Archaeological Services WYAS

Hatfield Lane
Doncaster
South Yorkshire

Geophysical Survey

Report no. 2549

December 2013

Client: Regent Park Energy Limited

Registered Organisation IfA

Hatfield Lane
Doncaster
South Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 2 hectares was carried out on land immediately east of Hatfield Lane, east of Edenthorpe, to inform the determination of an outline planning application for the proposed development of the site. Linear anomalies, indicative of soil-filled ditches, forming two small enclosures, one with possible internal sub-divisions, have been identified. Linear ditch type anomalies are probably part of a wider system of land division previously identified as cropmarks. The geophysical survey has not recorded all the cropmark features but, conversely, has identified some probable features not previously seen as cropmarks. Part of the proposed area was unsuitable for survey due to the presence of a potato crop. On the basis of the magnetic survey the archaeological potential of the site is considered to be high.

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Report Information

Client:	Regent Park Energy Limited
Address:	Edwinstowe House, High Street, Edwinstowe, Nottinghashire, NG21 9PR
Report Type:	Geophysical Survey
Location:	Hatfield Lane, Doncaster
County:	South Yorkshire
Grid Reference:	SK 6320 0644
Period(s) of activity:	Iron Age/Romano-British
Report Number:	2549
Project Number:	4090
Site Code:	HLD13
OASIS ID:	archaeol11- 166534
Planning Application No.:	
Museum Accession No.:	n/a
Date of fieldwork:	July 2013
Date of report:	December 2013
Project Management:	Alistair Webb BA MIfA
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Photography:	Site Staff
Research:	n/a

Authorisation for distribution: --

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Cert. No. 125

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Regent Park Energy Limited (the Client), to undertake a geophysical (magnetometer) survey of land off Hatfield Lane, Doncaster (see Fig. 1), prior to the determination of a planning application for the proposed development of the site. The work was undertaken in accordance with a Project Design (Sykes, 2013) supplied to and approved by Andy Lines of the South Yorkshire Archaeology Service (SYAS), in his capacity as archaeological advisors to Doncaster Metropolitan Borough Council, with guidance contained within the National Planning Policy Framework (2012) and in line with current best practice (David *et al* 2008). The survey was carried out on July 11th 2013 in order to provide additional information on the archaeological potential of the site.

Site location, topography and land-use

The Proposed Development Area (PDA) comprises an irregularly shaped piece of agricultural land, centred at SK 6320 0644, immediately east of Hatfield Lane (see Fig. 2), covering an area of approximately 2.8 hectares. Agricultural land extends to the north, south and east of the PDA. The site is flat at approximately 10m above Ordnance Datum (aOD). Although comprising a single parcel of land the PDA was under three different planting regimes. The south-eastern third of the PDA was under a low growing brassica crop with carrots planted across the middle of the site. Potatoes were planted to the north-west of the PDA. The density of the potato plants and the ridged up soil around the growing tubers prohibited survey in this part of the site (see Plate 3).

Soils and geology

The underlying bedrock comprises Permian and Triassic sandstone (British Geological Survey 2013) which are overlain by sandy soils of the Cuckney 2 and Newport 1 soil associations (Soil Survey of England and Wales 1983). There are no recorded superficial deposits.

2 Archaeological Background

The proposed development area is located in a landscape of archaeological potential predominantly known for its cropmark field systems of the brickwork type. The Edenthorpe landscape is typical of the ‘brickwork’ type which comprise large rectilinear field systems of Late Iron Age and Roman date. These cropmarks extend into and across the PDA from the north (see Fig. 2). Consequently the archaeological potential of the site is considered to be high.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of potential sub-surface archaeological remains and for further evaluation or mitigation proposals, if appropriate, to be recommended. To achieve this aim a magnetometer survey covering all of the PDA that was suitable for survey, was carried out, an area of 1.8 hectares.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). Bartington Grad601 magnetic gradiometers were used during the survey, taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids, so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 is a large scale (1:3000) location plan displaying the processed greyscale magnetometer data. Figure 3 is an overall data interpretation plot at the same scale. Figures 4 and 5 display the magnetic data in processed (greyscale) and minimally processed (X – Y trace plot) format at a scale of 1:1000. Figure 6 is an interpretation of the recorded anomalies at the same scale.

Further technical information on the equipment used, data processing and survey methodologies is given in Appendix 1 and Appendix 2. Appendix 3 describes the composition and location of the site archive.

