ARCHAEOLOGICAL SERVICES WYAS

Whinthorpe
York

Geophysical Survey

Report no. 2620

June 2014

Client: Field Archaeology Specialists Ltd

Whinthorpe
York

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 58 hectares was carried out on agricultural land south-east of York where it is proposed to develop a new settlement at Whinthorpe. The survey has identified linear anomalies indicative of recent agricultural activity (ploughing and drainage), and others that locate some (but not all) of the 19th century boundaries shown on early Ordnance Survey mapping. The most numerous anomalies reflect the varying nature of the superficial deposits across the Vale of York. The survey has not identified any anomalies of obvious archaeological potential.

ARCHAEOLOGICAL
SERVICES
WYAS

Report Information

Client:	Field Archaeology Specialists Ltd
Address:	Unit 8, Fulford Business Centre, 35 Hospital Fields Road, York, YO10 4DZ
Report Type:	Geophysical Survey
Location:	Whinthorpe
District:	York
County:	North Yorkshire
Grid Reference:	SE 643 485
Period(s) of activity:	medieval/post-medieval?
Report Number:	2620
Project Number:	4237
Site Code:	WTY14
OASIS ID:	archaeol11-182923
Museum Accession No.:	n/a
Date of fieldwork:	May 2014
Date of report:	June 2014
Project Management:	Sam Harrison BA MSc MIfA
Fieldwork:	Sam Harrison BA MSc MIfA
	Christopher Sykes MSc BA
	Alex Schmidt BA
	Dan Waterfall BA
	Tom Fildes BA
Report:	Alistair Webb BA MIfA
Illustrations:	David Harrison and Sam Harrison
Photography:	Site Staff
Research:	n/a

Authorisation for distribution: ---

PO Box 30, Nepshaw Lane South, Morley, Leeds
LS27 0UG
Telephone: 0113 383 7500.
Email: admin@aswyas.com

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Field Archaeology Specialists Ltd (FAS), on behalf of Halifax Estates, to undertake a geophysical (magnetometer) survey of land south-east of York (see Fig. 1), in order to support the proposed allocation and development of a new settlement. The work was undertaken in accordance 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 between April 28th and May 16th 2014 in order to provide additional information on the archaeological potential of the site. To accommodate different cropping regimes the survey will be undertaken in stages and by two geophysical contractors. This report details the results of the first phase of survey undertaken by ASWYAS.

Site location, topography and land-use

The Proposed Development Area (PDA), centred at SE 643 485, comprises sixty fields, including some woodland, in a single block of land that covers approximately 200 hectares (see Fig. 1). The site is bounded by the A64 to the north-west and the disused airfield at Elvington to the south. This phase of survey covered twelve fields (see Fig. 2), an area of approximately 58 hectares, with Fir Tree Farm to the south, Langwith Lodge to the east and White House Farm to the north (see Fig. 2). All of the fields were sown with either barley or wheat. The crops did not exceed 0.4m in height (see plates) and no problems were encountered during the survey.

The fields were all relatively flat and low lying ranging from 8m above Ordnance Datum (aOD) in Field 38, north of Fir Tree Farm, at the southern apex of the site, to 9m aOD in the fields surrounding White House (Fields 43 to 48 inclusive), to 13m aOD in the fields south of Langwith Lodge.

Soils and geology

The solid geology comprises Sherwood Sandstone but this is overlain throughout by glacially derived superficial deposits of sand, gravel, clay and silt of the Vale of York, Elvington Glaciolacustrine, Sutton and Naburn Formations. The distribution of these deposits across the survey areas is shown in Figure 5.

The soils are predominantly classified in the Blackwood association, characterised as deep, permeable sandy and coarse loams. To the east the soils are classified in the Holme Moor association, which comprise deep, stoneless sands (Soil Survey of England and Wales 1983).

2 Archaeological Background

A Desk-based Archaeological Assessment of the site (FAS Heritage 2014) identified 20 cultural heritage assets (CHAs) recorded within the proposed allocation and safeguarded land. These include a Neoliothic axe and two Roman coin hoards, however, only three assets are identified within the areas covered by this phase of the survey. These comprise records of ridge and furrow ploughing in two adjoining fields (CHA 35 and CHA 52) and linear cropmarks interpreted as Iron Age/Romano-British field boundaries (CHA 14). These three assets are indicative of the extent of the known remains within the site as a whole which the assessment stated represented '*limited evidence for field systems of possible Iron Age to Roman date, and a number of areas of medieval ridge and furrow, identified through aerial photographs*'. The assessment concluded that the identified assets do '*indicate the potential for archaeological remains …. but do not allow a characterisation of the potential extent and significance …*'. Following consultation with the City Archaeologist (John Oxley) a programme of field evaluation, including geophysical (magnetometer) survey, was recommended.

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 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 parts of the PDA currently accessible 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

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 survey location plan displaying the processed greyscale magnetometer data at a scale of 1:7500 which has been superimposed in Figure 3 and Figure 4 by the first edition mapping and the superficial deposits respectively. Figure 5 is an overall interpretation plot of the data, also at a scale of 1:7500. Detailed data plots ('raw' and processed) and full interpretative figures are presented at a scale of 1:1000 in Figures 6 to 47 inclusive.

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 (Harrison 2014) and guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2013). 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 6 to 47 inclusive)

Numerous anomalies have been identified by the survey, falling into several different types and categories according to their origin. These are discussed below and cross-referenced to specific examples and locations within the site, where appropriate.

Agricultural Anomalies

Linear trend anomalies are identified in virtually all the surveyed fields all of which are interpreted as agricultural in origin. The most extensive parallel linear anomalies, identified in Field 38, Field 39 and Field 43, are caused by ploughing. The anomalies are noticeably straight and close together suggesting they are more likely to be indicative of a recent ploughing regime. However, cropmarks in Field 38 and Field 39 (Cultural Heritage Asset (CHA) 35 and CHA52 – FAS Heritage 2014) have previously been recorded as broad medieval ridge and furrow.

The weak linear trend anomaly, **A**, crossing Field 38 and Field 39 on an east/west alignment at an oblique angle to the field boundaries is interpreted as a field drain. A radiating series of linear anomalies, **B**, in Field 44, and a single linear, **C**, in Field 43, which terminates at a former field boundary, are also interpreted as field drains.

A fourth possible drain, **D**, is located slightly oblique to the south-eastern boundary of Field 43.

