ARCHAEOLOGICAL SERVICES WYAS

High Boar Windfarm
Harrogate
North Yorkshire

Geophysical Survey

Report no. 2413

November 2012

Client: WYG Environment Planning Transport Ltd

REGISTERED ORGANISATION IfA

High Boar Windfarm
Harrogate
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 25 hectares, was carried out at the proposed site of a windfarm to the west of Harrogate. Anomalies due to field drains, a former field boundary and variation in the superficial till deposits have been identified. No anomalies of obvious archaeological potential have been identified. On the basis of the geophysical survey, the site is considered to have a low potential for currently unknown archaeological features or deposits.

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Report Information

Client:	WYG Environment Planning Transport Ltd
Address:	Arndale Court, Headingley, Leeds, LS6 2UJ
Report Type:	Geophysical survey
Location:	High Boar, Harrogate
County:	North Yorkshire
Grid Reference:	SE 252 555
Period(s) of activity: represented	-
Report Number:	2413
Project Number:	3969
Site Code:	HBH12
OASIS ID	archaeol11-138445
Planning Application No.:	12/03934/EIAMAJ
Museum Accession No.:	n/a
Date of fieldwork:	October 2012
Date of report:	November 2012
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Photography:	David Harrison
Research:	n/a

Authorisation for distribution: ---

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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Kirsten Holland, Principal Consultant at WYG Environment Planning Transport Ltd, on behalf of their client Tapar PF Ltd, to carry out a geophysical (magnetometer) survey as part of pre-determination work to inform a planning application for a proposed windfarm at High Boar, near Harrogate, North Yorkshire (see Fig. 1). The results of the survey will help assess the extent of the archaeological resource. The scheme of work was undertaken in accordance with guidance contained with the National Planning Policy Framework (2012) and to a Written Scheme of Investigation (WSI) produced by the client (WYG 2012a). The survey was carried out between October 1st and October 12th 2012. The land was waterlogged throughout the duration of the survey.

Site location, topography and land-use

The proposed development area (PDA) occupies a large block of agricultural land situated immediately to the south of Penny Pot Lane, just to the west of Harrogate, and is centred at SE 251 555 (see Fig. 2). The site comprises several fields, all of which are under permanent pasture (see Plates 1-6), situated along the eastern end of a ridge ranging in height between 180m above Ordnance Datum (aOD) and 195m aOD. The survey comprised the whole of the PDA in order to maintain flexibility for the final design layout.

Geology and soils

The underlying bedrock geology comprises Lower Follifoot Grit, a sandstone overlain by superficial deposits of Devensian till (British Geological Survey 2012). The soils are classified in the Wilcocks 1 association being characterised as slowly permeable, seasonally waterlogged, fine loam and fine loams over clay (Soil Survey of England and Wales 1983).

2 Archaeological Background

An archaeological desk-based assessment of the site and surrounding area concluded that there are no known archaeological features or deposits within the PDA and that there was only one recorded heritage site within the overall study area, namely the Forest of Knaresborough (WYG 2012b). There was considered to be some potential for currently unknown features within the PDA with the highest perceived potential being for features dating to the medieval or post-medieval periods and relating to Haverah Park where a number of undated enclosures have been identified.

To the west of the PDA and north of Penny Pot Lane, at Knabs Ridge Windfarm, situated at *c*. 215 aOD, an archaeological investigation was carried out by Archaeological Services University of Durham (ASUD 2005). This identified a limited number of undated features that are thought to indicate the presence of archaeological activity in this general region.

A geophysical survey has recently been completed on another proposed windfarm, Penny Pot Windfarm that immediately adjoins this site to the west (Webb 2012). No anomalies of archaeological potential were identified by this survey and the site was assessed as having a low archaeological potential. Two anomalies of uncertain origin were noted, although a modern cause for both, rather than archaeological, was considered more likely.

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 the proposed development on any potential archaeological remains and for mitigation proposals, if appropriate, to be recommended. To achieve this aim, a magnetometer survey covering the whole of the PDA was carried out.

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

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 Ordnance Survey map, is shown in Figure 1. Figure 2 is a large scale (1:7500) site location plan showing the greyscale magnetometer data. Figure 3 shows the interpretation of the data across the whole site at a scale of 1:2500. The site has been divided into four sectors and the processed and minimally processed data, together with interpretation graphics of the survey results are presented in Figures 4 to 15 inclusive, at a scale of 1:1000.

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

Archaeological Services WYAS is registered with the Online Access to the Index of archaeological investigations project (OASIS). The OASIS ID for this project is archaeol11-138445.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2010). 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 (see Figs 4-15 inclusive)

Ferrous anomalies

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

Areas of magnetic disturbance are noted at several locations, primarily bordering tracks/roads or along, and at the junction of, field boundaries. These areas of anomalous response are not considered to be of any archaeological potential being due to the proximity of magnetic material in the boundary itself or to the accumulation of ferrous debris along the edges of fields.

Agricultural anomalies

Parallel linear trend anomalies have been identified at two locations. In the north-west of the site (Sector 1) they are aligned south-west/north-east and in the south-west corner of the site (Sector 3) the trends are aligned north-west/south-east. In both instances the regular spacing and the very straight nature of the anomalies suggests that these anomalies are caused by field drains.

Aligned broadly west/east 25m south of, and parallel with, Penny Pot Lane, is another linear anomaly. Both this and a second linear anomaly that intersects with it at right angles correspond with field boundaries shown on the first edition Ordnance Survey mapping.

Geological anomalies

Across all parts of the site numerous discrete anomalies of varying magnitude, which gave the data a ‘speckled’ appearance, have been identified. The number of these anomalies, the absence of any obvious pattern and the lack of any other archaeological activity on site preclude an archaeological interpretation. Rather all these anomalies are interpreted as geological in origin being due to variations in the composition and depth of the undifferentiated superficial till deposits. Other broad vague linear trends aligned south-west/north-east in the northern half of the PDA and north-west/south-east in the southern half of the site are also interpreted as geological in origin.

