Potgate Quarry Extension
North Stainley
North Yorkshire

Geophysical Survey

Report no. DRAFT

May 2012

Client: Lightwater Quarries Limited

Potgate Quarry
North Stainley
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering 22 hectares, was carried out to inform a Review of Mineral Permission submission with regard to assessing the archaeological potential of the remaining areas of extraction and landscaping at Potgate Quarry. A pentagonal enclosure and associated field system have been identified to the north-east of the quarry whilst a former field system, including two possible trackways, has been identified to the west. Elsewhere, several linear and curvilinear anomalies have been attributed a possible archaeological origin on the basis that they are not on the same alignment as the current pattern of land division. However, an agricultural interpretation for any of these anomalies is plausible. Based on the results of the geophysical survey, the archaeological potential of this site is thought to be locally high to the north-east and west and relatively low elsewhere.

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Report Information

Client:	Lightwater Quarries Ltd
Address:	Potgate Quarry, Stainley, North Yorkshire
Report Type:	Geophysical survey
Location:	Potgate Farm, North Stainley
County:	North Yorkshire
Grid Reference:	SE 277 756
Period(s) of activity: represented	Iron Age/Romano-British?
Report Number:	2347
Project Number:	3913
Site Code:	PQR12
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	May 2012
Date of report:	May 2012
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Authorisation for distribution: ---

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1 Introduction

Archaeological Services WYAS was commissioned by Steve Timms of Mike Griffiths and Associates Ltd, on behalf of their client Lightwater Quarries Limited, to undertake a geophysical (magnetometer) survey of three fields located to the immediate north-east and south-west of Potgate Quarry, North Stainley (see Fig. 1) in order to inform a Review of Mineral Permission submission. The purpose is to assess the archaeological potential of the remaining areas of extraction and landscaping in the review area. The scheme of work was undertaken in accordance with the requirements of the National Planning Policy Framework. The survey was carried out between May 8th and May 14th 2012.

Site location, topography and land-use

Potgate Quarry is located approximately 1.5km south-west of North Stainley and 4.5km north-west of Ripon. The review area covers approximately 74 hectares. The areas undisturbed by the operations thus far amounts to 27 hectares located in the north-east and south-west of the site (see Fig. 2). These areas comprise the survey areas for the purpose of this study. The survey area was reduced to 22ha by the presence of trees in the northern corner of Field 1 and along the southern boundary of Field 2, by a disused reservoir between Field 1 and Field 2 and by topsoil bunds and a stand of maize in Field 3.

The survey areas are situated on a gentle south-east facing gradient. Fields 1 and 3 were under a maturing wheat crop at the time of the survey whilst Field 2 contained pasture/silage (see Plates).

Geology and soils

The underlying bedrock comprises Cadeby Formation Dolomitic Limestone overlain by superficial deposits of till (BGS 2012). The soils in this area are classified in the Nercwys association, characterised as deep fine loams with slowly permeable subsoils and slight seasonal waterlogging (SSEW 1983).

2 Archaeological background

The site is situated within a landscape of some archaeological significance with 32 sites recorded on the North Yorkshire Historic Environment Record (NYHER) within a 2km radius of the review area. These sites range in date from the Neolithic through to the medieval and post-medieval periods and include Castle Dikes Defended Roman Villa, a scheduled ancient monument. Analysis of aerial photographs and the subsequent plotting and interpretation of identified cropmarks, undertaken as part of the National Mapping Programme, has identified a possible enclosure within the east of the review area as well as former field systems within the west (see Fig. 2).

A geophysical survey conducted to the north-west of the review areas (see Fig. 2), in advance of a potential extension, identified a possible trackway (ASWYAS 2010).

3 Aims, Methodology and Presentation

The general aim of the geophysical survey was to establish and clarify the nature of the archaeological resource within the review area.

Specifically the survey sought to provide information about the nature and possible interpretation of any anomalies identified during the survey and thereby determine the presence or absence and likely extent of any buried archaeological remains. The survey covered all of the proposed extension area that was suitable for survey, approximately 22 hectares.

The information from the geophysical survey will enable further evaluation and/or mitigation measures, if required, to be designed in advance of any proposed extraction.

The survey area was set-out with a Trimble 5800 VRS differential GPS to the national grid. Temporary reference objects (wooden survey marker stakes) were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference objects are shown on Figure 2 and their Ordnance Survey co-ordinates tabulated in Appendix 2.

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. Figures 2 and 3 are large scale (1:5000) site location plans showing the greyscale magnetometer data and overall interpretation plan respectively. The processed and minimally processed data, together with interpretation graphics of the survey results are presented in Figures 4 to 21 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.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeology (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

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. An alignment of ferrous anomalies is visible towards the south of Field 1, Sector 1. These correspond closely to a former field boundary depicted on first edition Ordnance Survey mapping (1856). Elsewhere, throughout 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.

Broad areas of magnetic disturbance have been identified at the perimeters of Fields 1 and 2. Such areas of disturbance are caused by the proximity of perimeter fencing and are of no archaeological interest.