Analysis of the first edition Ordnance Survey mapping shows that in the late 19th century the landscape was divided into smaller fields (see Fig. 3). Some of these former boundaries are still identifiable as linear anomalies, such as **E** and **F** in Field 43 and **G** and **H** in Field 56. Other former boundaries, such as those in Fields 46, 47 and 48, are not identified as magnetic anomalies although one of these boundaries, which crosses Field 46 and Field 47, does correspond with a linear cropmark (FAS Heritage 2014 – CHA 14; see Fig. 5). This cropmark and three others south and east of White House Farm have been interpreted as Iron Age/Romano-British boundary ditches; only one of these cropmarks manifests as a magnetic anomaly, **I**.

Geological Anomalies

Perhaps the most noticeable aspect of the data recorded during this survey is the variation in magnetic background across the twelve fields (see Fig. 2). Although the bedrock is sandstone it is overlain by superficial deposits of sand, silt, gravel and clay across all parts of the site (see Fig. 4). This variation (and indeed the vast majority of the anomalies identified by the survey), is due to the changes in the superficial deposits. No definite conclusions can be drawn but there are obvious correlations between the number and types of anomalies and the mapped changes in the superficial deposits. The boundaries between these superficial deposits are shown on Figure 5.

The most magnetically ‘quiet’ parts of the site are those where the Vale of York deposits (clays, sands and gravel) are present (in an east/west band across Field 38 and most of Field 43), the presence of the clay resulting in a fairly uniform (greytone) magnetic background. At the other end of the scale the magnetic background is particularly perturbed across the majority of Field 54, 55 and 56 such that the data has a speckled appearance. Here the wind blown Aolian sand of the Sutton Sand formation predominates. Sands, silts and gravels of the Naburn Sand Formation predominate across the majority of the rest of 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 modern ferrous debris in the soil.

5 Conclusions

Although numerous magnetic anomalies have been identified by this phase of the survey almost all of them are interpreted as geological in origin being caused by variation within and between the four different superficial deposit types recorded in the survey areas.

Linear anomalies provide evidence of recent agricultural activity, such as ploughing and drainage, whilst other linear anomalies locate former field boundaries removed over the last 120 years as field sizes increased. However, not all the former boundaries manifest as magnetic anomalies.

One linear cropmark east of White House Farm has been identified as a magnetic anomaly but it is considered more likely to locate a medieval or post-medieval boundary than one of Iron Age or Romano-British date. Other linear cropmarks to the south of the farm have not been identified by the survey.

Despite the presence of an extensive cropmark settlement site less than 0.5km to the south of the site the survey undertaken to date has not identified any anomalies of obvious archaeological potential.

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.

