2m by the electrical pseudosection and GPR data. However, none of the methods could determine without doubt whether this or any other of the anomalies detected was of archaeological origin. Subsequent test excavation has indicated that the feature is natural in origin.

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TEWITFIELD, N. LANCASHIRE

Report on Geophysical Survey, February/March 1998.

INTRODUCTION

A geophysical survey was carried out at Tewitfield, Lancashire, over an area in which six objects of Viking period hack silver had been discovered by a metal detectorist. The finds were recovered from the topsoil within an area of about 200 sqm (NGR SD 5136 7372). The aim of the survey was to search for any subsurface features that might be related to these finds.

Previously unknown as being of any archaeological importance, the site is currently within a pasture field and does not contain any significant earthworks near to the find-spot, except for a slight ridge indicating the position of a previous field boundary. A natural hill is present some 150m towards the northern end of the field.

The local geology consists of Lower Carboniferous limestones (OS 1979) overlain by glacial till (OS 1977).

METHOD

Survey Grid

A grid of 30m x 30m squares had been positioned by the Lancaster University Archaeological Unit (LUAU) (see Figure 1). A further grid of four squares was laid out by the AML over the hill at the north end of the field.

Magnetometer Survey

Two Geoscan FM36 fluxgate gradiometers were used to survey the part of the area centred over the findspot with a sample interval of 0.25m and traverse separation of 1m.

Resistivity Survey

A Geoscan RM15 resistivity meter was used with 1m sample intervals and traverse separation. This method revealed an anomaly (A) over which a series of 12 parallel pseudosections separated by 2m were made in an E-W orientation. Each line consisted of 25 electrodes placed at 1 metre intervals. Two further profiles were measured in the same manner, the first along the long axis of the anomalous area, and the second running SW-NE across a similar nearby anomaly (B) suspected to be a palaeochannel. A Campus Imager 50 system was used to collect resistance measurements using the dipole-dipole configuration [Annex 1], with a maximum electrode separation of 8m. The data from each line of electrodes was reconstructed to create a vertical electrical profile using the RES2DEC0 software package (see Figures 5 and 6). Data from discrete levels in the profiles were also combined into horizontal slices, to produce plans of resistance at varying depths (see Figure 6a).

Ground Penetrating Radar (GPR)

A GPR survey was conducted over the anomaly with a Pulse Ekko pe1000 GPR, utilising antennae with centre frequencies of 225, 450 and 900 MHz. Data were collected at a sample interval of O.O5m from a series of 20m parallel E-W traverses separated by 1.0m for both the 450MHz and 900MHz antennae, and at 0.1m intervals for the 225MHz antenna (see Figure 7a). No signal processing or gain control was applied to the digitally recorded data during acquisition.

Post acquisition processing was restricted to the application of automatic gain control to amplify late reflections and moderate smoothing of individual traces for improved visual display. Due to antenna coupling of the GPR transmitter with the ground to an approximate depth of $\lambda/2$ very near-surface reflection events should only be detectable below a depth of 0.2m, assuming a 225MHz antenna and a velocity of 0. 1m/ns. However, the broad bandwidth of a pulse GPR signal results in a range of frequencies to either side of the centre frequency which, in practice, will record significant near-surface reflections closer to the ground surface. Such reflections are often emphasised in amplitude time slices where the recorded signal from a series of parallel traces collected with the same antenna are averaged over a short time window (Meats 1995, Conyers and Goodman 1997).

The resultant data forms a series of 2-dimensional area plots representing the amplitude of reflections from successively deeper layers of the subsurface. If the average velocity of the radiation through the subsurface is determined and assumed to be constant over the area of the survey then the time-slice windows may be calibrated to provide an approximate depth estimate from which reflection anomalies occur. In this case time slices were produced over a 4ns down-trace window and are averaged over a 1m horizontal radius between adjacent survey lines (Figure 8).

Magnetic Susceptibility (MS)

Samples of topsoil were taken from various positions across and around anomaly A (see Figure 9a) and laboratory measurements of mass magnetic susceptibility were made using a Bartington MS1 l00cc bench sensor. The E-W sample line (see Figure 9a) was not positioned over the optimum part of the anomaly because preliminary plots of the data were all that were available when planning where to take samples from. Ideally, a line of samples would have been taken from the northern end of the anomaly, over the lowest resistance area. The MS data values are displayed in Figure 9.

RESULTS (Figures 2-9)

Magnetometer Survey (Figure 2)

The magnetometer survey results are displayed in Figure 2 as a greyscale plot of values between +/-2nT, and also as a trace plot. The data has not been filtered to remove reactions to iron objects, as is usually done, in case such objects may be of archaeological significance. The magnetic data are on the whole unrevealing, with the most prominent anomaly being due to an old field boundary running WNW-ESE. A weaker linear feature parallel to this boundary exists approximately 15m to the north.

Several anomalies which may indicate infilled pits have been detected and the more prominent of these are marked on Figure 2c, as are the strongest dipolar responses attributable to ferrous metal on or near the ground surface. An area of slightly accentuated magnetic disturbance (diameter about 13m) is present in the west of the area.

A broad swathe (10-12m wide) of slightly raised readings (referred to below as resistivity anomaly B) can be distinguished running NW-SE across the old field boundary.

No anomalous features have been detected close to the find-spot; the scatter of ferrous reactions located nearby, and elsewhere over the survey area, are likely to be relatively modern in origin rather than of Viking age. Modern debris was observed at the time of the survey.

A distinct positive linear anomaly of 4nT, about 11m long, is present in the southeast of the survey grid. This may be a short ditch-like feature, but remains unexplained.

Resistivity Survey (Figures 3 and 4)

Results of the resistivity survey are displayed in Figure 3 as greyscale and trace plots. A Wallis sharpening filter of window radius 8m has been applied to the data to enhance the differences between areas of high and low resistance. The field boundary detected with the magnetometer survey is apparent in the resistivity data as a narrow line of low resistance (C, Figure 4).

The main survey area is characterised by a pattern of previous cultivation, a trend of alternating bands of high and low resistance running NNE-SSW with a frequency of approximately 8m.

On a different orientation are several other less regular low resistance anomalies. Most prominent is a broad (14m) linear anomaly (B) running NW-SE across the survey area and interpreted as a buried channel (also detected faintly in the magnetometer survey).

More significant, in view of its location near the finds of silver, is a low resistance anomaly (A) measuring approximately 20m x 5m. Towards its northern end is a more restricted area of diameter 4m where the negative anomaly is at its most extreme.

The sample survey grid on the hill at the north end of the field shows as much resistivity variation as in the southern survey grid. An area of low resistance is present on the top of the hill, measuring 15m by at least 40m. Altogether, three linear swathes of low resistance with similar proportions to (A) have been labelled (D) on Figure 4. It seems probable that these are geomorphological in origin.

An angular arrangement of high resistance values on the hill, initially thought during the survey to indicate buildings, is indicated on Figure 4 (E) but may in fact also be of natural rather than artificial origin.

Vertical Electrical Imaging (Figures 5 and 6)

In the following discussion it is important to remember that electrical profiling maps the variation in resistivity of the subsurface. This variation depends largely on the distribution of soil moisture which, whilst influenced by buried physical structures, can also be influenced by local weather and drainage. The anomalies detected in the electrical profiles may therefore not always accurately reflect buried structures in the ground.

As the depth of investigation of the dipole-dipole configuration is approximately 1/3 of the dipole separation the maximum depth of investigation was about 2.7 metres.

In figure 5a the northernmost (top) profile was chosen to be slightly too far north to intersect the target anomaly (see also figure 5b). Hence the only feature visible in the plot is the broad, dark band of low resistance values at shallow depth, presumably representing the topsoil, some 20-30cm deep. Looking at the profiles further south, a low resistance ditch shaped anomaly is apparent extending down from the topsoil layer into the higher resistance material beneath. This anomaly is most pronounced in the 5th and 6th profiles down the page, corresponding with the lowest resistivity measurements in the area twin electrode survey. In these two profiles the ditch anomaly appears to be about 4m wide and 1. 2 to 1. 5m deep at its deepest point. The southernmost profiles show the anomaly continuing in this direction but becoming slightly broader (5-6m) and shallower (1m at its deepest point).

Studying the longitudinal profile along anomaly A in Figure 6b(iv), a similar interpretation may be drawn. It is deepest (~1.2m) at the northern end of the profile (right hand side of the plot) which corresponds in location with the 5th and 6th cross sectional profiles mentioned above. It becomes shallower to the south, until it is only about 0.5m deep at the end of the profile.

Figure 6a presents the resistivity measurements horizontally as a series of layers, at eight successive depths below the surface. In the top five of these layers the ditch anomaly is visible as a dark linear feature extending from just north of the centre of the imaged area, to the southern edge. This suggests both that anomaly A becomes very shallow towards its northern end, and that it is perhaps 1.5m deep at its deepest point, as the lowest three layers do not show it as a clear contiguous feature.

Also of interest in Figure 6a is the circular, high resistance anomaly appearing in the centre of the imaged area in the deepest three layers. It is particularly apparent in the left hand column (Figure 6a(i)), and suggests a discrete high resistivity feature beneath anomaly A. It should be noted that the electrical imaging technique is more susceptible to random noise for deeper measurements, so it is not possible to be categorical about this feature.

Finally Figures 6b(i) to (vi) compare two selected profiles across anomaly A with a profile across anomaly B, thought to represent a palaeochannel. It is clear from these figures that anomaly B (6b(i)) most closely compares with the profile across the shallow northern end of anomaly A (6b(v)), rather than the deeper, more well defined ditch feature in the central profiles (6b(vi)). This suggests that anomaly A is, in its central portion at least, a deeper feature than the nearby anomaly B and may thus have a different origin. However, it should be born in mind that, had time allowed a more extensive profiling of anomaly B, variations in its depth might also have been discovered, so this inference cannot be conclusive.

In summary, anomaly A appears to be about 1.2 to 1.5m deep in its central portion, becoming shallower towards its northern and southern ends. In its deepest portion it does appear to be different in character to the nearby putative palaeochannel (anomaly B) detected in the area twin-electrode survey. Furthermore, it is possible that a discrete high resistivity feature underlies it at this point.

Ground Probing Radar (Figures 7 and *8)*

A single 20m test traverse was completed with all three available antennae and the resultant traces are presented in Figure 7b. Note that the horizontal scale of the traces presented in this Figure varies between the 900MHz and the 450/225MHz due to the increased sample interval used with the high frequency antenna. Fiducial markers at the bottom of each plot were added at 1m intervals along each traverse to indicate the true horizontal scale and position of reflection anomalies with respect to the survey grid.

Initial field evaluation of this data suggested that only the two lower frequency antennae were obtaining significant signal penetration into the ground due, no doubt, to the high conductivity of the clay-rich glacial till geology of the site. Whilst this restriction compromised the lateral resolution of the survey the dimensions of the anomaly under investigation were considered great enough to be recorded in sufficient detail with either of the 450 or 225MHz antennae.

Both antennae record their highest amplitude reflections between 0-24ns, with few significant events later than this (Figure 8). Furthermore, the initial 0-4ns window of the 225MHz data contains no high amplitude reflections due, most probably, to increased antenna coupling with the very near surface occurring to a slightly greater depth than for the 450MHz data. Analysis of the time slices reveals only one highly tentative anomaly (labelled G1, Figure 8) replicated in the 10- 14ns window of both datasets as a ~ 7m wide negative response (black) following an E-W alignment across the survey area. This anomaly equates with the location of the low resistance response recorded during the initial survey.

Common midpoint (CMP) determinations were made in the field for both antennae and suggested a radar signal velocity of 0.15 m/s. From this determination the anomaly discussed above would appear to represent a shallow feature extending from ~0.8 to 1.0m from the ground surface. However, signal velocities determined through the CMP technique should be viewed with caution as they often represent the velocity of radar propagation in the very near surface topsoil only. In many cases the dielectric properties of the organic rich topsoil may differ considerably from the underlying, more water retentive soils and sediments.