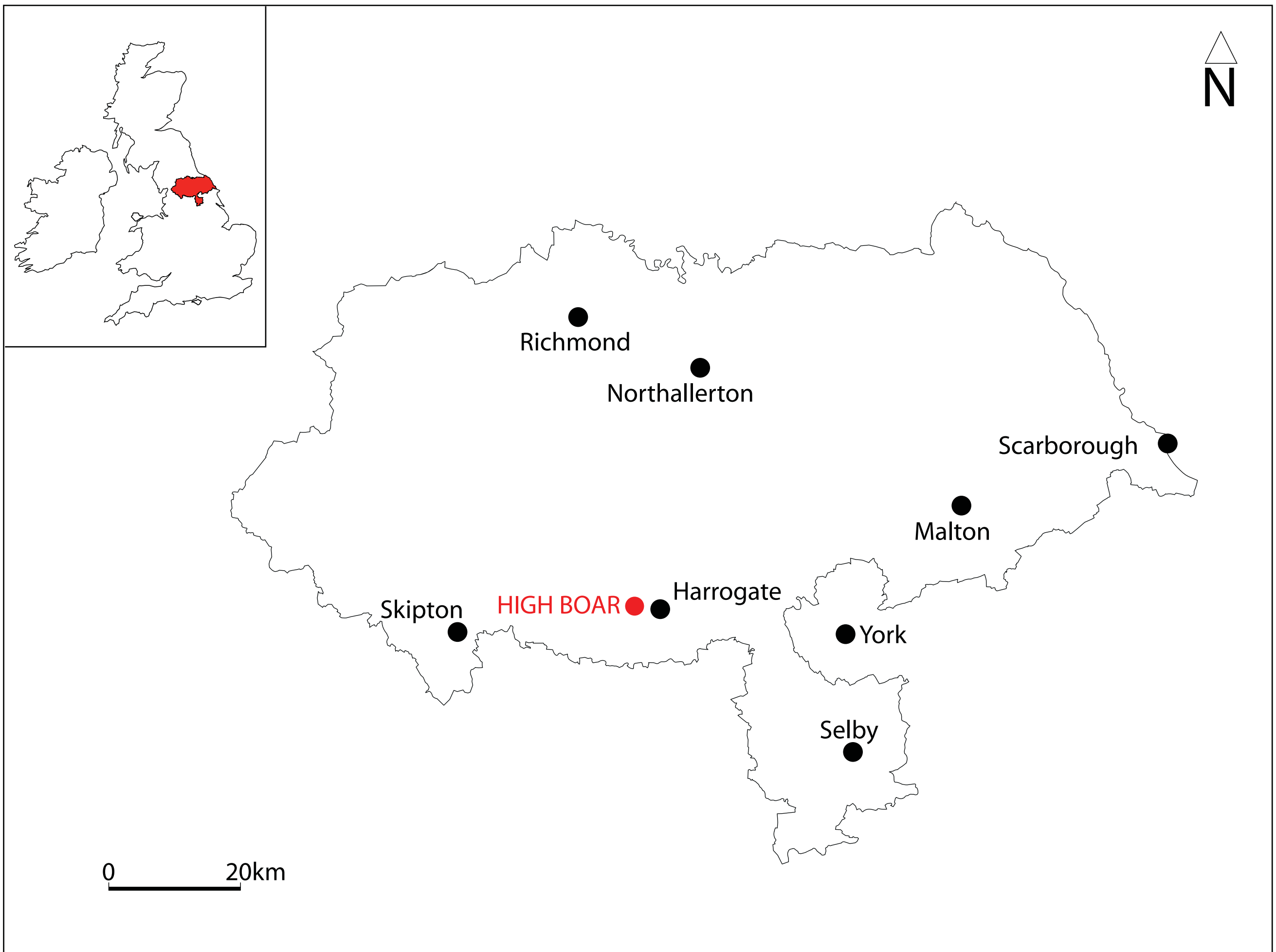
5 Discussion and Conclusions

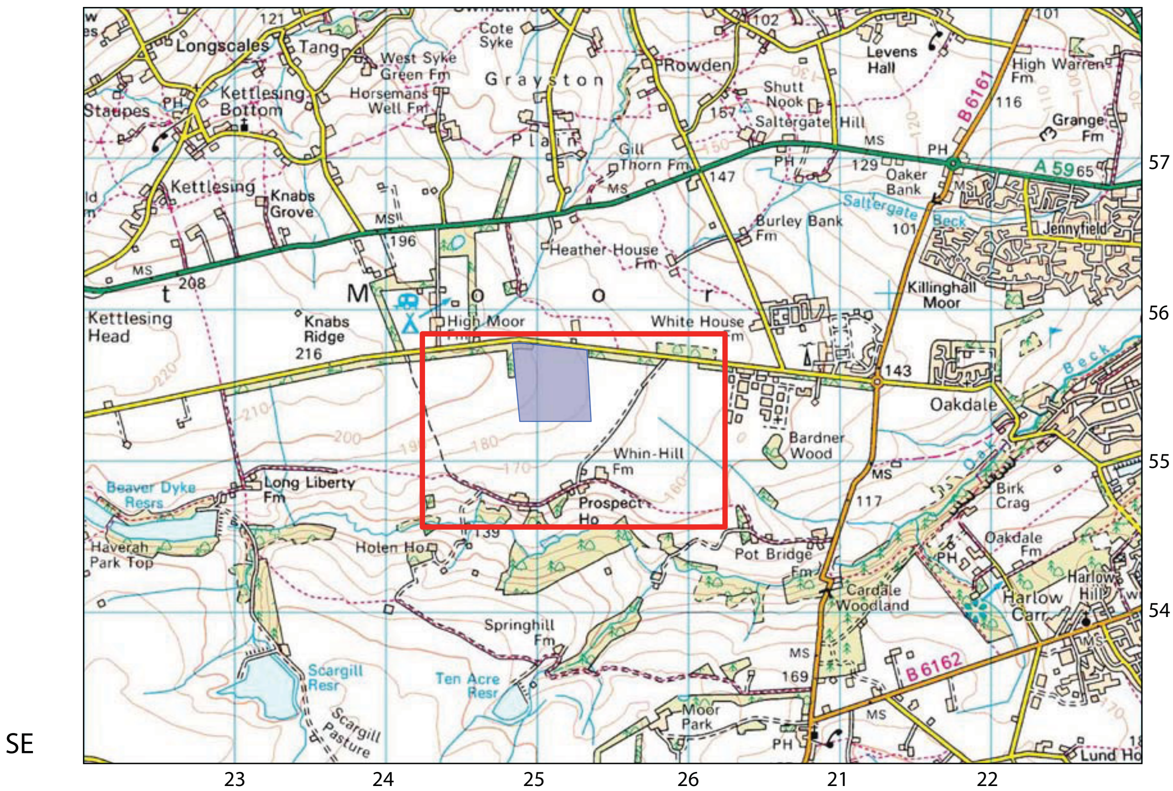
The previous archaeological investigation (ASUD 2005) at Knabs Ridge Windfarm did identify weak geophysical anomalies. These were targeted by subsequent trial trenching which also recorded further undated features. Knabs Ridge is situated on the top of the ridge that Penny Pot Lane runs along, with the PDA located 15m further down the slope of this ridge.

The geophysical survey within the PDA has not identified any anomalies of possible archaeological potential, with all the anomalies being caused either by variation in the superficial deposits or to recent agricultural activity such as former field boundaries and infilled ponds. This result mirrors the results of a geophysical survey recently undertaken at the adjoining Penny Pot Windfarm site, although the geophysical survey of that site did identify two groups of anomalies that were different to the background geological magnetic responses, which are thought to be modern in origin. The archaeological potential of this site based on the results of the geophysical survey, therefore, is considered to be low.

Disclaimer

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.





Inset see Fig. 2.

Proposed Development Area

0 2km

Fig. 1. Site location

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Fig. 2. Site location showing greyscale magnetometer data (1:7500 @ A3)

