ARCHAEOLOGICAL SURVEYS

GEOPHYSICAL SURVEY REPORT

Threekingham NK

Spanby, Lincolnshire

Magnetometer survey

for

Archaeological Project Services

On behalf of

Lowfields Leisure Ltd.

David Sabin and Kerry Donaldson

April 2006

Ref no. 142

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Spanby, Lincolnshire

Magnetometer survey

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Report and fieldwork by David Sabin and Kerry Donaldson

Survey date – **10th April 2006**
Ordnance Survey Grid Reference – **TF 092 371**

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SUMMARY

A magnetometer survey was carried out across approximately 1.5ha of land at Spanby in Lincolnshire. A number of linear and area anomalies were located that cannot be accurately characterised. The site contains evidence for former land drainage activity and a removed field boundary. A pair of parallel linear anomalies were located that may be consistent with former drainage ditches associated with a road or track.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys were commissioned by Archaeological Project Services (APS) on behalf of their client, Lowfields Leisure Ltd, to undertake a geophysical survey of an area of land south of Spanby in Lincolnshire, that has been outlined for a proposed leisure development. This survey formed part of an assessment of any potential archaeology that may be affected by the construction of 3 lakes within the area.

1.2 Survey objectives

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to intrusive activity relating to excavation of lakes.

1.3 Site location

1.3.1 The site is located south of the village of Spanby in Lincolnshire, Ordnance Survey (OS) grid reference TF 092 371.

1.4 Site description

1.4.1 The geophysical survey covers an area of approximately 1.5ha of agricultural land within one field that currently has short grass cover. Land boundaries are formed from mixed hedgerows and a small copse, Little Plantation, protrudes into the field from the north, see Figure 02.

1.4.2 The site lies within a shallow valley with land rising to the south, east and northeast. Drainage appears poor across much of the field with damp areas attesting to poor permeability and significant invasion by Juncus (probably compact rush).

Plate 1 Area 2 looking towards the northeast

1.5 Site history and archaeological potential

1.5.1 The site lies close to the junction of two Roman roads, Mareham Lane and the A52 Salter's Way, lying partially alongside Mareham Lane. Prehistoric flints have previously been found on the site itself. Scatters of Iron Age and Roman pottery have been found a short distance to the north, on either side of Mareham Lane. Cropmarks have also been identified in this same area. Slightly further to the northwest is an extensive complex of cropmarks of settlement remains and field systems of probable late prehistoric and Roman date. This cropmark complex extends north- south for over 2km but fades out to the south where geological conditions are not conducive to cropmark formation. Consequently, it is possible that the archaeological remains responsible for the cropmarks are more extensive than currently known (APS, 2006).

1.6 Geology and soils

1.6.1 The underlying geology solid geology is Cornbrash (BGS 2001) this is likely to be overlain with Boulder Clay deposits (BGS 1977).

1.6.2 The overlying soils across much of the site are from the Denchworth association which are pelo-stagnogley soils. These soils are generally seasonally waterlogged and agricultural regimes may be influenced by precipitation levels and drainage (Soil Survey of England and Wales 1983).

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Detailed magnetometry records localised magnetic fields that can relate to former human activity. Alteration of iron minerals present within topsoil is related to activities such as burning and the break down of biological material. These minerals become weakly magnetic within the Earth's magnetic field and can accumulate in features such as ditches and pits that are cut into the underlying subsoil. Mapping this magnetic variation can provide evidence of former settlement and land use. Additional technical details can be found in Appendix A.

2.1.2 The localised variations in magnetism are measured as sub-units of the tesla which is a SI unit of magnetic flux density. These sub-units are nanoteslas (nT) which are equivalent to 10^{-9} tesla (T). Archaeological features have a response often well below 10nT, occasionally less than 1nT, modern ferrous objects may well have a response of several thousand nT.