Magnetic Susceptibility (Figure 9)

The soil samples measured in the laboratory bench sensor gave values of mass specific MS varying between 66 and $156 \times 10^{-8} m^3/kg$.From Figure 9, it can be seen that there is no significant difference in average value of those samples taken from the resistance anomaly location and those taken from around it. The wide and seemingly random variation in these relatively high values in part explains the lack of definition obtained by the magnetometer survey. Such values may partly result from modern contamination - as hinted at by the presence of flecks of brick and charcoal noticed in the samples during measurement.

DISCUSSION

The finds of Viking silver at Tewitfield, from a relatively restricted area, raised the possibility that they were once part of a deliberate deposit. The apparent association of the silver with finds of iron nails even led to speculation that there may have been a boat burial. Whatever the case, the aim of the geophysical investigation was to establish any evidence from the sub-surface which might provide an archaeological context for the finds.

The survey results are ambiguous. However, anomaly (A), owing to its proximity to the finds, could not be discounted as a natural feature and was therefore investigated in more detail, and its geophysical signature compared with the supposed buried channel to the NE. The depth of the palaeochannel (B) is shown by the electrical pseudosection to be approximately 0.5m (see Figure 6b(i)). The longitudinal profile over anomaly (A) shows a similar depth along most of its length, deepening locally at its northern end. Had anomaly (B) been investigated elsewhere along its length it may have also revealed depth variations, thus forbidding any categorical statement that these anomalies are of differing origins.

GPR survey was not very successful at this site probably due to the combination of a high clay content and signal scattering from numerous small pebbles forming point-type reflectors dispersing the incident signal. Both these latter attributes are recognised impediments when surveying over glacial till, effects exacerbated by a high water content leading to the rapid attenuation of the radar signal in the ground (Davis and Annan 1989). Despite these conditions a tentative linear anomaly has been identified within the GPR data which appears to correspond with the shallow ditch suggested by the resistivity pseudosections recorded over the same area.

The possible presence of a boat burial, once raised, received some initial support from the identification of anomaly (A). The size, shape and orientation of this anomaly are consistent with the range of sizes of boats found in both the British Isles and Scandinavia[1]. The electrical pseudosection data indicate that the depth of (A) is at a maximum 1.2m to 1.5m; the GPR results suggest a depth of 0.8m to 1m. The anomaly is oriented roughly in a N-S direction,

[1]The Balladoole boat measured approximately 11m x 3m (Bersu and Wilson 1966), Ladby 20.6m x 3.2m (Hale 1998), and Skuldelev, 29m long (Hale 1998). Three boat burials found in Norway showed very similar dimensions: from Gokstad, 22.8m x 5.25m, Tune, 19.5m x 4.2m, and Osberg, 21.5m x S.1m (Brøndsted 1982). These vessels were 1.95m, 1.35m and 1.5m deep respectively (Brøndsted 1982). The ship discovered at Ladby was 1m deep at the midpoint (Hale 1998), and that at Knoc-y-doonee an estimated O.9m (Kermode 1930).

which may be significant[2]. And finally the large amount of iron nails found at the site by the metal detectorist was also suggestive; the few boat burials found in the British Isles having been recognised by the local concentrations of clench nails. The nails and the possibility of a grave covering of burnt materials[3] led to the expectation of detection of any burial with the magnetometer in the form of an elongated area of magnetic disturbance. Unfortunately the method was inhibited by the presence of modern ferrous rubbish, and the lack of variation in the magnetic susceptibility values of the soil. The positions of all the nails found had not been mapped for comparison with the other data. However, following examination, it would appear that the examples found at the site are much more recent than appropriate for a Viking connection (G Chitty pers comm).

Boat burials commonly see the position of the body either at the stern, or amidships in later burials (Kermode 1930). Resistivity anomaly (A) has its lowest point at the northern end which, although too wide to represent a body, may indicate some associated archaeological feature. A discrete high resistivity anomaly was detected in the electrical pseudosections beneath and just NE of the extreme readings of the overlying anomaly here.

Despite the circumstantial evidence referred to above, the position of anomaly (A) within the context of the local topography deserves comment. Scandinavian burial sites have often been found to favour elevated positions on or near the seashore (eg at Knoc-y-doonee a boat was found at the highest point of the local landscape: Kermode 1930), or to be inserted as a secondary burial into the top or side of a pre-existing mound (as at Balladoole, where a cairn was built into the side of a hillfort: Bersu and Wilson 1966). Although the altitude of the site does not prohibit the possibility of a boat being transported from the sea or a local watercourse[4], it seems strange that it would be deposited so close to, but not on top of, the natural mound present at the northern end of the field.

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[2]The Ladby ship was also found N-S (bow to the S) (Brøndsted 1982), and those at Knoc-y-doonee (Kermode 1930) and Balladoole (Bersu and Wilson 1966) NE-SW.

[3]Boat burials have been found either to have coverings of soil and stones (Hall 1990, Kermode 1930), or, in the case of Ballateare, of turf (Hall 1990). The Norwegian boats mentioned in footnote 2 above, although of very similar size to anomaly (A), were discovered beneath large burial mounds. Where a mound is present over a Viking burial, excavation has shown the cover to contain soil and debris collected from funerary cremation of livestock. No evidence could be seen at the site of the existence of a mound over the anomalous feature, natural or otherwise. It is of course possible that a mound could be levelled by many years of ploughing.

[4]The site is currently 27m above sea level (OS map 97, J. Quartermaine pers comm). Research suggests that during the years normally termed the 'Viking' age (ie. 800-1100AD), the mean tide level around Lancashire would have been 1m or 2m above today's level (Tooley 1978, p130). This was during a period of downwards land movement which began in about AD700 and reached a peak just before AD1200 (Tooley 1978, p198). (The sea levels when compared with todays were +0.4m and +6.5m respectively.) Today, the tidal range along the Lancashire coastline is >6m (Tooley 1978) - in other words, sea levels may vary by plus or minus 3m - and it is safe to assume a similar tidal action occurred during the Viking period. Therefore, the position of the site at Tewitfield may have been 25-22m above the contemporary sea level, depending on the tidal variation. The River Keer, just one mile from the site, crosses a wide area of fairly constant altitude (approx. <10m OD) between Carnforth and Warton: it is possible that with the slightly higher sea level in the Viking period this land formed a tidal inlet zone or salt flats.

In conclusion, and despite such speculation, the geophysical evidence indicates only that a large elongated resistivity anomaly exists adjacent to the find positions, and is estimated to extend to a depth of between 0.8m and 1.2m. There is insufficient evidence to distinguish this anomaly from similar ones nearby which are probably geomorphological in origin, or of post-Viking age. Indeed trial excavation by the Lancaster University Archaeology Unit has subsequently established that the feature (anomaly A) is natural in origin (Quartermaine pers comm).

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End note: An interim report, with excavation section drawings and an explanatory summary of stratigraphy encountered by the Lancaster University Archaeology Unit, forms Annex 2. Anomaly A was found to be 0.9m deep; rather shallower than suggested by the resistivity pseudosection but in good agreement with the GPR data.

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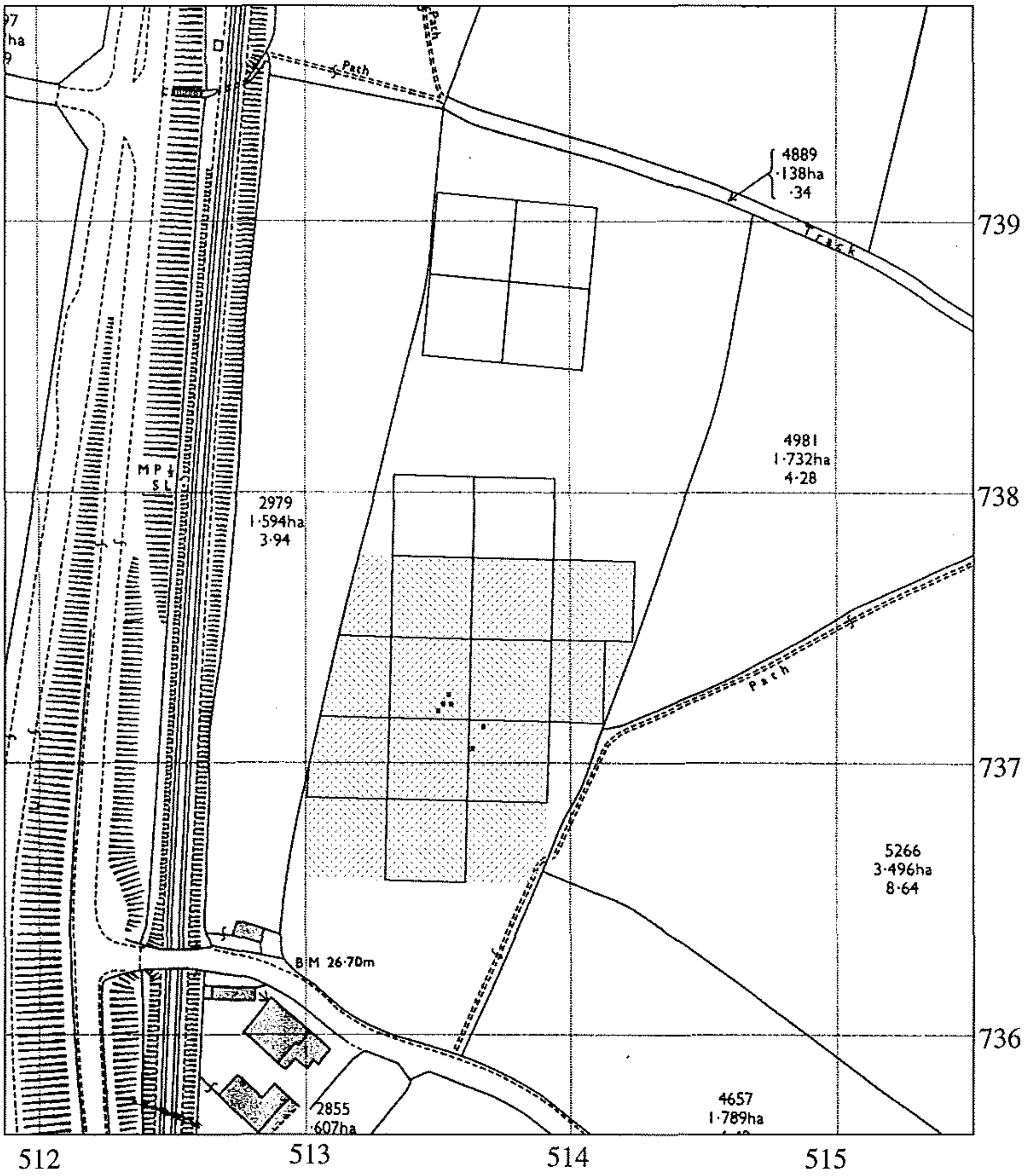
List of Figures

Surveyed by:	E. Bray P. Linford N. Linford A. Payne A. David	Dates of Surveys:	2-6/2/1998 16-18/3/1998
Reported by:	E. Bray N. Linford P. Linford	Date of Report:	16/10/1998

Figure 1: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, February 1998

Location of survey grids

SD 5173



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Squares surveyed with RM15 resistivity meter