0 150m

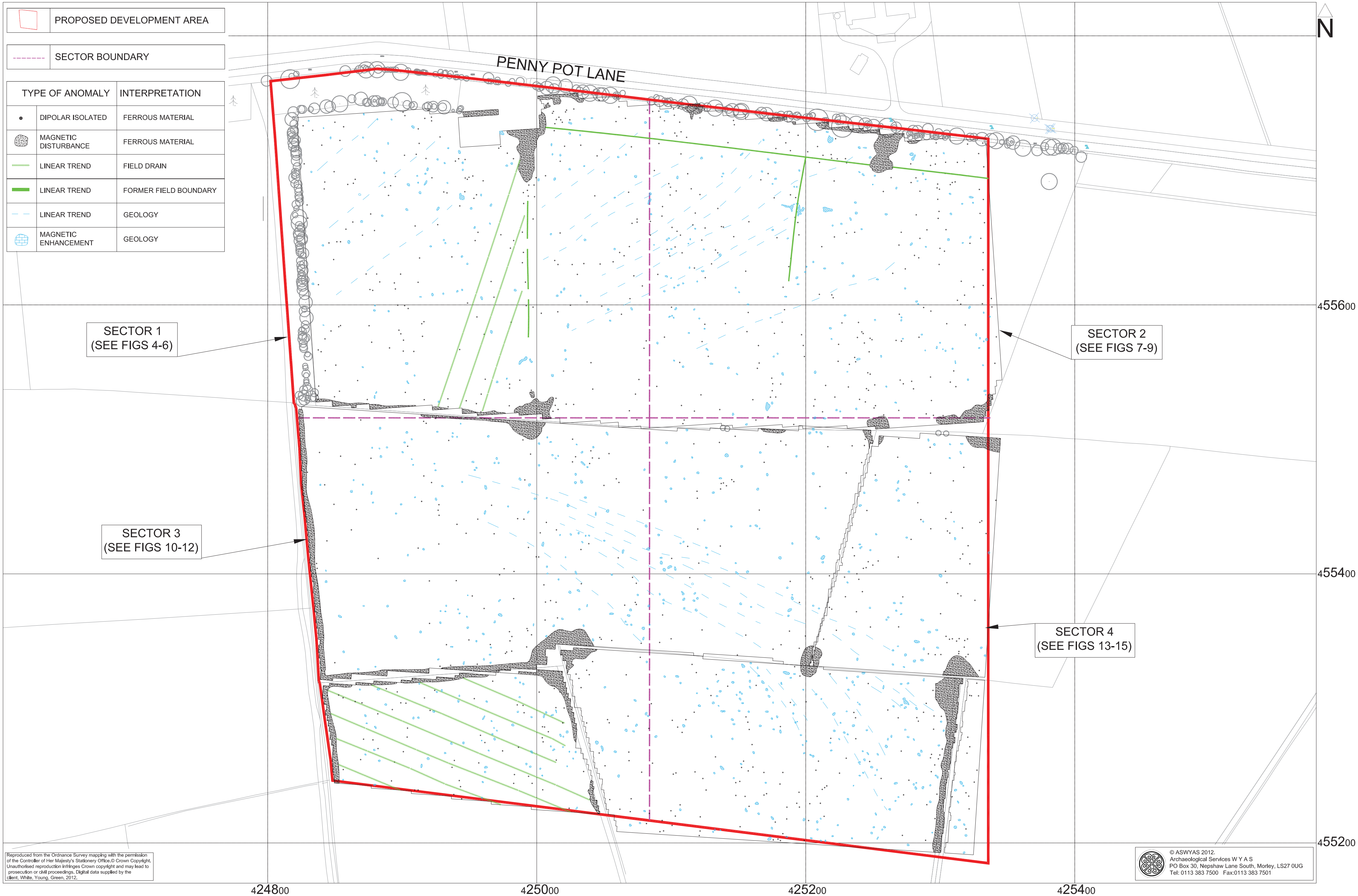

Fig. 3. Overall interpretation of magnetometer data (1:2500 @ A3)

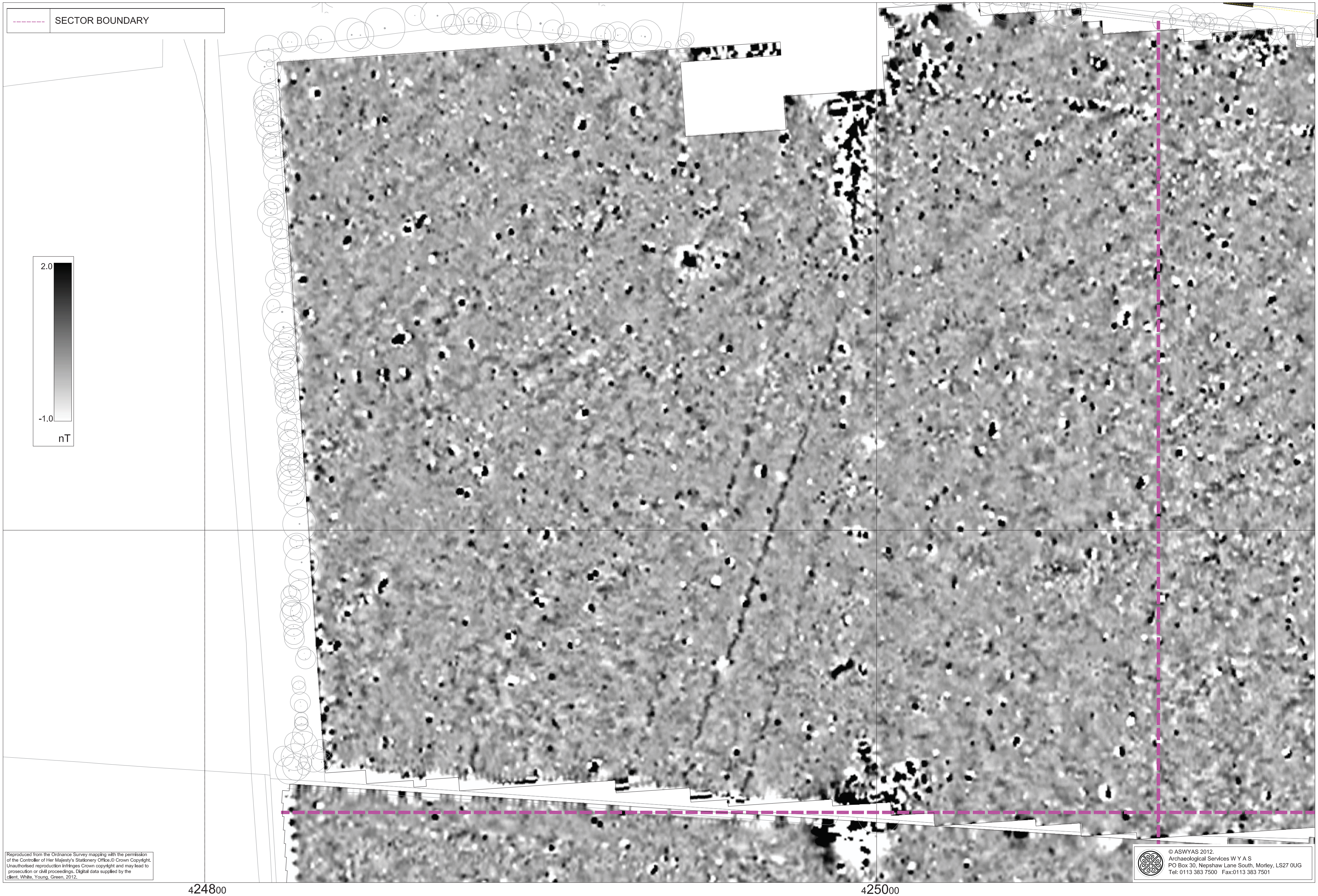

Fig. 4. Processed greyscale magnetometer data; Sector 1 (1:1000 @ A3)