Agricultural Anomalies

The pattern of land division and field layout within the review area has altered somewhat since the publication of the first edition Ordnance Survey map in 1856. Two parallel field boundaries have been removed from within Field 1. The southernmost of these manifests within the data as a loose alignment of ferrous anomalies (see Figs 4, 5 and 6). A further two former field boundaries have been identified within Field 2 as parallel linear anomalies dividing separate ridge and furrow ploughing regimes (see Figs 7 to 12 inclusive). The characteristic striped appearance to the data is a result of the magnetic contrast between the infilled furrows and former ridges. These anomalies may be of local historical interest although their archaeological significance is likely to be low. Three more former field boundaries depicted on the first edition Ordnance Survey map within Field 3 do not appear in the data, perhaps indicating of a low magnetic contrast between the fill of the former boundary ditches and the surrounding subsoil.

Faint parallel trends have been identified throughout the survey areas and are generally orientated parallel with the existing boundaries. These trends are caused by modern ploughing regimes and are of no archaeological interest. Likewise, a series of negative parallel trends throughout Field 2 (see Figs 7 to 12 inclusive) are typical of modern field drains and are of no archaeological interest.

Geological Anomalies

Across all parts of the survey areas discrete, low magnitude, anomalies (areas of magnetic enhancement) have been identified. Whilst any of these anomalies could be caused by an archaeological feature, such as a pit, the sheer number precludes an archaeological origin and they are therefore interpreted as being geological in nature, probably relating to natural pedological variations and to variations in the composition of the superficial deposits of till. A sinuous negative trend within the west of Field 3 (see Figs 13 to 18 inclusive) is thought to be geological in origin, perhaps demarcating the former course of a palaeochannel.

Archaeological? Anomalies

In the north-east of the review area in Field 3 a pentagonal enclosure, **A**, has been identified that corresponds with the cropmark data (see Figs 13, 14 and 15). The enclosure extends beyond the eastern survey boundary but, given the cropmark data, it can be postulated that it measures approximately 45m in diameter. Several low magnitude anomalies have been identified within the interior of the enclosure, perhaps representing features indicative of occupational activity, such as pits and post-holes. Fragmented curvilinear anomalies, **L**, to the south-west of **A** may indicate an annexe, whilst linear anomalies, **B**, to the north of the enclosure, are thought to represent former field boundary ditches – the positive anomalies resulting from the magnetically enhanced fill of the ditch.

Within Field 1, a former field system has been identified manifesting in the data as fragmented linear anomalies, **E**, **F**, **C** and **D** (see Figs 4 to 9 inclusive). Whilst anomalies **E** and **F** are thought likely to represent single ditches, anomalies **C** and **D** appear as two parallel anomalies, spaced 4.5m apart, and may indicate a trackway. The anomalies are not on the same alignment as the current pattern of land division, nor that depicted on the first edition Ordnance Survey map, and an archaeological interpretation is therefore considered likely. However, no definite archaeological pattern is discernable.

A further probable ditch, **G**, has been identified towards the south-west of Field 3 (See Figs 16 to 21 inclusive), appearing as a positive linear anomaly. The anomaly extends beyond the limits of the survey at both its eastern and western extent and therefore interpretation is tentative. However, the east/west orientation differs from the current pattern of land division and therefore an archaeological interpretation is considered likely.

Within Field 2 several ill-defined negative linear and curvilinear anomalies, **H**, **I**, **J** and **K**, have been identified (see Figs 10, 11 and 12). Although the anomalies form no clear archaeological pattern, they cannot easily by attributed either agricultural or geological interpretations. It is possible that these anomalies represent plough-damaged archaeological remains although the lack of any clear pattern would suggest an agricultural interpretation is more likely.

5 Discussion and Conclusions

The geophysical survey has confirmed the cropmark evidence and revealed a pentagonal enclosure, **A**, measuring 45m in diameter within Field 3. Anomalies representing possible internal features such as pits and post-holes have been suggested within the interior of the enclosure whilst a possible annexe, **L**, and associated field system, **B**, have been identified to the immediate exterior.

A separate field system has been identified in Field 1 to the west comprising a number of fragmented positive linear anomalies, **C**, **D**, **E** and **F**, which are thought to represent ditches. The orientation of these anomalies is not in keeping with the known field layout pattern and whilst an agricultural interpretation cannot be dismissed, an archaeological origin is thought to be more likely. Anomalies **C** and **D** differ in form from anomalies **E** and **F**, and the former anomalies may locate trackways defined by parallel, flanking, ditches, 4.5m apart.

Elsewhere, a more tenuous archaeological interpretation has been suggested of linear anomaly **G**, due to limits of the survey area, and of ill-defined negative anomalies **H**, **I**, **J** and **K**, due to the lack of any clear patterns. Whilst the orientation of these anomalies contrasts with the surrounding agricultural anomalies, no clear archaeological patterns are discernable, and an agricultural origin remains a possibility.

Elsewhere, anomalies have been identified which are due to geological variation in the soils and superficial deposits and to agricultural activity over at least the last 150 years.

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.

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.

Station	Easting	Northing	Elevation (aOD)
A	427027.1096	475843.2290	94.9380m
B	427080.8908	475664.1260	93.0800m
C	427374.8684	475603.5050	91.5490m
D	427351.8016	475520.7740	91.3480m
E	427430.0028	475542.8870	92.8890m
F	427519.3784	475487.0310	89.0250m
G	427887.9594	476306.5580	75.9730m
H	427988.7238	476053.9820	70.9990m
I	428295.6306	476168.6250	63.4170m

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.
- 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 relevant Historic Environment Record).

Bibliography

BGS, 2012. http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html (Viewed 18th May 2012)

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

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

Soil Survey of England and Wales, 1983. Soils of Northern England, Sheet 1.

