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Ancient Monuments Laboratory
Report 59/95

REPORT ON GEOPHYSICAL SURVEY, 1995 HINXTON QUARRY, HINXTON, CAMBS.

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Summary

During an excavation at Hinxton quarry, undertaken by the Cambridge Archaeological Unit prior to borrow pitting for gravel extraction, an Iron Age cemetery containing eight cremation burials was discovered, near the south eastern edge of the excavated area. The Ancient Monuments Laboratory was asked to carry out a geophysical survey in farmland adjacent to the excavation to determine whether the cemetery continued into the neighbouring field. Unfortunately, conditions at the site were not particularly favourable for the detection of the subtle anomalies usually produced by these types of remains and it was not possible to conclusively deduce whether or not the cemetery continued into the surveyed field. Nevertheless, a number of pit-like anomalies were detected in another part of the field which exhibited properties characteristic of deliberate burning.

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HINXTON QUARRY, Hinxton, Cambridgeshire.

Report on geophysical survey, 1995

Introduction

An excavation of the Mid Field Arm at Hinxton quarry was undertaken by the Cambridge Archaeological Unit prior to borrow pitting for gravel extraction. The work took place between the 18th September and the 14th October 1994, and investigated an area of 60 by 110 metres. Near the south eastern edge of this area eight cremation burials were discovered, five of which were centrally placed within ring ditches (Alexander 1994). Pottery from the cremations provisionally dates them to the period between 50 and 10 BC.

The cemetery area appeared to continue beneath the trackway which bounded the eastern edge of the excavation, separating the quarry area from farmland.The Ancient Monuments Laboratory was asked to carry out a geophysical survey on the farmland to the east to try and gauge the extent of the cemetery and identify any formal boundary that may have existed.

The underlying solid geology in the Hinxton region is Upper Cretaceous Middle Chalk but in the excavated area this was covered by the 'lowest' and intermediate gravel terraces of the River Cam (or Granta). These terraces extend eastwards into the field where the geophysical survey (centred on TL 489 465) took place, where they peter out to leave chalk as the immediate substrate. Unfortunately, past experience suggests that river gravel is not necessarily a particularly favourable subsurface for geophysical prospecting of archaeological targets, as it can produce a widely variable background both electrically and magnetically, which often swamps the response from subtle archaeological features. Furthermore, there is the possibility that alluvial deposits are present in parts of the survey area.

Method

An area of approximately 3 hectares was marked out for geophysical survey, abutting the western edge of the field immediately to the east of the archaeological excavation. Figure 1 depicts this area which was divided up into a grid of 30 metre squares, located by measurement to the field boundaries; four such measurements are shown. If the cemetery described above does extend into the surveyed field then it is estimated from the excavation plans that it should project into one or more of the squares numbered 5, 9 or 12 in this figure. A magnetometer survey was conducted over all the numbered squares using the standard method outlined in note 2 of Annex 1.

The two shaded squares, numbered 9 and 12, where remains of the cemetery were thought most likely to be found, were also surveyed using the resistivity technique outlined in Annex 1, note 1; time constraints unfortunately precluding any greater coverage. Also the entire survey area, including the unnumbered squares, was surveyed with a Bartington MS1 magnetic susceptibility meter and field measurement loop, readings were taken on a 10 metre grid to produce a volume specific topsoil magnetic susceptibility map.

Finally, an auger hole was sunk over one of the anomalies identified in the magnetometer survey to try and establish the nature of the material causing it. Bagged samples of soil were taken from the hole after every 20cm of coring for subsequent laboratory measurement. In the laboratory five 10cc sub-samples were extracted from each bag and the mass specific magnetic susceptibility of these, χ, was measured using a Bartington MS2 meter and 10cc bench sensor. The median of the five sub-sample measurements for each bag was chosen as a representative determination of its magnetic susceptibility. The sub-samples were then remeasured using the susceptibility meter's high frequency setting; representative determinations for the high frequency susceptibility of each bag being determined via the same method as before. These high frequency measurements were combined with the first set to estimate the frequency dependence of magnetic susceptibility, χ_{FD}, for each bag.

Results

The Magnetometer Survey

The results of the magnetometer survey are plotted at 1:1000 scale in Plan A. In this plan, A.1 shows a stacked trace plot of the data, the only correction to the raw measured values being to remove 'striping' between adjacent traverses. A.2 shows a greytone plot of the same survey after some digital enhancement to remove the detrimental effects produced by soil noise and surface iron objects. The enhancement employed was to 'despike' the data by filtering with a 3m by 3m thresholding median filter, then to slightly smooth it by low pass convolution with a 0.5m radius gaussian mask.

It is immediately apparent from the trace plot of the raw data that the magnetic response is extremely quiet; the standard deviation of the raw data values is only 1.2nT and, once the statistical distortion caused by surface iron spikes is removed, this drops to 0.57nT. Indeed in the raw data 95% of all the measurements lie between $\pm$1nT. Low dynamic range can be a feature of magnetometer surveys on sites over undisturbed chalk but this is an extreme example, caused perhaps by a low magnetic mineral content in the soil complicated by alluviation on top of the original surface. In such circumstances the magnetic contrast between archaeological features and natural background levels is likely to be slight, thus any anomalies caused will be difficult to detect. Nevertheless, some anomalies are apparent and these are marked on an annotated version of the greytone plot depicted in figure 3; codes in bold in the text below refer to annotations on this figure.