2.2 Equipment details and configuration

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally. The instrument is extremely sensitive and is able to measure magnetic variation to 0.1 nanoTesla (nT). All readings are saved to an integral data logger for analysis and presentation.

2.2.2 Data was collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 1995).

2.2.3 The survey grids were set out using a Topcon APL1 robotic total station and orientated in order to give coverage of target areas as set out by the landowner/developer. The survey areas were referenced using a CSI Wireless dGPS (differential Global Positioning System) with additional basic referencing to topographic features carried out with the APL1.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger is analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Each 30m by 30m grid is assembled into a composite dataset for each of the survey areas.

2.3.2 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data is always analysed and displayed in the report as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey and the order in which those functions were carried out:

- Clipping of the raw data at ±10nT to improve greyscale resolution
- Zero mean traverse is applied in order to balance readings along each traverse
- Clipping of processed data at ±3nT to enhance low magnitude anomalies
- Destagger to enhance linear anomalies
- Clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses.

2.3.3 The main form of data display used in this report is the greyscale, data is also displayed as a traceplot. Both 'raw' and 'processed' data have been plotted followed by an abstraction and interpretation plot. Graphic raster images in windows bitmap format are initially prepared in ArcheoSurveyor. These images are combined with base mapping using AutoCAD LT creating DWG file formats. All images are fully embedded within the file and not externally referenced. Although AutoCAD DWG files are a universally excepted format, the programme does not handle fully embedded graphics well and there is inevitable compromise of quality. Quality is also compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive including raster images is produced with this report allowing separate analysis if necessary, see 2.4 below.

2.3.4 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. A brief summary of each anomaly with an appropriate reference number is set out in list form within the results (Section 3), to allow a rapid assessment of features within each survey area. Where further interpretation is possible or where a number of possible origins should be considered, further more detailed discussion is set out in Section 4.

2.4 Archiving

2.4.1 This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 1.0.3.7 (geophysical data analysis)
- AutoCAD LT 2007 (report figures)
- JASC Paint Shop Pro 8 (image rotation)
- Microsoft Word 2000 (document text)
- PDF Creator version 0.9 (PDF archive).

2.4.2 Digital data is supplied on CD ROM and includes the following files:

- ArcheoSurveyor grid and composite files for all geophysical data
- CSV files for raw and processed composites
- Composite graphics as windows bitmaps
- AutoCAD DWG file in 2000 version
- Microsoft Word 2000 doc file
- PDFs of all figures
- Photographic record in JPEG format

2.4.3 The CD ROM structure is formed from a tree of directories under the title J142 Spanby – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data with data - grid, composite and graphic files and CSV composite data held in export. An additional text file lists composite coordinates in eastings and northings as derived from digital base mapping and/or dGPS measurements.

2.4.4 The CAD file contains embedded graphics as bitmaps, see 2.3.3, with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen.

3 RESULTS

3.1 General overview

3.1.1 The detailed magnetic survey was carried out over a total of two survey areas covering an area of approximately 1.5ha. Geophysical anomalies located can be generally classified as positive linear responses of possible archaeological origin, positive linear and area anomalies of an uncertain origin, linear anomalies relating to land drains and former field boundaries, areas of magnetic debris and strong dipolar anomalies relating to ferrous objects and material in the topsoil. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in section 4.

3.1.2 The brief listing of anomalies below attempts to set out a number of separate categories that reflect the range and type of likely causative features:

Anomalies with a possible archaeological origin

(Positive anomalies abstracted are plotted in red)

The category is used where archaeological features are known to have been located in immediately adjacent areas or where there are certain characteristics to an anomaly that could be consistent with an archaeological feature. Without this additional evidence the anomalies would fall within an uncertain category, see below.

Anomalies with an uncertain origin

(Positive anomalies abstracted are plotted in orange)

The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features but equally relatively modern features, geological/ pedological anomalies and agricultural features should be considered.