Webb, A., 2010. Potgate Farm Quarry, Phase 2 Extension, North Stainley, North Yorkshire: Geophysical Survey. ASWYAS Report No. 2108. Unpubl. Client Report

Fig. 2. Site location showing greyscale magnetometer data (1:5000 @ A3)

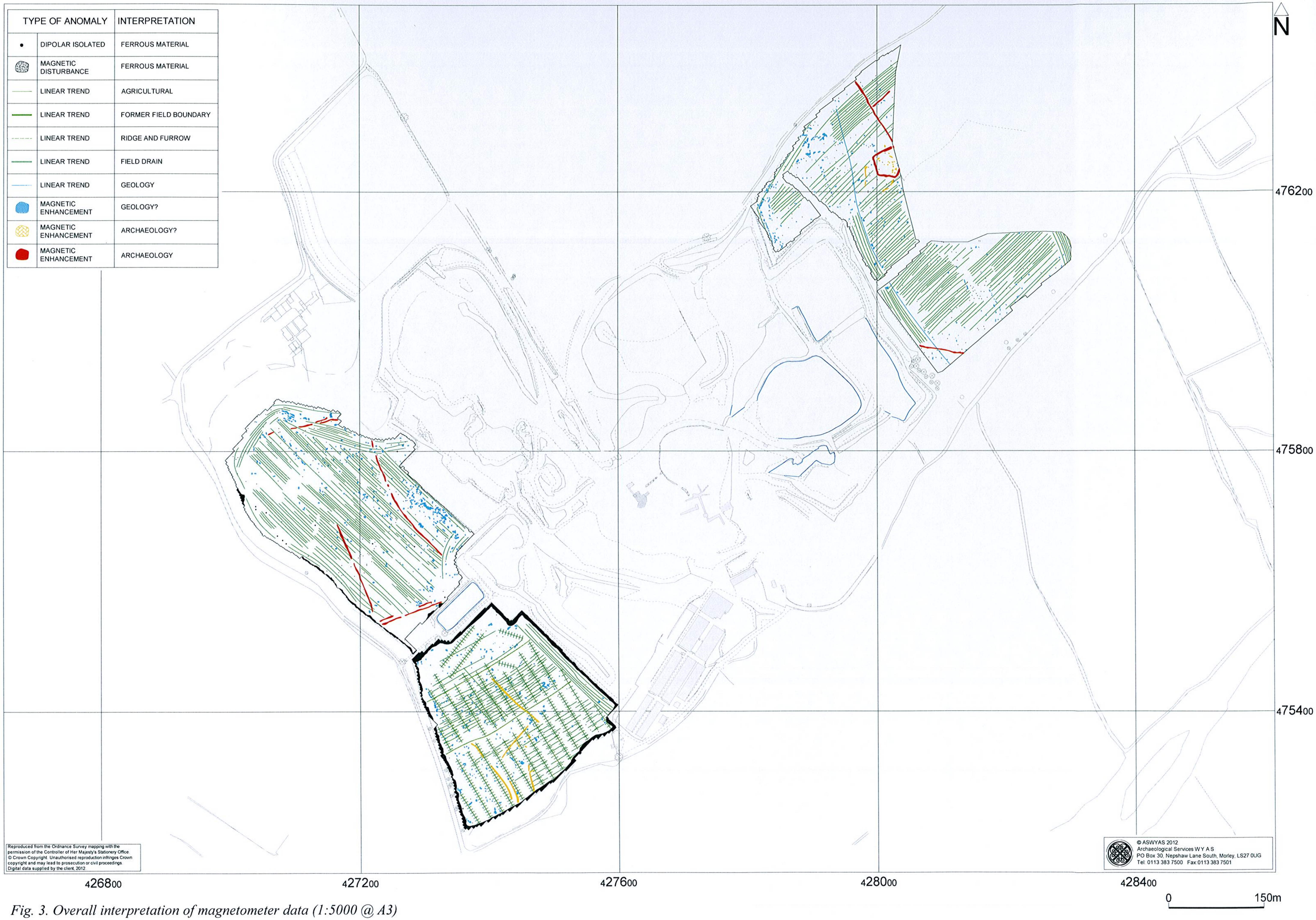

Fig. 3. Overall interpretation of magnetometer data (1:5000 @ A3)