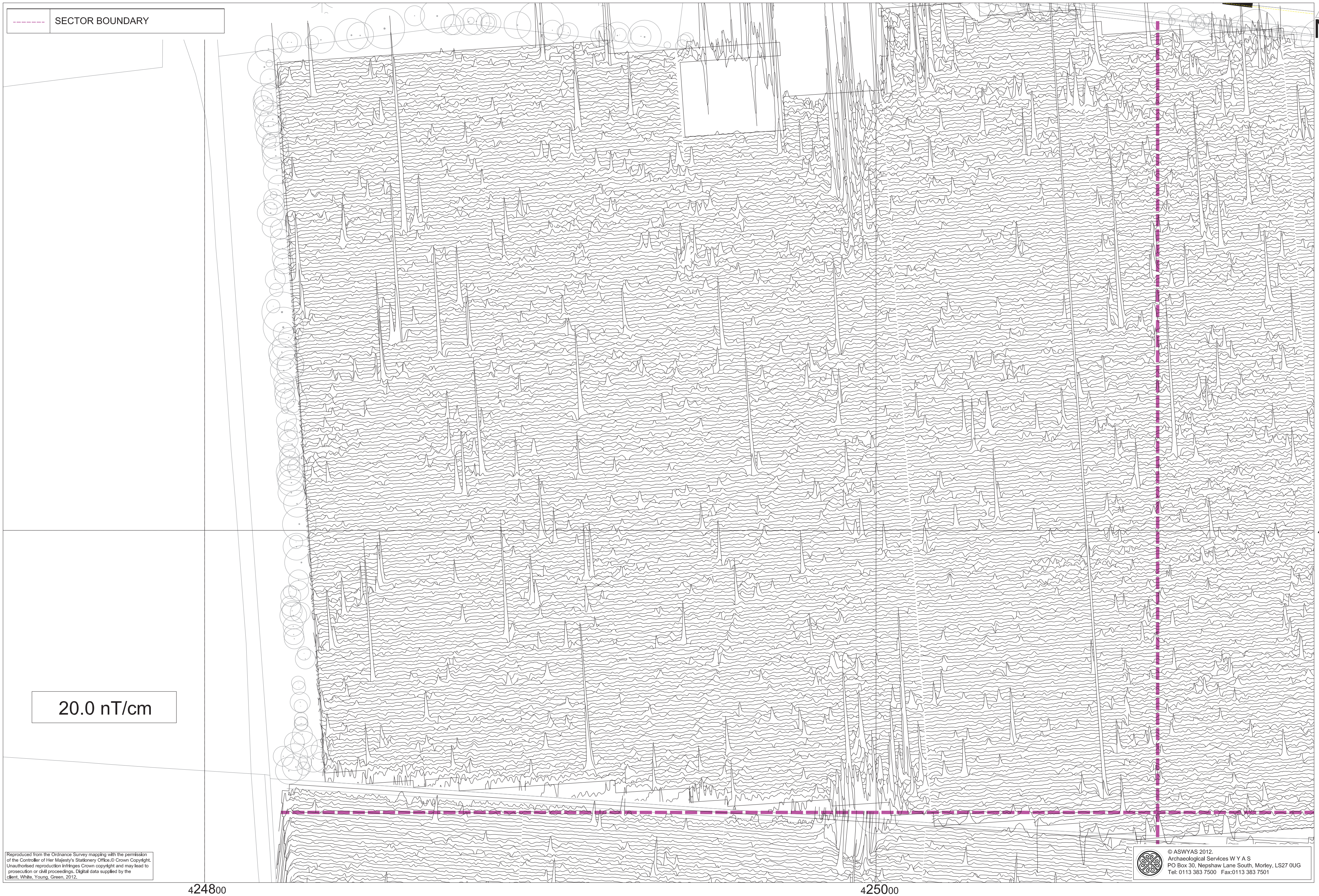

Fig. 5. XY trace plot of minimally processed magnetometer data; Sector 1 (1:1000 @ A3)

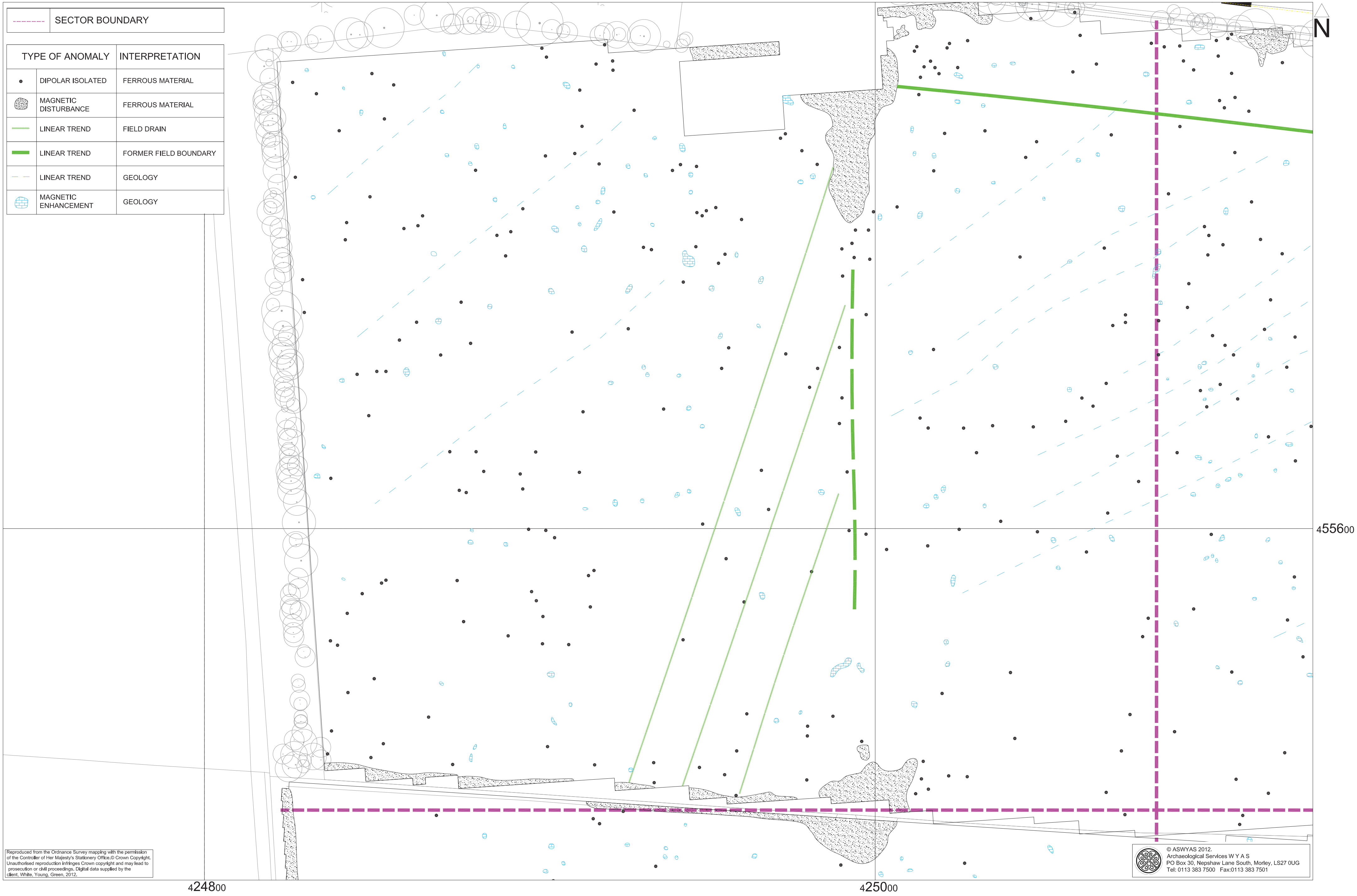

Fig. 6. Interpretation of magnetometer data; Sector 1 (1:1000 @ A3)