Squares surveyed with FM36 gradiometer

Locations of main metal detector finds

0 90m

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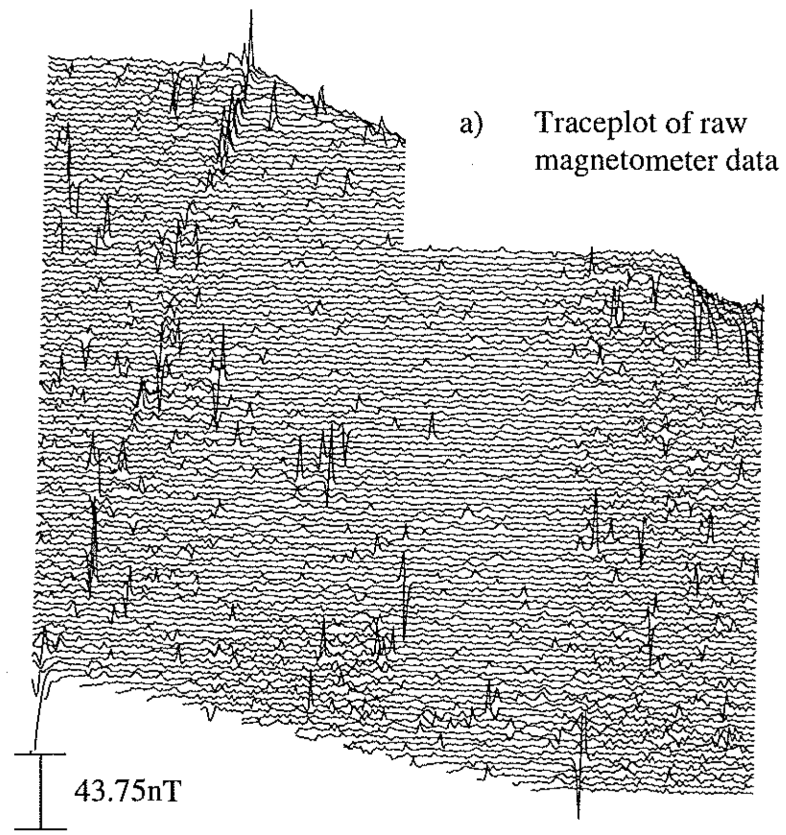
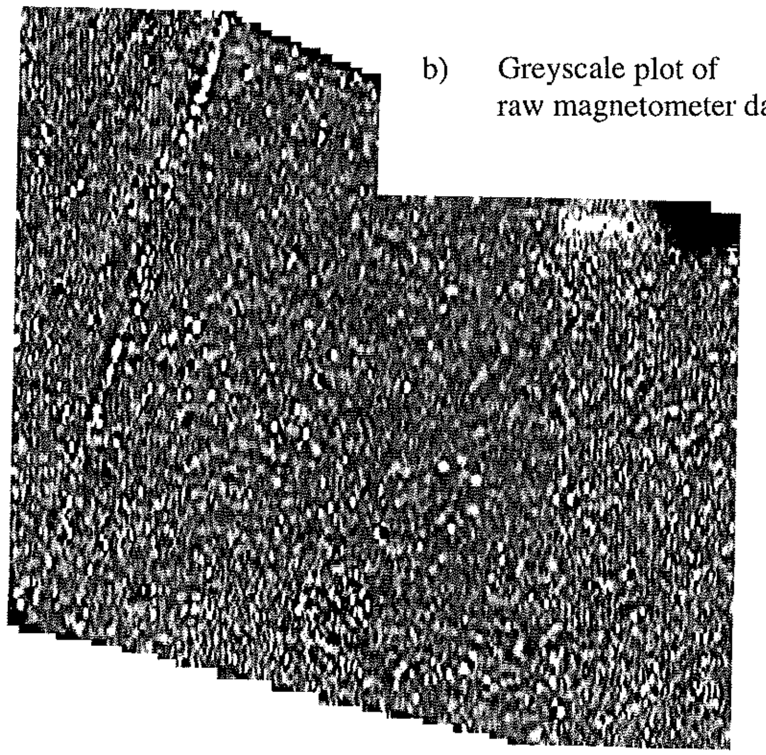
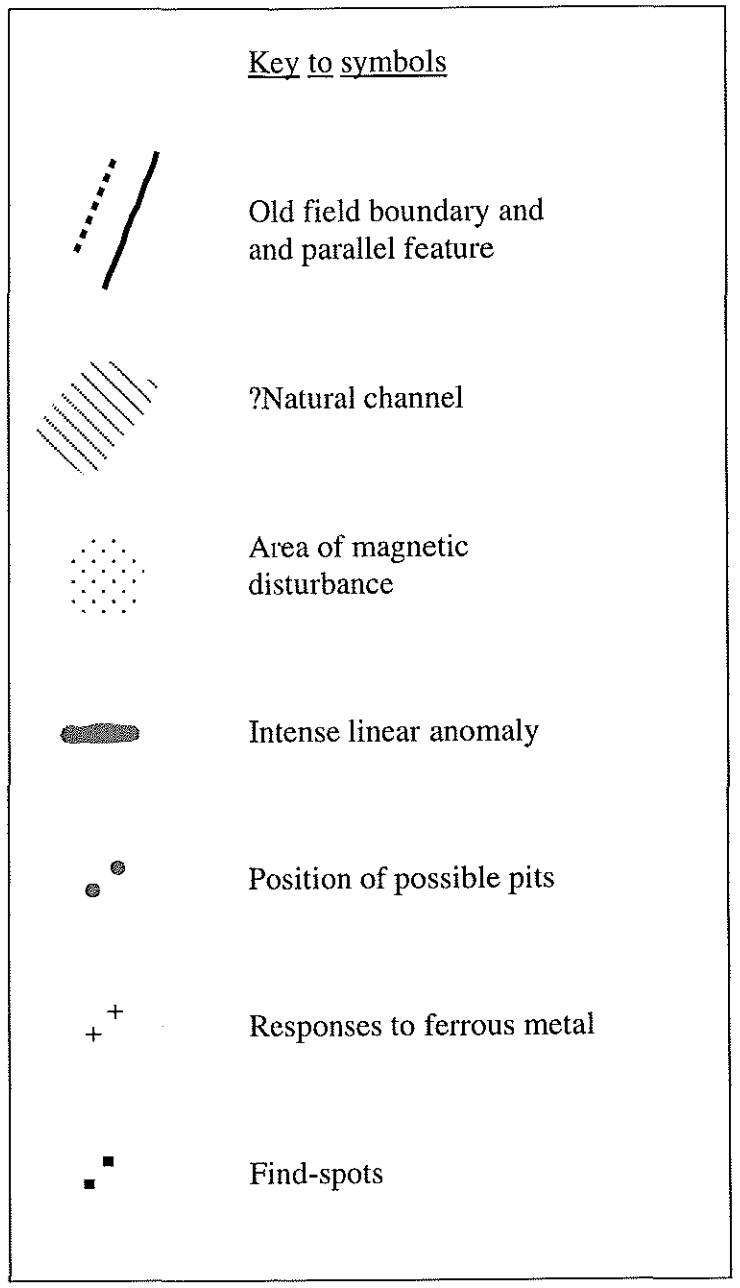
Figure 2: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, February 1998

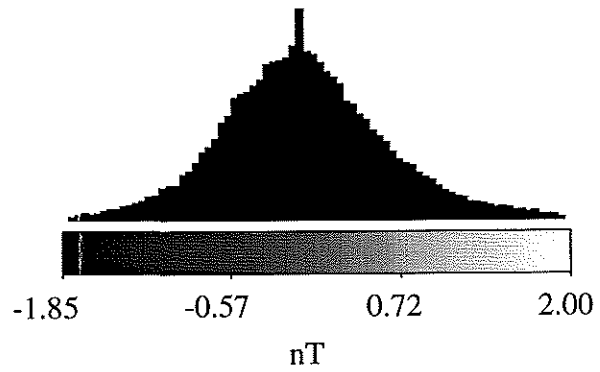


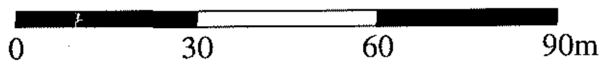
a) Traceplot of raw magnetometer data

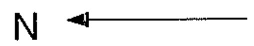


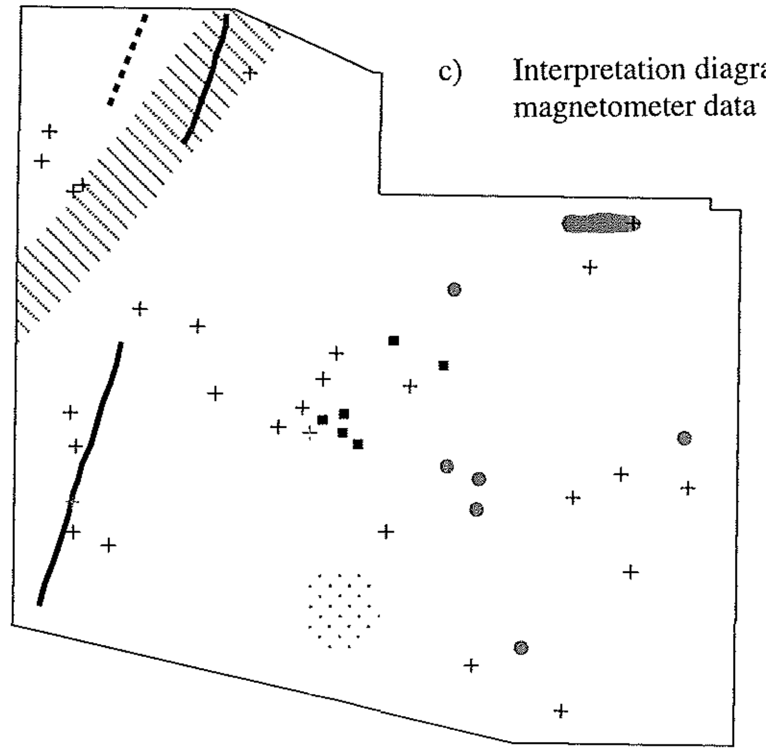
b) Greyscale plot of raw magnetometer data