Anomalies with an agricultural origin

(Land drains are plotted in cyan, former field boundary in brown)

Where confidence is high that anomalies have been caused by agricultural features this category is applied. Land drains of ceramic origin often cause a characteristic response relating to their thermoremnant magnetism, they also form a series of parallel features across the survey area. Former land boundaries are indicated by linear anomalies with supporting evidence from topographic features within the survey area and on modern or historical mapping.

Ferrous anomalies and anomalies with a modern origin

(Anomalies abstracted are plotted in magenta)

The majority of magnetic anomalies fall within this category. The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables etc. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance – such disturbance can effectively obscure low magnitude anomalies if they are present. Magnetic debris often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other ferrous objects (occasionally magnetic debris may be associated with kilns, furnace structures or hearths and may therefore be archaeologically significant). Iron objects such as agricultural parts, horseshoes, fencing material etc. can cause discrete dipolar anomalies and are usually not archaeologically significant. Former bonfire sites may also produce magnetic debris and disturbance.

3.2 Area 1

Area centred on OS NGR 509193, 337135 see Figures 3-6.

Anomalies with an uncertain origin

(1) – Positive linear anomaly orientated southwest to northeast and probably extending beyond the survey area. This may represent a cut feature.

(2) – Fragmented linear anomalies that may be related to agriculture or drainage.

(3) – Faint linear anomalies of uncertain origin but may be associated with other nearby anomalies.

(4) – Possible curving linear anomaly with a faint curving area anomaly of amorphous form that may be associated.

(5) – Discrete area anomalies with pit-like characteristics.

Ferrous anomalies

There are a large number of discrete dipolar responses across the survey area which are probably related to ferrous objects near the surface.

3.3 Area 2

Area centred on OS NGR 509385, 337295 see Figures 3-6

Anomalies with a possible archaeological origin

(6) – A parallel pair of positive linear anomalies approximately 7m apart having a length within the surveyed area of approximately 105m. The anomalies are orientated approximately east – west and are very likely to extend beyond the surveyed area to the west. At the eastern end the anomalies appear to fade close to a former field boundary. Although the anomalies may relate to former land drainage or reorganisation of field boundaries an archaeological origin should be considered.

Anomalies with an uncertain origin

(7) – A faint positive linear anomaly is of uncertain origin although may be related to former ploughing.

Anomalies with an agricultural origin

(8) – A series of linear anomalies cross the survey area and are characteristic of ceramic land drains.

(9) – A faint positive linear anomaly correlates with a linear earthwork crossing the survey area. This is a response to a former field boundary that was certainly present on 19th century mapping and can be seen to be associated with a kink in the hedgerow to the north.

Ferrous anomalies

(10) - A large area of magnetic debris has a very strong response over 3000nT which is indicative of a large ferrous object or objects. The anomaly occurs on the line of a former field boundary and it is suggested that this is either material dumped to infill a ditch or possibly the position of a former gateway where the ground has been made up by dumping.

There are a large number of discrete dipolar responses across the survey area which are probably related to ferrous objects near the surface.

4 DISCUSSION

4.1 Area 1

4.1.1 The area contains a number of anomalies of uncertain origin which appear fragmented, variable in magnitude and amorphous. There are no characteristics associated with these anomalies that allow for an accurate interpretation of their origin. The area is at the base of a shallow valley and the form of the local topography suggests that this area would effectively receive water draining land to the east and south, it is therefore possible that the anomalies are associated with land drainage attempts in a particularly wet area.

4.2 Area 2

4.2.1 Parallel positive linear anomalies crossing the survey area may represent former cut features and their characteristics suggest a possible track or road although land drainage or former boundary ditches should also be considered. The separation between the anomalies of around 7m is fairly consistent along the length of the feature and each linear is notably straight – such anomalies could be consistent with drainage channels either side of a Roman road as the width would certainly fall within the range expected for these features. The anomalies appear to stop within the survey area at a point where the gradient of the field starts to increase and the soil becomes drier; it is therefore tentatively speculated that drainage channels may only have been required on the lower poorly drained area and that the track may continue to the east.

