98/12

LAND AT LEA, nr. GAINSBOROUGH, LINCOLNSHIRE

Topsoil Magnetic Susceptibility & Gradiometer Survey

(Survey Ref : 1530698/LEL/OTT)

JUNE 1998

Produced by

OXFORD ARCHAEOTECHNICS LIMITED

under the direction of

A.E. Johnson *BA(Hons)*

Commissioned by

Lindsey Archaeological Services - ack 24 June
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on behalf of

Mr. & Mrs. Otter

OXFORD ARCHAEOTECHNICS

EVENTS L12526 L12527
MagSus Magnetometry
SOURCE L17113
S4030 Amed

OXFORD ARCHAEOTECHNICS

Specialist Archaeological Field Evaluation

OXFORD ARCHAEOTECHNICS
Noke
Oxford OX3 9TX

Tel / Fax 01865 375536
Mobile 0831 383295
Email archaeotechnics@dial.pipex.com

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SUMMARY

A geophysical evaluation programme comprising topsoil magnetic susceptibility mapping and gradiometer survey was carried out on 1 ha area of land at Lea in Lincolnshire (centred on NGR 482800 386900) in advance of proposed house construction. As the survey area lies close to previously excavated Romano-British pottery kiln, the primary objective was to investigate the 'footprint' and immediate environs of the two proposed building plots for any further associated Romano-British industrial or settlement remains.

The survey was based upon the principle that past human activity and its associated debris usually creates slight but persistent changes in the local magnetic environment which can be sensed from the surface (using magnetic susceptibility measurement and magnetometry), techniques which favour the discovery of kilns and associated structures.

An area of approximately 1 ha was investigated by 10 m topsoil magnetic susceptibility survey, of which 0.25 ha was detailed by gridded magnetometer (gradiometer) survey, supplemented by (limited) hand augering.

Apart from pockets of obviously modern contamination, the topsoil magnetic susceptibility pattern proved quite subtle, probably due to the presence of local windblown deposits. Within the proposed building plots gradiometer survey has suggested a few possible pits or pockets of burnt material. However, the presence of considerable modern debris resulted in locally 'noisy' background, which would have precluded the recording of more subtle magnetic information. Within the paddock immediately west of the building plots a single large pit was located, which was demonstrated by hand augering to contain burnt deposits.

1. INTRODUCTION

1.1 Geophysical survey was commissioned by Lindsey Archaeological Services on behalf of Mr. & Mrs. Otter on proposed building plots situated at the western end of Crowgarth Lane within the village of Lea, some 2 km southeast of Gainsborough, Lincolnshire. The fieldwork was carried out in June 1998.

1.2 The proposed development area (centred on NGR 482800 386900) lies within the eastern extremity of an L-shaped block of rough pasture (recently strimmed) paddock, the whole area totalling almost 1 ha in extent, lying at the rear of properties fronting the A 156 Gainsborough Road. The location is shown on Fig. 1.

1.3 The survey area lies on the western outskirts of the village, in an elevated position (above the 10 m AOD contour) overlooking the east bank and floodplain of the River Trent.

1.4 Although no sites or finds of archaeological significance have been recorded from the survey area, a Romano-British kiln was discovered (and excavated) during land clearance work at Green Lane in 1983, at a location less than 100m north of the proposed building site. The well preserved kiln, 1.2 m in diameter had been dug into the wind blown sand subsoil. Further excavation in the vicinity of the kiln in 1985 in advance of redevelopment located several pits and gullies containing large quantities of Roman pottery, together with a substantial ditch, which were believed to represent part of a much more extensive industrial complex lying further south. Ten Romano-British kilns have also been discovered at Grange Farm,on the southeastern outskirts of Lea village, some 270 m southeast of the Green Lane kiln (Field & Palmer-Brown 1991, Swan 1984a & b).

1.5 The geophysical survey comprised a combination of topsoil magnetic susceptibility field sensing and magnetometry, supplemented by limited hand augering. An explanation of the techniques used, and the rationale behind their selection, is included in an Appendix to the present report.

2. MAGNETIC SURVEY DESIGN

2.1 Survey control was established to OS 1:2500 Sheet SK 8286.

2.2 The equipment used for the direct topsoil magnetic susceptibility survey was a Bartington Instruments MS2 meter with an 18.5 cm loop.

2.3 *In situ* magnetic susceptibility readings were taken on a 10 m grid, an interval known to give a high probability of intersecting with dispersed horizons from a wide range of archaeological sites, particularly those associated with occupation and industrial activity from the later prehistoric period onwards. Soils over former occupation and industrial sites usually register as stronger patterning, frequently showing a marked focus. Agricultural activity helps to both generate (by ploughing casting up underlying deposits), and ultimately disperses the more magnetic soils over a wider area. Patterns recorded by 10 m magnetic susceptibility mapping tend to define zones of former activity rather than locate individual elements. Nevertheless, in some contexts, a focus of markedly stronger soil magnetic susceptibility (or markedly magnetically lower soils indicative of ploughed down earthworks) is occasionally found to relate to material dispersed from specific underlying features.

2.4 Following gradiometer scanning, two areas were targeted for detailed gridded gradiometer survey with a Geoscan Research FM 36 Fluxgate Gradiometer (sampling 4 readings per metre at 1 metre traverse intervals in the 0.1 nT range). The nanotesla (nT) is the standard unit of magnetic flux (expressed as the current density), here used to indicate positive and negative deviations from the Earth's normal magnetic field.

2.5 The topsoil magnetic susceptibility colour shade plot (Fig. 3) shows contours at 10 SI intervals. Magnetometer data have been presented as grey scale and stacked trace (raw data) plots (Figs. 4 & 7), an interpretation of results is shown on Fig. 5 and an overview on Fig. 6.

3. SURVEY RESULTS

TOPSOIL MAGNETIC SUSCEPTIBILITY SURVEY (Fig. 3)

3.1 Despite the obvious potential for modern contamination within a paddock bounded by modern properties, topsoil magnetic susceptibility mapping was nevertheless carried out in an attempt to isolate any strong magnetic soil patterns which might be attributable to former kiln sites or associated occupation debris.

3.2 110 *in situ* magnetic susceptibility readings were recorded. Susceptibility is reported in SI: volume susceptibility units (x 10^{-5}), a dimensionless measure of the relative ease with which a sample can be magnetized in a given magnetic field.

3.3 *In situ* topsoil susceptibility measurements ranged between 16 and 198 (x 10^{-5}) SI units, the higher readings reflecting an area of relatively recent activity associated with existing and former smallholding features and obvious dispersed modern debris. The mean for the survey was 33 SI units and the standard deviation calculated against the mean was 23.2 SI units.