c) Interpretation diagram of magnetometer data

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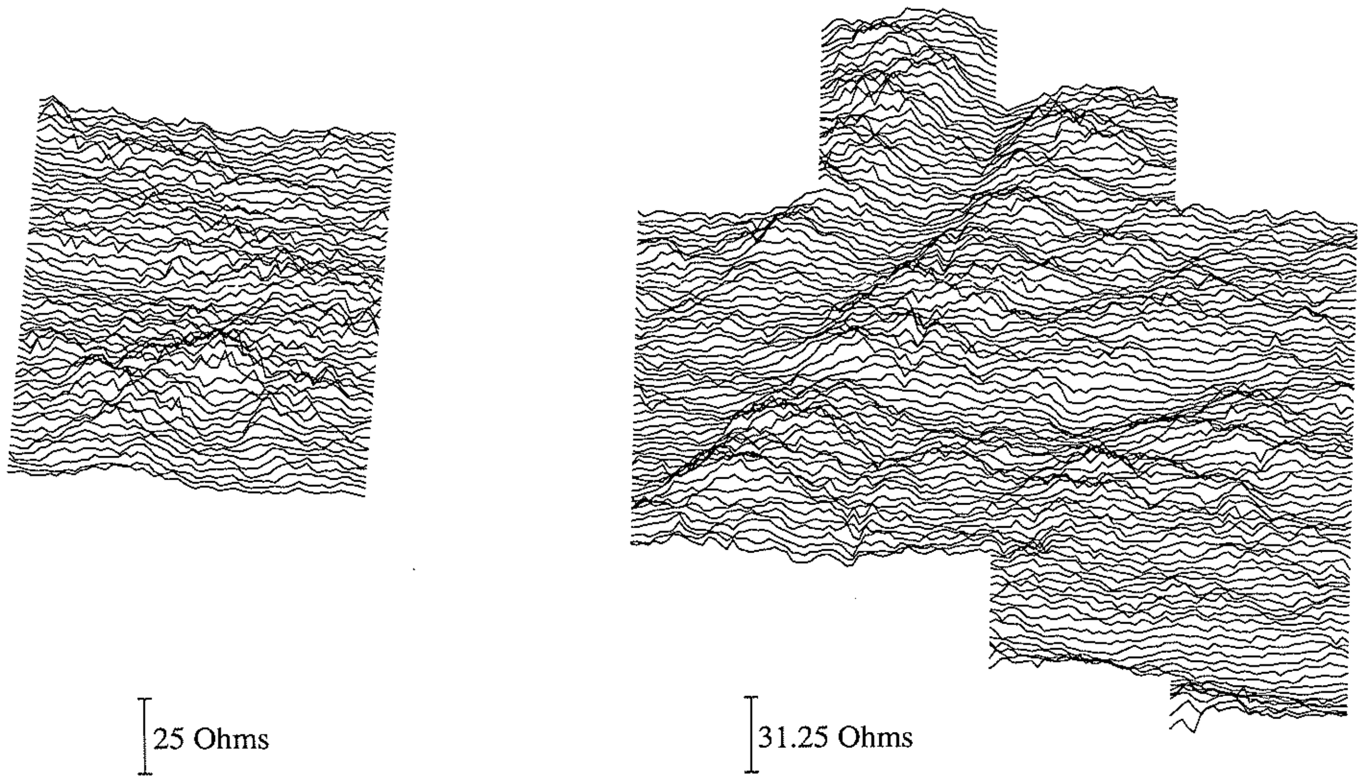
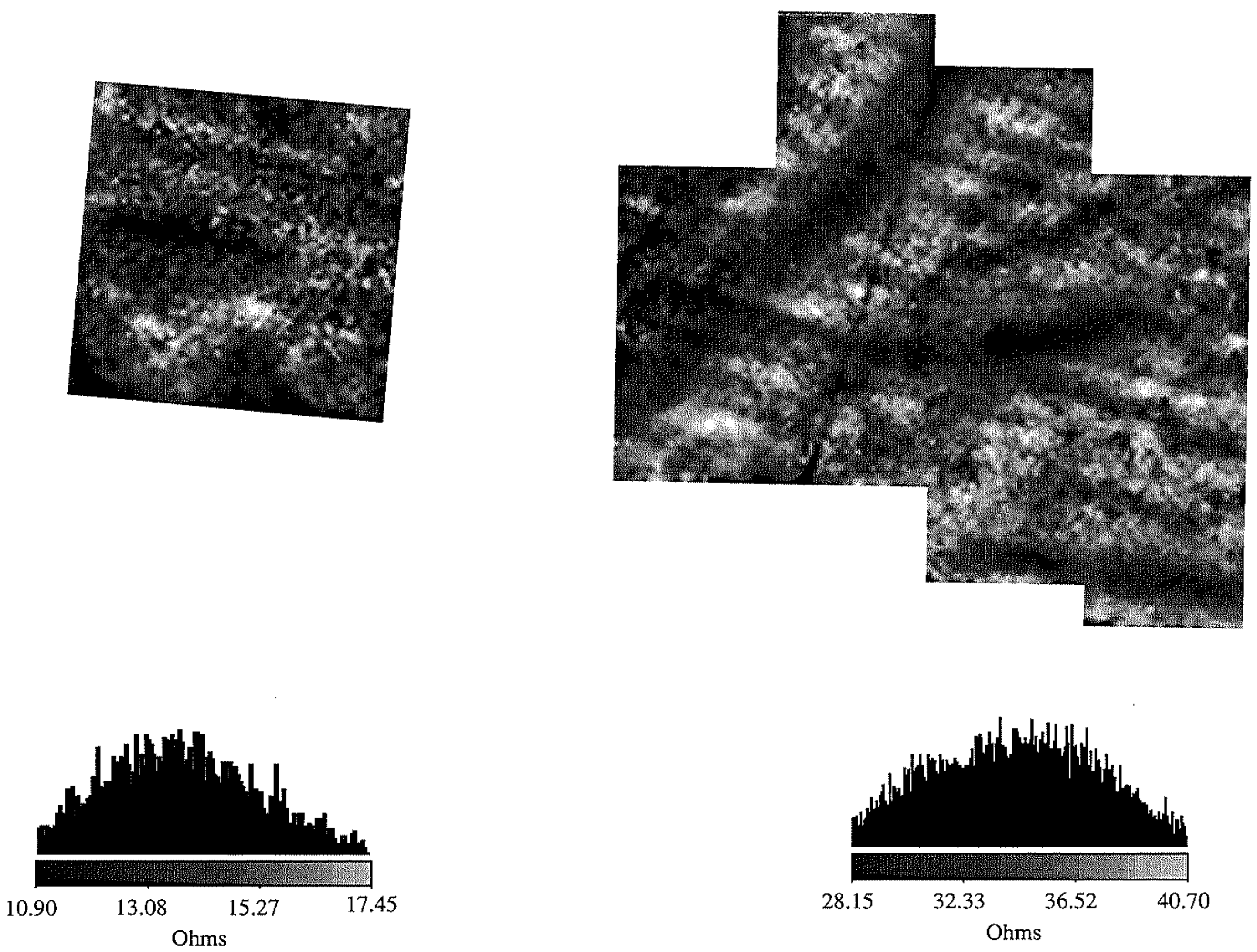
Figure 3: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, February 1998

a) Traceplot of raw resistivity data



b) Greyscale plot of Wallis filtered resistivity data



N ←

0 30 60 90m

Figure 4: TEWITFIELD, N. LANCASHIRE
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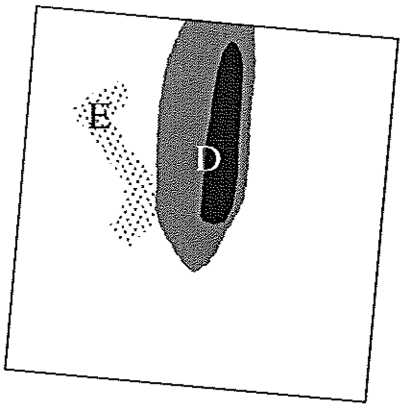
Interpretation of resistivity data
also showing positions of main metal detector finds



A Main anomaly of interest, showing circular area of lowest values

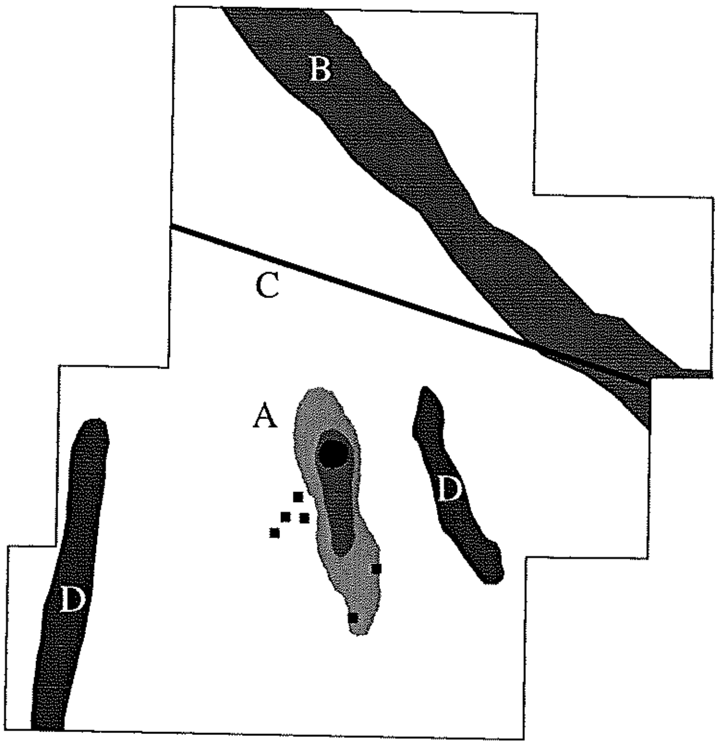
B Linear low resistance anomaly, assumed to be natural channel

C Old field boundary

D Linear low resistance anomalies of similar proportions to 'A'. Assumed to be natural

E Angular high resistance anomaly

▪ Locations of main metal detector finds



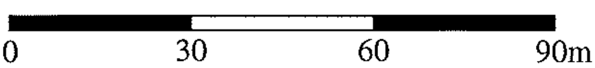


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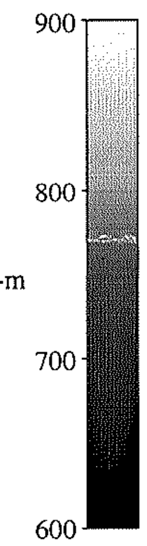
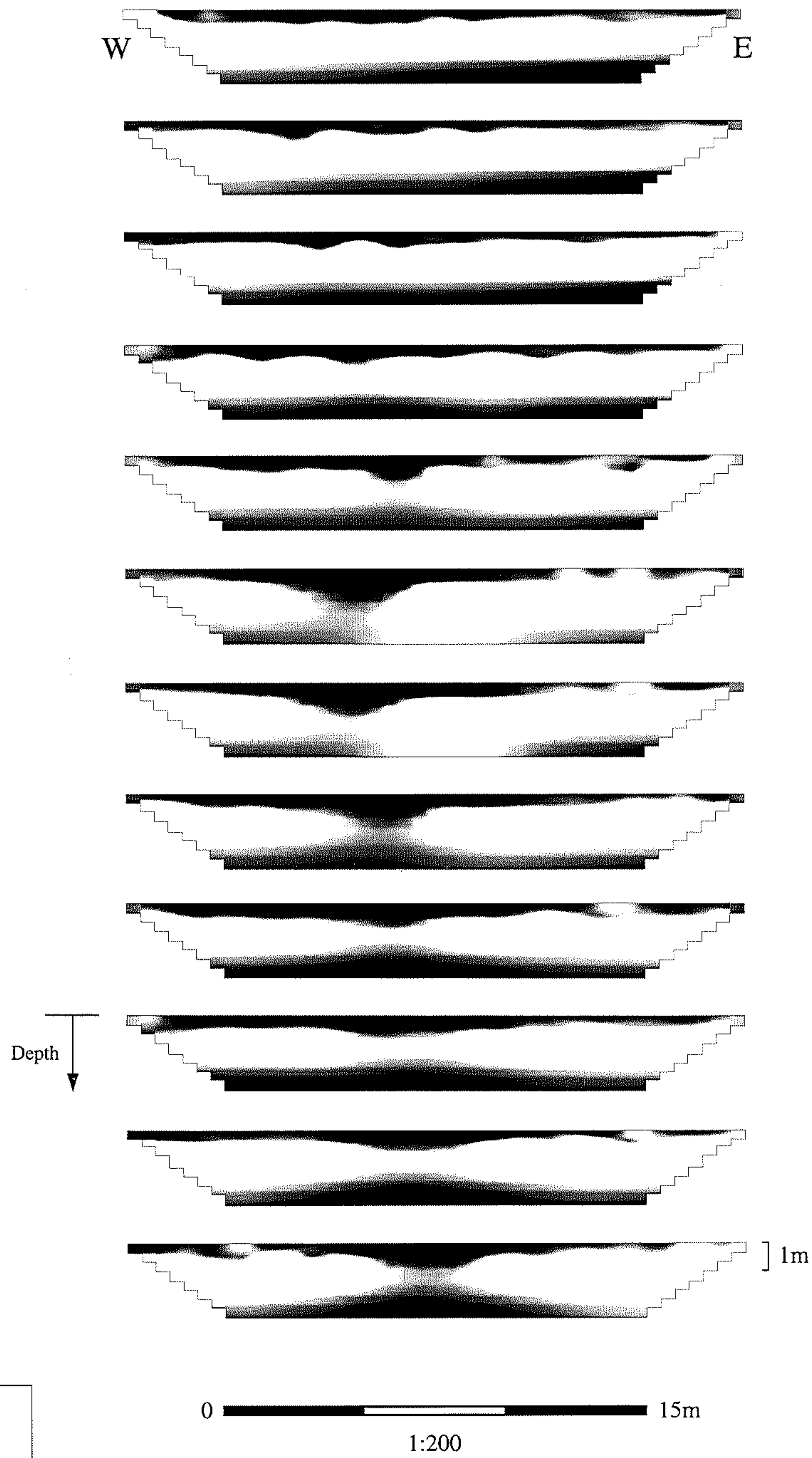
Figure 5: TEWITFIELD, N. LANCASHIRE   Geophysical Survey, March 1998