4.2.2 A linear anomaly crossing the survey area from north to south is likely to be a former land boundary that has been removed relatively recently. The boundary appears on 19th century OS mapping of the area (Old Maps, 2006) and there is a distinct bank an increase in grass growth associated with the feature. It is also likely that there has been some dumping of ferrous material in a ditch associated with the boundary.

5 CONCLUSION

5.1 A number of anomalies were located by the magnetometry survey that do not have characteristics that allow for confident and accurate interpretation, a range of origins should be considered such as agricultural drainage, plough marks, natural features etc. Other linear anomalies have been confidently interpreted as land drainage and a former field boundary.

5.2 Two parallel positive anomalies crossing Area 2 probably represent former cut features and it is suggested that there are characteristics associated with this pair that may be consistent with a former track or road.

6 REFERENCES

APS, 2006, Background literature supplied by Archaeological Project Services.

British Geological Survey, 1977, *Geological Survey Ten Mile Map, South Sheet, First Edition (Quaternary),* Scale 1:625 000.

British Geological Survey, 2001, *Solid Geology Map, UK South Sheet, 1:625 000 scale, 4th edition.*

English Heritage, 1995, *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No 1.*

Old Maps, 2006, [online] http://www.old-maps.co.uk/

Soil Survey of England and Wales, 1983, *Soils of England and Wales, Sheet 4 Eastern England.*

Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field on cooling.

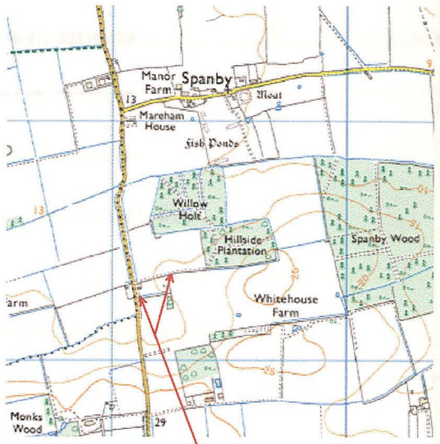
Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with the surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength of magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.



Survey areas

N

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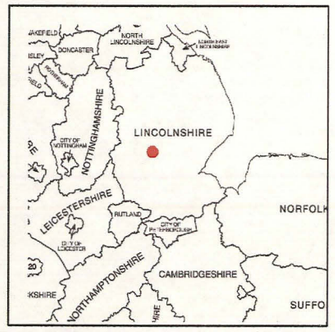
Map of survey area