3.4 Beyond the area obviously affected by modern input, the topsoil magnetic susceptibility map has proved remarkably stable, with only subtle variations recorded, particularly within the paddock to the west of the proposed building plots.

3.5 No dramatic magnetic variations were recorded which might be indicative of the upcast of Roman industrial material into the topsoil. Hand augering (see 3.11 below) suggested that features may be locally masked by relatively clean (?windblown) overburden.

MAGNETOMETER (GRADIOMETER) SURVEY (Figs. 4 - 7)

3.6 Following topsoil magnetic susceptibility mapping and gradiometer scanning, detailed gridded gradiometer survey was carried out in two areas: Area 1 was selected to cover the 'footprint' of the proposed dwellings, and Area 2 was sited to investigate several magnetic anomalies detected by gradiometer scanning within the adjoining paddock.

Area 1 (60 x 30 m)

3.7 The gradiometer plot shows considerable modern contamination along its western edge, in the vicinity of a former field boundary, together with a number of isolated areas of strong ferrous contamination.

3.8 A few anomalies which might possibly be pit forms or pockets of burnt material were also been recorded, together with a suggestion of an extremely weak linear 'cut' feature.

Area 2 (30 x 30 m)

3.9 This survey area was sited to cover a strong magnetic anomaly detected during gradiometer scanning. This plot shows a strong (50 nT) anomaly suggesting a reasonably deep pit measuring some 3 - 4 m in diameter.

3.10 Two further extremely strong (exceeding 100 nT) magnetic anomalies appear to have been generated by pockets of substantial ferrous material. Further ferrous objects were also recorded from the topsoil.

Hand Augering

3.11 Limited hand augering within Area 1 proved unproductive, having been variously obstructed by modern debris.

3.12 Within Area 2, both the pit-like feature one of the two strong magnetic anomalies containing ferrous material were investigated by hand augering. The large pit was shown to contain charcoal and burnt clay particles within a brown 'subsoil - like' matrix at a depth of 50-120 cm below the present ground surface. These deposits were sealed beneath an homogenous clean (mid brown), possibly windblown, overburden. The base of the pit was not reached at 1.2 m below the present surface. A single hand auger hole into the larger of the strong magnetic anomalies (close to the northwest angle of the gradiometer box) produced rusted iron fragments and glass at a depth of 50 cm; a modern pit with associated debris is suggested.

4. CONCLUSIONS

4.1 Magnetic survey has indicated few substantial 'cut' features which could confidently be identified as having potential archaeological significance. Although it is possible that the presence of a.50 m thick layer of overburden (possibly of wind-blown origin) confirmed by hand augering may have 'masked' archaeological horizons from topsoil magnetic susceptibility mapping, it is anticipated that the good magnetic contrasts and response of the site to the gradiometer would have been sufficiently strong to define areas of anthropogenic activity, particularly industrial activity such as pottery kilns.

4.2 In Area 1 several anomalies have been tentatively identified as possible pits, perhaps containing strongly magnetic material. Although burnt features or industrial activity cannot be entirely discounted, the majority of the signals appear to have been generated by ferrous material of relatively recent origin. However, deeply buried ferrous material may equally be responsible for the more ambiguous magnetic signals. As the nature of some of these anomalies was not immediately obvious on the field plot, none was specifically targeted for hand augering.

4.3 Within the paddock to the west of the proposed building plots (Area 2: which is not scheduled for building), a strong anomaly has been more unequivocally recognised as having some archaeological potential. This appears to be a substantial pit containing traces of burning (fragments of burnt clay and charcoal). As this feature was sealed below some 50 cm of 'clean' subsoil, an ancient origin is therefore suspected, and the presence of burnt material may indicate an association with the known Romano-British pottery industry identified locally. Gradiometer scanning elsewhere within the paddock suggested the presence of further features which could conceivably have some archaeological significance.

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Topsoil magnetic susceptibility mapping and magnetometer survey by Oxford Archaeotechnics Limited under the direction of A.E. Johnson *BA(Hons)*, with: P. Seaman *BSc(Hons), PhD.*

APPENDIX 1 - MAGNETIC TECHNIQUES: GENERAL PRINCIPLES

A1.1 It is possible to define areas of human activity (particularly soils spread from occupation sites and the fills of cut features such as pits or ditches) by means of *magnetic survey* (Clark 1990; Scollar et al. 1990). The results will vary, according to the local geology and soils (Thompson & Oldfield 1986; Gale & Hoare 1991), as modified by past and present agricultural practices. Under favourable conditions, areas of suspected archaeological activity can be accurately located and targeted for further investigative work (if required) without the necessity for extensive random exploratory trenching. Magnetic survey has the added advantages of enabling large areas to be assessed relatively quickly, and is non-destructive.

A1.2 Topsoil is normally more magnetic than the subsoil or bedrock from which it is derived. Human activity further locally enhances the magnetic properties of soils, and amplifies the contrast with the geological background. The main enhancement effect is the increase of *magnetic susceptibility*, by fire and, to a lesser extent, by the bacterial activity associated with rubbish decomposition; the introduction of materials such as fired clay and ceramics - and, of course, iron and many industrial residues - may also be important in some cases. Other agencies include the addition and redistribution of naturally magnetic rock such as basalt or ironstone, either locally derived or imported.

A1.3 The tendency of most human activity is to increase soil magnetic susceptibility locally. In some cases, however, features such as traces of former mounds or banks, or imported soil/subsoil or non-magnetic bedrock (such as most limestones), will show as zones of lower susceptibility in comparison with the surrounding topsoil.

A1.4 Archaeologically magnetically enhanced soils are therefore a response of the parent geological material to a series of events which make up the total domestic, agricultural and industrial history of a site, usually over a prolonged period. Climatic factors may subsequently further modify the susceptibility of soils but, in the absence of strong chemical alteration (e.g. during the process of podzolisation or extreme reduction), magnetic characteristics may persist over millions of years.

A1.5 Both the magnetic contrast between archaeological features and the subsoil into which they are dug, and the magnetic susceptibility of topsoil spreads associated with occupation horizons, can be measured in the field.

A1.6 There are several highly sensitive instruments available which can be used to measure these magnetic variations. Some are capable, under favourable conditions, of producing extraordinarily detailed plots of subsurface features. The detection of these features is usually by means of a *magnetometer* (normally a fluxgate gradiometer). These are defined as passive instruments which respond to the magnetic anomalies produced by buried features in the presence of the Earth's magnetic field. The gradiometer uses two sensors mounted vertically, often 50 cm apart. The bottom sensor is carried some 30 cm above the ground, and registers local magnetic anomalies with respect to the top sensor. As both sensors are affected equally by gross magnetic effects these are cancelled out. In order to produce good results, the magnetic susceptibility contrast between features and their surroundings must be reasonably high, thereby creating good local anomalies; a generally raised background, even if due to human occupation within a settlement context, will sometimes preclude meaningful magnetometer results. The sensitive nature of magnetometers makes them suitable for detailed work, logging measurements at a closely spaced (less than 1 metre) sample interval, particularly in areas where an archaeological site is already suspected. Magnetometers may also be used for rapid 'prospecting' ('scanning') of larger areas (where the operator directly monitors the changing magnetic field and pinpoints specific anomalies).