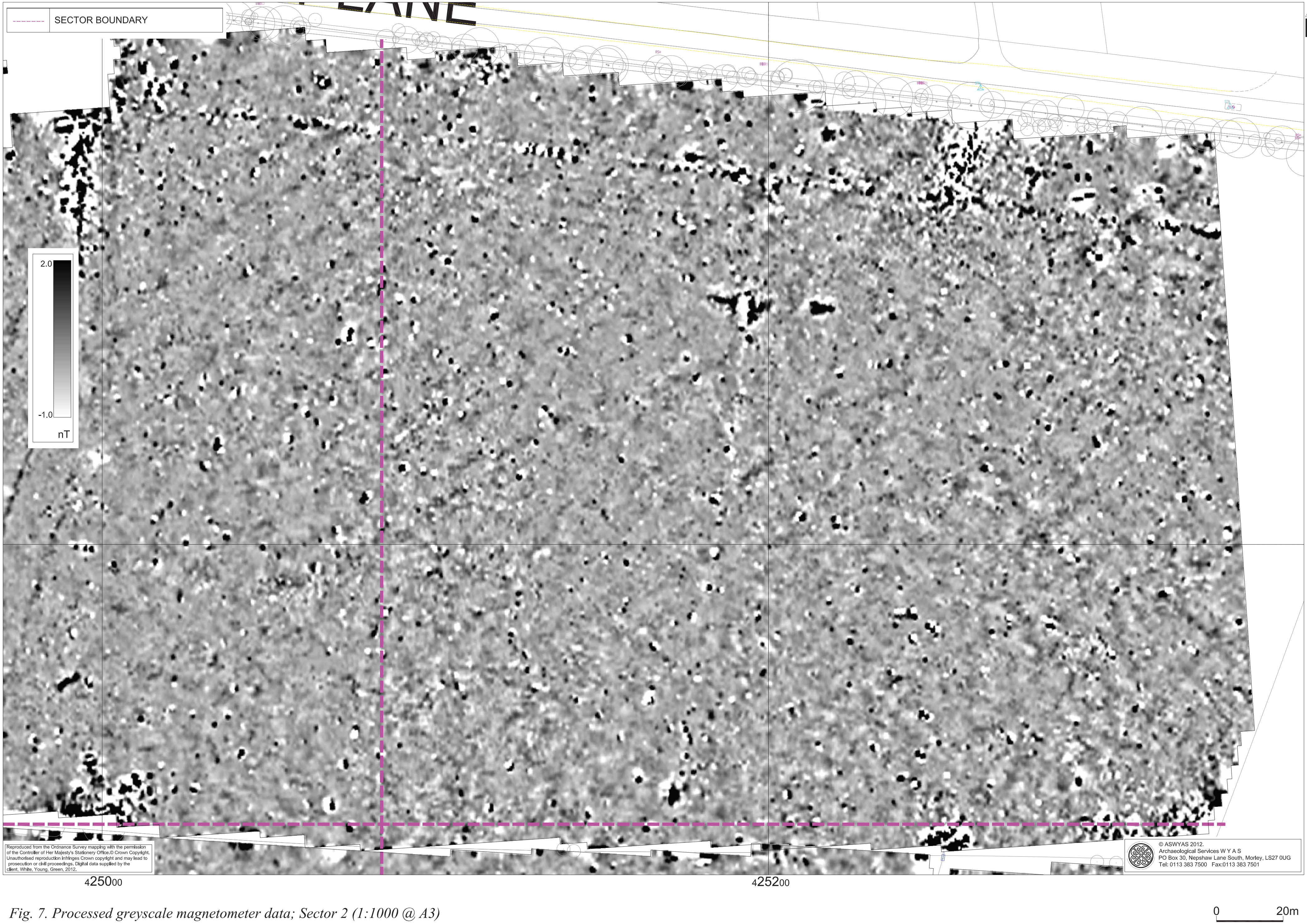

Fig. 7. Processed greyscale magnetometer data; Sector 2 (1:1000 @ A3)

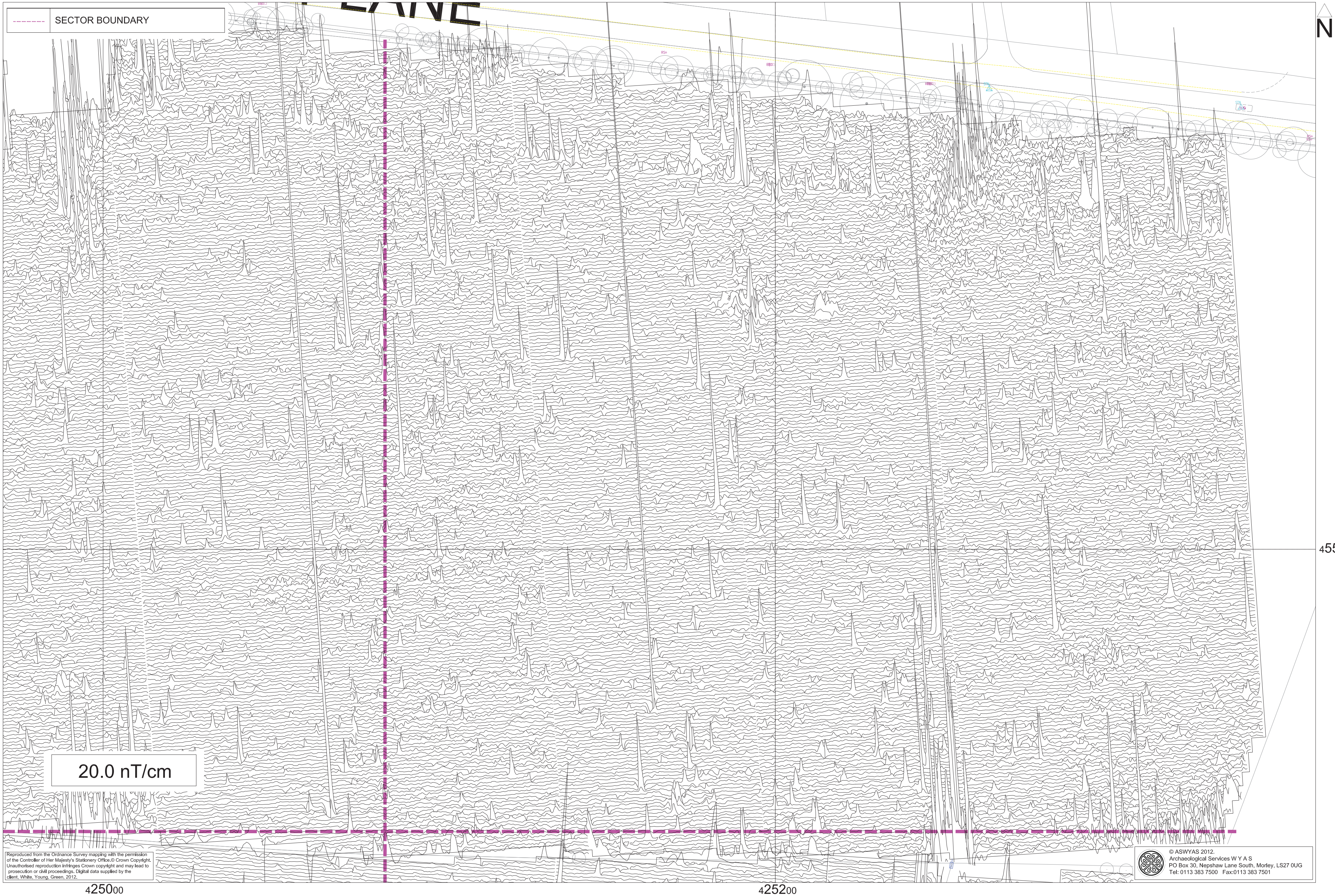

Fig. 8. XY trace plot of minimally processed magnetometer data; Sector 2 (1:1000 @ A3)