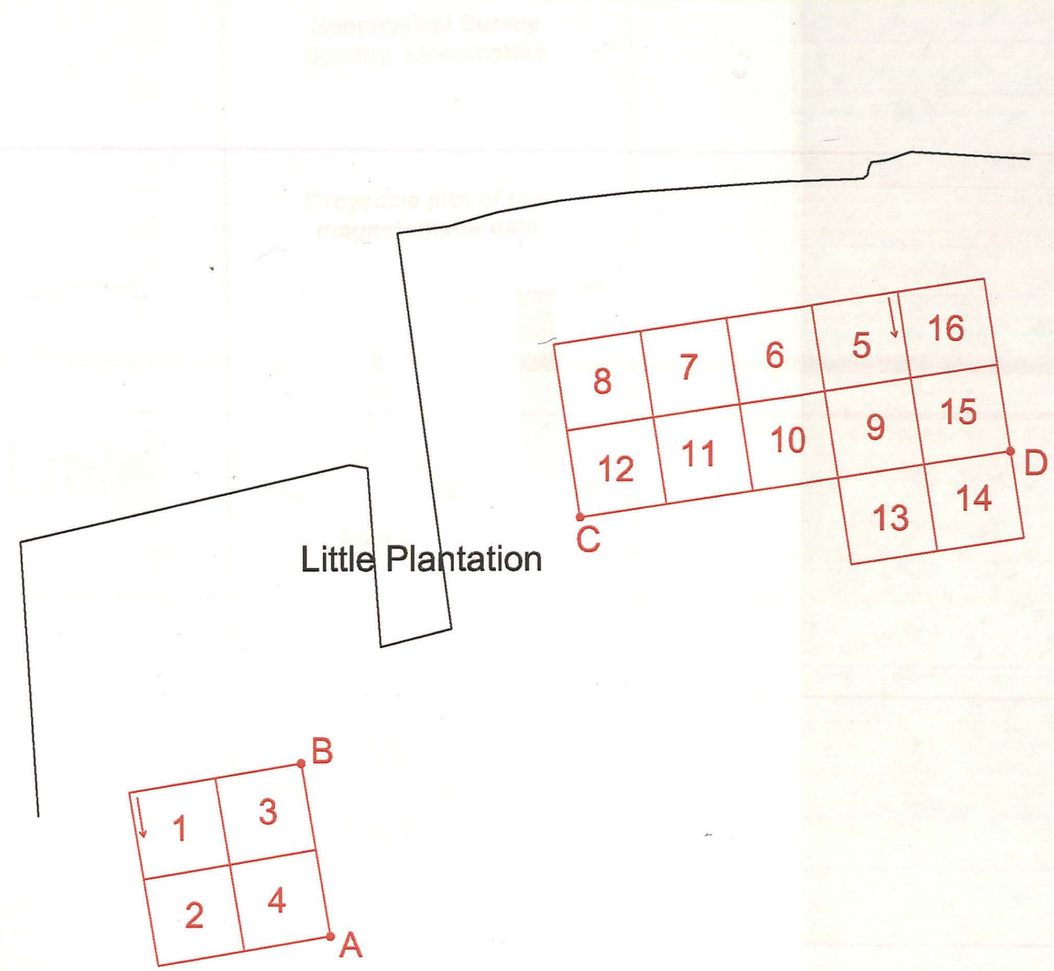
Survey location

Site centred on OS NGR
TF 092 371

SCALE 1:25 000

0m 500m 1000m

FIG 01



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Referencing information

Based on OS coordinates (OSGB36)

A 509228.35, 337110.82

B 509218.41, 337169.99

C 509314.35, 337254.09

D 509462.65, 337276.58

DGPS coordinates - positional accuracy better than 1m

Survey start and traverse direction

SCALE 1:2000

0m 20 40 60 80 100m

FIG 02

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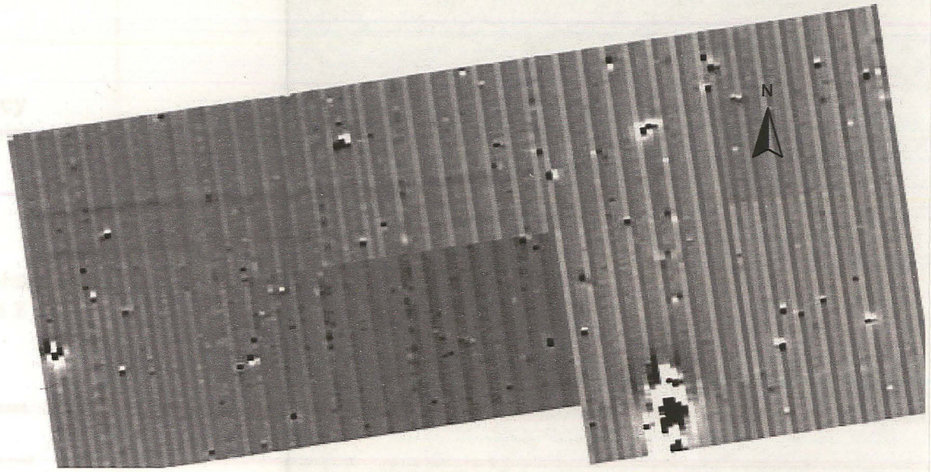
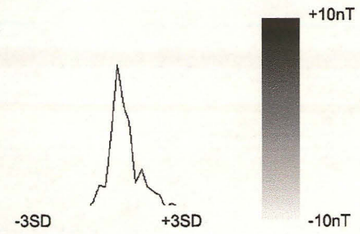
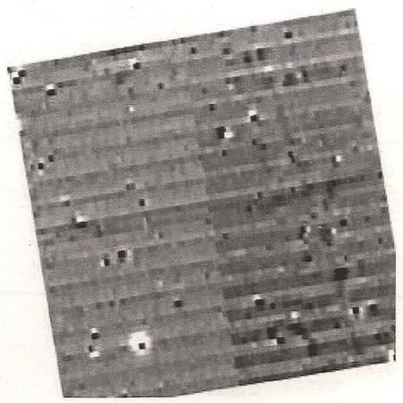
Greyscale plot of raw magnetometer data