Two linear anomalies are visible in the plot running east-west, one near the southern end of the survey area at **A1**, the other some 70 metres north and appearing much fainter at **A2**. Information provided by the farmer suggests that these have similar positions and alignment as the field drains which were installed around 1980. The position of the outfalls of these field drains into the ditch at the western edge of the field are marked by posts and the locations of two of these have been marked on the location plan (figure 1). One of these is close to, but not exactly coincident with the end of **A2**, so it is not entirely certain that this anomaly represents a field drain. The other shows that another, undetected, field drain lies about 90 metres to the north of **A2**. This undetected drain, in conjunction with the weaker strength of **A2** relative to **A1**, may indicate that the soil overburden becomes progressively deeper towards the northern end of the field, so that this third drain is too deeply buried to cause a measurable anomaly at the surface.

The strongest anomalies that are apparent in the plots are the clusters of discrete circular anomalies at **B1** and in the southwest corner of the survey at **B2**. These have peak anomaly strengths of about 10-15nT which, given their shape, would be consistent with that caused by a buried pit filled with burnt material. However, this assertion cannot be made entirely without qualification as a fenland site recently surveyed in Lincolnshire produced similar anomalies, although with higher peak magnitude, which were found to be caused by natural iron panning (Cole 1995). Furthermore, investigation by the Cambridge Archaeology Unit of localised regions of high susceptibility in a magnetic susceptibility survey to the north of this survey area also uncovered pit-like anomalies, that were found to be natural solution hollows (Kasia Gdaniec *pers. comm.*). An auger hole was bored over one of the anomalies in the cluster at **B1** to gain additional information about the material causing it and the findings are discussed below. It should be noted that if the depth of overburden does indeed increase towards the north of the field, as suggested above, then the faint anomalies at **B3** may represent more deeply buried instances of the same type of feature.

Another complex group of diffuse, almost linear, anomalies occurs in the southern part of the survey area, centred on **C1**. These have a peak anomaly strengths of between 2-4nT and are likely to be caused by underlying geomorphological features with higher magnetic susceptibilities than the surrounding soil, perhaps deposits of clay. The linear group at **C2** are particularly strong, either because they are nearer the surface or because they are composed of a material of higher magnetic susceptibility. An archaeological explanation for these should not, perhaps, be entirely dismissed as such areas of magnetic enhancement could be caused by past excavation, possibly to extract clay. In this case one might tentatively infer an association between the anomalies at **C2** and those at **B1**.

It is estimated that the Iron Age cemetery described in the introduction is situated at **D** relative to the survey area, so any traces of its continuation into the surveyed field would be expected to be in this vicinity. However, no anomalies have been detected in this area that are not consistent with those produced by surface iron objects. This cannot be taken as unequivocal evidence that the cemetery does not continue into the surveyed field as a number of linear field boundaries are known, from cropmark evidence, to extend into the field near **A1**. The magnetometer survey has not detected these, suggesting that conditions at the site are not favourable for magnetic prospecting. Thus negative evidence cannot be taken to imply the absence of archaeological features.

Finally, two very faint, negative anomalies may just be discerned in the north east corner of the survey area, running parallel to the field boundary at **E**. Since their peak anomaly strength is less than 1nT and they lie parallel to the modern field boundary it seems most likely that they are caused by recent agricultural activity but it is possible that they mark the position of earlier boundary ditches with an alluvial fill of lower magnetic susceptibility than the surrounding soil.

The Resistivity Survey

Whilst the very dry weather conditions this summer were not conducive to good resistivity contrast, an attempt was made to find traces of any ditches or pits dug for cremation burials, after rainfall which occurred during the survey. Owing to time constraints only a limited area could be surveyed, at one metre by one metre reading interval, so two squares were selected where remains of the cemetery were thought most likely to be found; these are shown in figure 1. The results of this survey are plotted in plan B, where B.1 shows a traceplot of the raw resistivity data and B.2 depicts an equal area greytone plot of the same data, after the application of a thresholding median filter to remove 'spikes' caused by high contact resistance and convolution with a 15 metre radius gaussian, high-pass mask to remove regional trends.

It is immediately clear from plan B that the primary response has been to drainage patterns caused by the gravel terraces underlying this part of the site. No anomalies are visible that might be suggestive of the ring ditches or pits for the burials found in the adjacent excavation. As with the magnetometer results this absence of anomalies cannot be taken to imply an absence of archaeological features as the resistivity technique has often been found to give confused results over gravel, failing to detect features subsequently revealed through excavation (*cf* Linford 1994).

One possible, low resistance (dark grey) linear anomaly can be discerned in B.2 running from the middle of the northern edge of the survey to the middle of the western edge. This response is consistent with the anomaly expected from an infilled ditch and comparison with cropmark evidence suggests that this is the case (C. Evans *pers comm.*).

The Magnetic Susceptibility Survey

An area of approximately 3 hectares was sampled at 10 metre intervals to measure volume specific magnetic susceptibility using a Bartington MS1 magnetic susceptibility meter and 20cm field loop. This instrument measures the magnetic susceptibility of the top 10cm of soil and will theoretically detect any magnetically enhanced soil derived from buried archaeological ditch fills and brought to the surface by worm action or ploughing. In the present case, magnetically enhanced soil caused by pyres associated with the burning of cremations might be detected.

A greytone plot of the results of this survey, superimposed onto the relevant portion of the 1:2500 map, is depicted in plan C. The values in this plot have been smoothed with a 3 by 3 median filter to reduce the distracting effect of random measurement noise. It is immediately clear from the plot that magnetic susceptibility on the site is generally low; nevertheless some differentiation is apparent between regions.