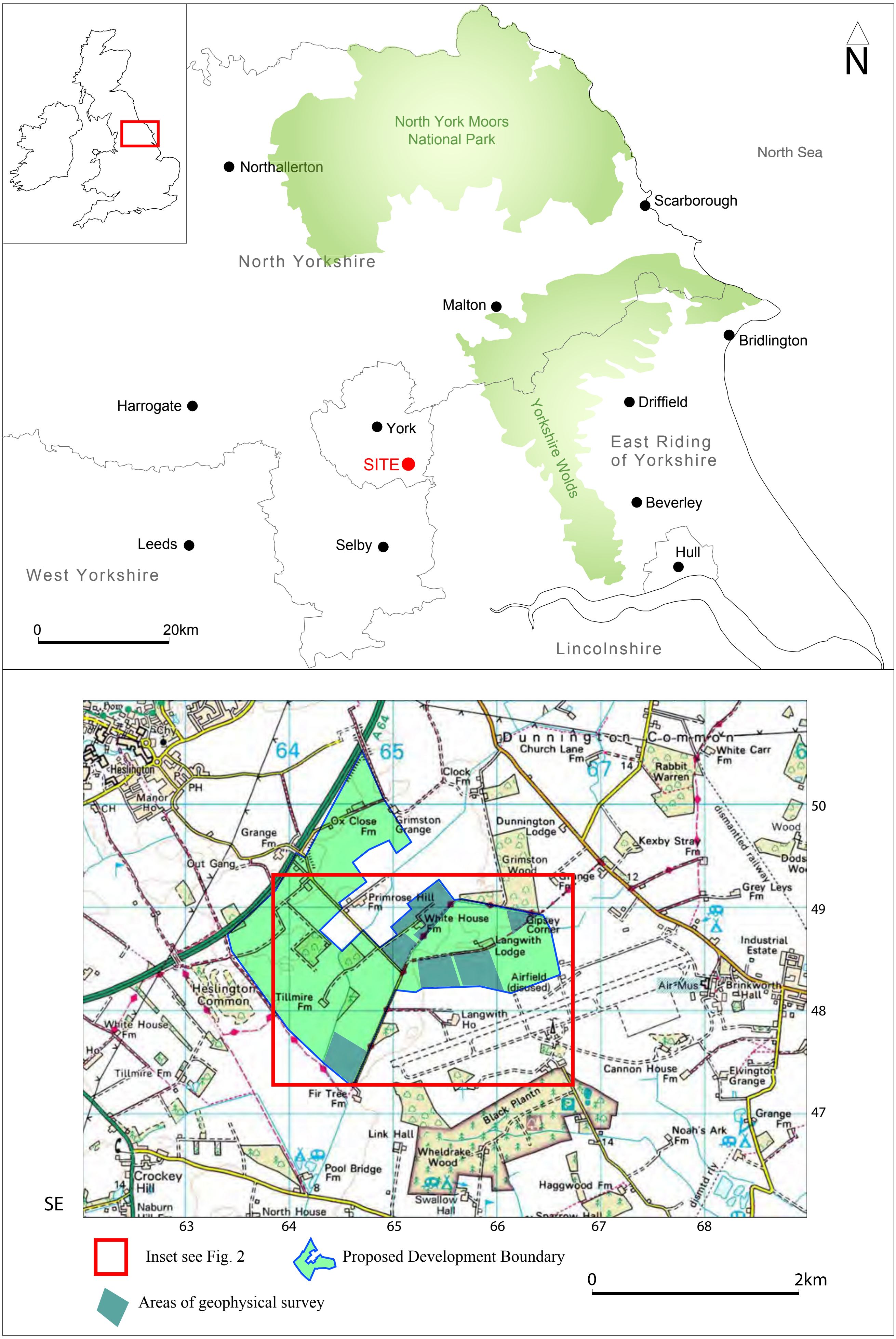


Fig. 1. Site location

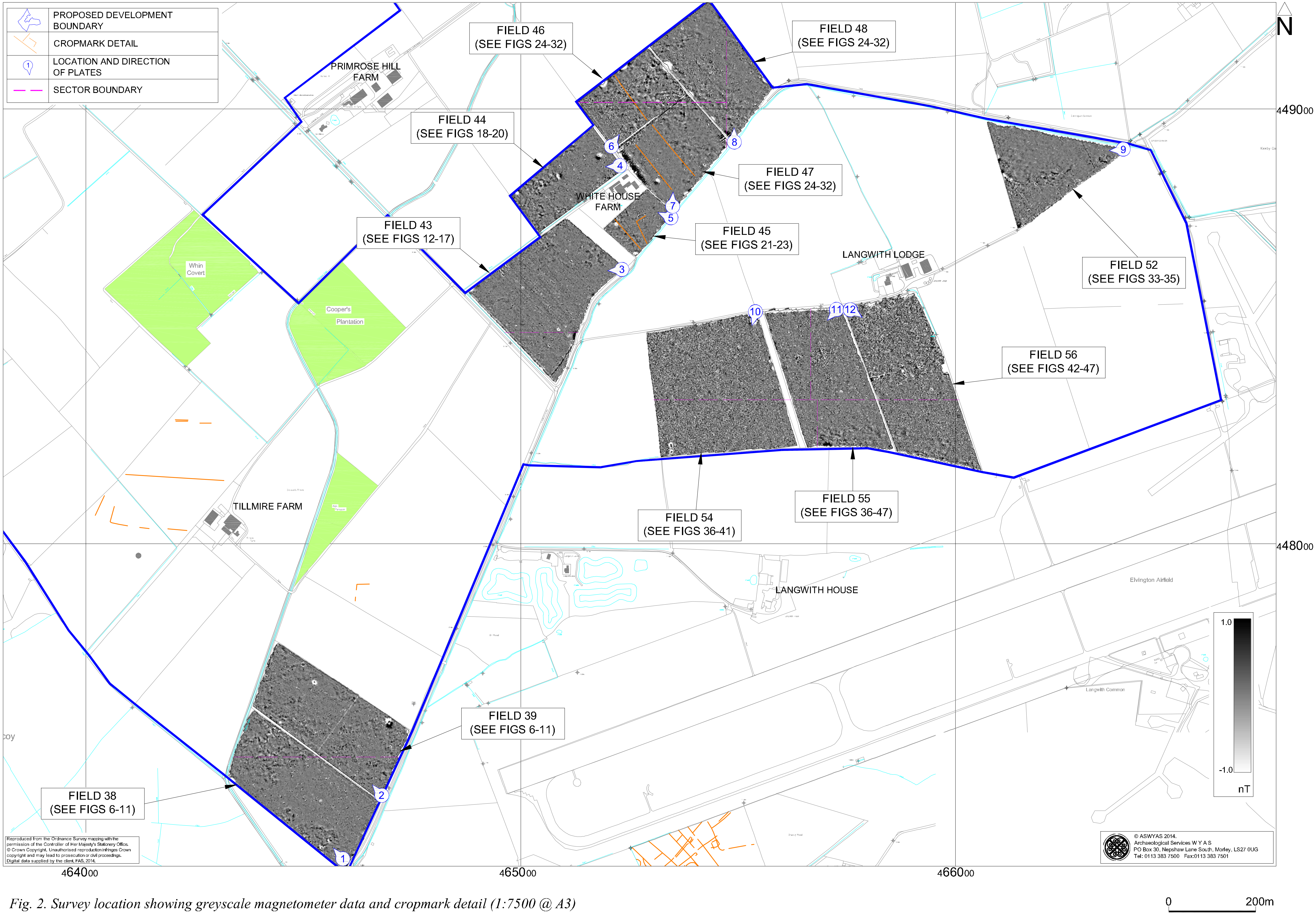


Fig. 2. Survey location showing greyscale magnetometer data and cropmark detail (1:7500 @ A3)