The survey methodology, report and any recommendations comply with the Project Design (Sykes 2013) and guidelines outlined by English Heritage (David *et al* 2008) and by the Institute for Archaeologists (IfA 2011). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion (see Figs 4, 5 and 6)

The anomalies identified by the survey fall into a number of different types and categories according to their origin and these are discussed below and cross-referenced to specific examples and locations within the site.

Ferrous Anomalies

Ferrous responses, either as individual 'spike' anomalies or more extensive areas of magnetic disturbance, are typically caused by modern ferrous (magnetic) debris, either on the ground surface or in the plough-soil, or are due to the proximity of magnetic material in field boundaries, buildings or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation as ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the PDA individual iron 'spike' anomalies are common but there is no obvious pattern or clustering to their distribution to suggest anything other than a random background scatter of ferrous debris in the soil.

An extensive area of magnetic disturbance is recorded along the south-western edge of the survey area. This disturbance is caused by the proximity of an electricity pylon (see Plate 1). Any weaker anomalies within a radius of at least 25m of the pylon base would be 'masked' by the high magnitude readings caused by this steel structure.

Geological Anomalies

Throughout the survey area numerous discrete anomalies are identified giving the data a 'speckled' appearance. This effect is most obvious to the south-eastern corner of the site where the effects of the agricultural regime (see below) are minimal. These anomalies are interpreted as being caused by variations in the composition of the soils. However, it is not possible to discriminate between anomalies caused by natural geological variation and those that may have an archaeological origin. Therefore those that are located within the enclosure (described below) have been interpreted as of possible archaeological potential based on their location.

Agricultural Anomalies

Strong linear trends in the data, aligned south-west/north-east, to the north-western part of the survey area are caused by the low cultivation ridges of soil around the carrot crop.

Archaeological and ?Archaeological Anomalies

Against this variable magnetic background, caused by the soils and the effects of the agricultural regime, several other linear anomalies have been identified. These are interpreted as being caused by soil-filled features, predominantly ditches, forming small enclosures and possibly part of an associated field system.

Magnetic anomalies defining two separate enclosures are clearly identified. To the west a rectangular enclosure, **E1**, measuring approximately 50m by 35m, can be seen. All except the southern side of the enclosure were previously identified as cropmarks (see Fig. 3). A break in the magnetic response, **A**, on the eastern side of the enclosure may locate an entrance into the enclosure, protected by an overlapping ditch anomaly, **B**, approximately 8m further to the east. Anomaly **B** has not previously been identified as a cropmark.

Forty metres to the east a second enclosure, **E2**, is located. Linear anomalies, **C** and **D**, suggest that the enclosure was partitioned. As with **E1** the northern and western sides of the enclosure were visible as cropmarks whilst the eastern side and internal divisions were not.

Numerous discrete anomalies within both enclosures have been interpreted as possibly archaeological. As discussed above some or all of these anomalies are likely to have a geological origin but are indistinguishable from archaeological features, such as pits, and so due to their location within the enclosures have been interpreted as potentially archaeological.

5 Conclusions

The results of the survey clearly demonstrate the presence of sub-surface archaeological features within the survey area and that the archaeological remains are more extensive than suggested by the cropmark evidence. Interestingly some of the cropmarks do not manifest as magnetic anomalies. It is not clear at this stage whether the features causing the cropmarks that have not been detected have been truncated since the air photographs (on which they were first identified) were taken or whether a combination of poor ‘visibility’, due to the agricultural regime, and the lack of a strong magnetic susceptibility contrast between the fill of the archaeological features and the surrounding soils accounts for the non-detection of these features. On the basis of the geophysical survey the archaeological potential of the site is assessed as high.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