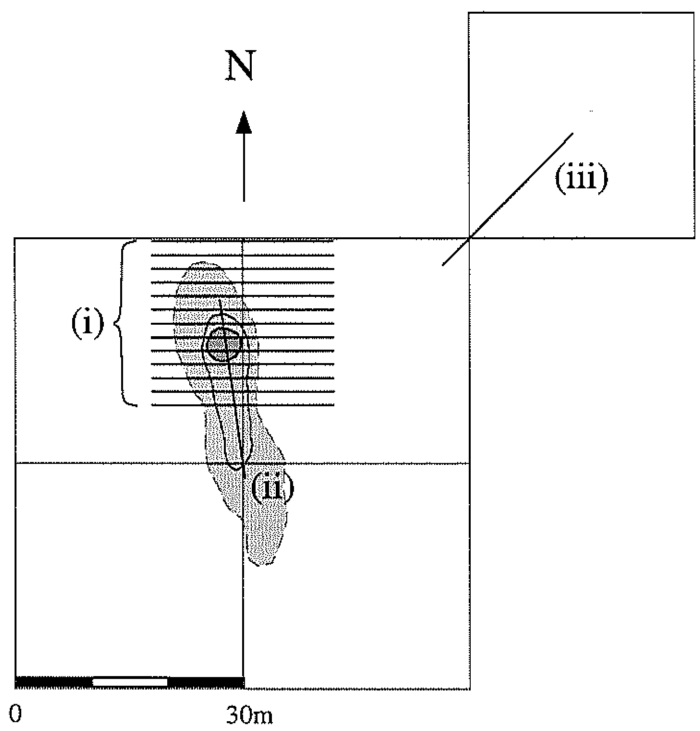




a) **The cross-sectional profiles through anomaly A.**

Profile separation is 2m, the most northerly at the top of the page.

See diagram below for plan view of relative positions.



b) **Plan view of profile locations**

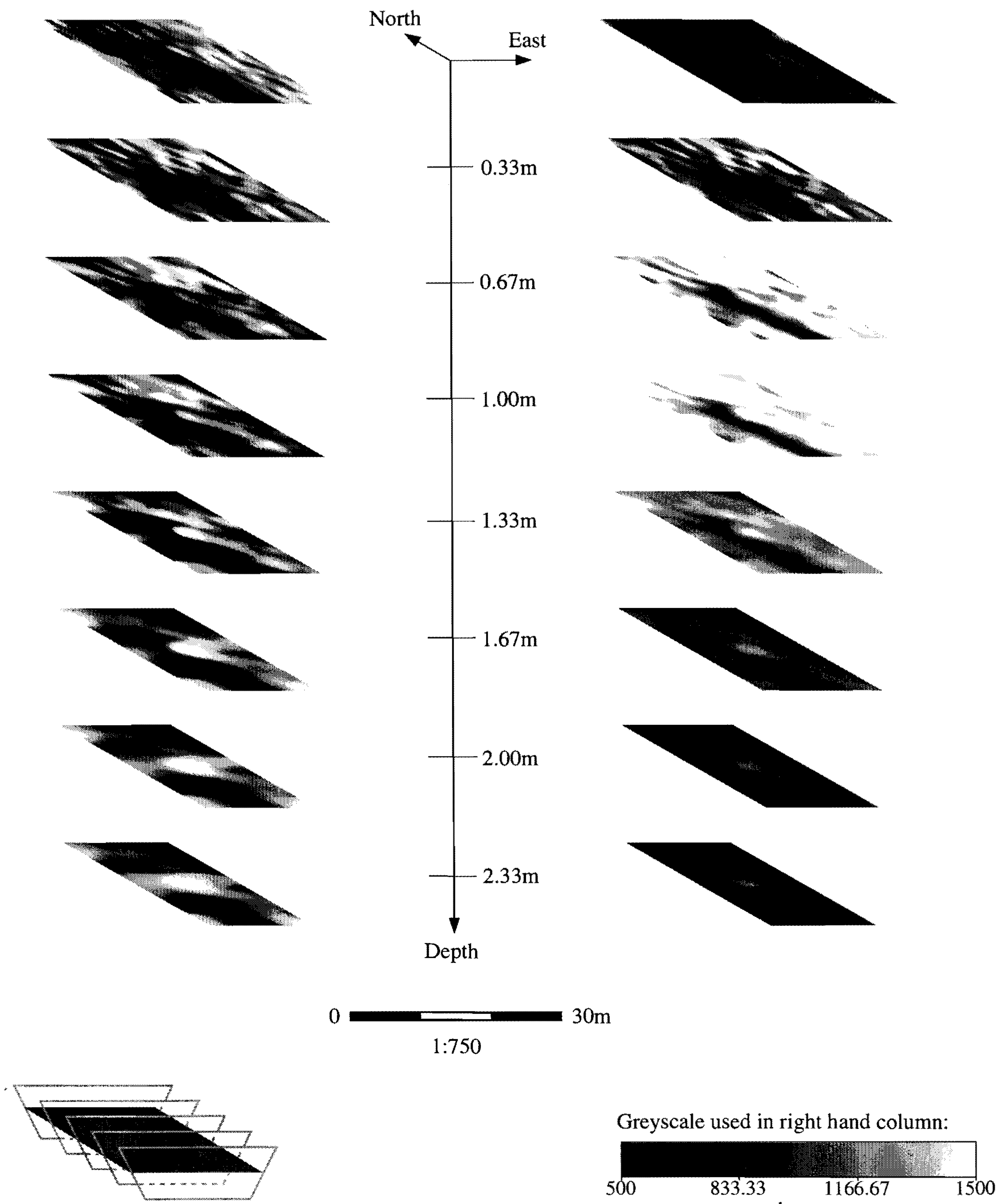
(i) Group of profiles over anomaly 'A' Separated by 2m.

(ii) Longitudinal profile over anomaly 'A' (displayed in Figure 6kjhdgiugt)

(iii) Profile position across with of assumed natural channel (displayed in Figure 6kdjhv)

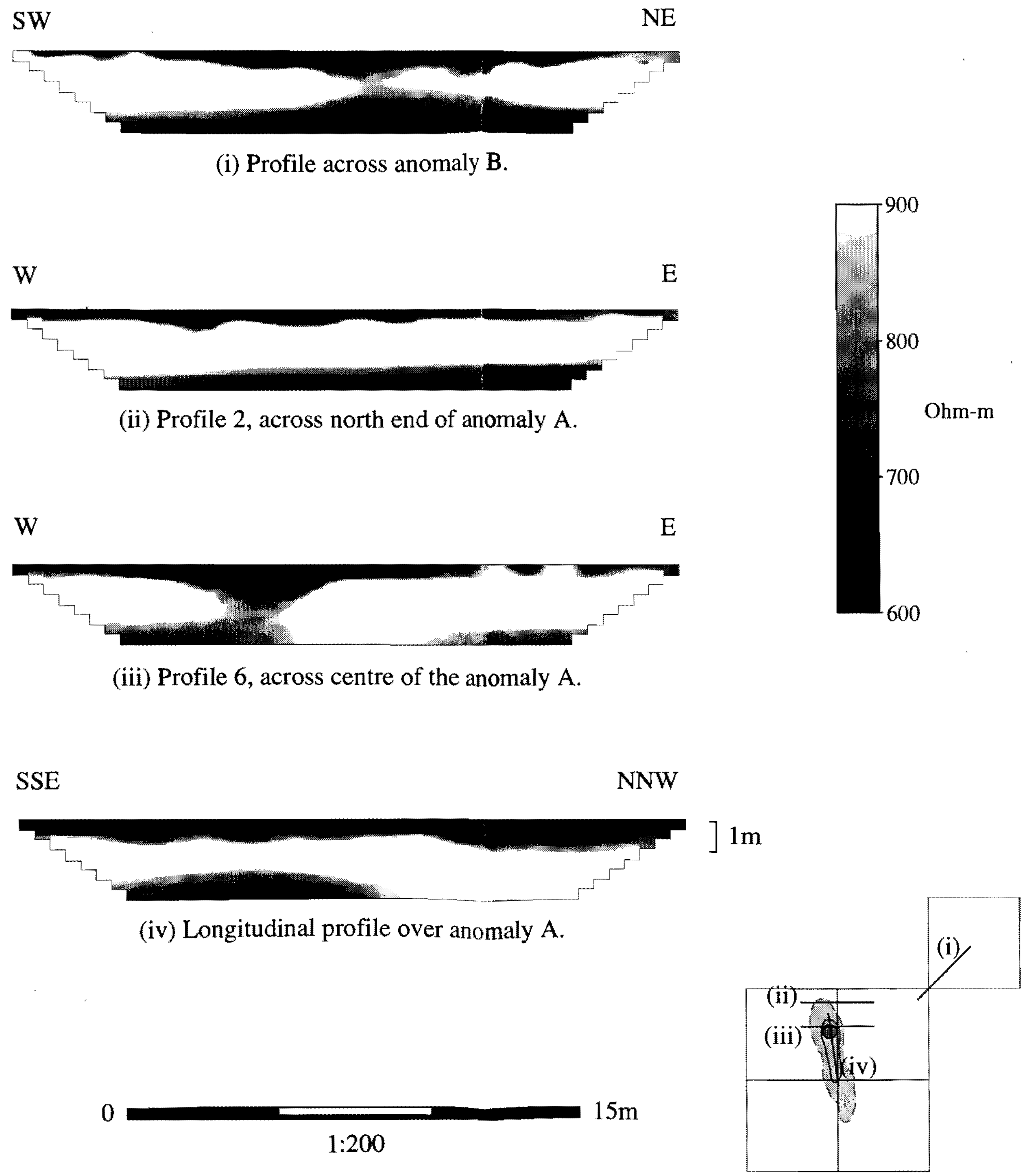
Figure 6: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, March 1998

a) Isometric greyscale plots of horizontal depth slices derived from stacked profiles over anomaly A;
(i) each slice plotted independently with an equal area greyscale
(ii) all slices plotted with the same linear greyscale.