Most striking is the dark semicircular area of very low susceptibility (dark grey-black) at the eastern edge of the survey. This is most likely to represent a geological or pedological change in this area of the field, given its scale and that it is a low susceptibility feature. In contrast to this the magnetic susceptibility reaches a peak of 24×10^{-5} SI in square 20 (see figure 1 for square numbers). This is the square in which the pit like anomalies labelled **B1** were detected in the magnetometer survey, suggesting that the magnetically enhanced fill from these features is being ploughed out into the surrounding soil.

A second peak of 20×10^{-5} SI appears in the south-western corner of square 6 and this is close to the area where the Iron Age cemetery was discovered. Hence, this is possibly an indication of anthropogenic activity, perhaps burning associated with the cremations. Unfortunately, the magnetic susceptibility increase is very slight and could be caused by natural variation, so the archaeological interpretation, uncorroborated by any of the other techniques applied on the site, should be treated with caution.

The Augered Anomaly

Soil samples were recovered at 20cm intervals to a maximum depth of 140cm over one of the pit-type anomalies identified in grid square 16 (*Figure 1* and *Figure 3; B1*). The variation of mass specific magnetic susceptibility (χ) and the frequency dependence of magnetic susceptibility (χ_{FD}) with depth were measured and are presented graphically in Figure 2. The results demonstrate the uniform nature of the first 60cm of overburden and the low χ exhibited by the underlying clay (?presumably natural) encountered beyond 120cm. In striking contrast to this, the samples recovered from between 60-120cm have an extremely high χ and contain flecks of orange, possibly burnt, material. A similar increase in χ_{FD} occurs within the same layer. Whilst it is impossible to rule out a natural origin, both the magnitude of χ and the increase of χ_{FD} suggest magnetic enhancement of the sediments has occurred through an intense redox reaction, perhaps as the result of deliberate burning episodes (*cf* Cole *et al* in press).

Conclusion

No traces of features of the type excavated in the Iron Age cemetery adjacent to the survey area have been detected in either the magnetometer or resistivity surveys. Local conditions appear to be unfavourable to the two techniques, so this result cannot be interpreted as proof that the cemetery does not extend into the field. The magnetometer's failure to detect linear features observed as cropmarks certainly suggests that the chalk-derived soil was not conducive to the creation of magnetic contrasts. There is also some evidence in the magnetic survey that points towards a deeper overburden of soil at the northern end of the survey area, where remains of the cemetery might be expected. This would not only make already weak magnetic anomalies more difficult to detect but might also account for the paucity of cropmarks observed in the northern part of the field. Resistivity prospecting in the area adjacent to the cemetery was also inconclusive as the results were clearly dominated by a response to drainage caused by the river gravel terraces underlying this part of the field. Nevertheless, a ditch anomaly visible as a cropmark was detected, suggesting that the resistivity is detecting larger archaeological features.

The magnetic susceptibility survey did detect an increase in topsoil magnetic susceptibility in the area adjacent to the cemetery remains. This may be a result of magnetically enhanced soil, caused by burning episodes in, or near, the cemetery area being translocated into the topsoil. If this is indeed the case then it might indicate that part of the cemetery does continue beneath the track and into the surveyed field. Unfortunately, no inference about the extent of the cemetery can be made as the pyres that created the enhancement would not necessarily have been located within it. Furthermore, the increase is only slight and could have occurred as a result of natural variation, so an anthropogenic interpretation should be treated with caution.

The magnetometer survey did detect two groups of discrete pit-like anomalies. As discussed above, the significance of these is uncertain as it is known that, in this region, natural processes can cause features that closely resemble deliberately dug pits. Nevertheless, soil samples taken from an auger hole bored over one such anomaly, whilst not containing any diagnostic artifacts, did have magnetic properties consistent with anthropogenic enhancement. Thus it is quite possible that these anomalies represent features similar to the neolithic/early bronze age pit of burnt flints found in the excavated area. If the amorphous areas of magnetic enhancement labelled **C2** in the magnetometer interpretation plot (figure 4) do represent clay deposits, then it is even possible that these anomalies are caused by the remains of pottery kilns. Trial excavation or test pitting of these anomalies would be highly desirable to corroborate the findings of the geophysical survey and prime candidates for such investigation would be the pit-like features in the area labelled **B1**.

Surveyed by: P Linford
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Date of survey: 4-8/9/95

Reported by: P Linford
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Date of report: 19/9/95

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Ancient Monuments Laboratory,
English Heritage.

References

Alexander, M. (1994). Hinxton Mid Field Arm 1994 Site Summary. *Unpublished report of the Cambridge Archaeological Unit.*

Cole, M (1995). Thurlby, Lincs: Report on Geophysical Survey. *Forthcoming Ancient Monuments Laboratory report.*

Cole, M. A., Linford, N. T., Payne, A. W. and Linford, P., K., (1994). Soil magnetic susceptibility measurements and their application to archaeological site investigation. In Beavis, J. (editor), *Science and Site: Archaeological Sciences Conference 1993* (London: Archetype Books): in press.

Linford, N.T. (1994). Mineral Magnetic Profiling of Archaeological Sediments. *Archaeological Prospection* **vol 1**, p 37-52.

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.