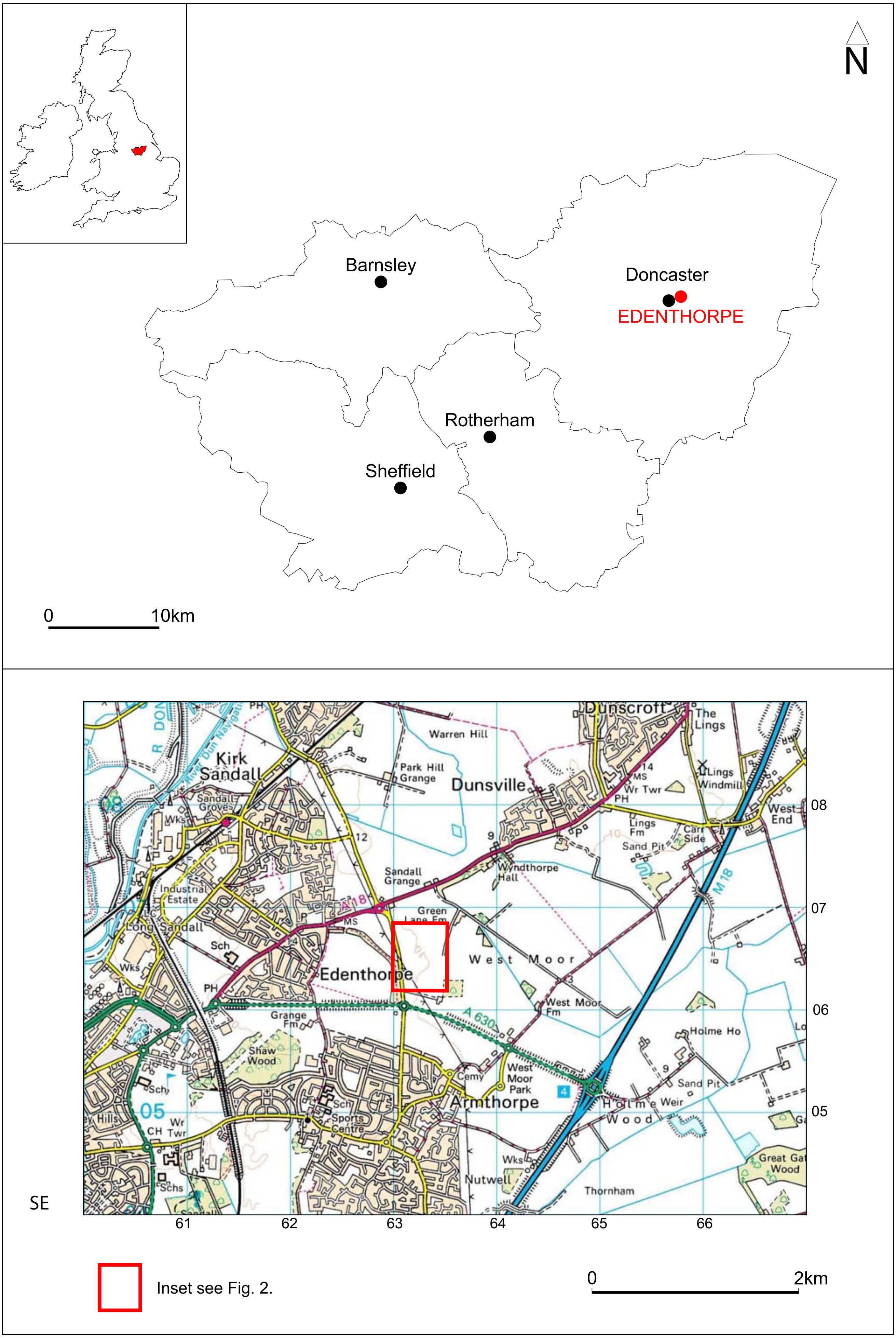

Fig. 1. Site location

Fig. 2. Survey location showing magnetometer data and cropmark detail (1:3000 @ A4)

Fig. 3. Overall interpretation of magnetometer data showing cropmark detail (1:3000 @ A4)