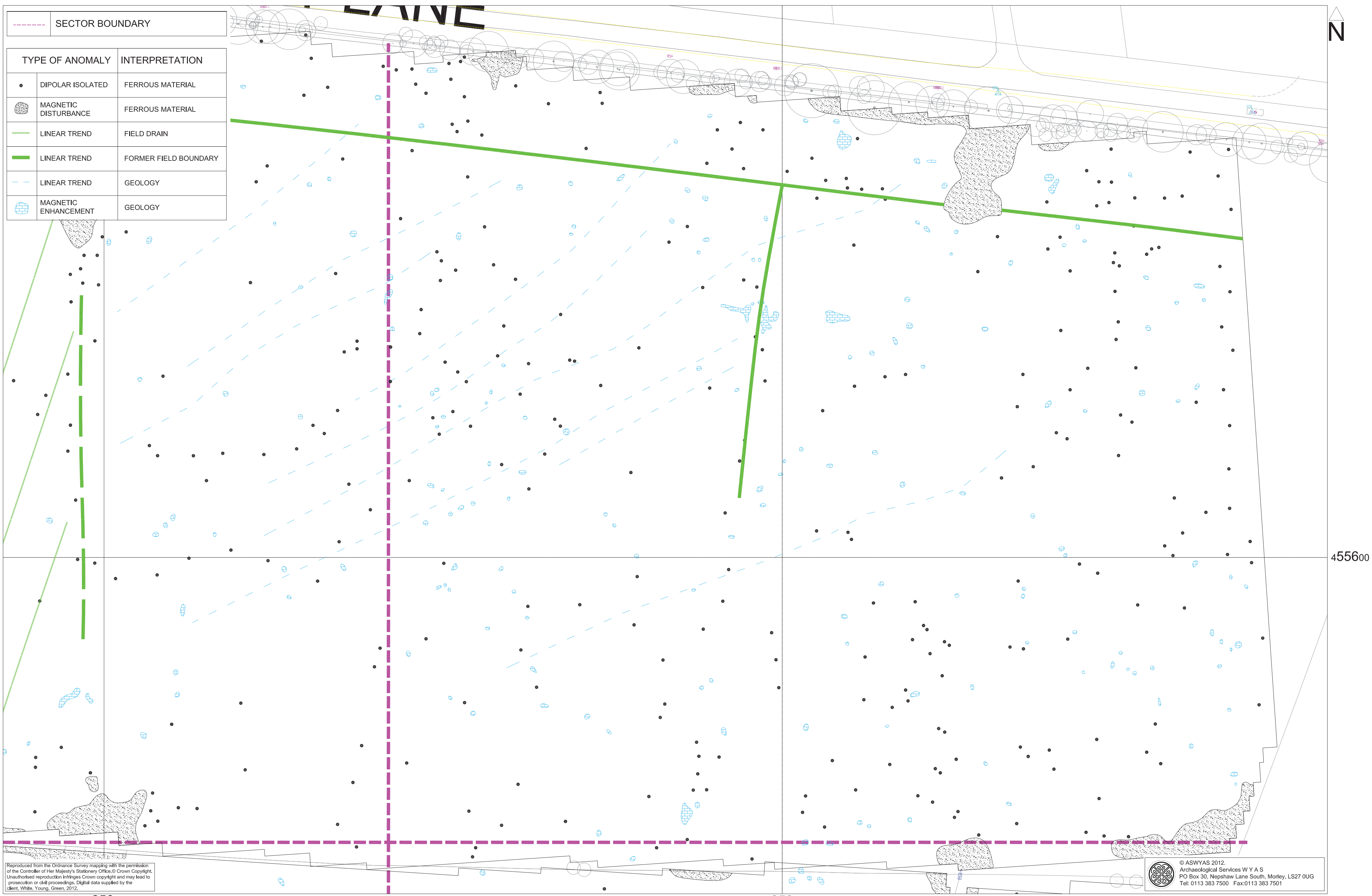

Fig. 9. Interpretation of magnetometer data; Sector 2 (1:1000 @ A3)

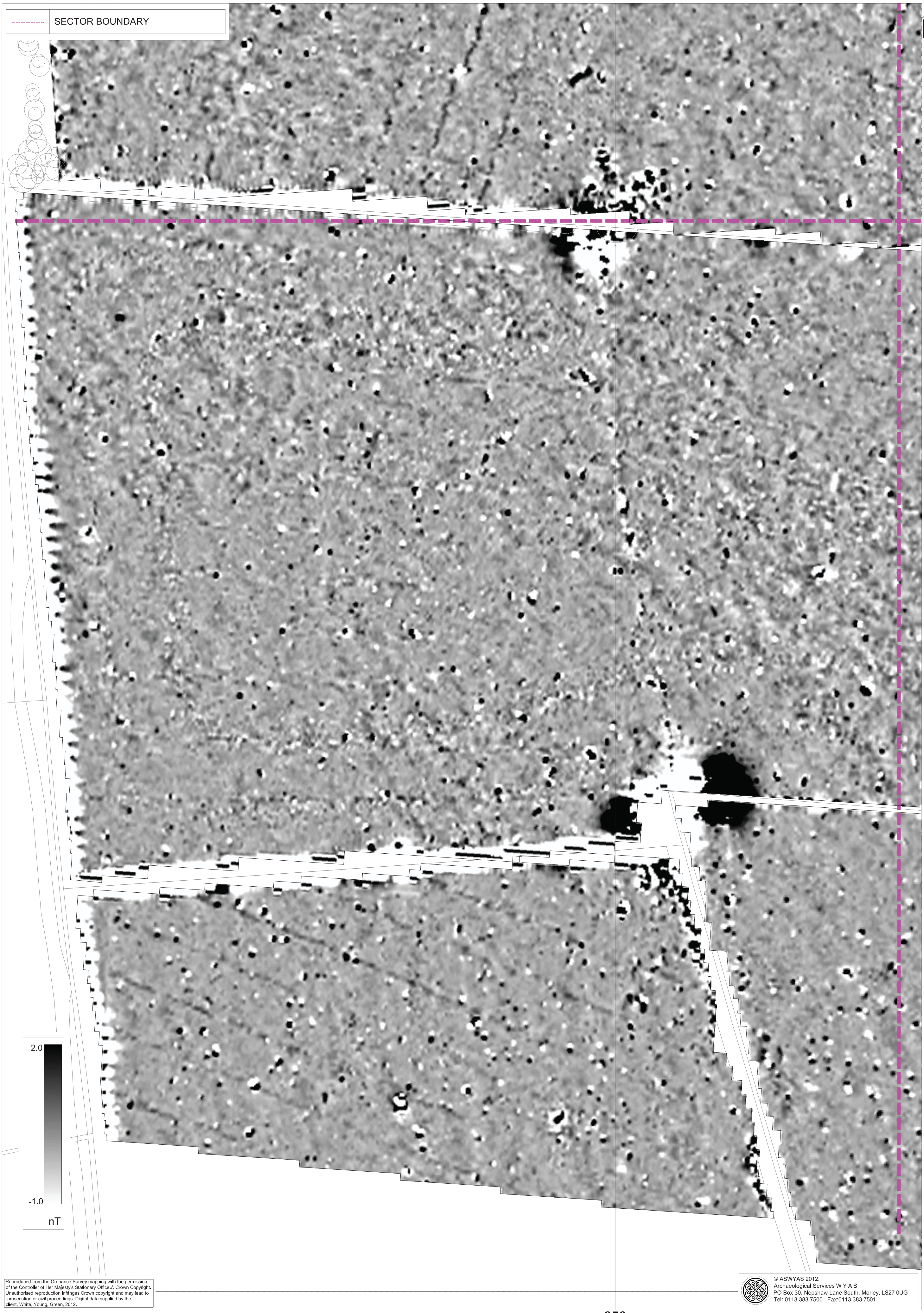

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Fig. 10. Processed greyscale magnetometer data; Sector 3 (1:1000 @ A3)