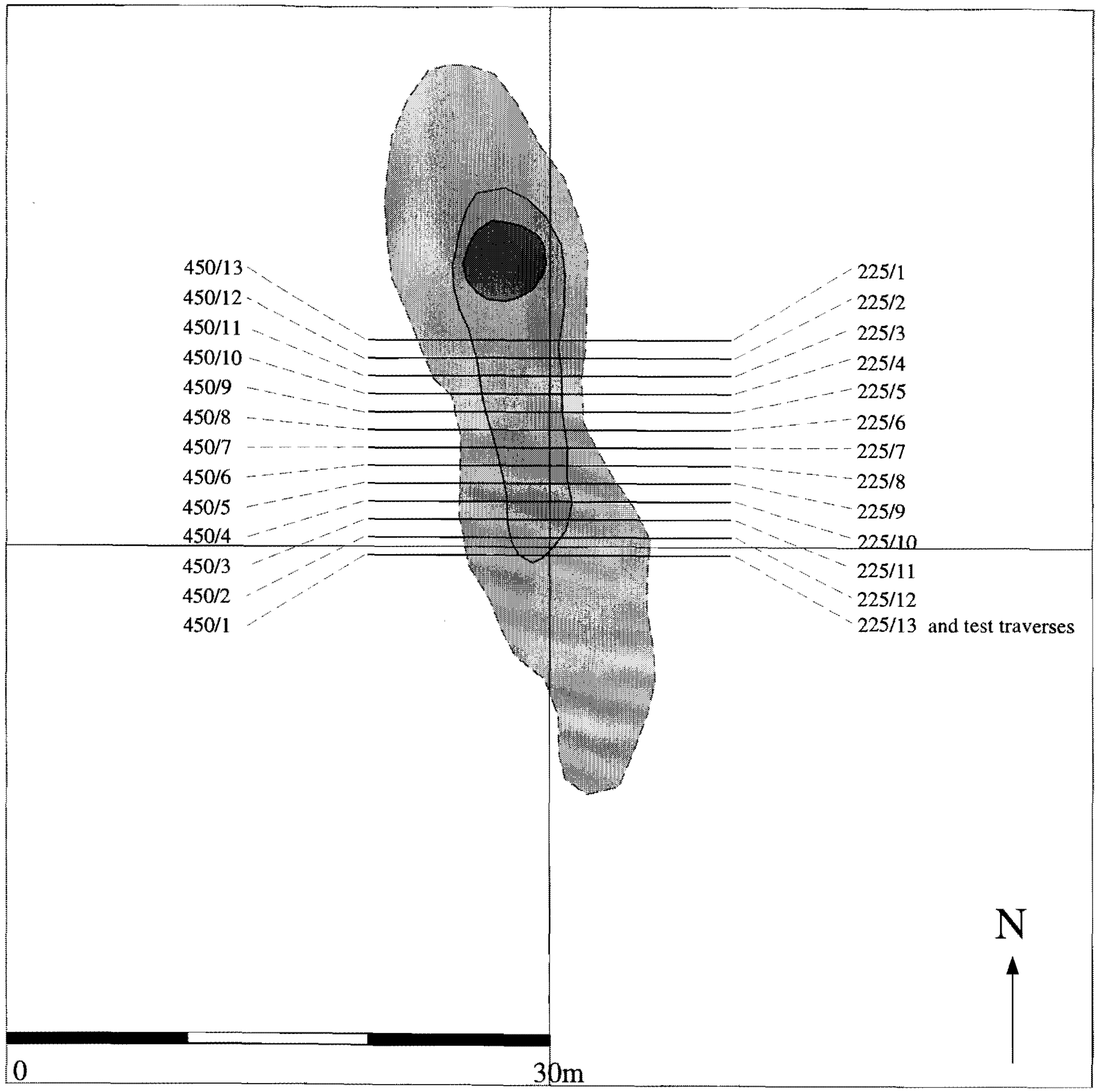
An horizontal slice through stacked profiles.

b) Comparison of possible palaeochannel feature, anomaly B, with selected profiles across anomaly A. Note differing orientations of each.



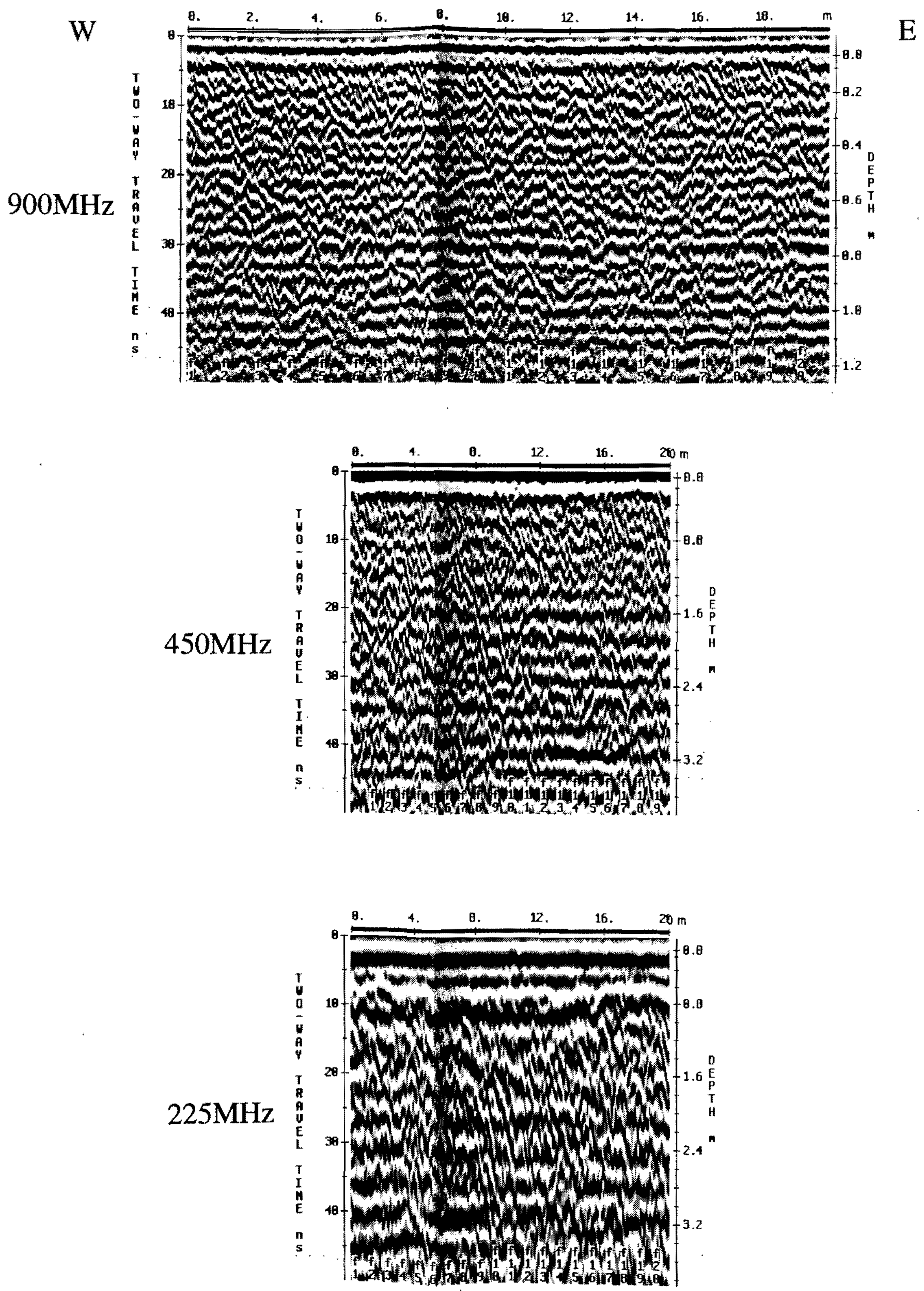
AMLab 1998

Figure 7: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, March 1998



a) Detail of GPR traverse positions over anomaly 'A'

All traverses performed W→E.
Traverse label convention, eg. 450/5: 450 = 450Hz signal frequency
5 = traverse number



b) Test traverse sections.
Note varying horizontal scales

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Figure 8: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, March 1998

GPR time slices over Anomaly A

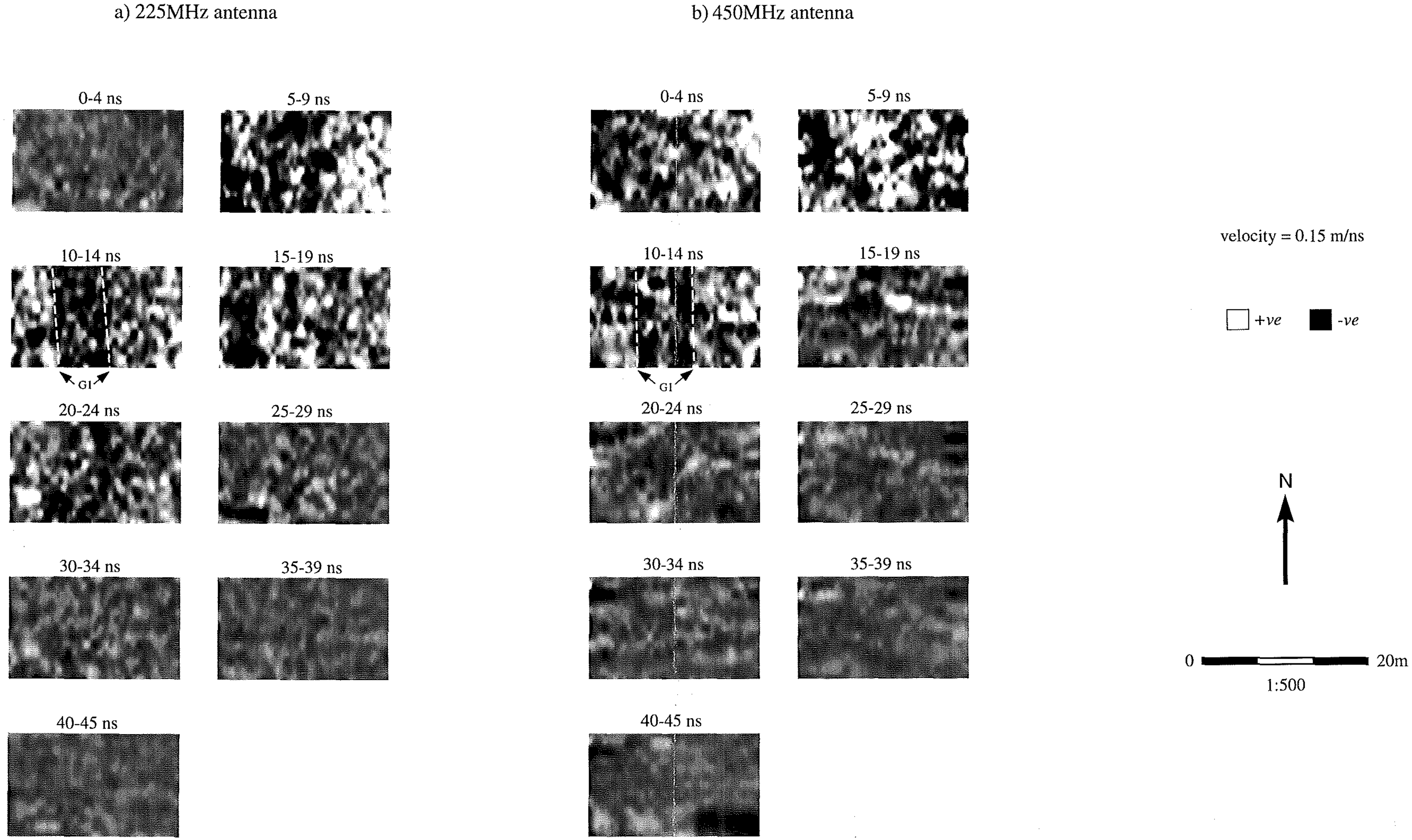
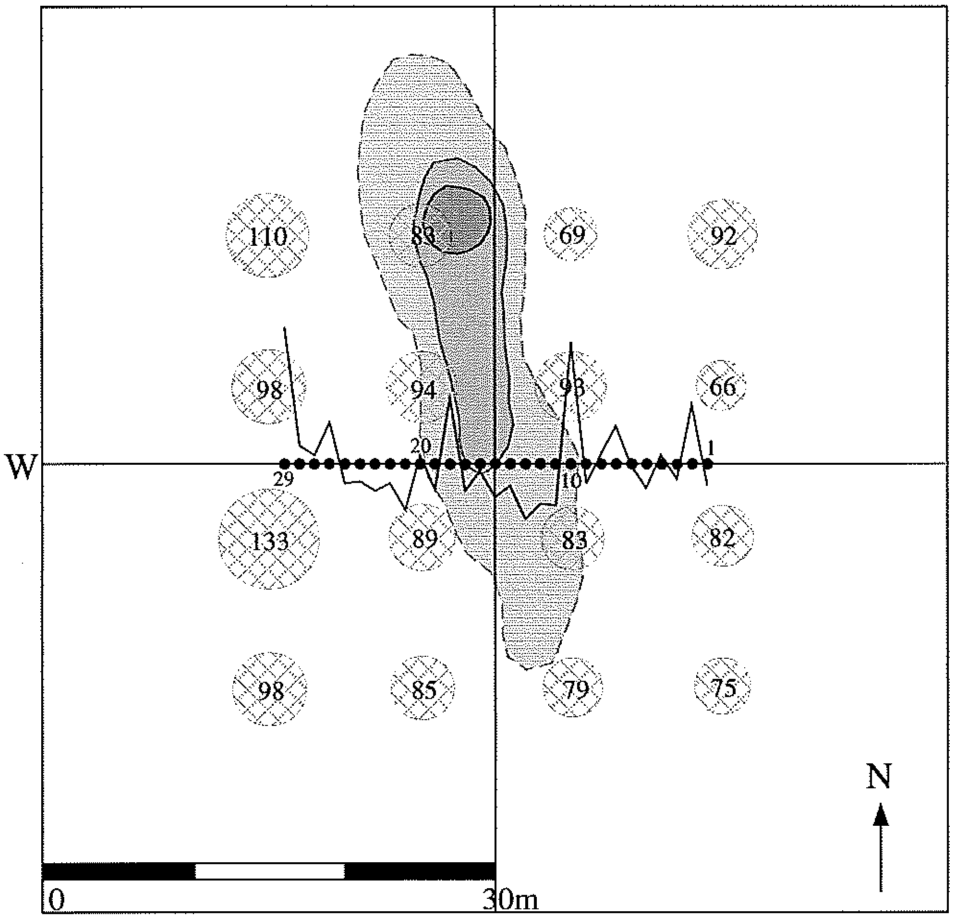