0 50m

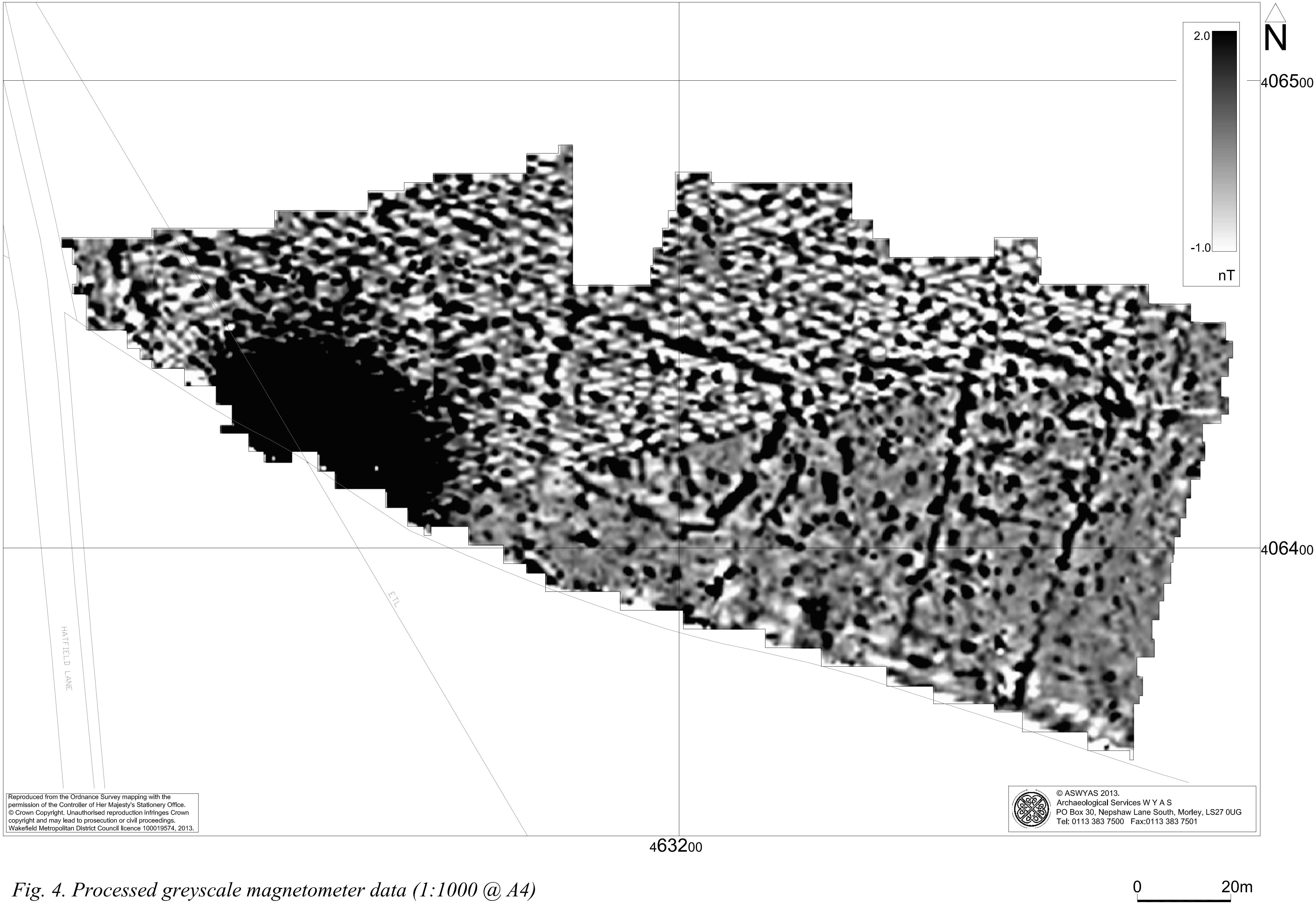

Fig. 4. Processed greyscale magnetometer data (1:1000 @ A4)