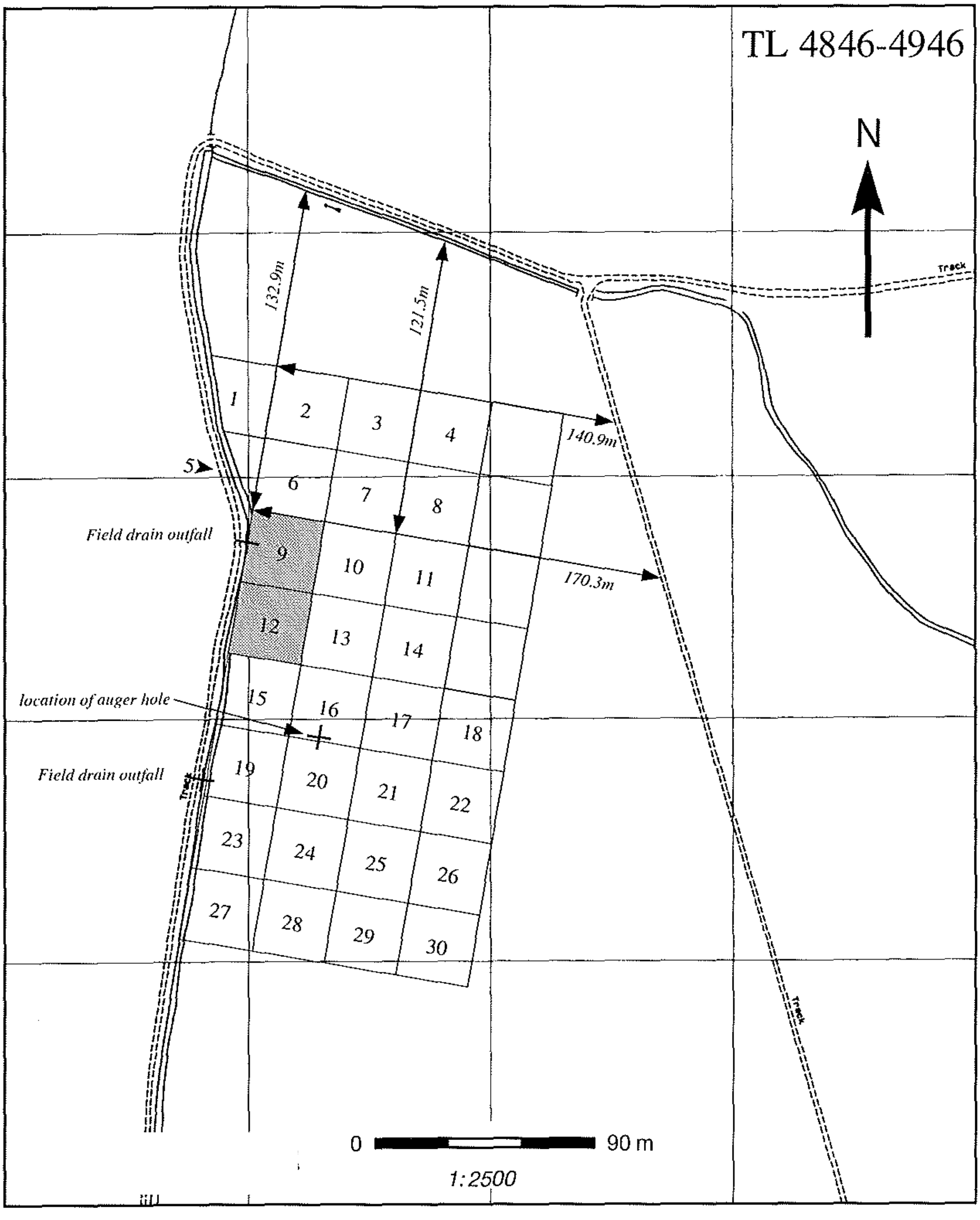
It is the opinion of the manufacturer of the Geoscan instrument that two sensors placed 0.5 metres apart cannot produce a true estimate of vertical magnetic gradient unless the bottom sensor is far removed from the ground surface. Hence, when results are presented, the difference between the field intensity 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).

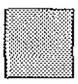
3) **Resistivity Profiling:** This technique measures the electrical resistivity of the subsurface in a similar manner to the standard resistivity mapping method outlined in note 1. However, instead of mapping changes in the near surface resistivity over an area, it produces a vertical section, illustrating 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.

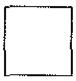
Hinxton Quarry, Cambs.

Figure 1





Location of trial earth resistance survey.



Magnetometer (numbered grid squares) and topsoil magnetic susceptibility surveys.