A1.7 *Magnetic susceptibility measuring systems*, whilst responding to basically the same magnetic component in the soil, are 'active' instruments which subject the sample area being measured (according to the size of the sensor used) to a low intensity alternating magnetic field. Magnetically susceptible material within the influence of this field can be measured by means of changes which are induced in oscillator frequency. For general work, measuring topsoil susceptibility *in situ*, a sensor loop of around 20 cm diameter is convenient, and responds to the concentration of magnetic (especially ferrimagnetic) minerals mostly in the top 10 cm of the soil. Magnetically enhanced horizons which have been reached by the plough, and even those from which material has been transported by soil biological activity, can thus be recognised.

A1.8 Whilst only rarely encountering anomalies as graphically defined as those detected by magnetometers, magnetic susceptibility systems are ideal for detecting magnetic spreads and thin archaeological horizons not seen by magnetometers. Using a 10 m interval grid, large areas of landscape can be covered relatively quickly. The resulting plot can frequently determine the general pattern of activity and define the nuclei of any occupation or industrial areas. As the intervals between susceptibility readings generally exceed the parameters of most individual archaeological features (but not of the general spread of enhancement around features), the resulting plots should be used as a guide to areas of archaeological potential and to suggest the general form of major activity areas; further refinement is possible using a finer mesh grid or, more usually, by detailing underlying features using a gradiometer.

A1.9 Magnetic survey is not successful on all geological and pedological substrates. As a rule of thumb, in the lowland zone of Britain, the more sandy/stony a deposit, the less magnetic material is likely to be present, so that a greater magnetic contrast in soil materials will be needed to locate archaeological features; in practice, this means that only stronger magnetic anomalies (e.g. larger accumulations of burnt material) will be visible, with weaker signals (e.g. from the fillings of simple agricultural ditches) disappearing into the background. Similar problems can arise when the natural background itself is very high or very variable (e.g. in the presence of sediments partially derived from magnetic volcanic rocks).

A1.10 The precise physical and chemical processes of changing soil magnetism are extremely complex and subject to innumerable variations. In general terms, however, there is no doubt that magnetic enhancement of soils by human activity provides valuable archaeological information.

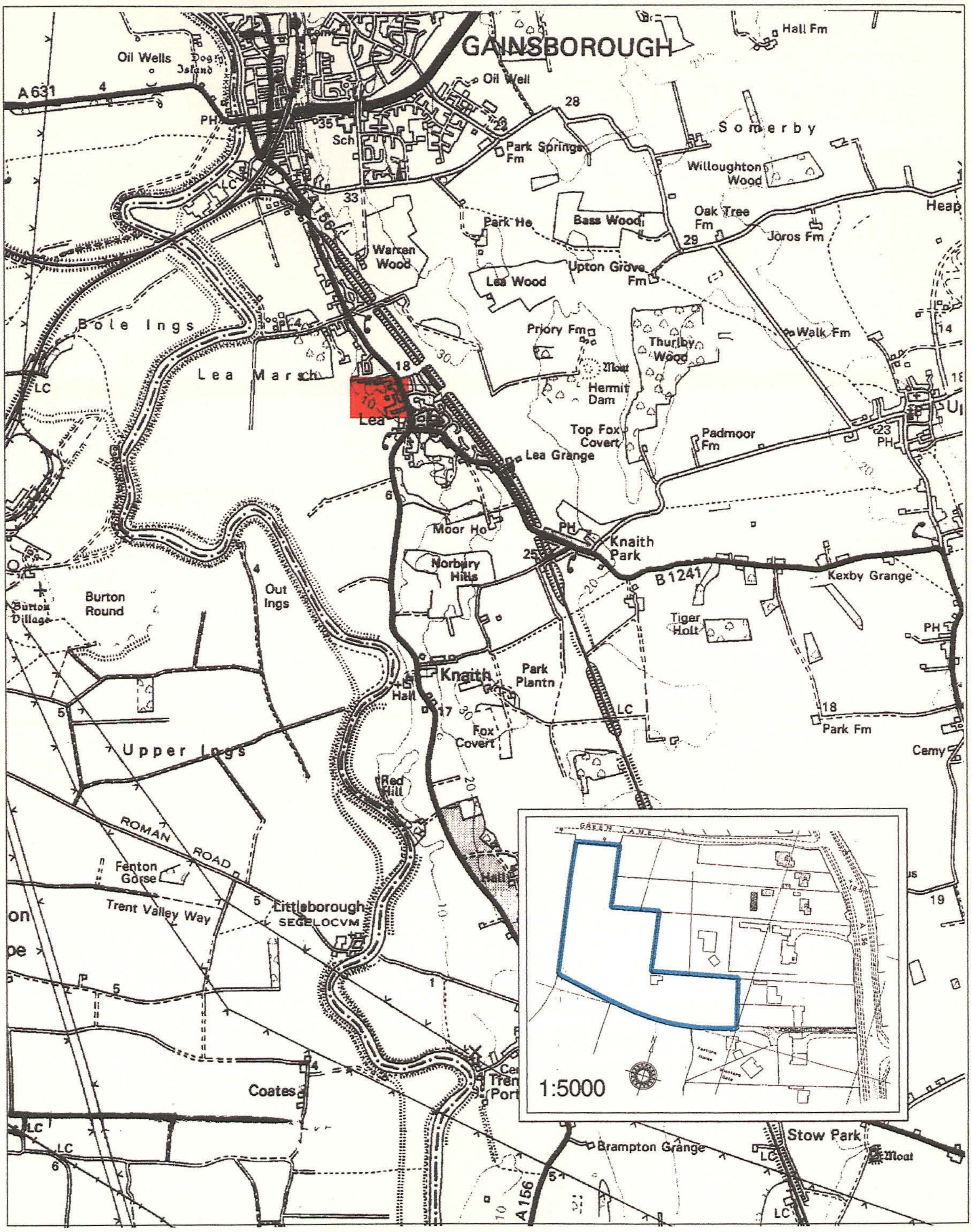
A1.11 As well as locating specific sites, topsoil magnetic susceptibility survey frequently provides information relating to former landuse. Variations in the soils and subsoils, both natural and those enhanced by anthropogenic agencies, when modified by agriculture, give rise to distinctive patterns of topsoil susceptibility. The containment of these spreads by either natural or man-made features (streams, hedgerows, etc.) gives rise to a characteristic chequerboard or strip pattern of varying enhancement, often showing the location of former field systems, which persist even after the physical barriers have been removed. These patterns are often further amplified in fields containing underlying archaeological features within reach of the plough. More subtle landuse boundaries and indications of former cultivation regimes are often suggested by topsoil magnetic susceptibility plots.