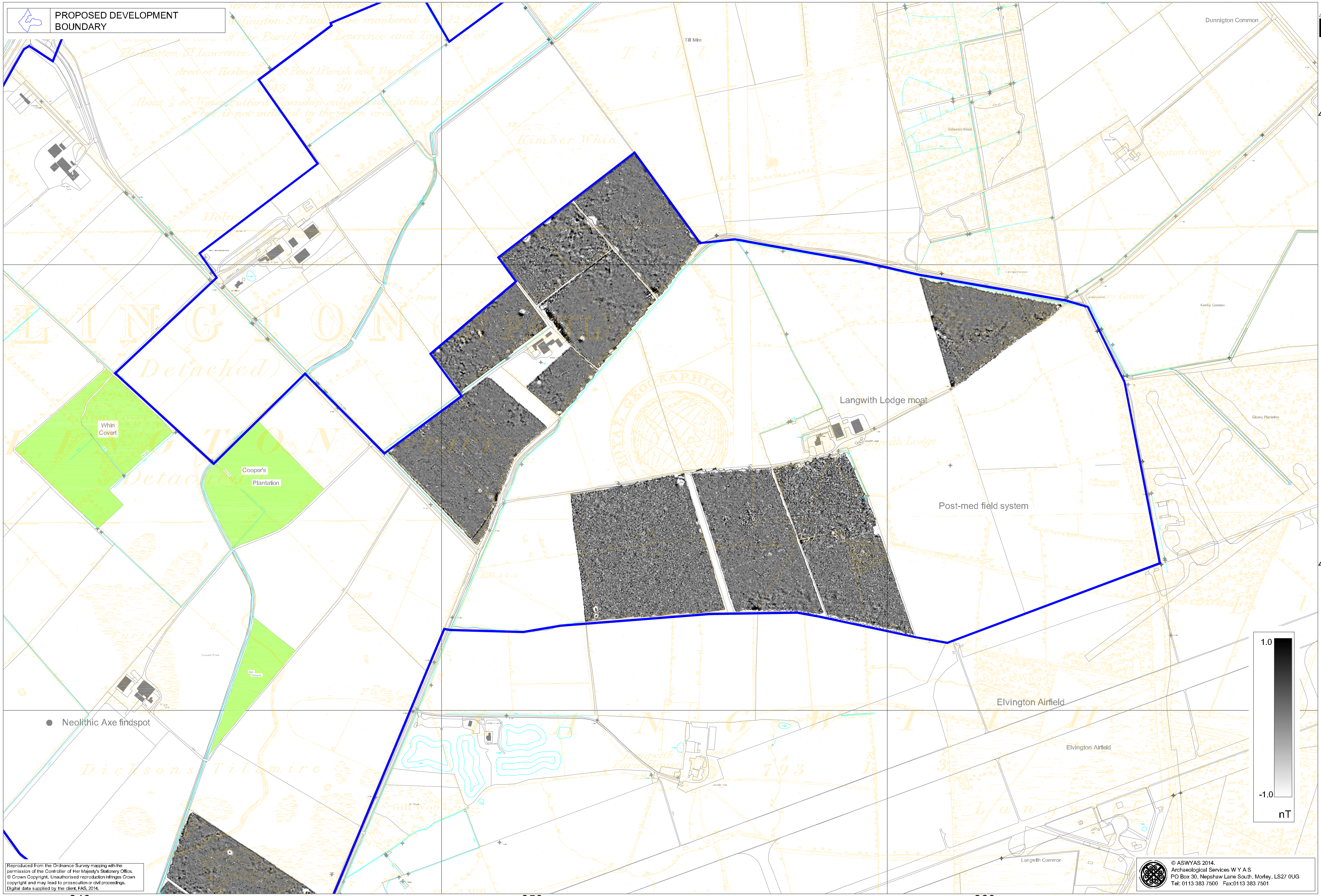


Fig. 3. Survey location showing greyscale magnetometer data and first edition Ordnance Survey mapping 1881-1884 (1:7500 @ A3)

0 200m

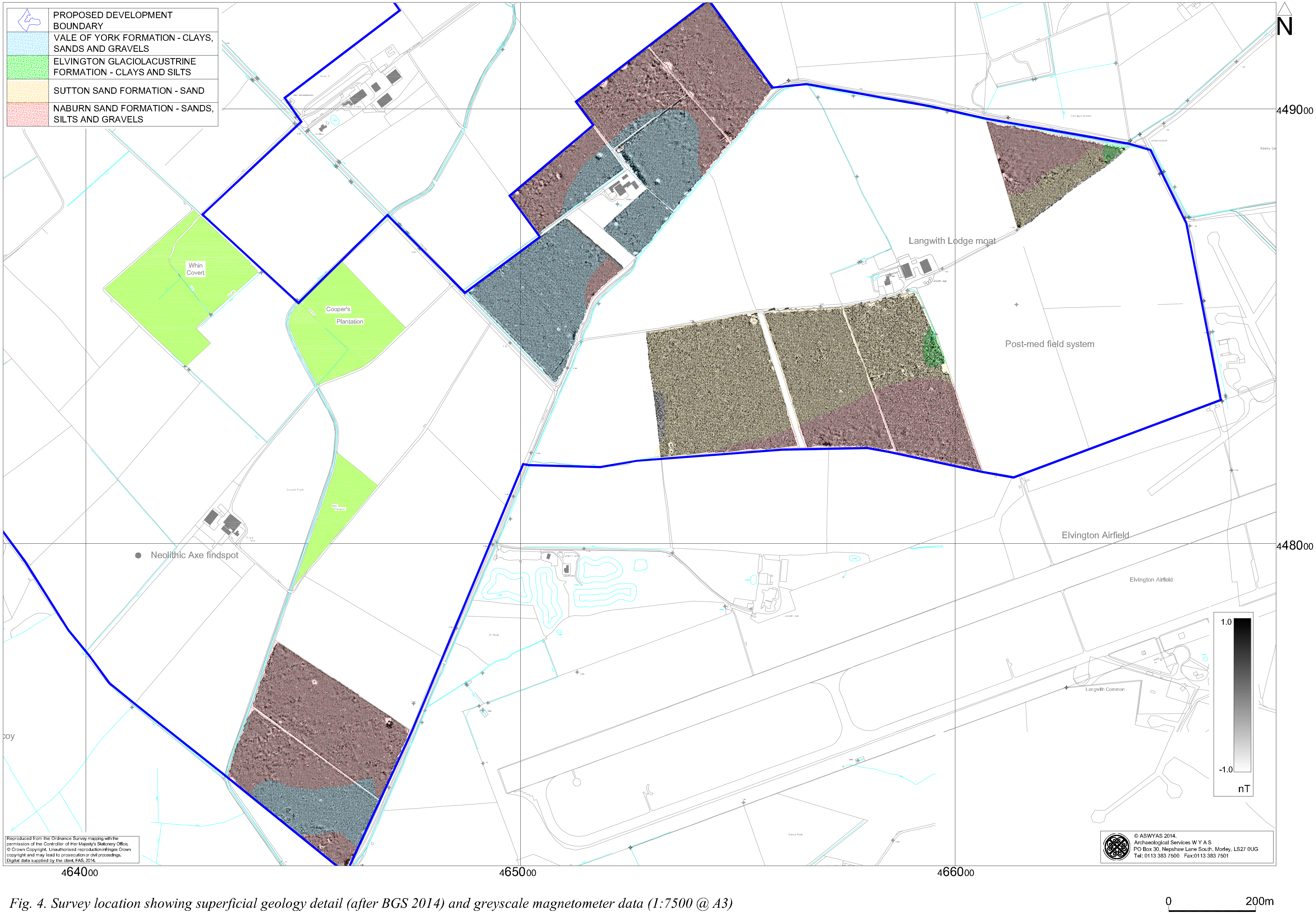


Fig. 4. Survey location showing superficial geology detail (after BGS 2014) and greyscale magnetometer data (1:7500 @ A3)