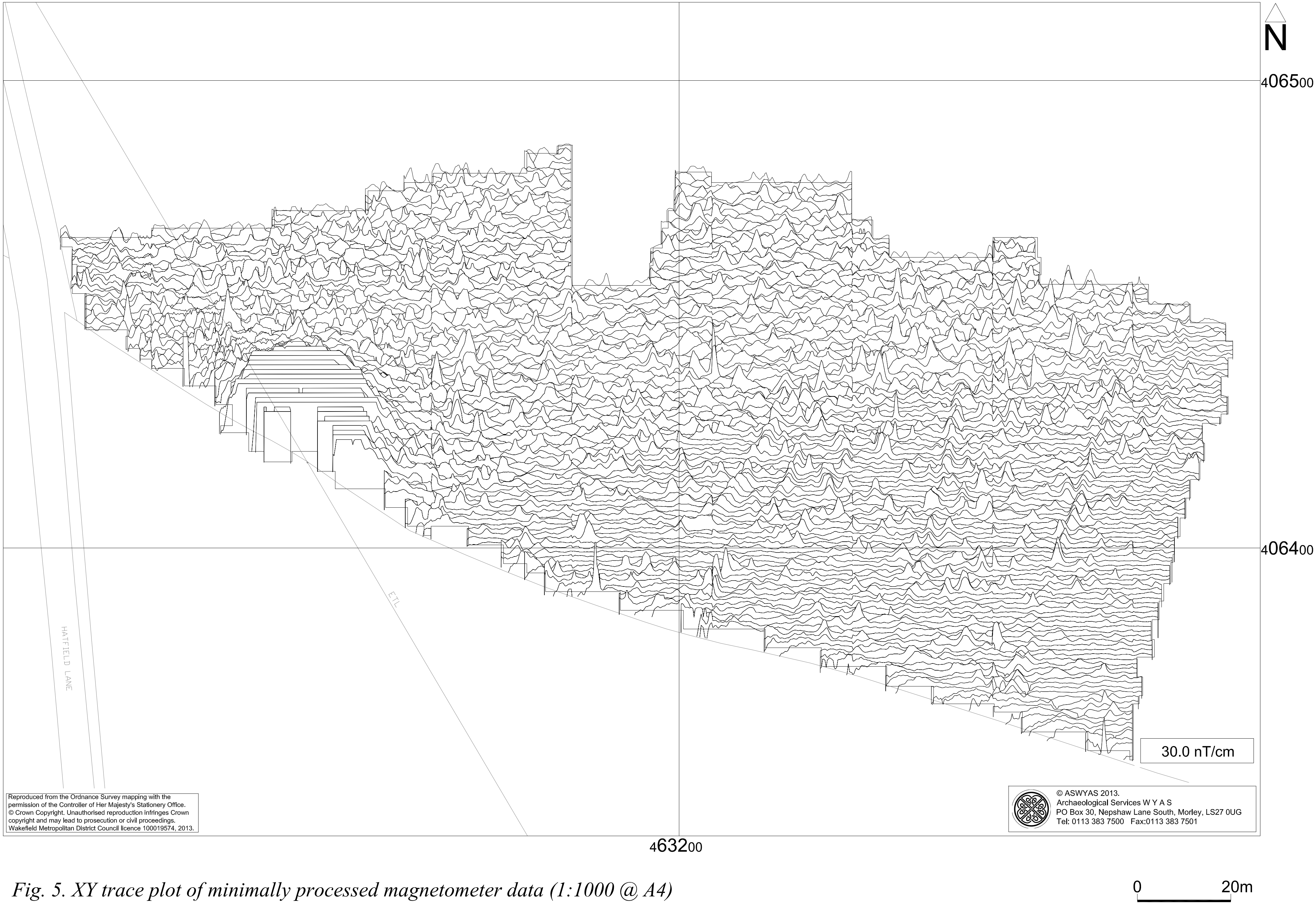

Fig. 5. XY trace plot of minimally processed magnetometer data (1:1000 @ A4)