A1.12 Where a general spread of magnetically enhanced soils contained within a long-established boundary becomes admixed over a long period by constant ploughing, it can be diffused to such a point that the original source is masked altogether. Magnetically enhanced material may also be moved or masked by natural agencies such as colluviation or alluviation. Generally, it appears that the longer a parcel of land has been under arable cultivation, the greater is the tendency for topsoil susceptibility to increase; at the same time there is increasing homogeneity of the magnetic signal within the soils owing to continuous agricultural mixing of the material. Some patterns of soil enhancement derived from underlying archaeological features are, however, apparently capable of resisting agricultural dispersal for thousands of years (Clark 1990).

FIGURE CAPTIONS

Land at Lea, Gainsborough, Lincolnshire

Topsoil Magnetic Susceptibility & Magnetometer (Gradiometer) Survey



1:50,000

Location

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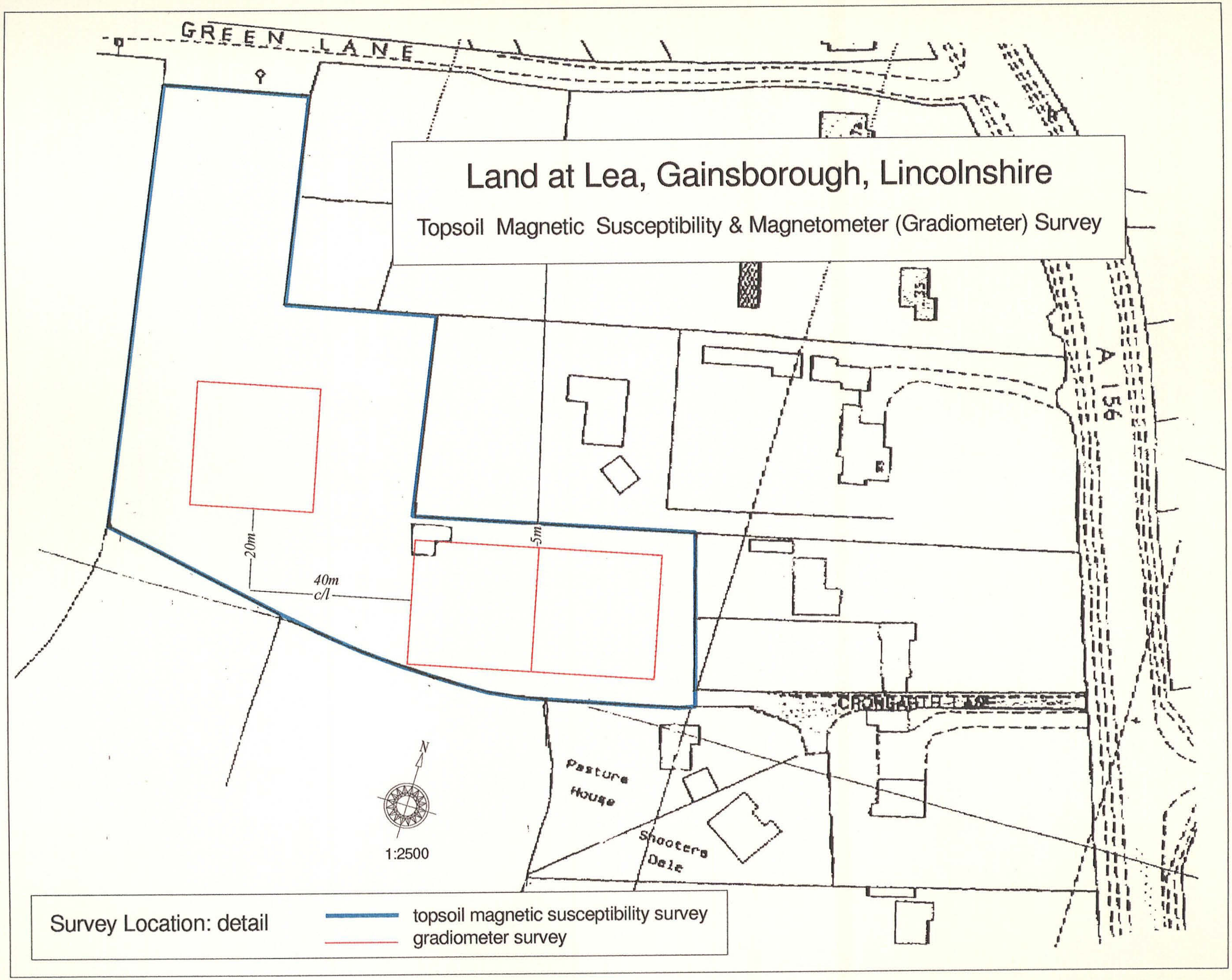
FIG. 1