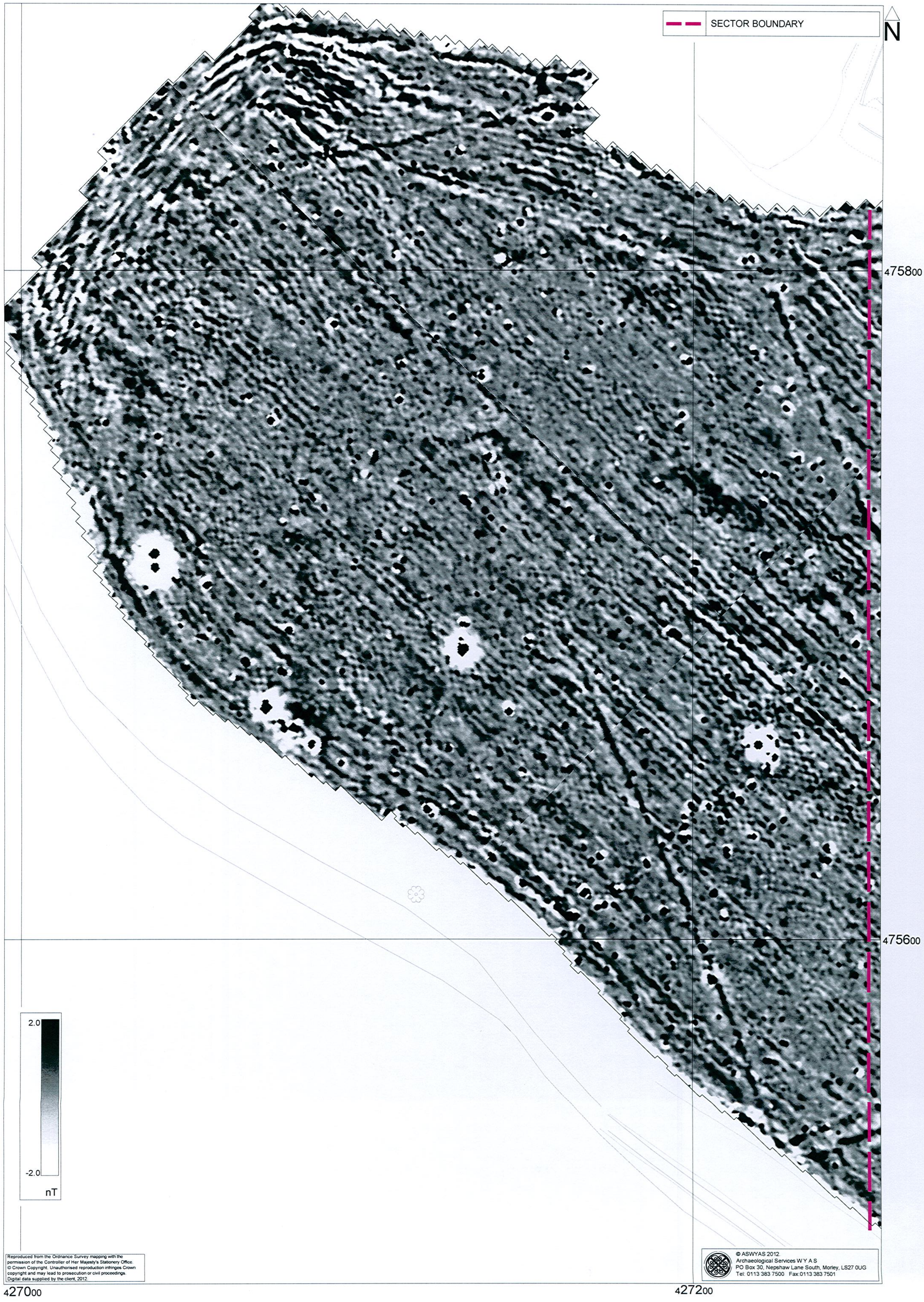

Fig. 4. Processed greyscale magnetometer data; Field 1, Sector 1 (1:1000 @ A3)