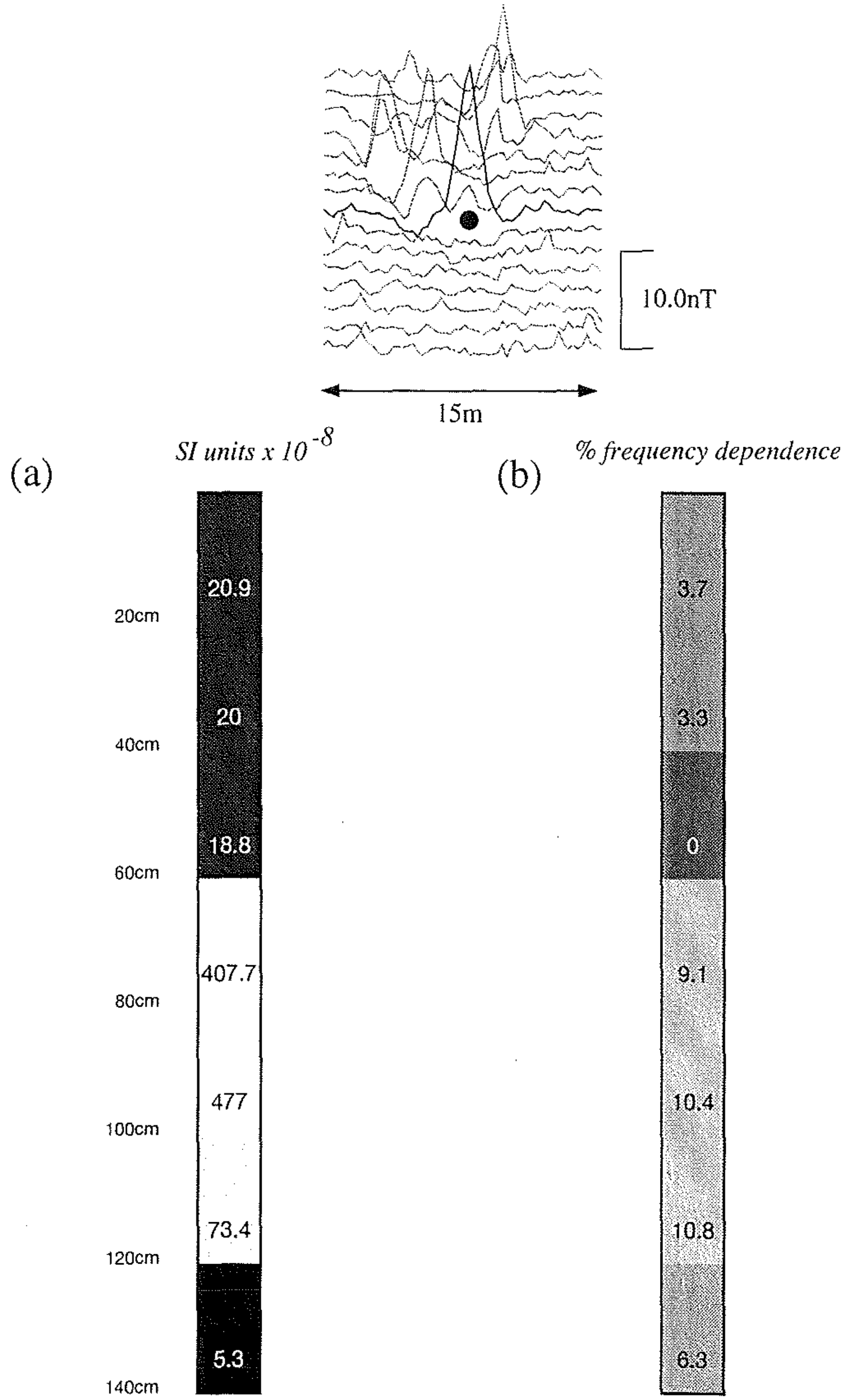


Figure 2; Hinxton Quarry, Cambs., Mass specific magnetic susceptibility (a) and percentage frequency dependence (b) results from augured anomaly.