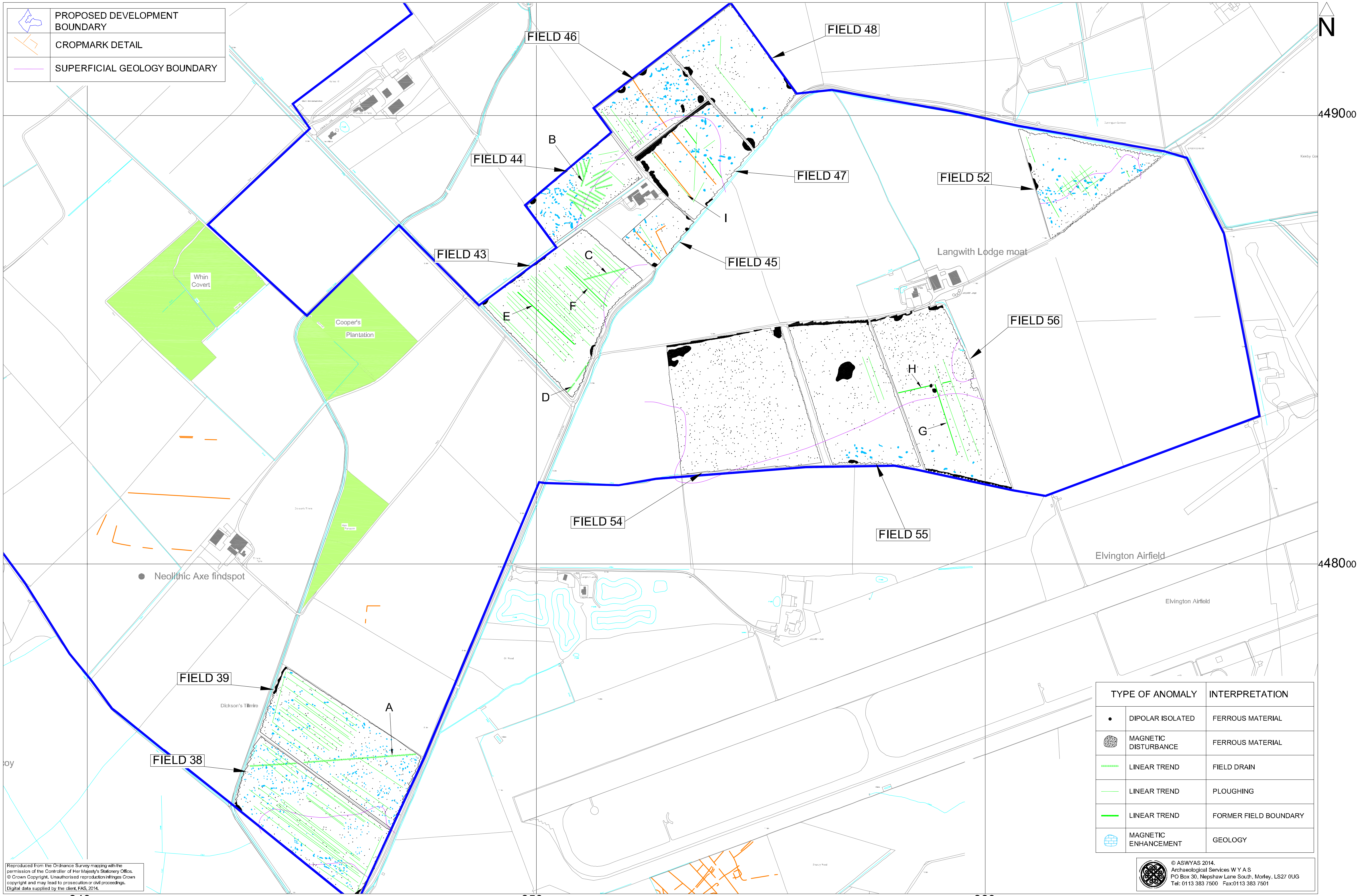


Fig. 5. Overall interpretation of magnetometer data (1:7500 @ A3)

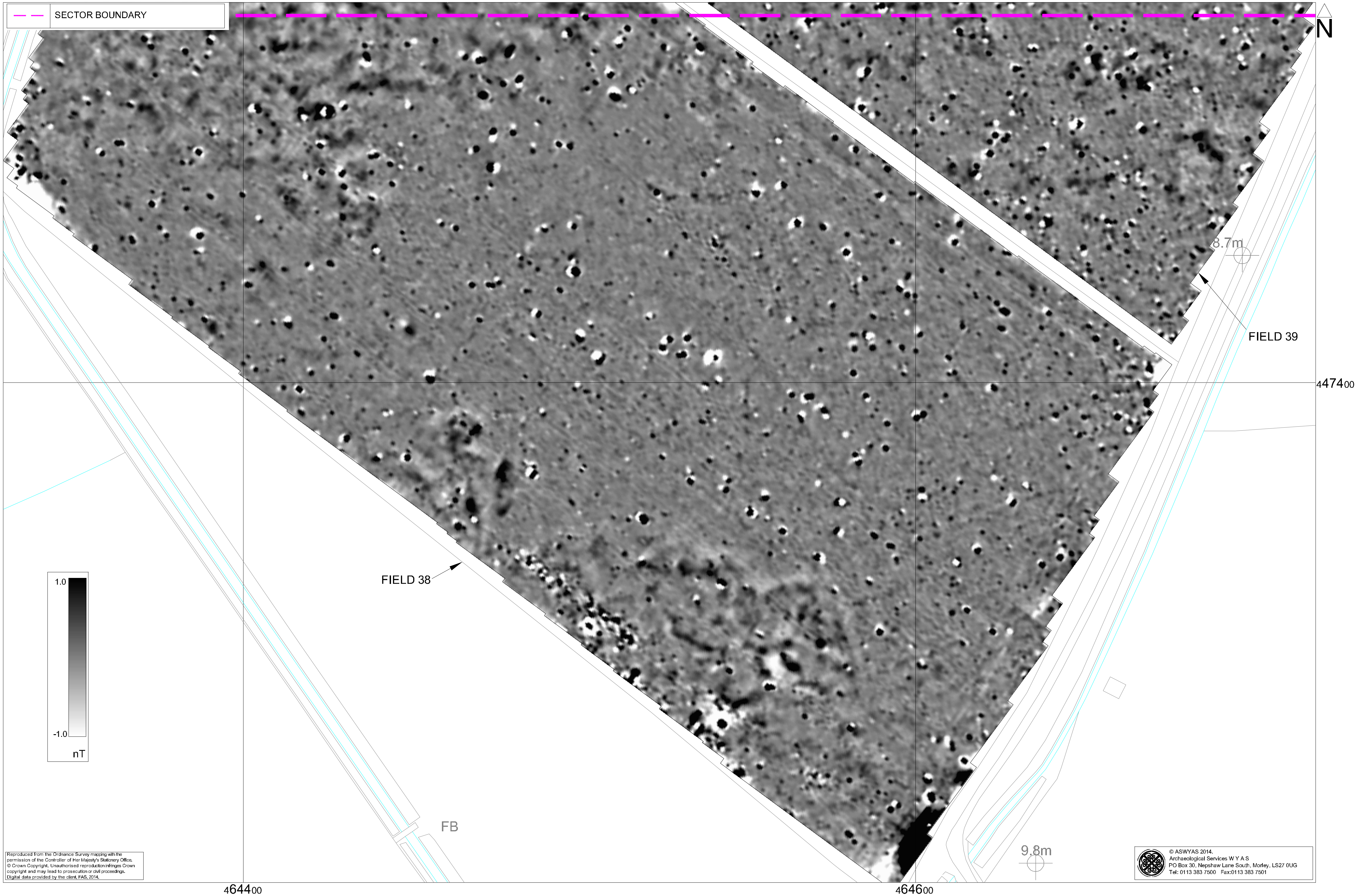


Fig. 6. Processed greyscale magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