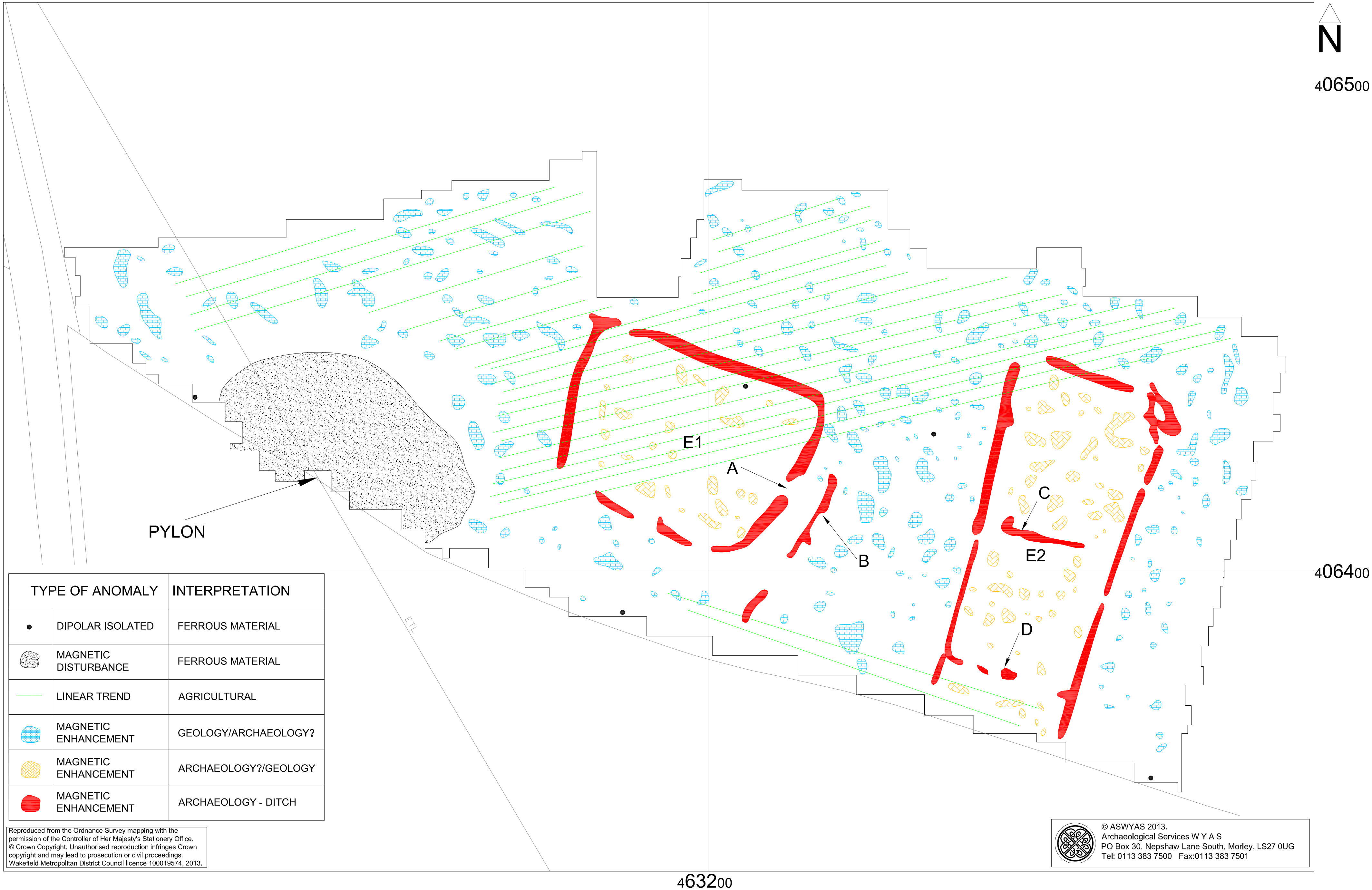

Fig. 6. Interpretation of magnetometer data (1:1000 @ A4)

Plate 1. General view of surveyed area, looking north-west

Plate 2. General view of surveyed area, looking north-east

Plate 3. General view of area unsuitable for survey

Appendix 1: Magnetic survey - technical information

Magnetic Susceptibility and Soil Magnetism

Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. The magnetic susceptibility of a soil can also be enhanced by the application of heat and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough. An advantage of magnetic susceptibility over magnetometry is that a certain amount of occupational activity will cause the same proportional change in susceptibility, however weakly magnetic is the soil, and so does not depend on the magnetic contrast between the topsoil and deeper layers. Susceptibility survey is therefore able to detect areas of occupation even in the absence of cut features. On the other hand susceptibility survey is more vulnerable to the masking effects of layers of colluvium and alluvium as the technique, using the Bartington system, can generally only measure variation in the first 0.15m of ploughsoil.

Types of Magnetic Anomaly

In the majority of instances anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

Methodology: Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample. For field surveys a Bartington MS2 meter with MS2D field loop is used due to its speed and simplicity. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

Methodology: Gradiometer Survey

There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as ***magnetic scanning*** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey.

The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect. The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected. If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features. The possible drawbacks mentioned above mean that a ‘negative’ scanning result should be validated by sample detailed magnetic survey (see below).

The second method is referred to as ***detailed survey*** and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m square grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

An XY plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a 'stacked' plot. A hidden line algorithm has been employed to block out lines behind major 'spikes' and the data has been clipped. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the 'shape' of individual anomalies can be discerned and potentially archaeological anomalies differentiated from 'iron spikes'. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better then 0.01m. The survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files; and
- a full copy of the report.

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the South Yorkshire Historic Environment Record).

Bibliography

British Geological Survey, 2013. www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html . (Viewed December 10th 2013)

David, A., N. Linford, P. Linford and L. Martin. 2008. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines (2nd edition)* English Heritage

Institute for Archaeologists, 2010. *Standard and Guidance for archaeological geophysical survey.* IfA

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

Sykes, C. 2013. Hatfield Lane, Doncaster, South Yorkshire: Geophysical Survey Project Design Unpublished ASWYAS Document