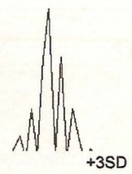




Area 1

Little Plantation





Area 2

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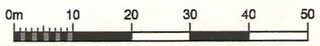
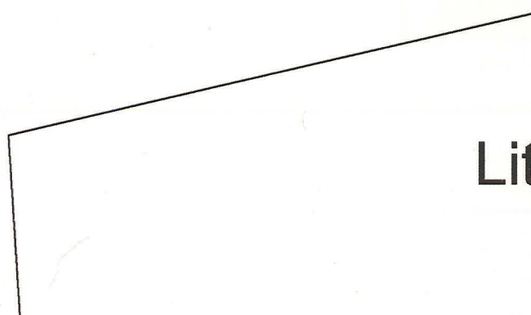
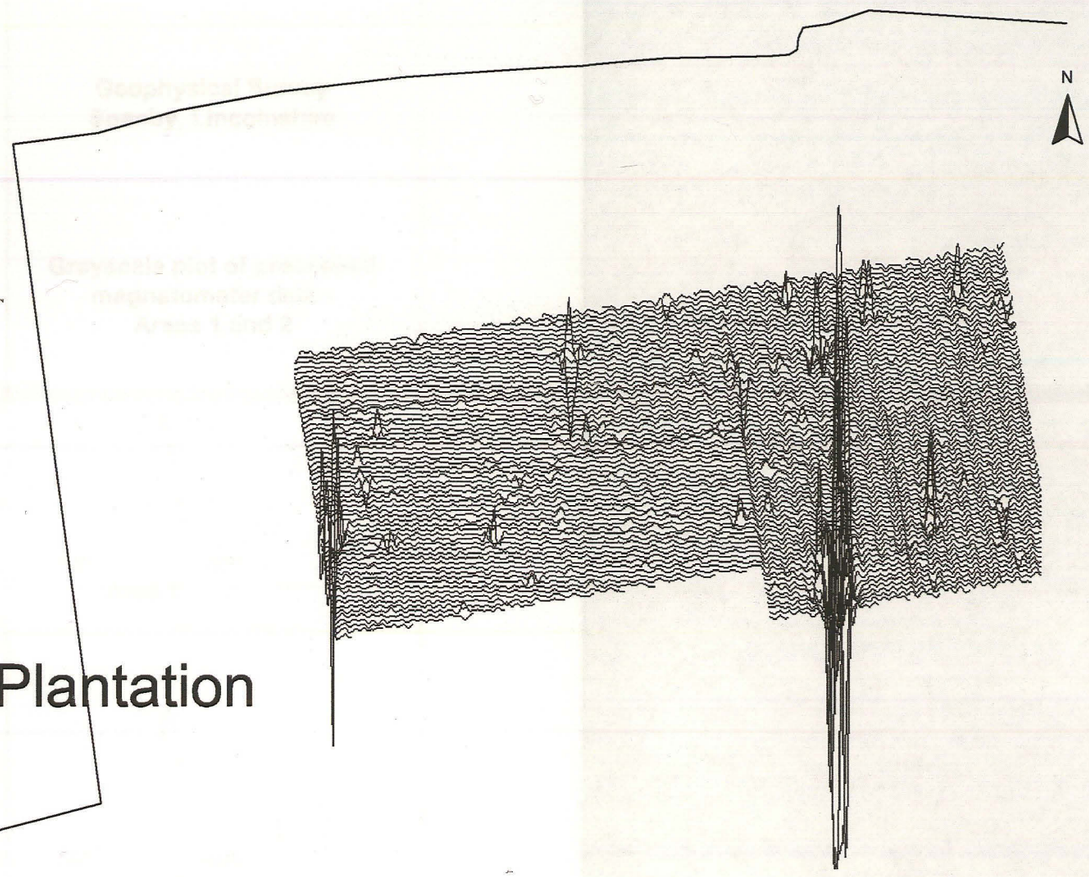
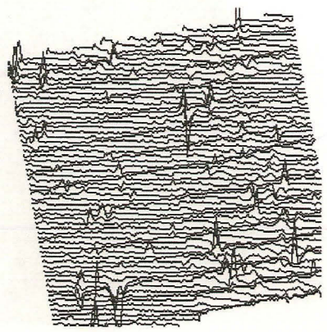