0 40m

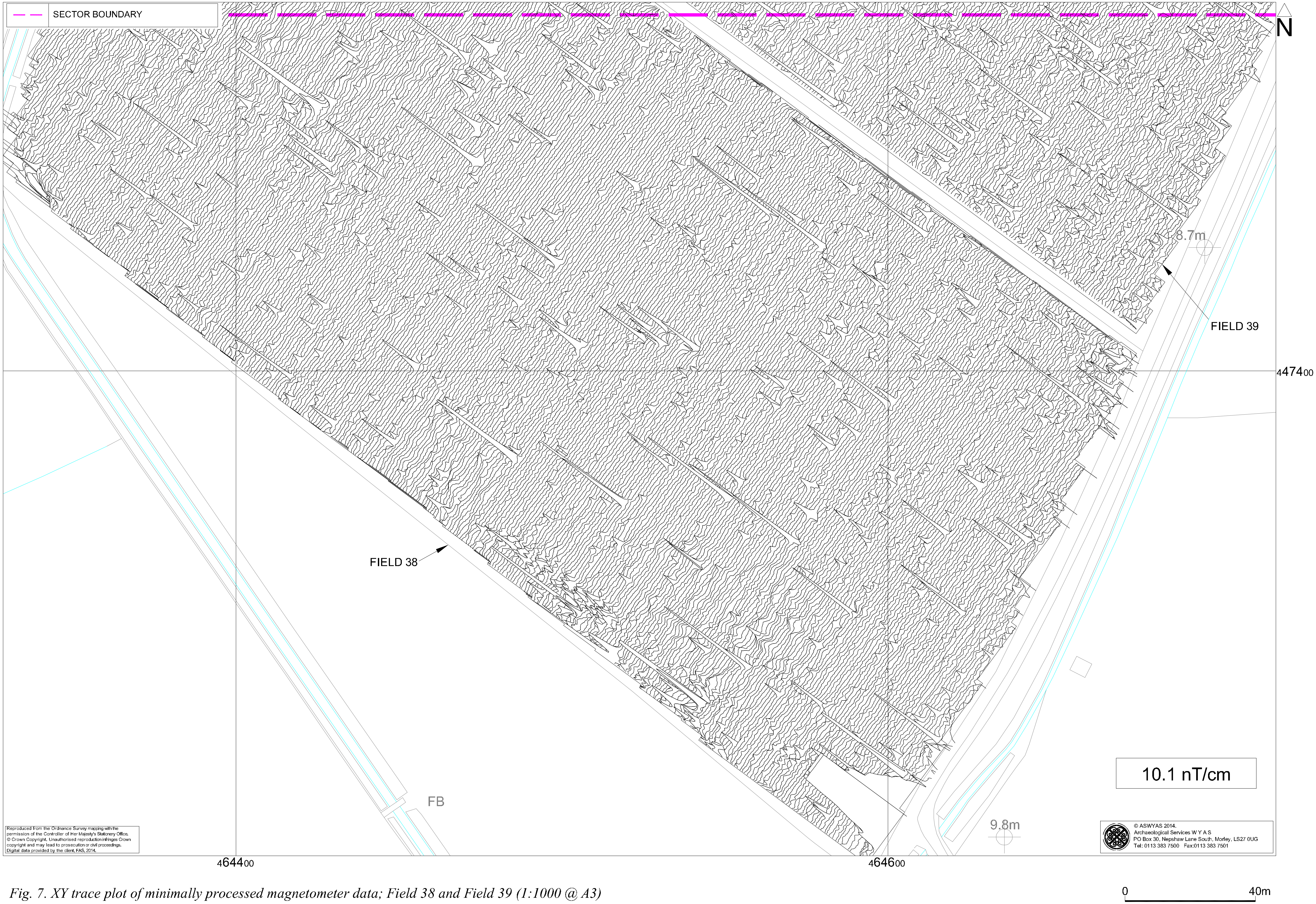


Fig. 7. XY trace plot of minimally processed magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