Land at Lea, Gainsborough, Lincolnshire

Topsoil Magnetic Susceptibility & Magnetometer (Gradiometer) Survey



Survey Location: detail

topsoil magnetic susceptibility survey
gradiometer survey

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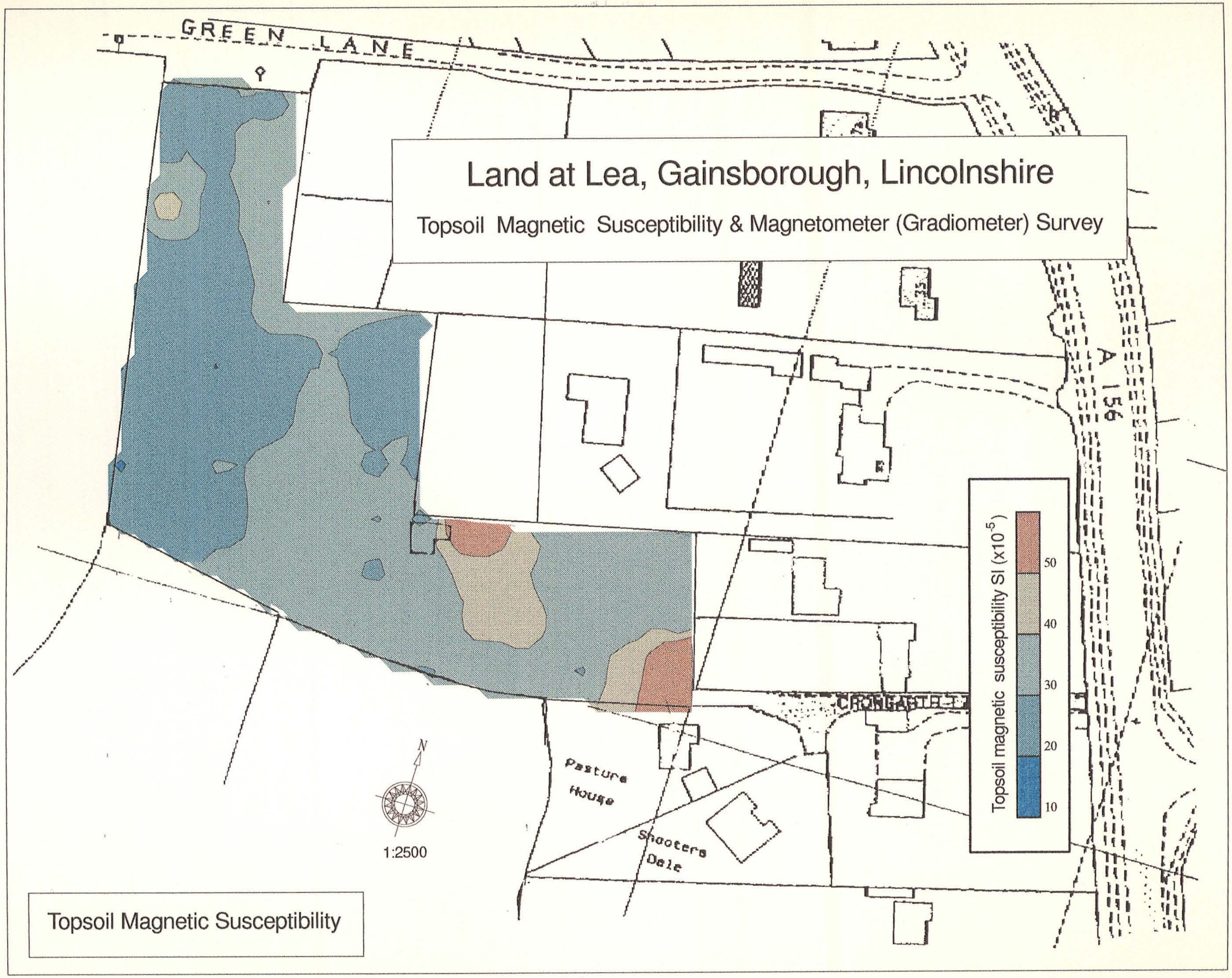
FIG. 2



Topsoil Magnetic Susceptibility

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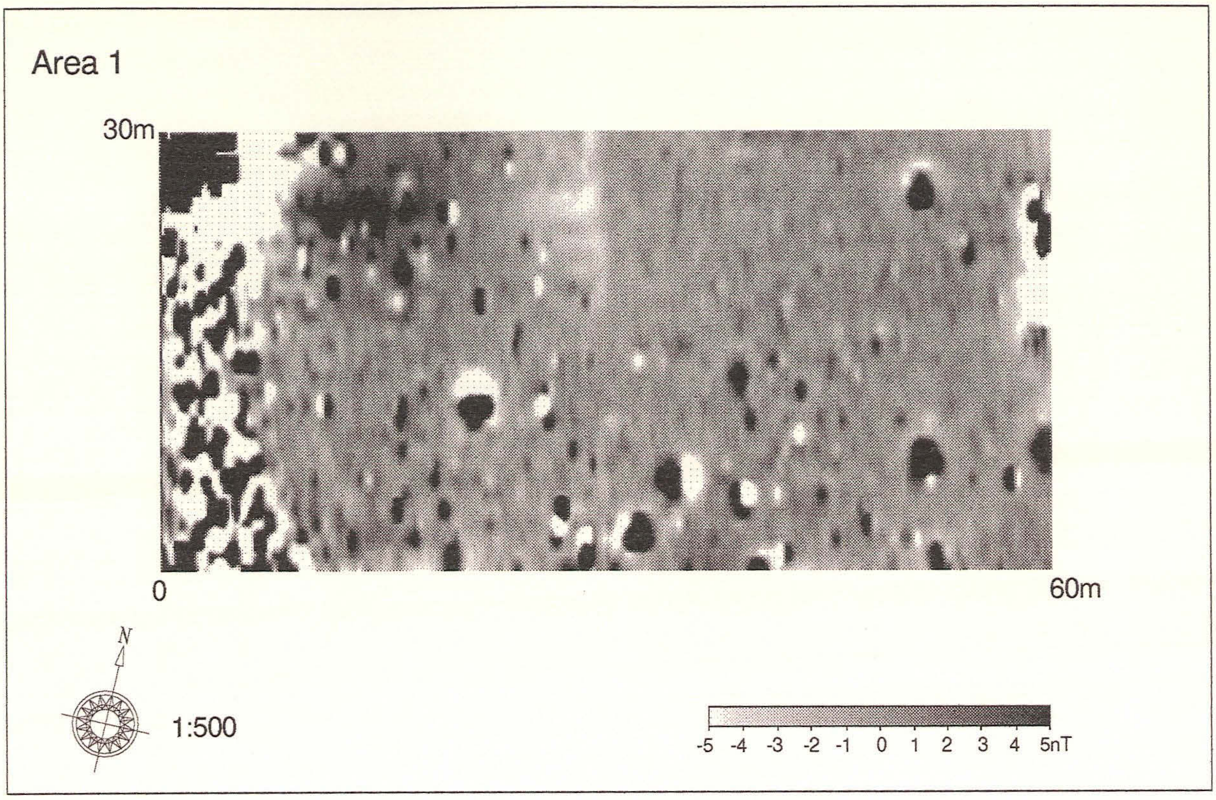
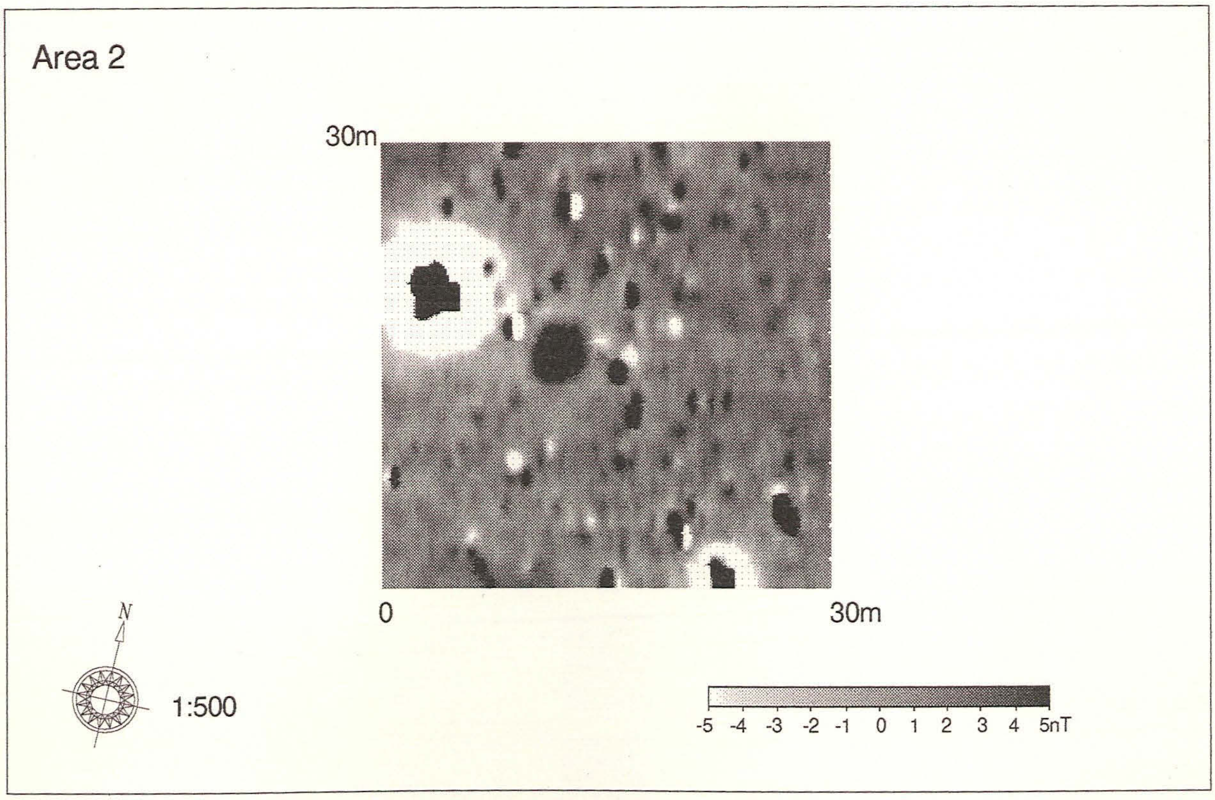
Land at Lea, Gainsborough, Lincolnshire