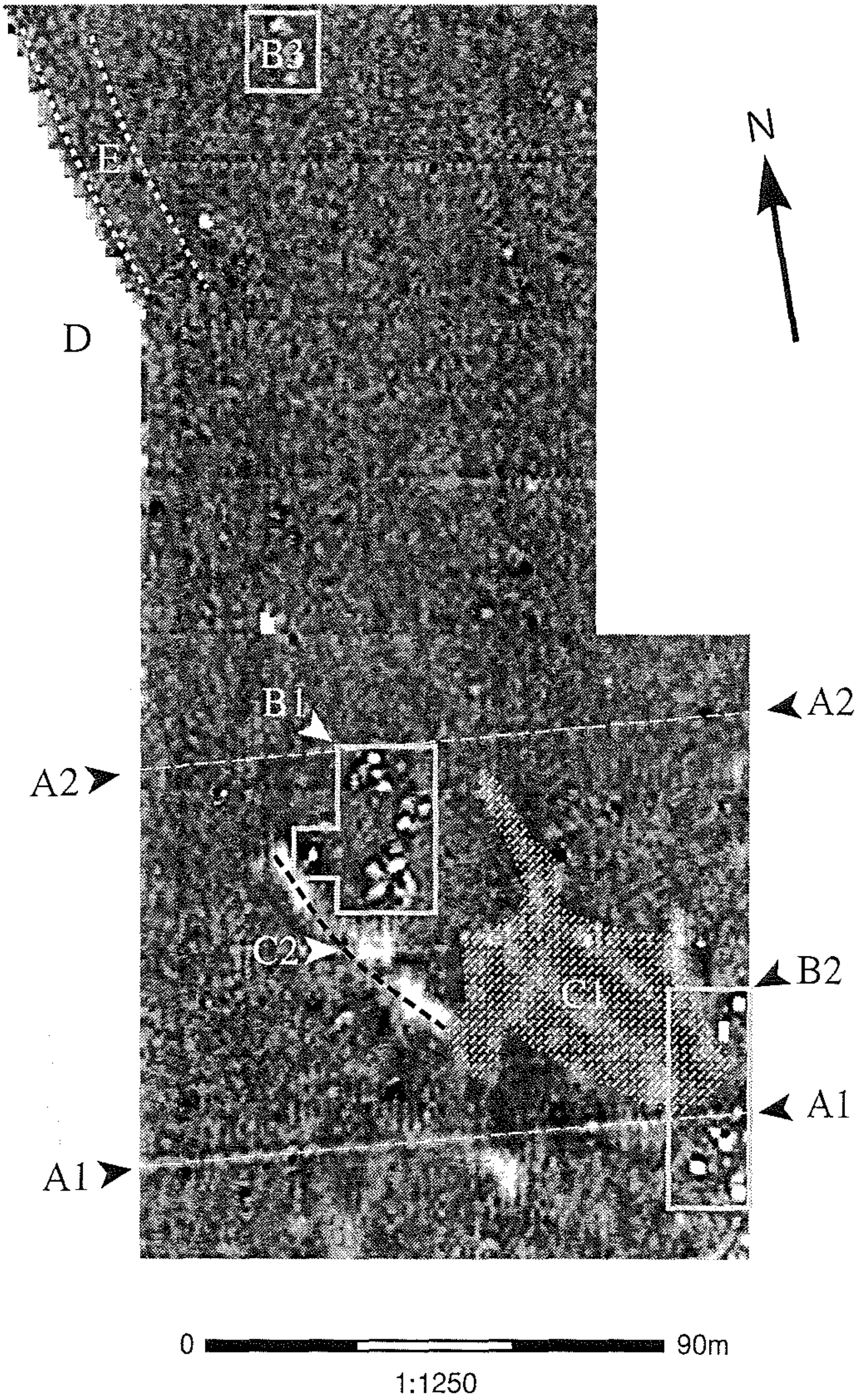
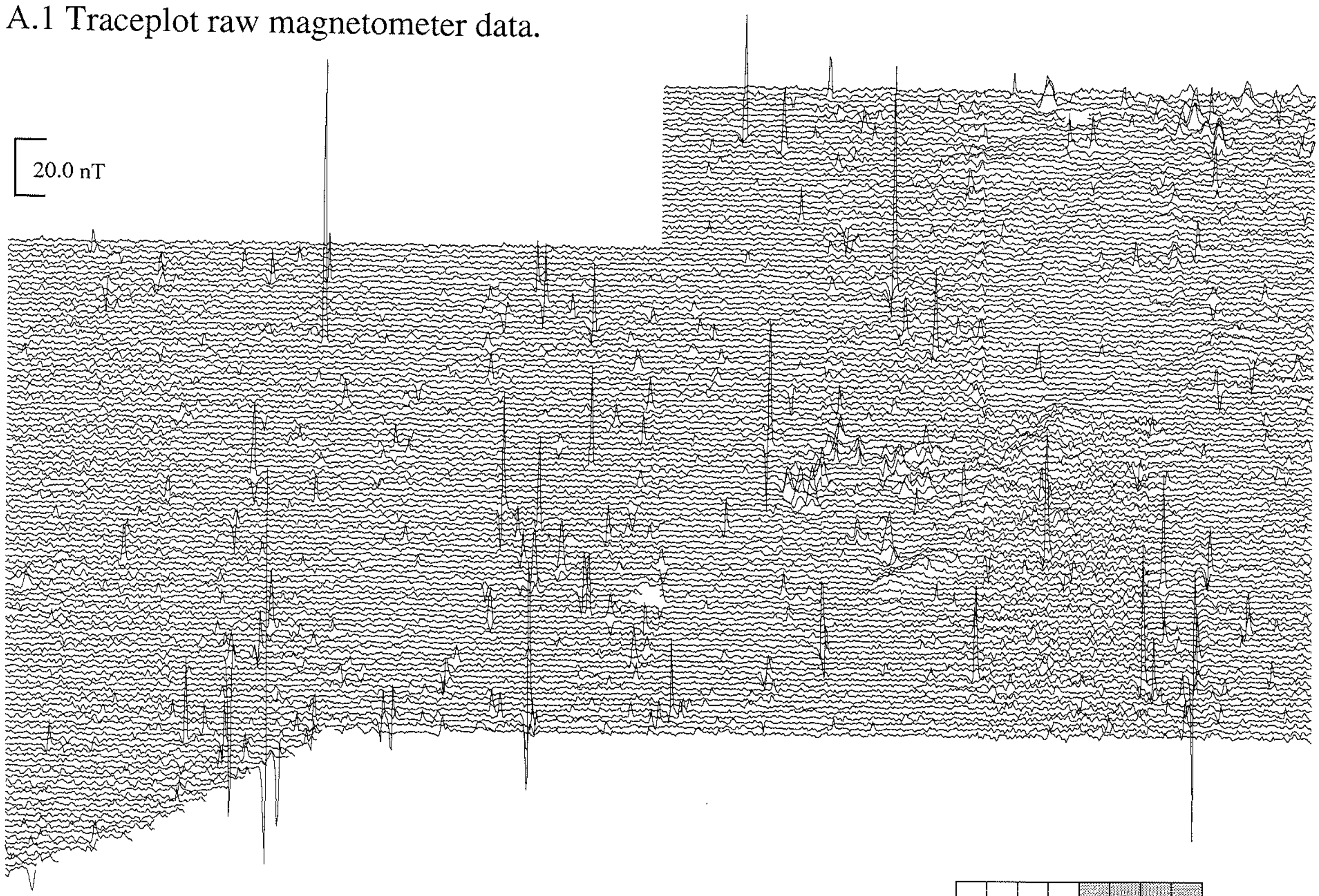


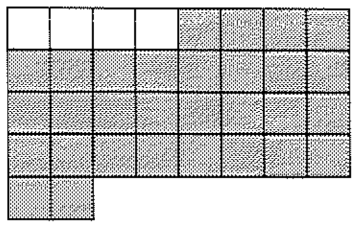
Figure 3; Hinxton Quarry, Cambs., summary of significant anomalies revealed by the September 1995 geophysical survey (see text for details).