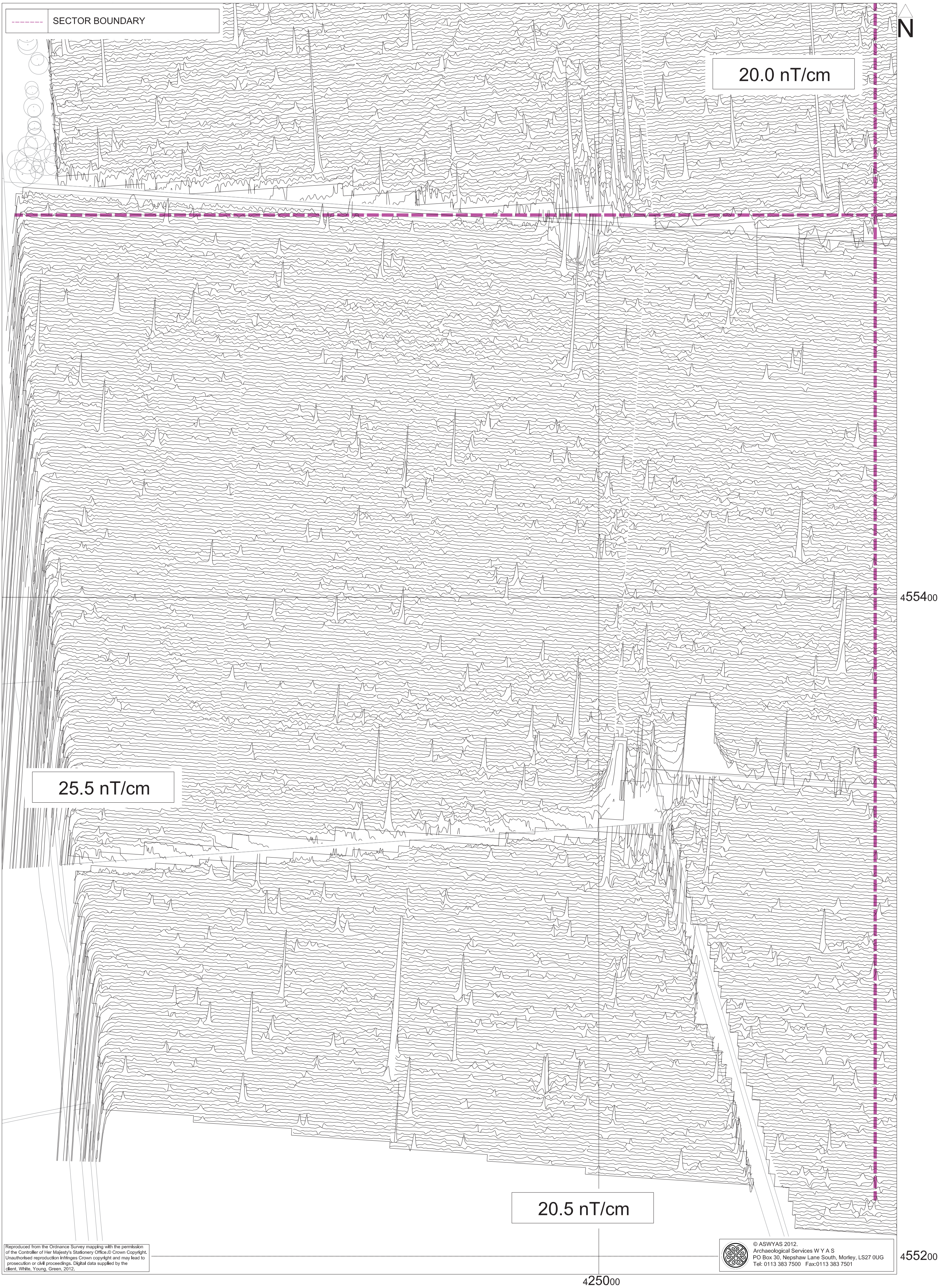

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Fig. 11. XY trace plot of minimally processed magnetometer data; Sector 3 (1:1000 @ A3)

0 20m

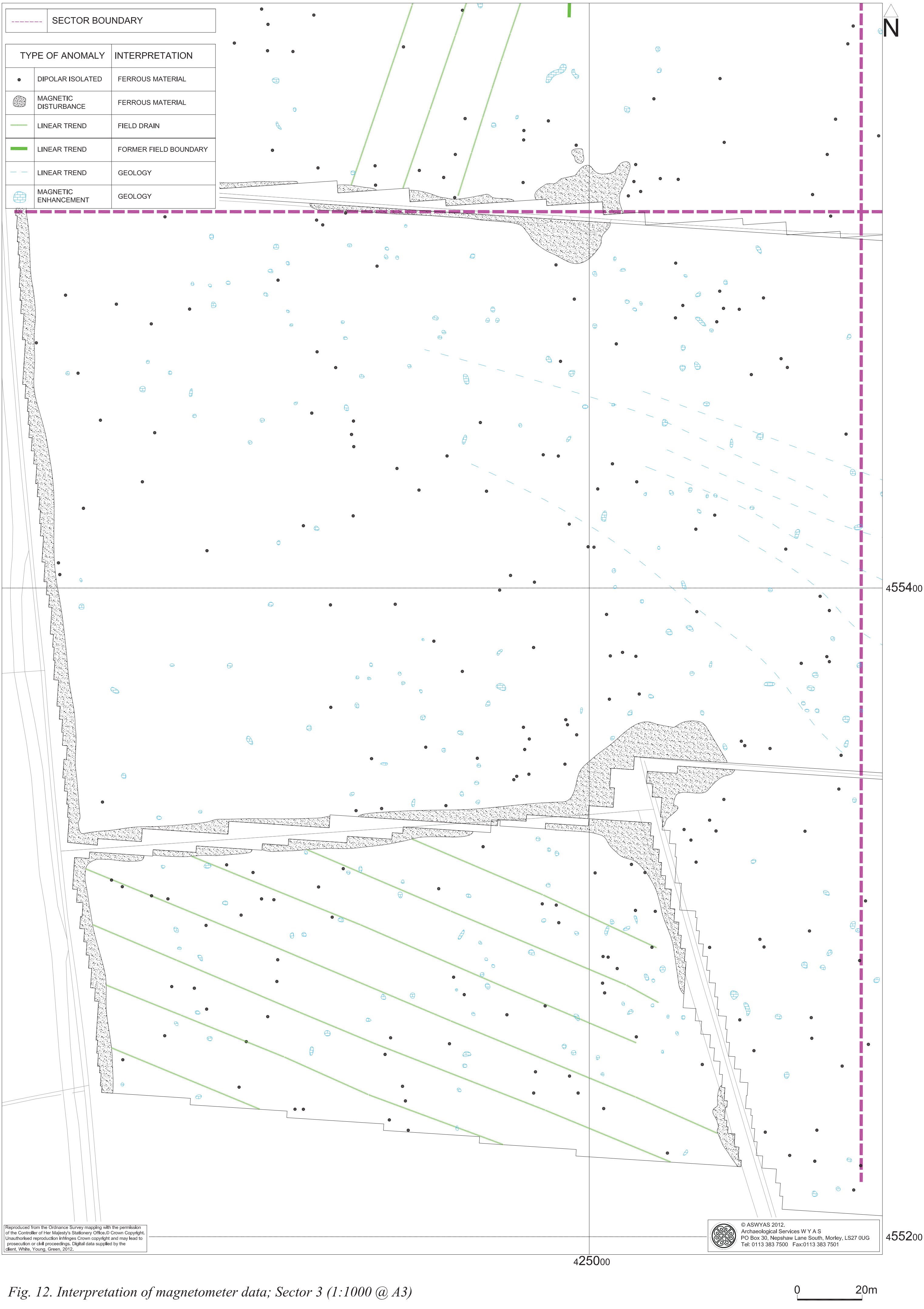

Fig. 12. Interpretation of magnetometer data; Sector 3 (1:1000 @ A3)