Topsoil Magnetic Susceptibility & Magnetometer (Gradiometer) Survey

Gradiometer Grey shade plots



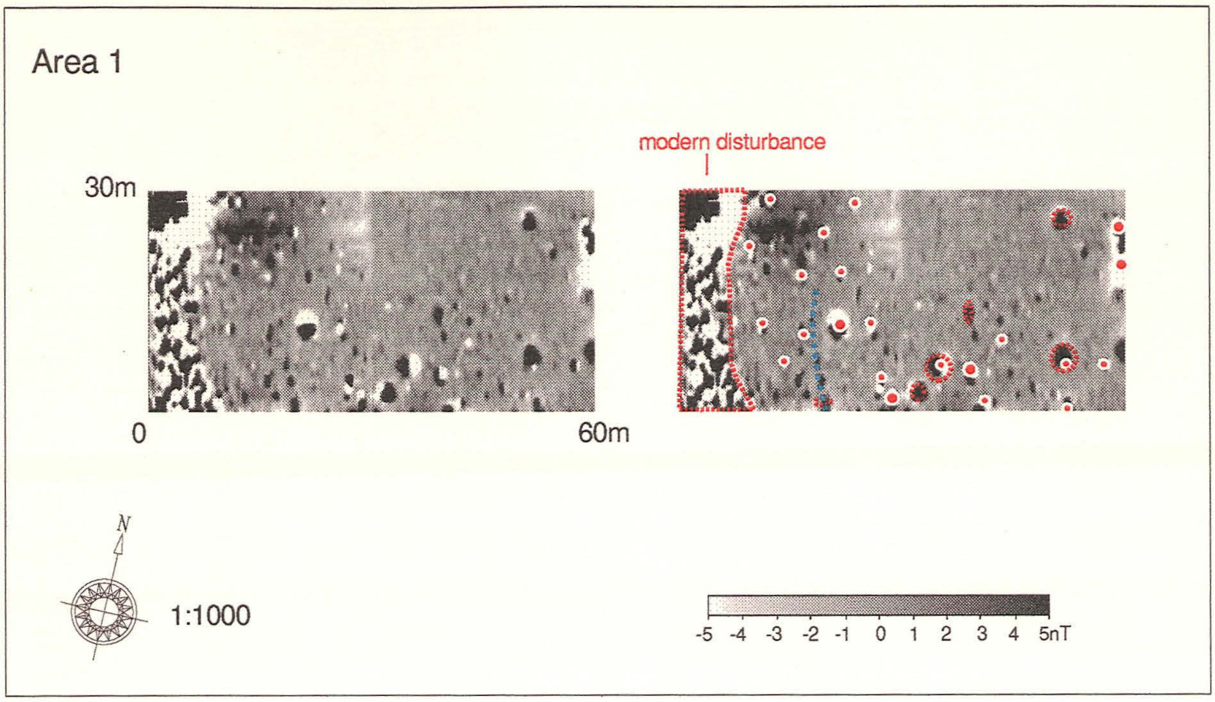


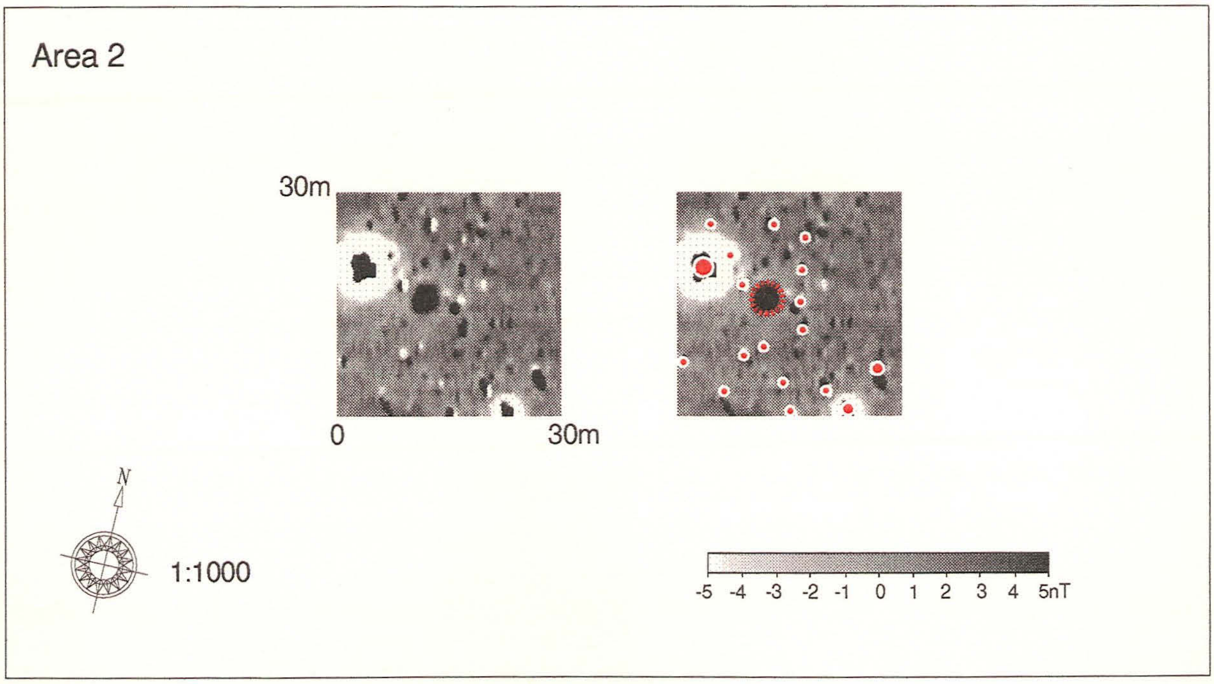
OXFORD ARCHAEOTECHNICS FIG. 4

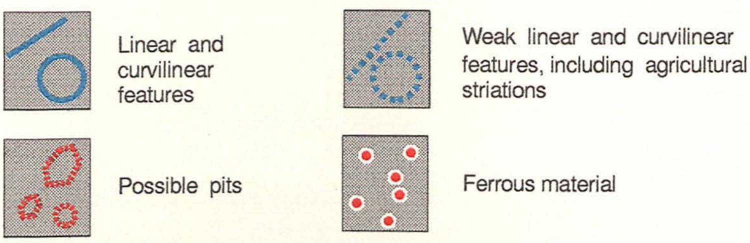
Land at Lea, Gainsborough, Lincolnshire

Topsoil Magnetic Susceptibility & Magnetometer (Gradiometer) Survey

Gradiometer Grey shade plots