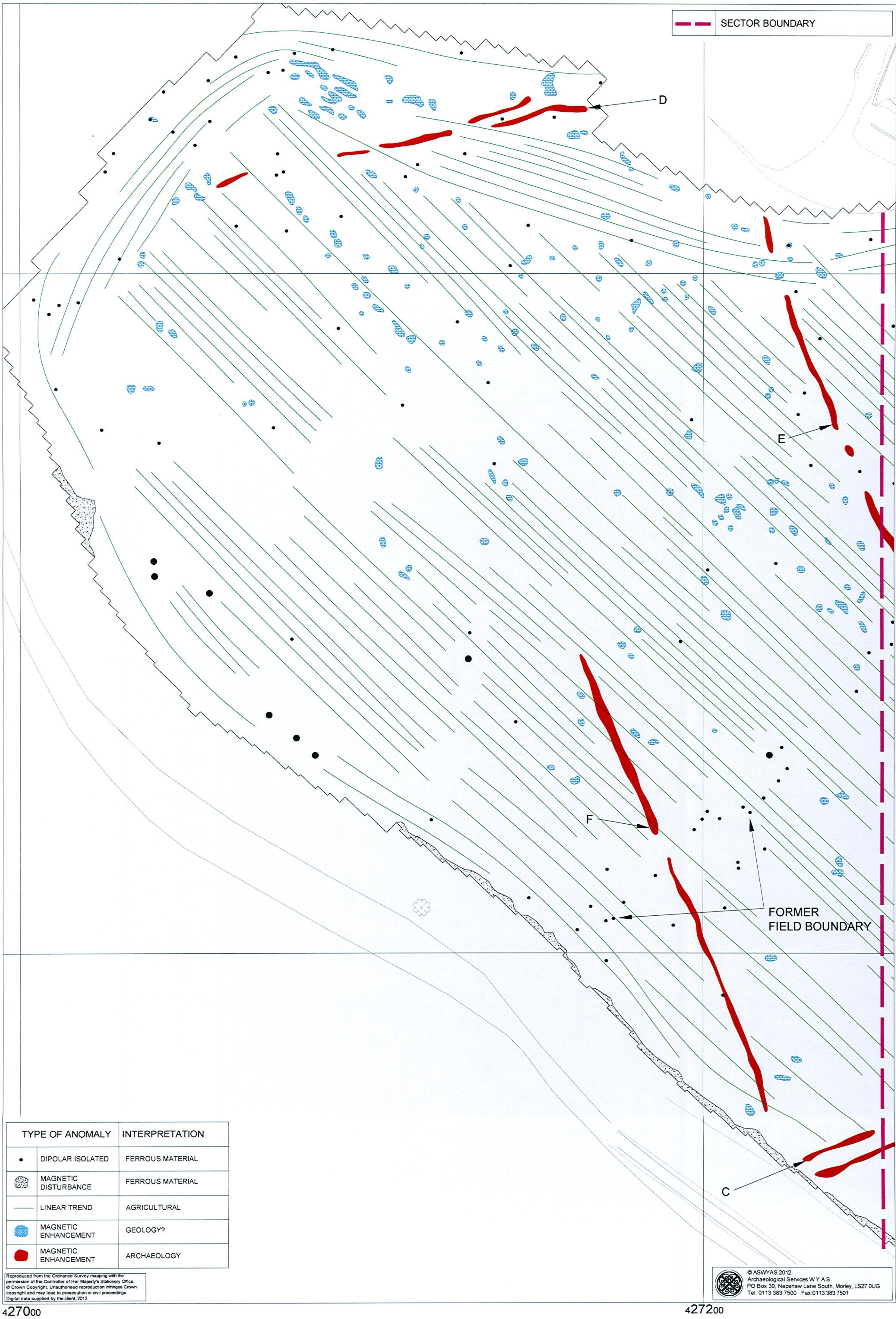

Fig. 6. Interpretation of magnetometer data; Field 1, sector 1 (1:1000 @ A3)

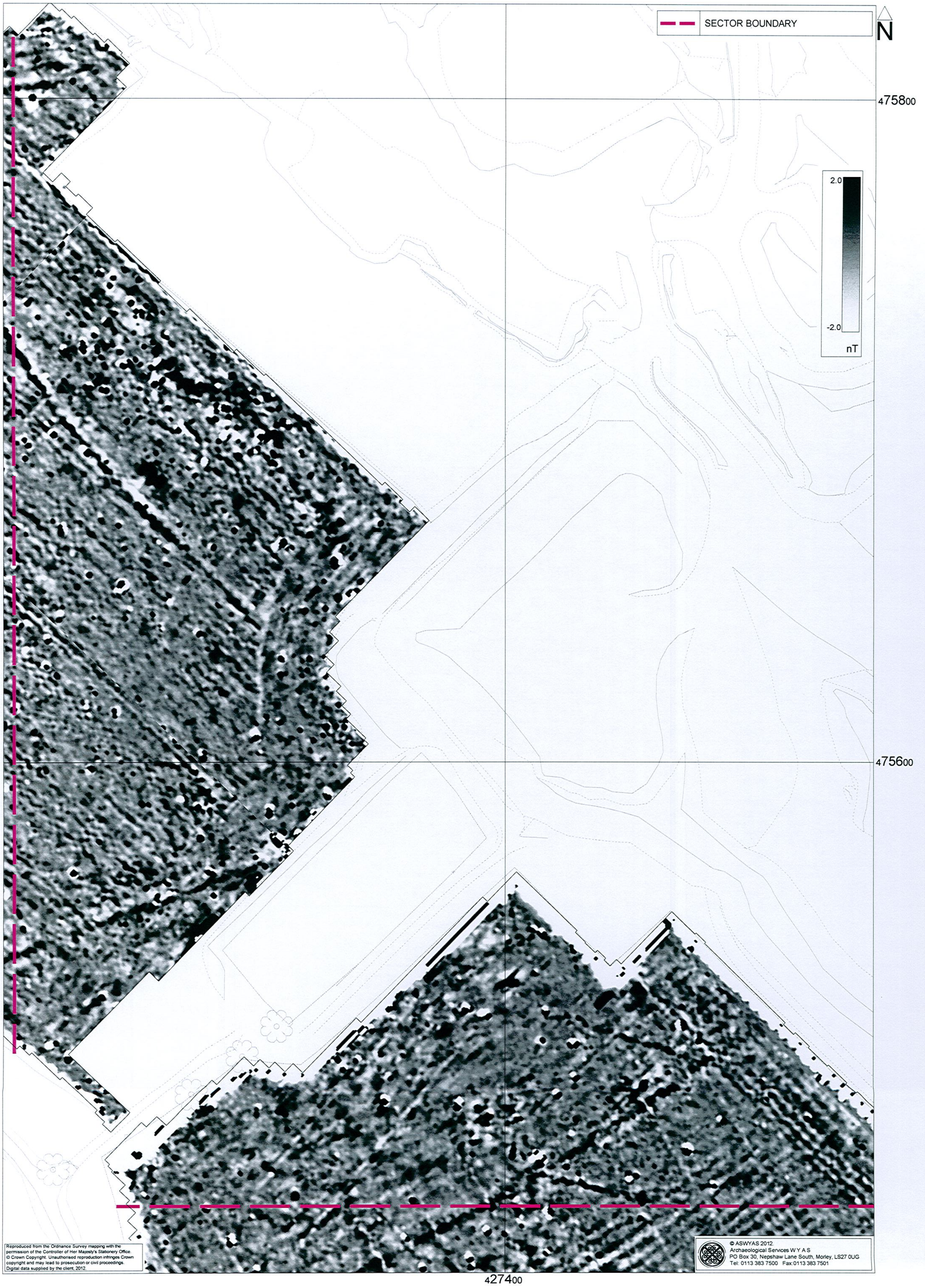

Fig. 7. Processed greyscale magnetometer data; Field 1, Sector 2 and Field 2, Sector 1 (1:1000 @ A3)