FIG 03







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Traceplot of raw magnetometer data - Areas 1 and 2

+40nT
+20nT
0nT
-20nT
-40nT

approx 20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 04

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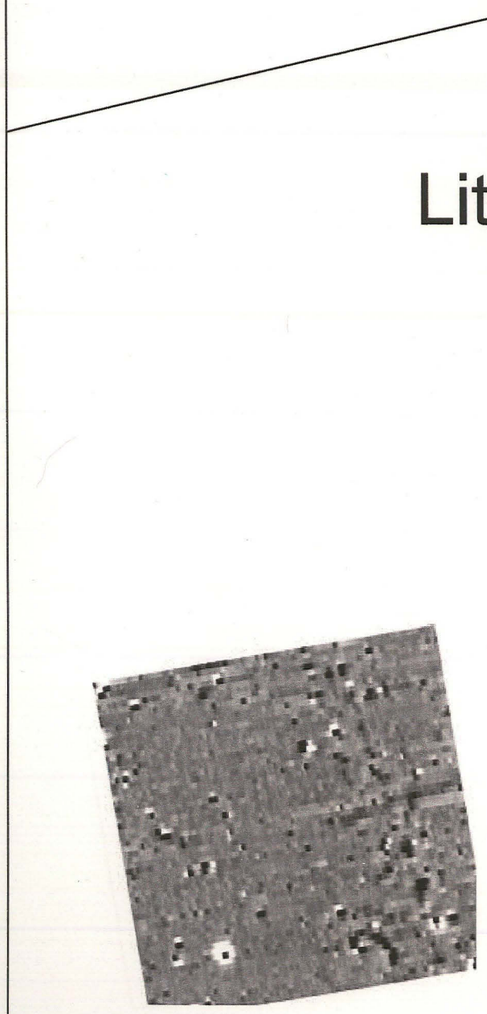
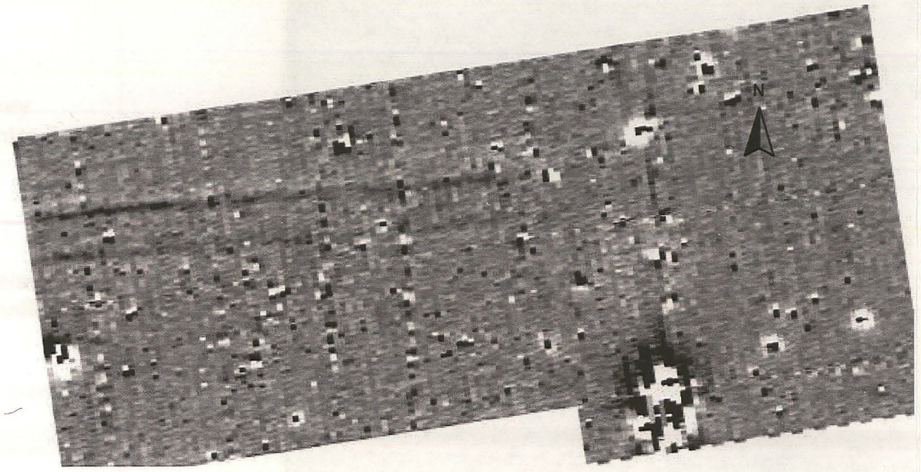
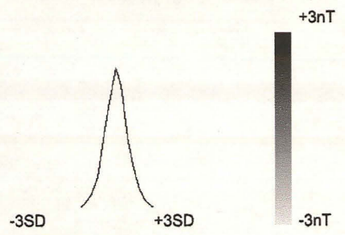
Greyscale plot of processed magnetometer data - Areas 1 and 2