HINXTON QUARRY, CAMBS.
Geophysical survey September 1995.

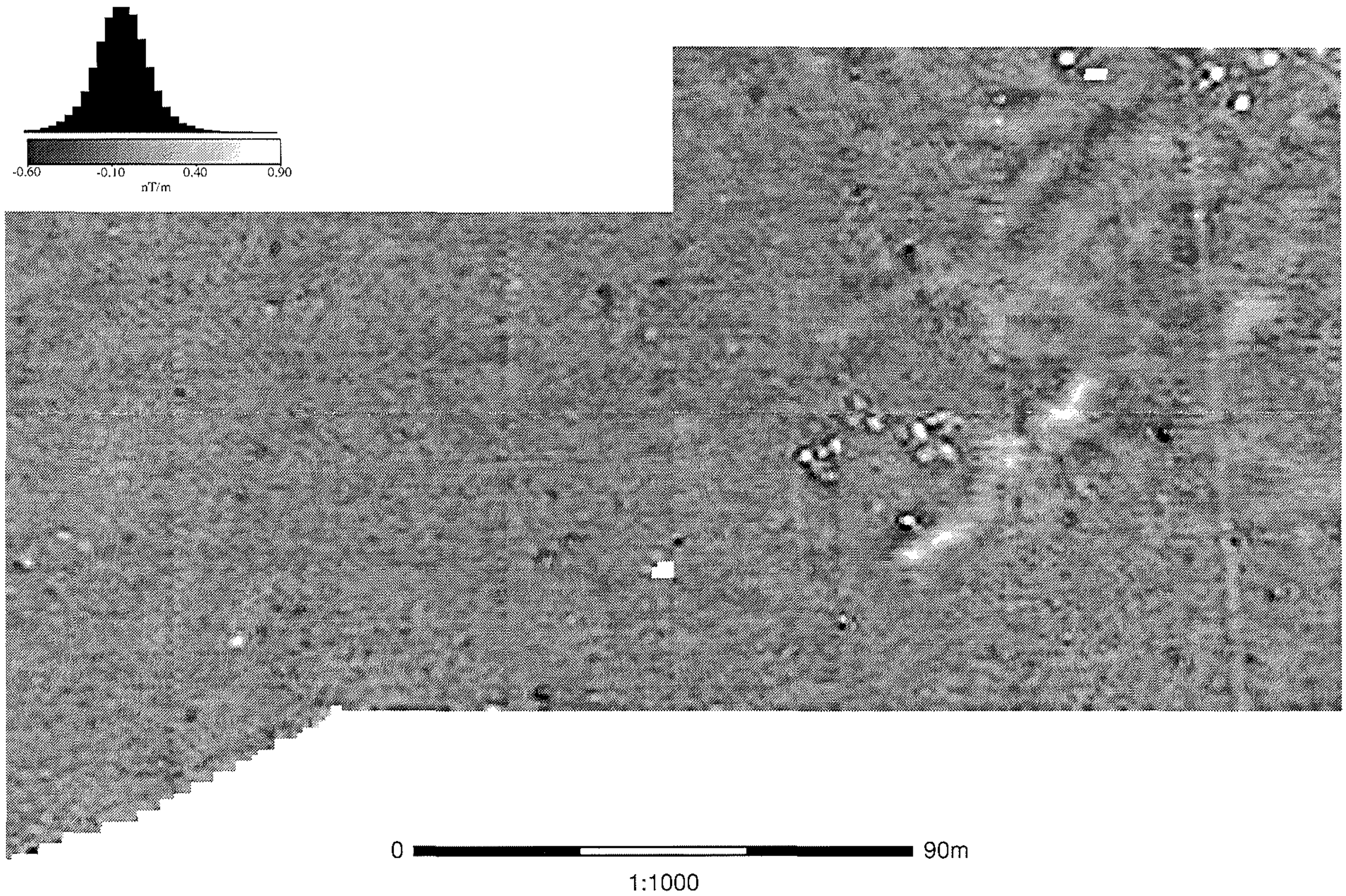
PLAN A

A.1 Traceplot raw magnetometer data.





A.2 Greytone enhanced magnetometer data.



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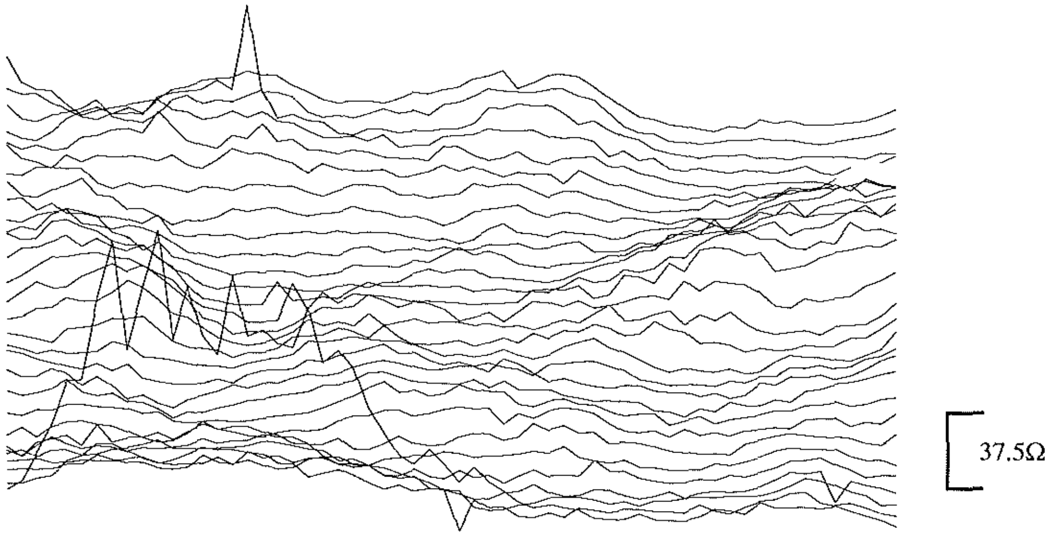
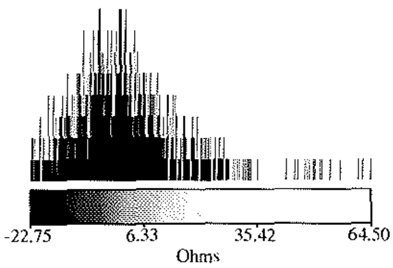
Hinxton Quarry, Cambs.
Geophysical survey September 1995.