Figure 9: TEWITFIELD, N. LANCASHIRE
Geophysical Survey, February 1998



a) Diagram showing relative mass specific MS values and sample locations over the anomalous area 'A'. Values within circles represent MS $x10^{-8}m^3/kg$. Numbers shown under the E-W line refer to sample numbers in the Table below.

Sample No.	MS value	Sample No.	MS value	Sample No.	MS value
1	84	11	75	21	73
2	121	12	76	22	85
3	87	13	69	23	82
4	98	14	84	24	86
5	83	15	79	25	85
6	93	16	91	26	113
7	111	17	82	27	98
8	99	18	124	28	102
9	85	19	82	29	156
10	149	20	98		

b) Mass specific MS values of soil samples taken along the E-W line shown in Figure 9a above. All values $x10^{-8}m^3/kg$.

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. 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.

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.

Annex 2: Interim report on trial excavation at Tewitfield

Lancaster University Archaeological Unit

4. INTERIM REPORT

4.1 INTRODUCTION

4.1.1 Summary results of the evaluation trenching are presented below.

4.2 TRENCH 1

4.2.1 Trench 1 was positioned in order to investigate the northern terminus of the elliptical geophysical survey anomaly. The trench measured *c* 6.60m x 1.60m wide, and was excavated to a maximum depth of 1.42m. It was aligned north /south.

4.2.2 A depth of *c*0.24m of dark greyish brown clay silt topsoil [104] was removed by machine. A single cut feature [109] was identified, which was roughly semi-circular in plan but extended beyond the western limit of excavation, and appeared to be a pit. It measured 1.09m x >0.79m x >1.12m deep, with near vertical sides and a sharp upper break of slope.

4.2.3 The upper fill [105] was a hard deposit of light grey sand and gravel (*c*0.50m deep) which may have been deposited as a capping of hardcore. Below, a grey silt fill was excavated [106] containing two sherds of modern pottery and a sherd of modern glass. It sealed a fill of yellowish brown clay silt [120], which was probably a backfill of redeposited geological clay. Two timber posts of rectangular cross section were also recorded within the cut [107] and [108]. Post [108] was centrally located within the excavated portion of the feature; it measured 0.14m x >0.06m x >0.92m long, and appeared to have been deposited before any of the recorded fills. It was not quite vertically positioned, lying at an angle of *c*1 in 12 (x in y). Post [107] lay on the southern edge of the cut, and measured 0.12m x 0.08m x 0.30m deep. It had been deposited before [105] but had no relationship with the other fills. The upper ends of both posts had been sawn off square, possibly before they were deposited.

4.2.4 Cut [109] truncated a layer of dark yellowish brown silty sand containing *c*20% small, medium and large rounded and sub-angular pebbles [110]. This deposit appeared to be of natural origin, but machine excavation was continued to a maximum depth of 1.42m to confirm its origin. Deposit [110] was found to be a maximum of 0.34m thick., which sealed a deposit of mid yellowish brown clayey silt with 5-10% small and medium sub-rounded pebbles [102]. Deposit [102] was present over the full extent of the trench, but became less thick from south to north, varying in depth from 0.44m to 0.23m. Below this was a deposit of gravel which was > 0.72 m thick [103]. This was only partially excavated, and was present from a depth of *c* 0.8 -0.9m to the base of the trench. The coarse component consisted of *c*60% small and medium sub-rounded pebbles, but the deposit became cleaner and looser with depth, with coarse sand gradually replacing fine silty sand as the predominant fine component. No archaeological finds or features were recorded within deposits [110], [102], or [103] and all are thought to be of natural origin (*Section 4.1.8*).

4.3 TRENCH 2

4.3.1 Trench 2 was positioned to examine the eastern side of the elliptical geophysical survey anomaly, at a point roughly midway along its length. It was aligned east / west, and measured *c*7.60m long x 1.60m wide. It was excavated to a maximum depth of 1.30m.

4.3.2 A depth of *c* 0.22m of topsoil [100] was removed by machine. Following cleaning no archaeological features were identified, and the machine was used again to excavate stratigraphically to the full depth of the trench. All the deposits removed would appear to have been formed by natural processes rather than human activity.

4.3.3 Deposit [101] lay immediately below the topsoil. It consisted of dark yellowish brown silty sand with *c*20% small, medium, and large sub-rounded pebbles, and was *c*0.18m deep. It appeared to have formed at the interface between the topsoil and the underlying strata, probably resulting from mixing of the topsoil and lower deposits. Its upper and lower interfaces were relatively diffuse.

4.3.4 A deposit of mid yellowish brown clayey silt with 5-10% small and medium sub-rounded pebbles [102] was recorded stratigraphically below [101]. This was essentially the same as the clayey silt deposit recorded in Trench 1, and the two were assigned the same context number. Within Trench 2, deposit [102] was a maximum of 0.48m thick, and was present over roughly the western half of the trench, lensing out to the east. The eastern edge of the deposit lay *c* 0.37m beyond the eastern edge of the elliptical geophysical survey anomaly, suggesting that the geophysical response might be related to the presence of the deposit. The deposit was clean, homogeneous, and well sorted, and was thought to be of natural origin and perhaps water-laid.

4.3.5 Deposit [102] was stratified above a layer of slightly clayey sand with *c* 20% small and medium sub-rounded pebbles [111] which was present predominantly towards the eastern end of the trench. Deposit [111] was *c*0.30m thick, and again appeared to be of natural origin.

4.3.6 Deposits [102] and [111] were both above a deposit of gravel [103] which extended across the whole of Trench 2, and was also recorded in Trenches 1, 3, and 4. Within Trench 2, the upper surface of the gravel [103] lay at a depth of *c*0.7m below the surface. The same deposit extended down to the limit of excavation at the base of the trench, at a maximum depth of 1.30m. The coarse component consisted of *c*60% of small and medium sub-rounded pebbles, but the surrounding matrix changed gradually with depth, from silty sand at the top of the deposit, to coarse sand and grit lower down. The lower part of the deposit was very free-draining. Deposit [103] covered the entire base of the trench, and contained no features or other deposits present; its appearance was entirely consistent with an origin as a naturally deposited layer of gravel.

4.4 TRENCH 3

4.4.1 Trench 3 was positioned to investigate the southern terminus of the elliptical geophysical survey anomaly. The trench measured *c*7.72m x 1.60m, and was excavated to a maximum depth of 1.18m. It was aligned north /south.

4.4.2 A depth of *c*0.25m of dark greyish brown clay silt topsoil [104] was removed by machine. Below this was the yellowish brown clayey silt deposit [102] which was also present in Trenches 1, 2, and 4. It extended over the whole trench, and no archaeological features or finds were present. The trench was then excavated stratigraphically by machine to its full depth.

4.4.3 Deposit [102] was found to extend to a maximum depth of *c* 0.50m at the northern end of the Trench. Its thickness decreased gradually towards the south, where it was a minimum of 0.34 thick. Below this was gravel layer [103] which was present from from a depth of *c*0.70m to the maximum depth of the trench. It covered the entire base of the trench, and no archaeological features were observed within it.

4.5 TRENCH 4

4.5.1 Trench 2 was positioned to examine the western side of the elliptical geophysical survey anomaly, at a point roughly midway along its length. It was aligned east/west, and measured *c*7.37m x 1.60m. It was excavated to a maximum depth of 1.20m.

4.5.2 A depth of *c*0.25m of topsoil [112] was removed by machine. No archaeological features were identified, and the machine was used again to excavate stratigraphically to the full depth of the trench. Deposits [101], [102], and [103] were again present (*Section 4.3*). Deposit [101] was *c*0.20m thick, and extended across the entire trench. Mid yellowish brown clayey silt deposit [102] was a maximum of 0.46m thick at the east end of the trench, and lensed out completely *c*1.7m from the western end. A gravel deposit [103] lay below, extending across the whole base of the trench. Again, these deposits appeared to be of natural rather than man-made origin, and no archaeological finds or features were identified. The western limit of deposit [102] lay *c*1.6m to the west of the edge of the elliptical geophysical survey anomaly.

4.6 TRENCH 5

4.6.1 Trench 5 was positioned to cross a negative geophysical anomaly thought probably to derive from natural variation in the drift geology. The trench measured *c*16.35m x 1.6m, and was excavated to a maximum depth of 0.43m. It was aligned roughly east/west.

4.6.2 A typical *c*0.27m depth of topsoil was removed by machine and below this was a deposit of dark yellowish brown silty sand and gravel [117]. This deposit [117] was found below the topsoil in each of Trenches 5-13, albeit with some variation in gravel content, and was also closely comparable with deposit [110] in Trench 1 and deposit [101] in Trenches 2 and 4. Within Trench 5 the deposit contained up to 70% small and medium rounded pebbles. No archaeological features or finds were identified, and the appearance of the deposit suggested that it represented the upper stratum of the naturally deposited gravels which has ben subject to limited mixing with the topsoil.

measured *c*17m x 10m x 0.15m deep. It was positioned to cover the area of the western cluster of Viking silver find spots.

4.15.2 Trench 14 was not intended as an excavation trench, and was not cleaned down to the surface of the underlying gravel deposits. Instead it was intensively scanned by metal detectors. A number of iron and other base metal objects were recovered and plotted in three dimensions. However, no silver objects were located, and no indication was gained as to the origin of the silver finds originally recovered from the field.

4.16 TRENCH 15

4.16.1 Trench 15 was a second open area partially stripped of topsoil, and was located to the east of Trench 3, in the area of the south-eastern cluster of Viking silver find spots. It measured *c* 10.75m x 10m x 0.15m deep.

4.16.2 Again, the area was not cleaned to the surface of the underlying gravels, but was subject to intensive metal detecting. Further iron and other base metal objects were recovered, but once more there was no further evidence relating to the origin of the Viking silver finds.

4.17 FINDS REPORT

4.17.1 A small number of objects were recovered during the clearance of the site, and by controlled use of metal-detecting equipment. The majority were relatively small iron nails, which, were for the most part of square section, suggesting that they were hand-forged. Their size makes it unlikely that they were used in any substantial structure of timber, including a boat. Other iron objects included a medieval or post-medieval horse-shoe.

4.17.2 One small copper alloy tack, and a copper alloy fitting resembling a furniture drawer knob, were recovered. Both are likely to be late in date, as are the two fragments of lead (one a stamped tag) and two ?lead-filled button caps. A small amount of glass and pottery was also recovered. None of the fragments were earlier than the late eighteenth century.