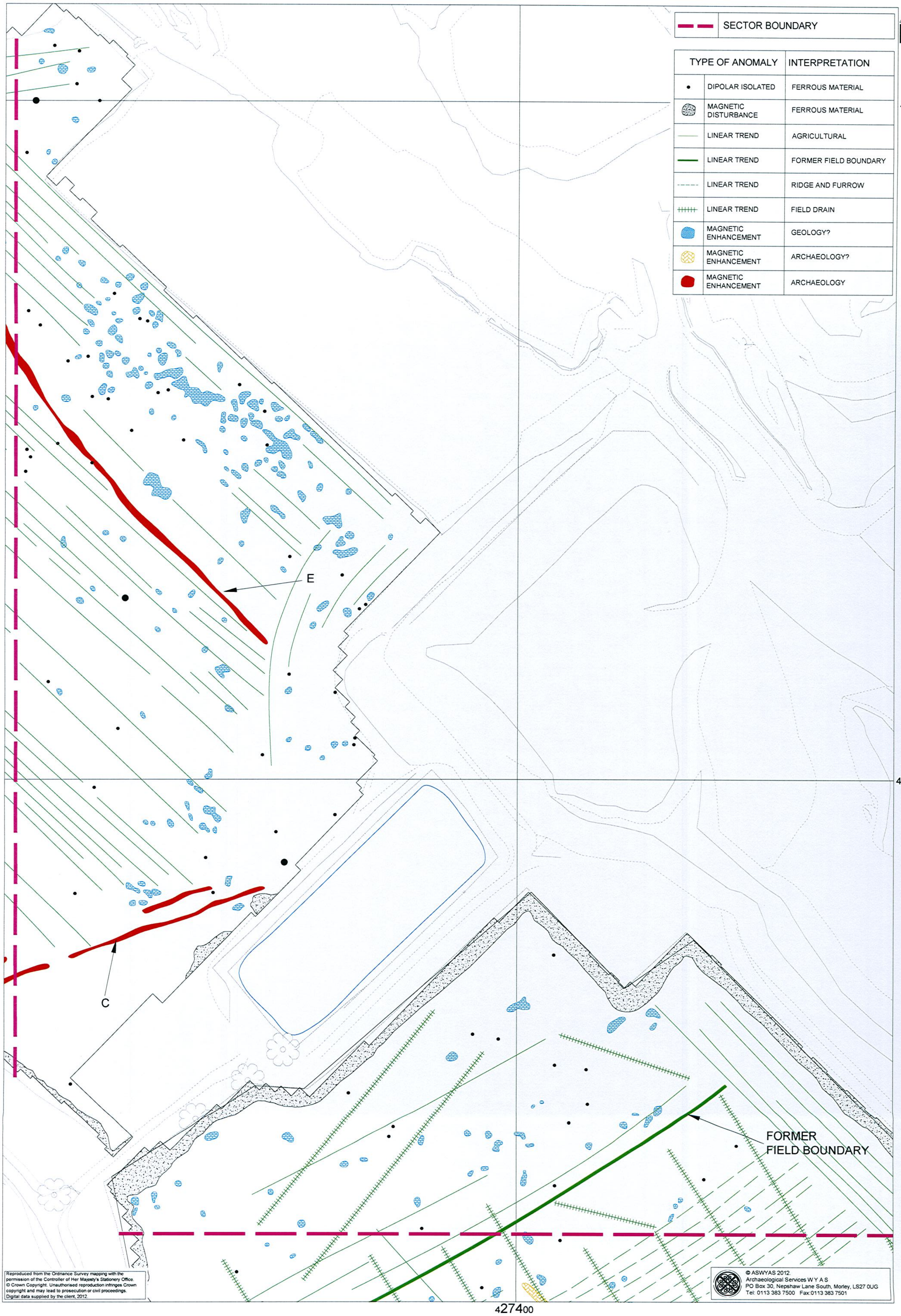

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Fig. 9. Interpretation of magnetometer data; Field 1, sector 2 and Field 2, sector 1 (1:1000 @ A3)