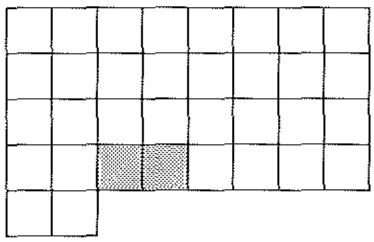
PLAN B

B.1 Traceplot raw resistivity data.



B.2 Greytone enhanced resistivity data.





0 30m

1:500

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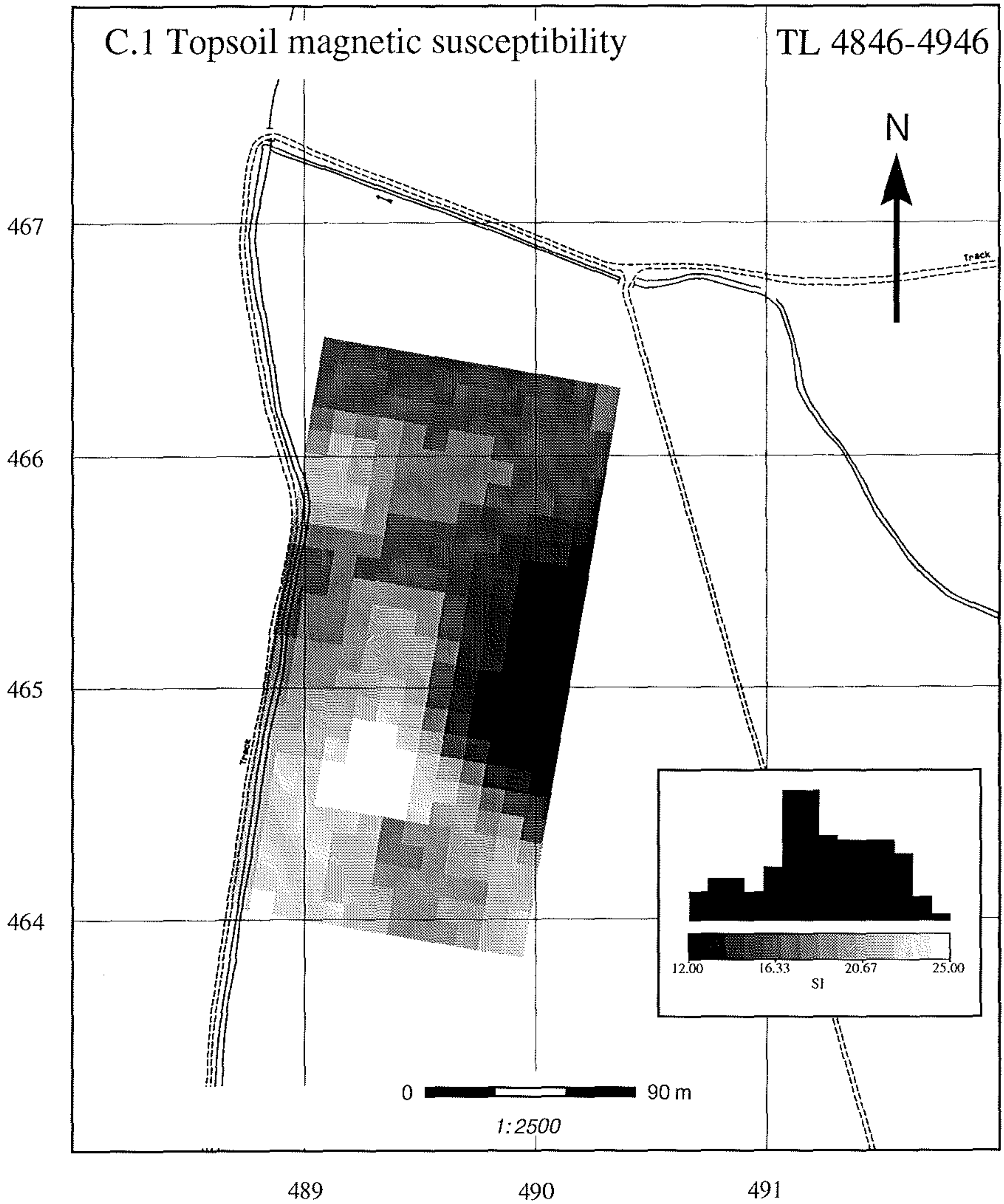
PLAN C

Hinxton Quarry, Cambs.
Geophysical survey September 1995.



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