4.17.3 It would appear that the material recovered from these excavations was in no way associated with the hoard of silver reported from the site.

4.18 DISCUSSION

4.18.1 ***Deposits in the area of the elliptical geophysical anomaly (Trenches 1-4):*** the eastern and western edges of the main elliptical geophysical anomaly corresponded closely with the edges of a deposit of yellowish brown clay silt lying within a depression in the underlying gravel. To the east, the clay silt extended *c*0.37m beyond the position of the anomaly; and to the west it extended beyond by *c*1.6m. To the north and south, the clay silt deposit did not end within Trenches 1 and 3, but did decrease in depth away from the position of the anomaly. Overall the clay silt deposit proved to be *c*8.4m wide x 14.0m long, extending from *c* 0.30m below the ground surface to a maximum depth of *c* 0.90m.

4.18.2 This deposit of clay silt was clearly of natural rather than man-made origin. It was a clean, homogeneous and unmixed deposit recorded as being well sorted. It contrasted strongly with the underlying gravel, suggesting that it had been deposited over the gravel by a powerful natural process; it certainly could not be regarded as the backfill of any cut through the gravel. The deposit was aligned roughly parallel with the direction of slope of a gentle hill centred *c*1km to the north, and was probably the fill of a periglacial channel, cut into the gravel by water action at the end of the last glaciation.

4.18.3 The gravel underlying this feature was exposed in each of Trenches 1-4. The matrix surrounding the sub-rounded pebbles became progressively coarser with increased depth, from silty sand to coarse sand and grit, and this appeared to confirm that the gravel here had been deposited naturally. There was no indication of any cut or other feature within the exposed gravel.

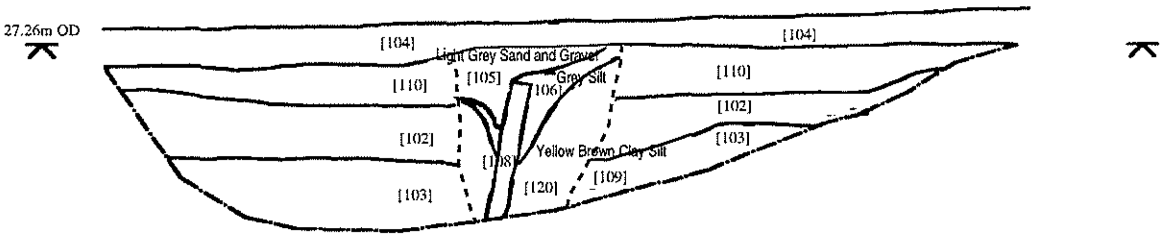
4.18.4 If it is accepted that both the yellowish brown clayey silt and gravel were naturally laid deposits, deriving from at least the last glaciation, it follows that any geophysical anomaly at a greater depth cannot have an archaeological derivation. It is impossible that any cut through these deposits has gone undetected, because disturbance would have been particularly visible in section at the sharp interface between the yellowish brown clay silt, and darker, coarser gravels.

4.18.5 In the absence of other features, it is highly probable that the deposit of clayey silt [102] was responsible for the elliptical geophysical survey anomaly. As noted above, the eastern and western edges of the anomaly and the deposit correspond relatively closely, while the deposit had a maximum depth of *c*0.90m compared with the suggested maximum depth for the anomaly of 1.2-1.5m. The anomaly was detected as an area of low resistance, and it can be suggested that the difference between the water holding properties of the clay silt and the extremely free draining gravels immediately below may be responsible for the resistivity survey results. It can also be noted that, when Ground Probing Radar profiles across the anomaly and across the supposed natural palaeochannel crossed by Trenches 6 and 10 are compared, there appears to be little difference between the response at the centre of the anomaly and that generated by the palaeochannel.

4.18.6 The resistivity data also suggested the presence of a possible high resistance anomaly below the elliptical anomaly, and thus at a considerable depth. The evaluation demonstrates that any such response must have been generated from deep within the naturally laid gravels, and cannot be considered to be of archaeological significance. The resistivity survey also highlighted the presence of a small circular area of particularly low resistance towards the northern end of the elliptical anomaly. This might at first appear to have been generated by the modern cut feature [109] which was partly revealed within Trench 1. However, cut [109] appears to be located *c*4m too far north to account for this phenomenon, as well as being probably of insufficient size. In summary, the main elliptical anomaly and the underlying high resistance anomaly can both confidently be attributed to variations within naturally laid deposits; the area of particularly low resistance remains unexplained, but as it was roughly central to the larger ellipse, it is probable that this, also, was not generated by human activity.

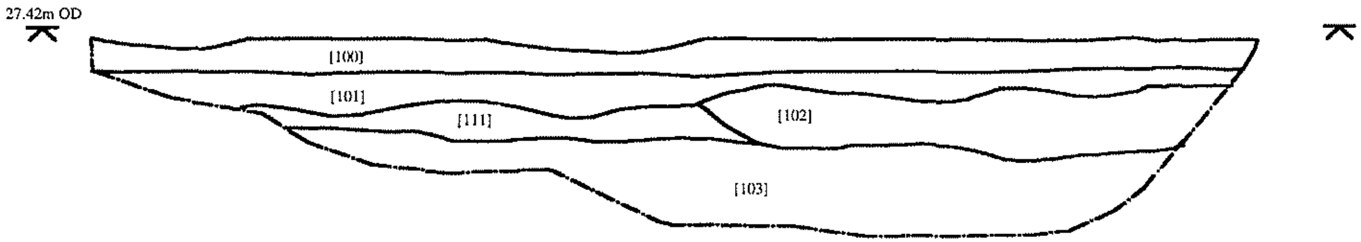
TRENCH 1

SOUTH — EAST FACING SECTION — NORTH



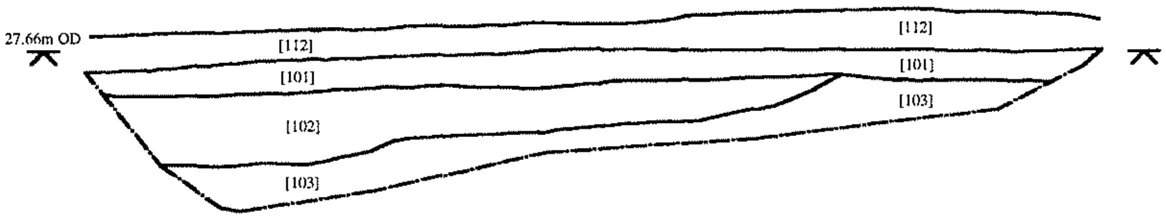
TRENCH 2

EAST — NORTH FACING SECTION — WEST



TRENCH 4

EAST — NORTH FACING SECTION — WEST



LANCASTER UNIVERSITY ARCHAEOLOGICAL UNIT

STOREY INSTITUTE
MEETING HOUSE LANE
LANCASTER
LA1 1TF

TEL: 01524 848666

PROJECT:

TEWITFIELD VIKING TREASURE FIND SITE

DRAWING No:

SCALE

0 1m

DRAWN BY: A.P.

DATE: October 1998

LOCATION:

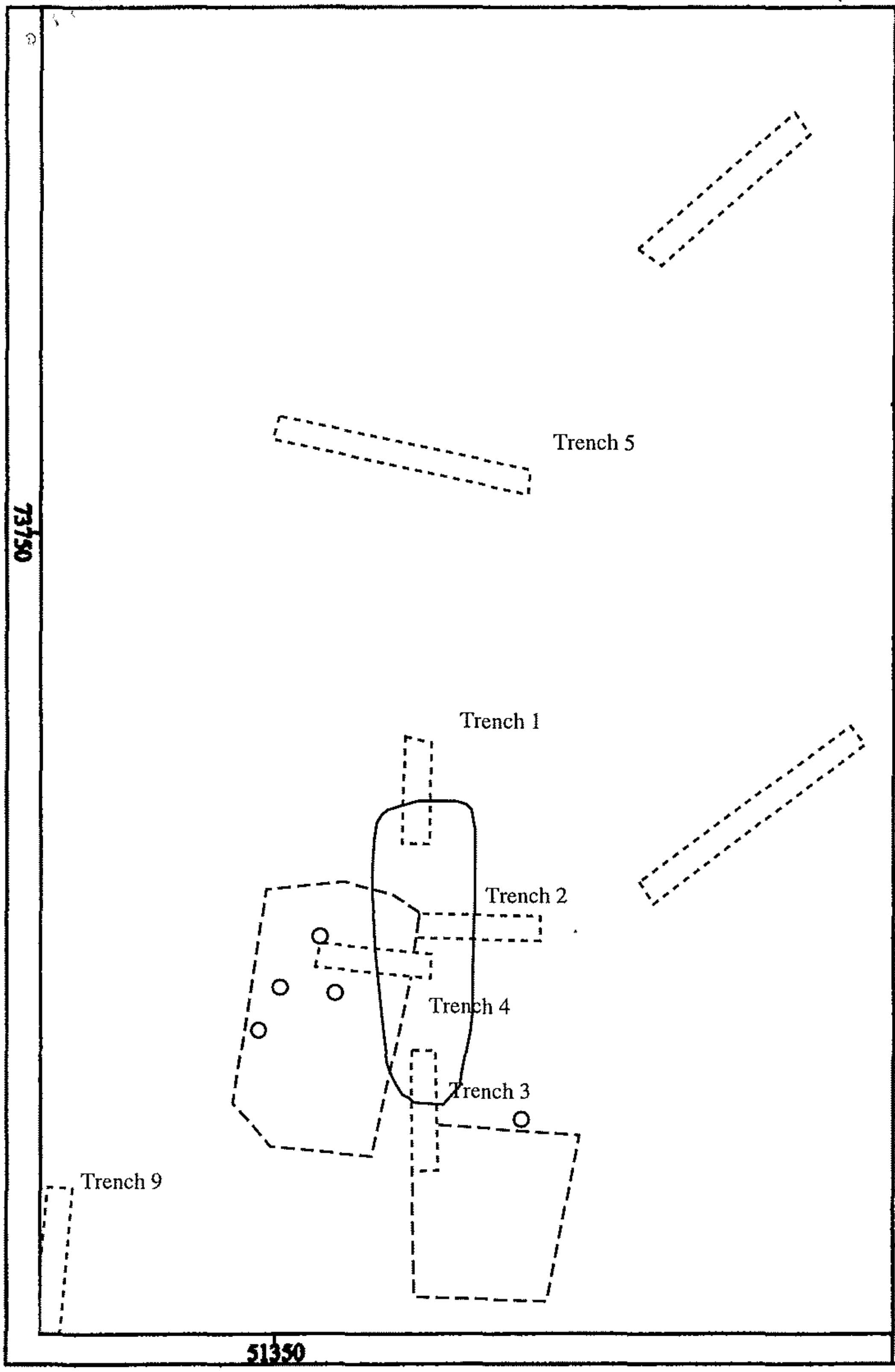
N

KEY

[110]	Context Number
- - - -	Unclear Edge
—·—·—	Limit of Excavation

TITLE: TRENCH SECTIONS

COMMISSIONED BY: ENGLISH HERITAGE



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TEL: 01524 848666

PROJECT:

TEWITFIELD VIKING TREASURE FIND SITE

DRAWING No:

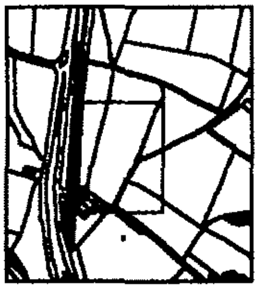
SCALE

0 10m

DRAWN BY: A.P.

DATE: October 1998

LOCATION:



N

KEY

Topsoil Removal

Silver Find

Oval Anomaly

Actual Trench Locations

TITLE:

TRENCH LOCATIONS

COMMISSIONED BY:

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