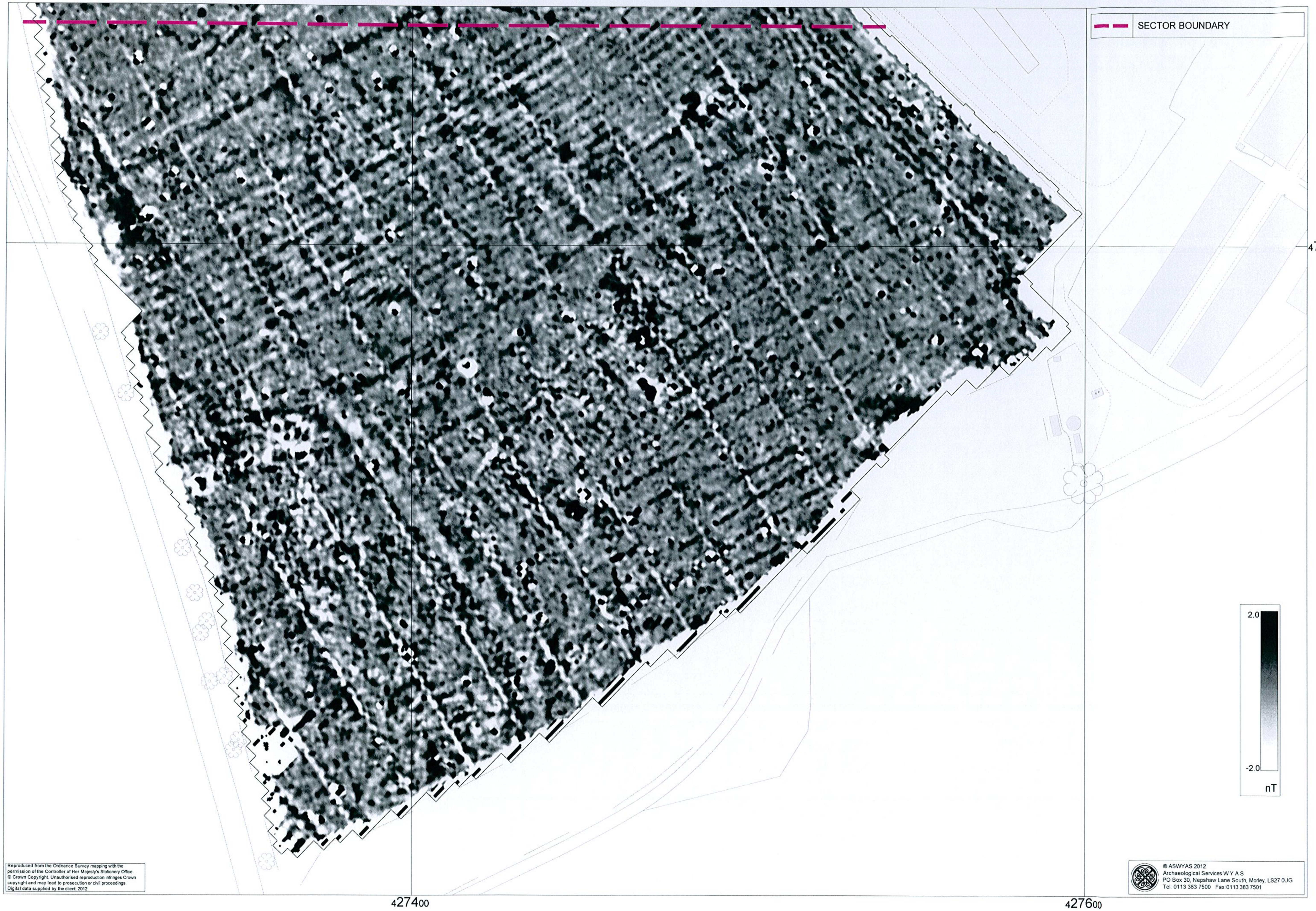

Fig. 10. Processed greyscale magnetometer data; Field 2, Sector 2 (1:1000 @ A3)

Fig. 12. Interpretation of magnetometer data; Field 2, sector 2 (1:1000 @ A3)