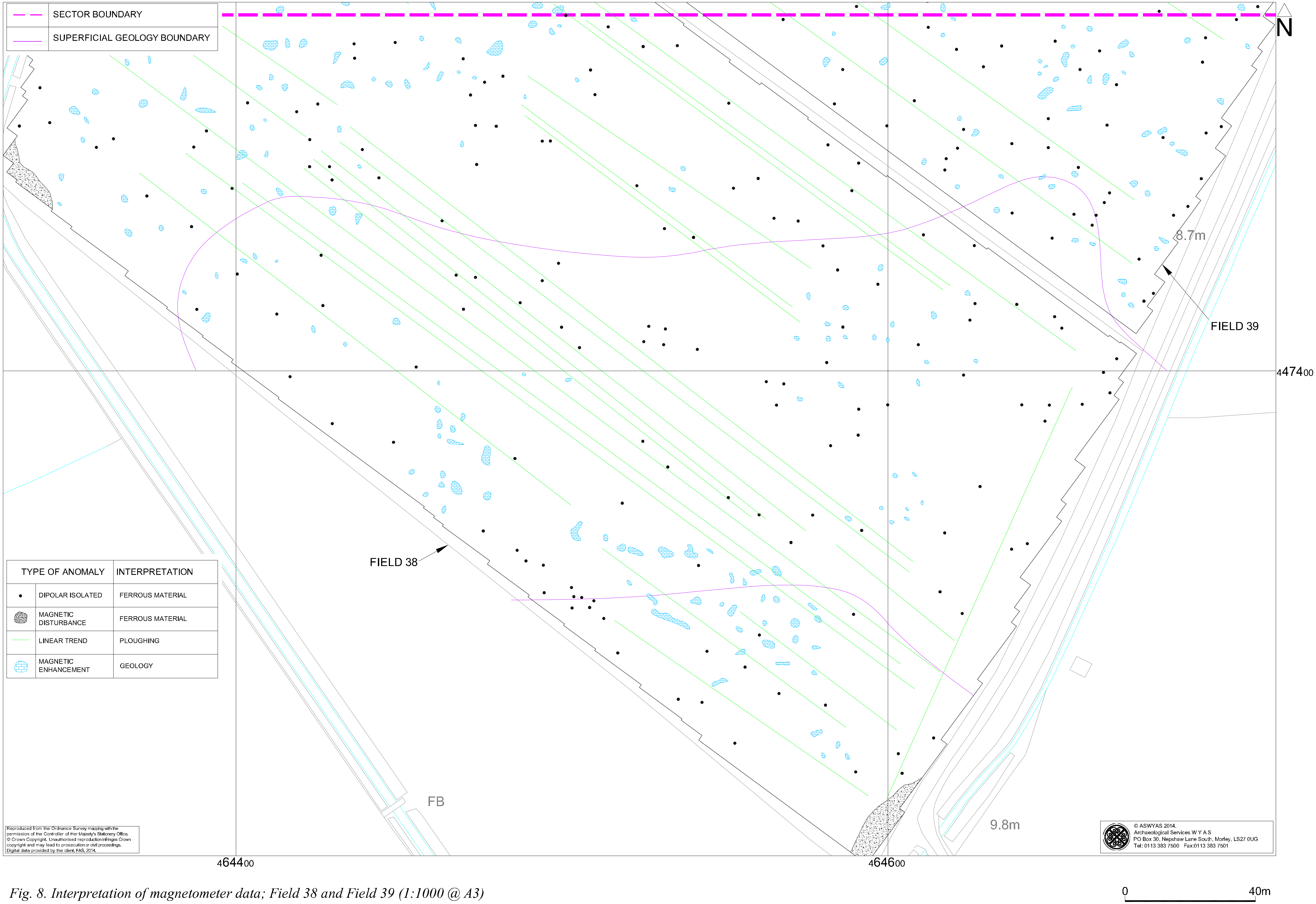


Fig. 8. Interpretation of magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

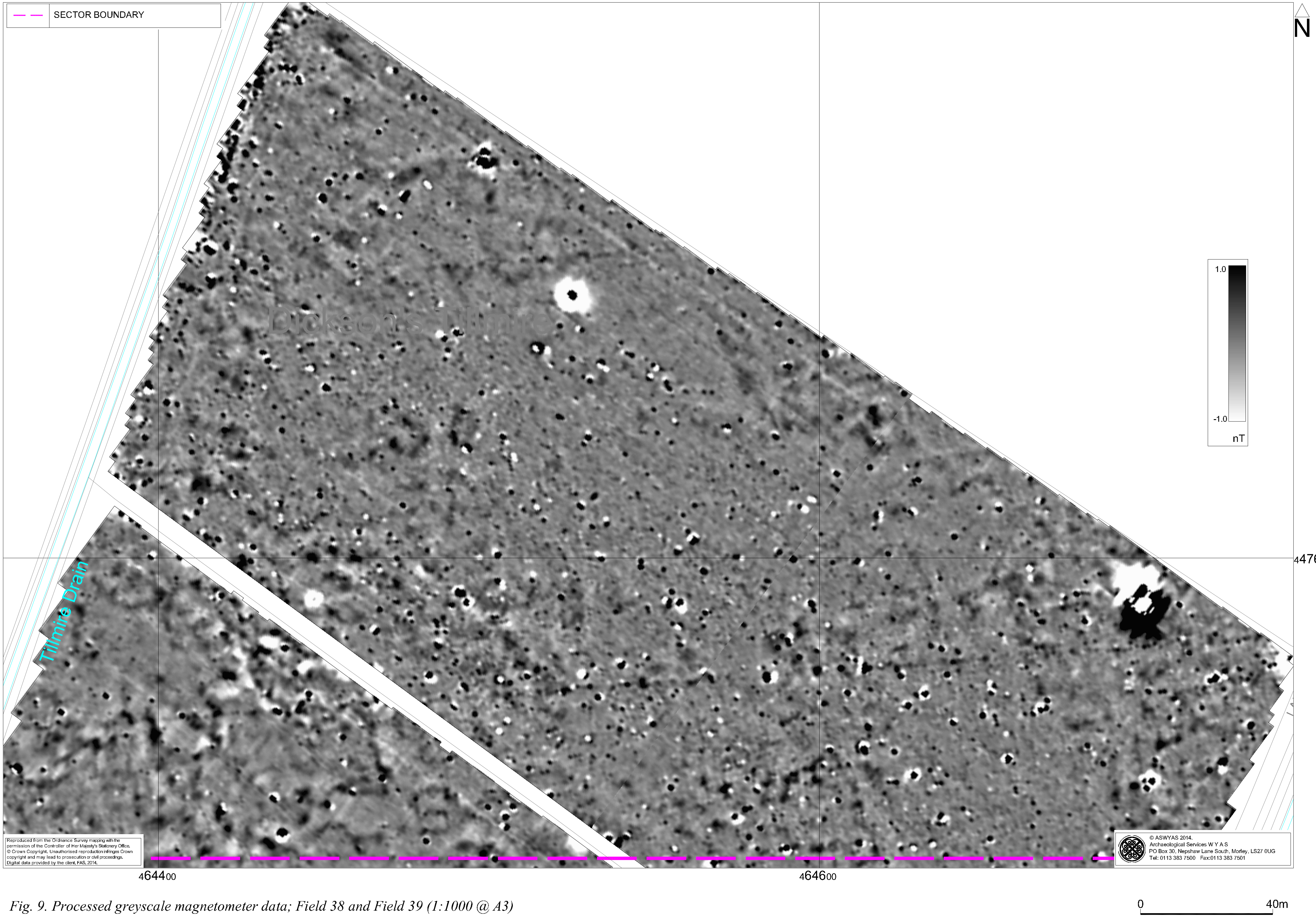


Fig. 9. Processed greyscale magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 10. XY trace plot of minimally processed magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