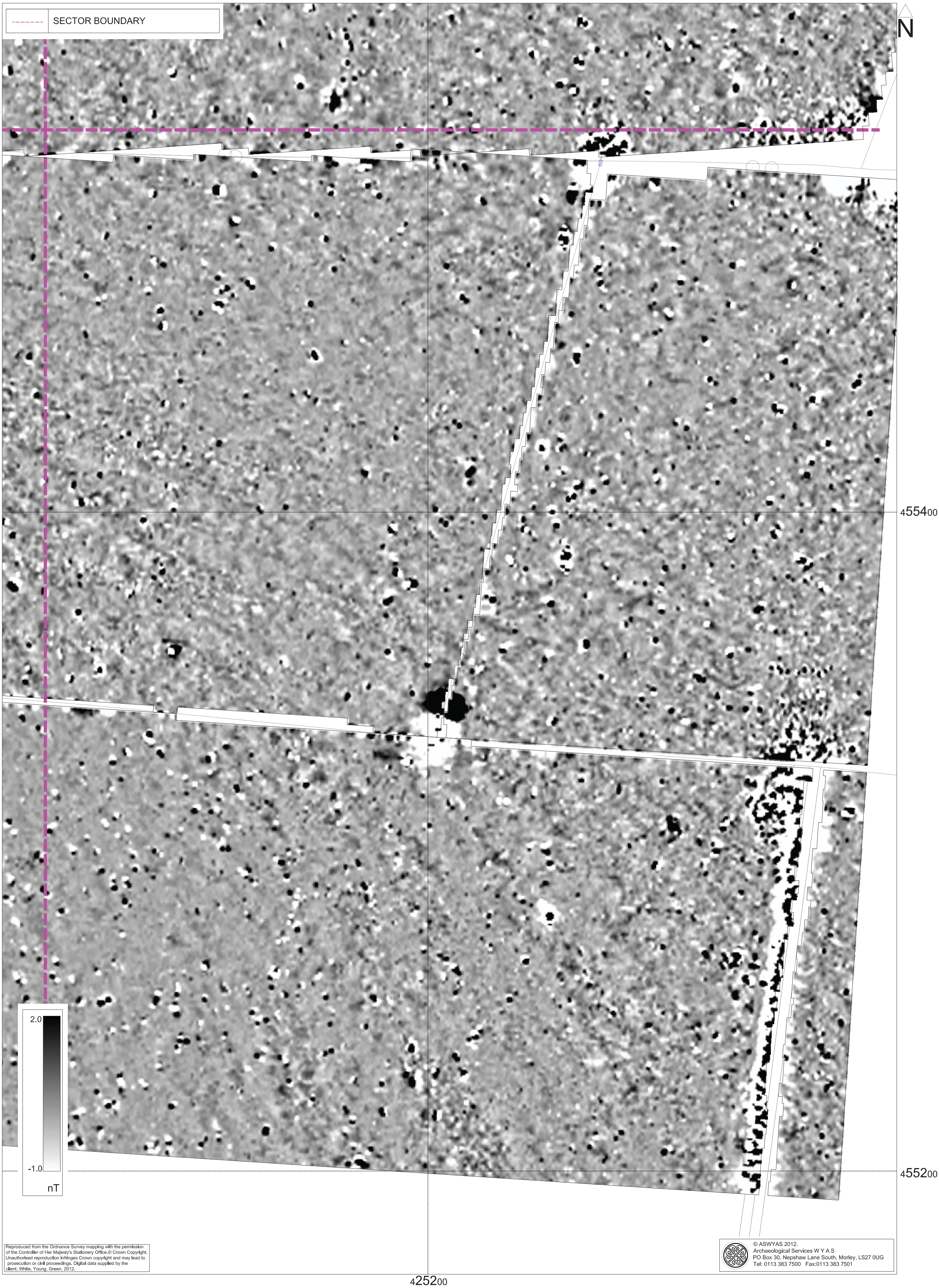

Fig. 13. Processed greyscale magnetometer data; Sector 4 (1:1000 @ A3)

0 20m

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Fig. 14. XY trace plot of minimally processed magnetometer data; Sector 4 (1:1000 @ A3)

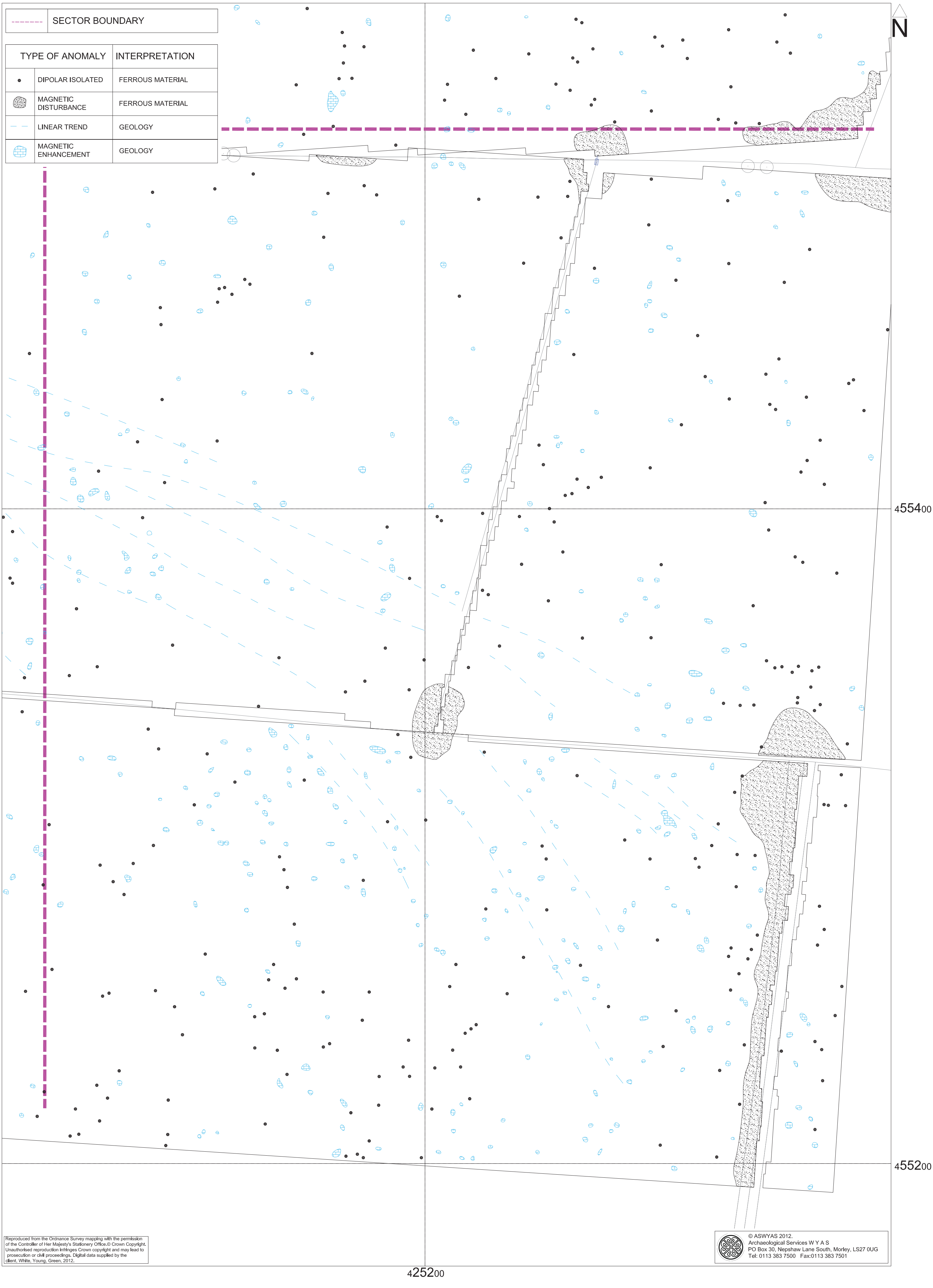

Fig. 15. Interpretation of magnetometer data; Sector 4 (1:1000 @ A3)

Plate 1. General view of Sectors 1 and 2, facing north-east

Plate 2. General view of Sector 3, facing south-east

Plate 3. General view of Sector 3 (south), facing south-west

Plate 4. General view of Sector 4, facing north

Plate 5. General view of Sector 4 (south-west), facing south-west

Plate 6. General view of Sector 4 (south-east), facing south

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 North Yorkshire Historic Environment Record).

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