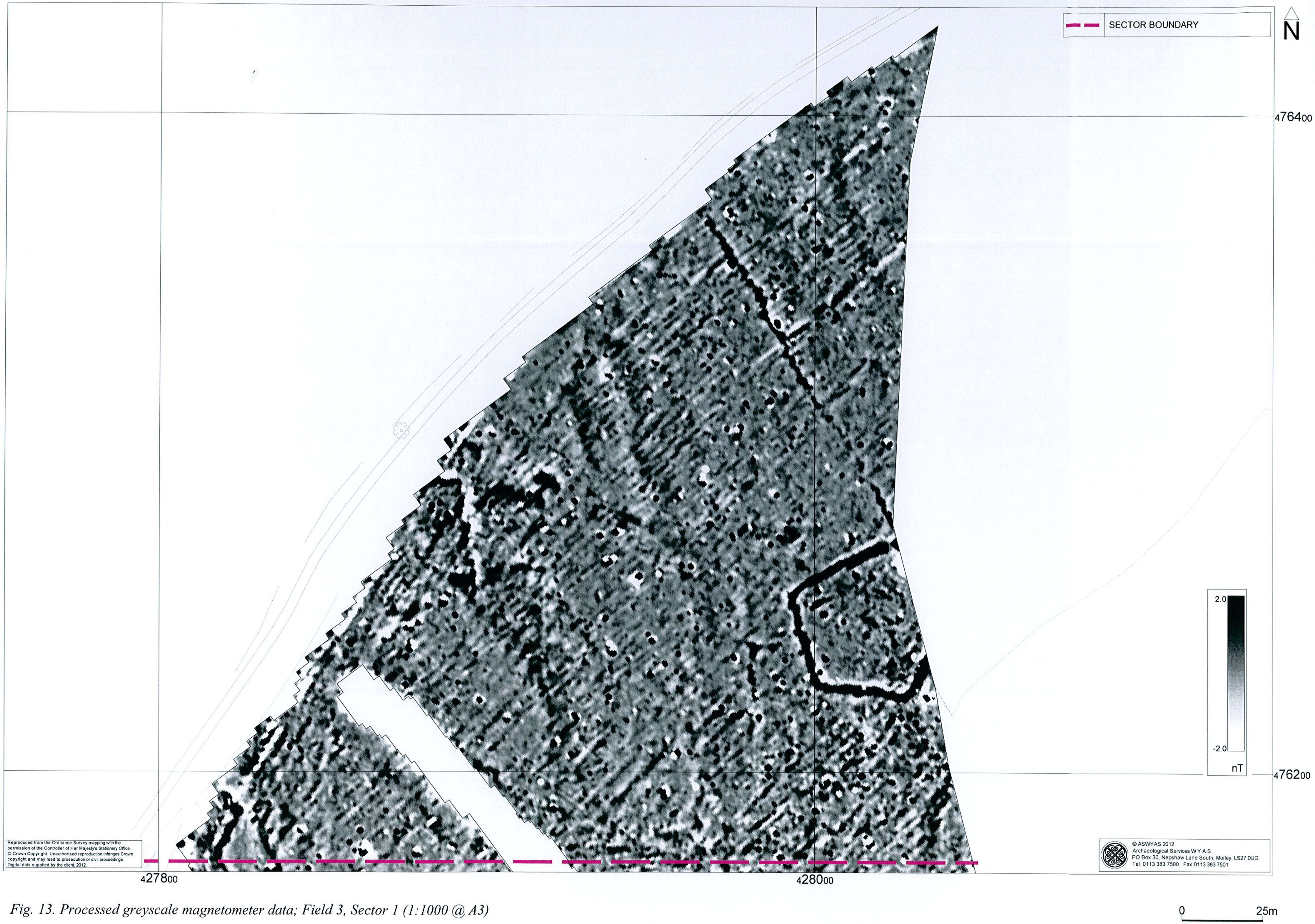

Fig. 13. Processed greyscale magnetometer data; Field 3, Sector 1 (1:1000 @ A3)

Fig. 15. Interpretation of magnetometer data; Field 3, sector 1 (1:1000 @ A3)

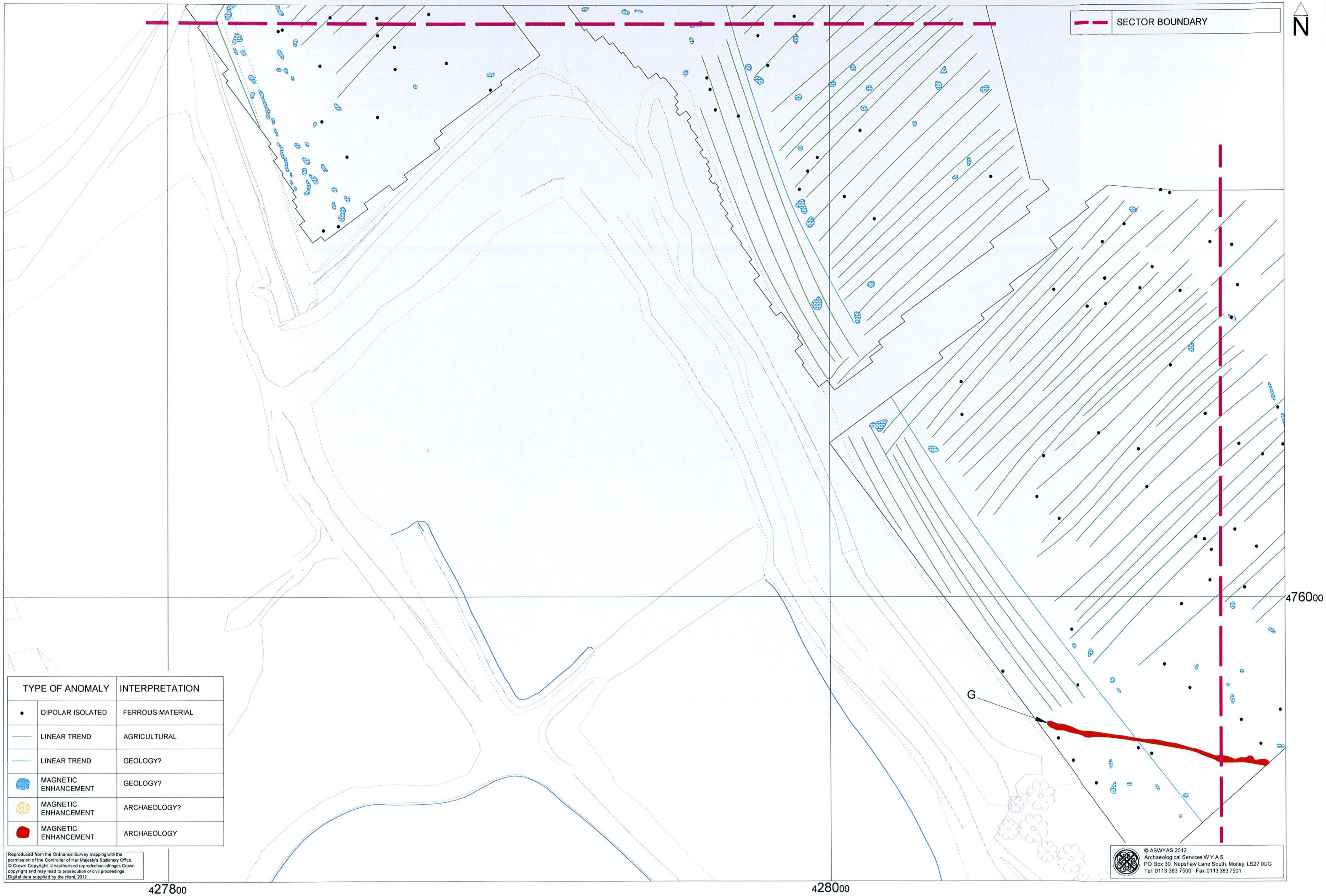

Fig. 18. Interpretation of magnetometer data; Field 3, sector 2 (1:1000 @ A3)

Fig. 19. Processed greyscale magnetometer data; Field 3, Sector 3 (1:1000 @ A4) 0 25m