Area 1

Area 2

SCALE 1:1000

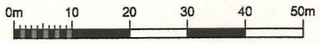


FIG 05

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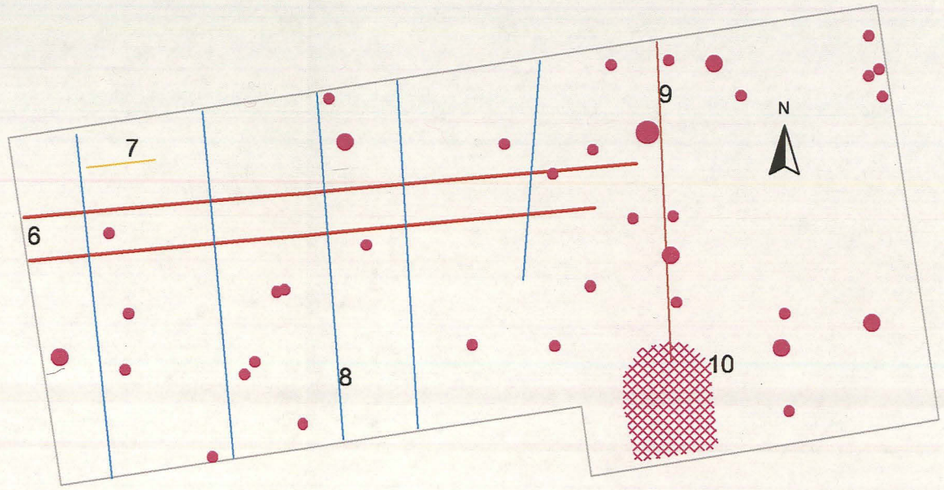
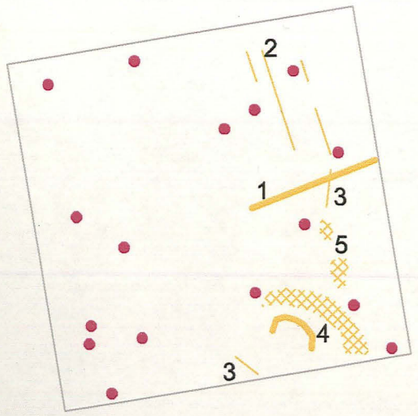
Abstraction and interpretation of magnetometer anomalies



Little Plantation



- Positive linear anomaly - cut feature of possible archaeological origin
- Positive linear anomaly - uncertain origin
- Linear anomaly - probable land drain
- Linear anomaly - former field boundary
- Positive area anomaly - uncertain origin
- Magnetic debris - spread of thermoremnant material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

FIG 06