OXFORD ARCHAEOTECHNICS FIG. 5

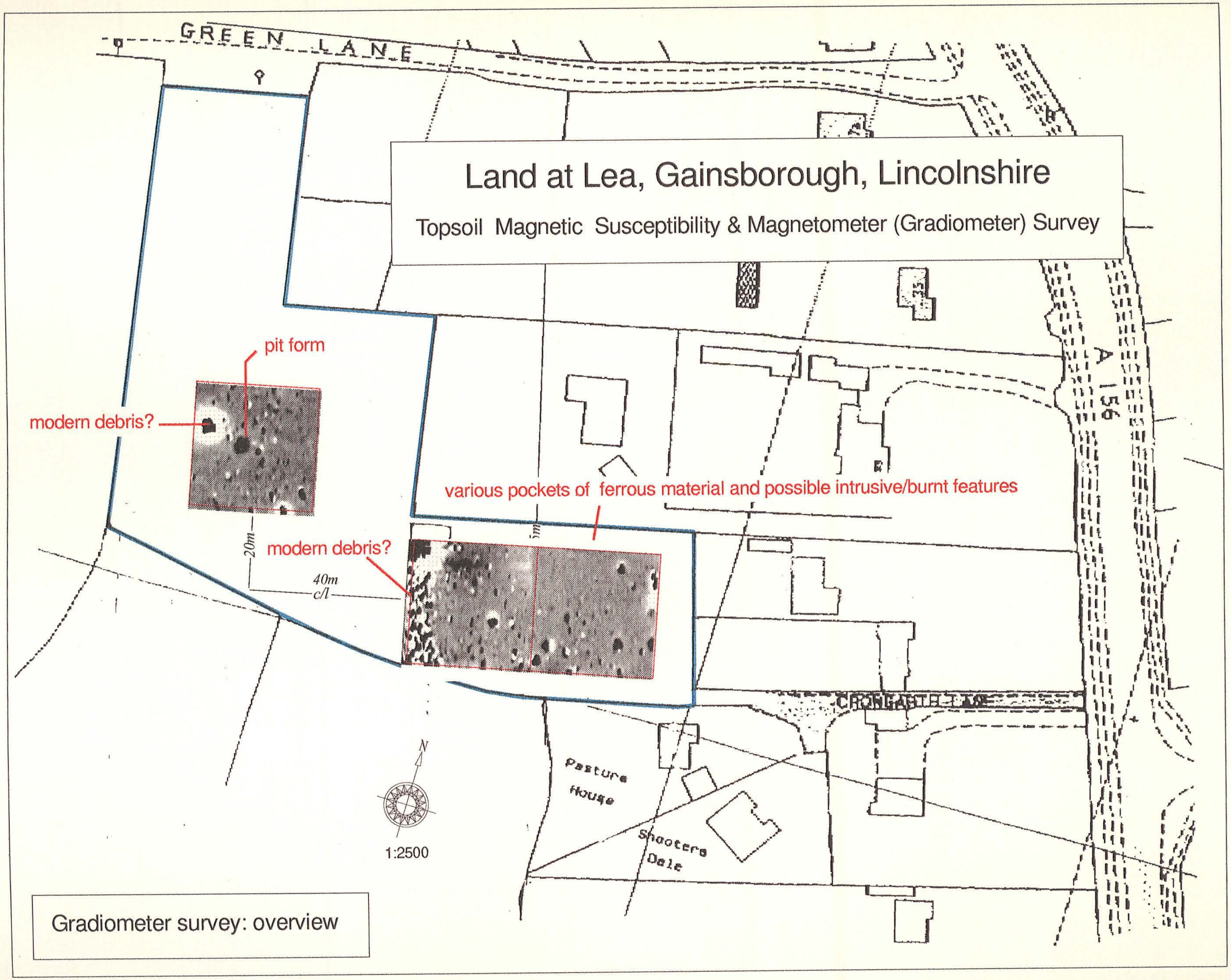


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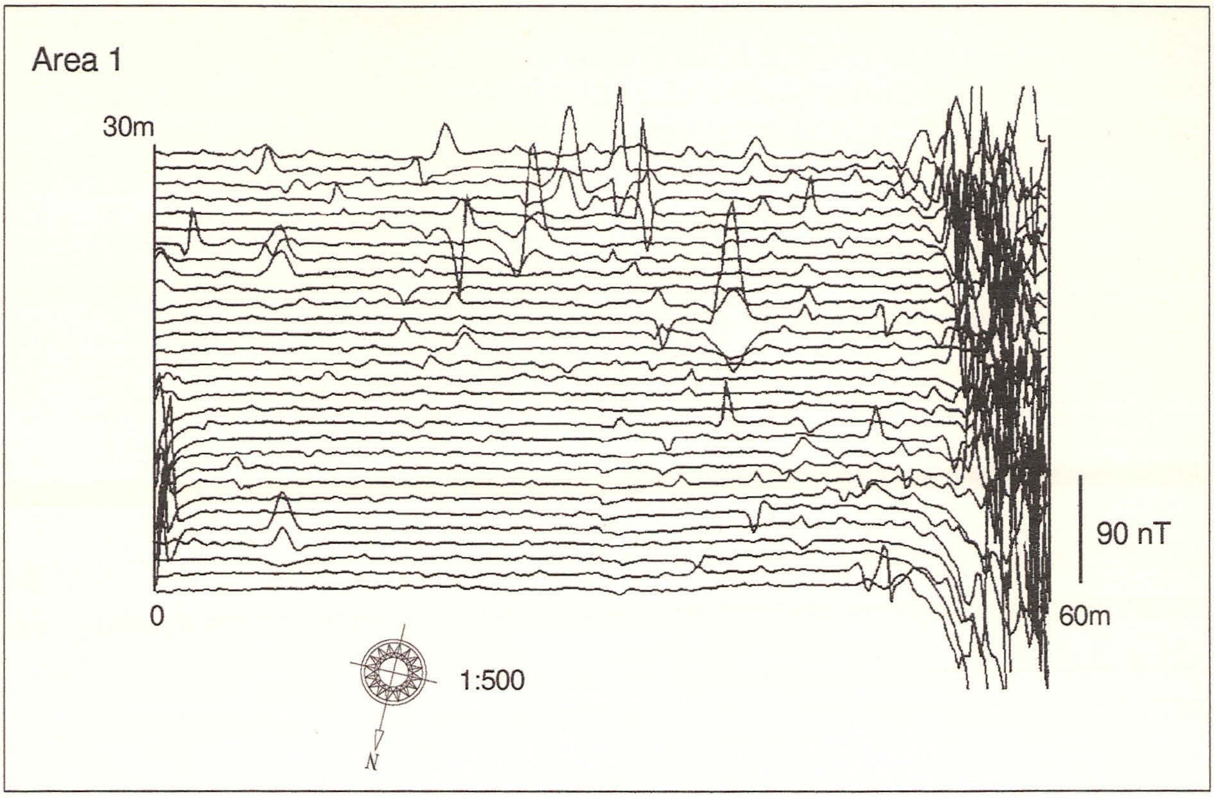
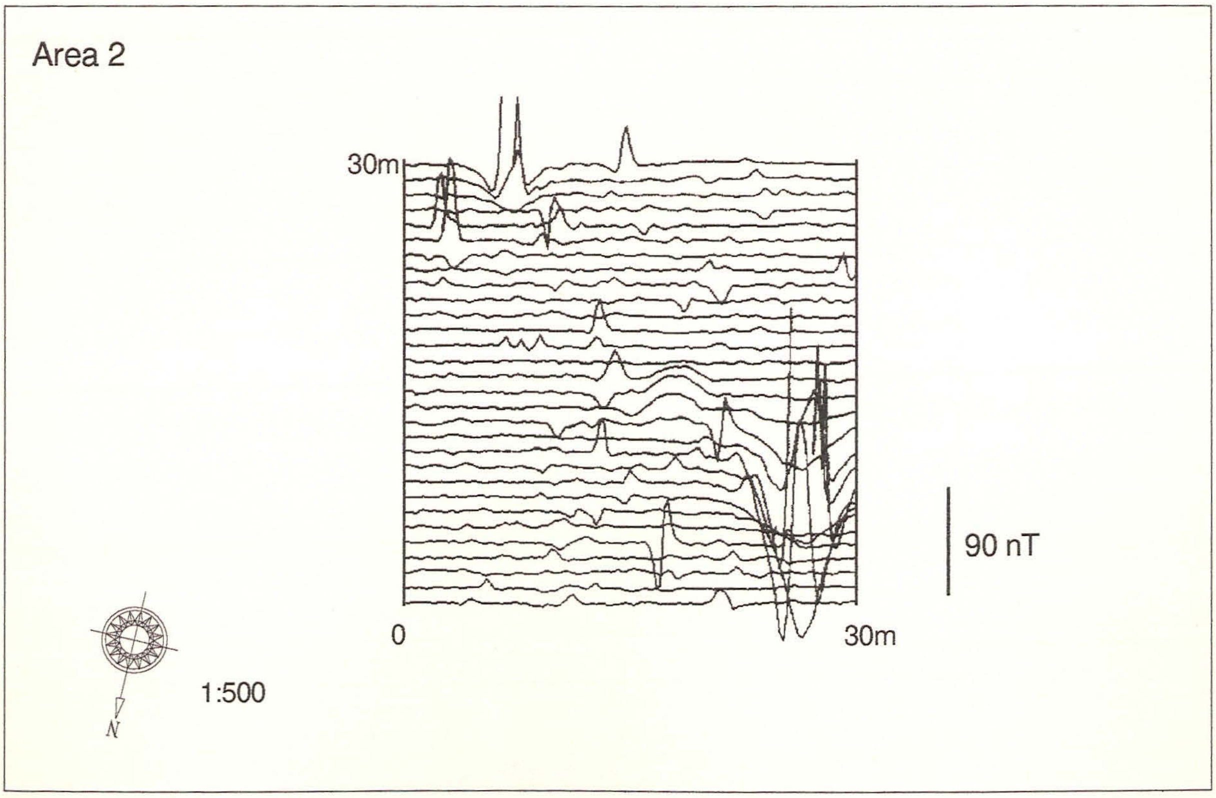
FIG. 6

Land at Lea, Gainsborough, Lincolnshire

Topsoil Magnetic Susceptibility & Magnetometer (Gradiometer) Survey

Gradiometer Stacked Trace plots





OXFORD ARCHAEOTECHNICS FIG. 7

Specialist Archaeological Field Evaluation

INTERNAL QUALITY CHECK

Survey Reference	1530698/LEL/OTT	
Primary Author		Date 17/6/98
Checked By	APJ	Date 17-6-98
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Further Corrections		Date

OXFORD ARCHAEOTECHNICS

Noke

Oxford OX3 9TX

Tel / Fax 01865 375536

Mobile 0831 383295

Email archaeotechnics@dial.pipex.com

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