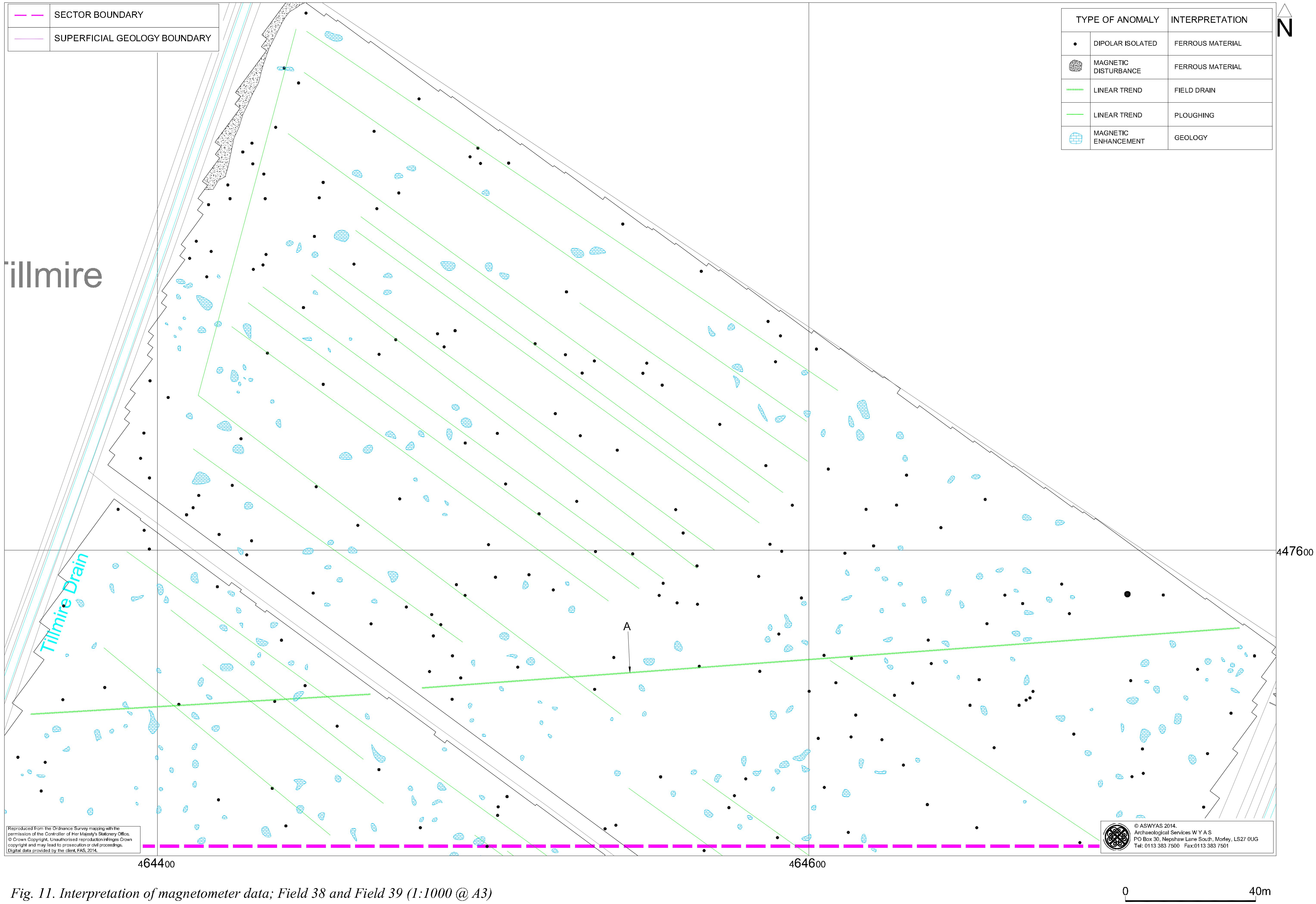


Fig. 11. Interpretation of magnetometer data; Field 38 and Field 39 (1:1000 @ A3)

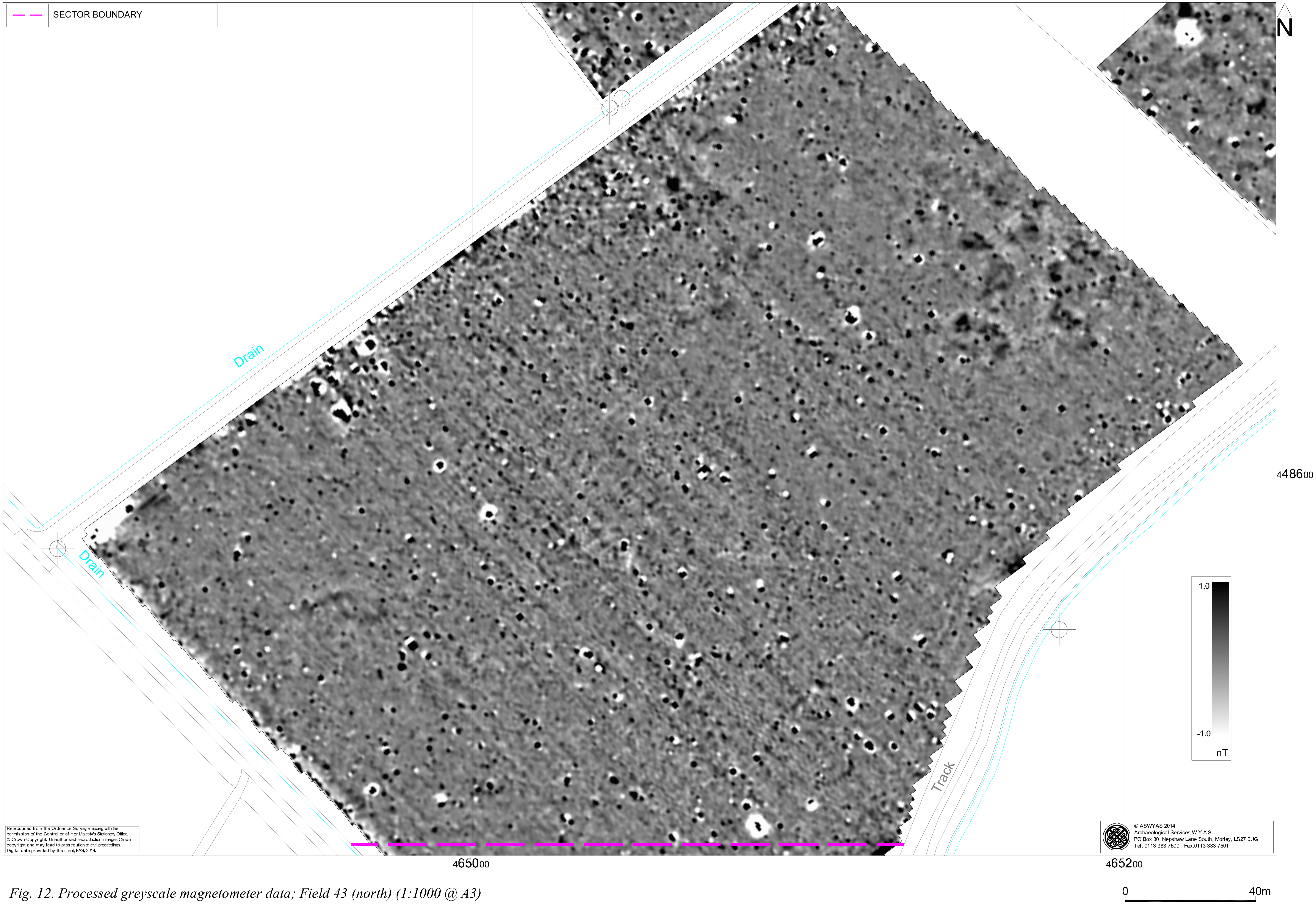


Fig. 12. Processed greyscale magnetometer data; Field 43 (north) (1:1000 @ A3)

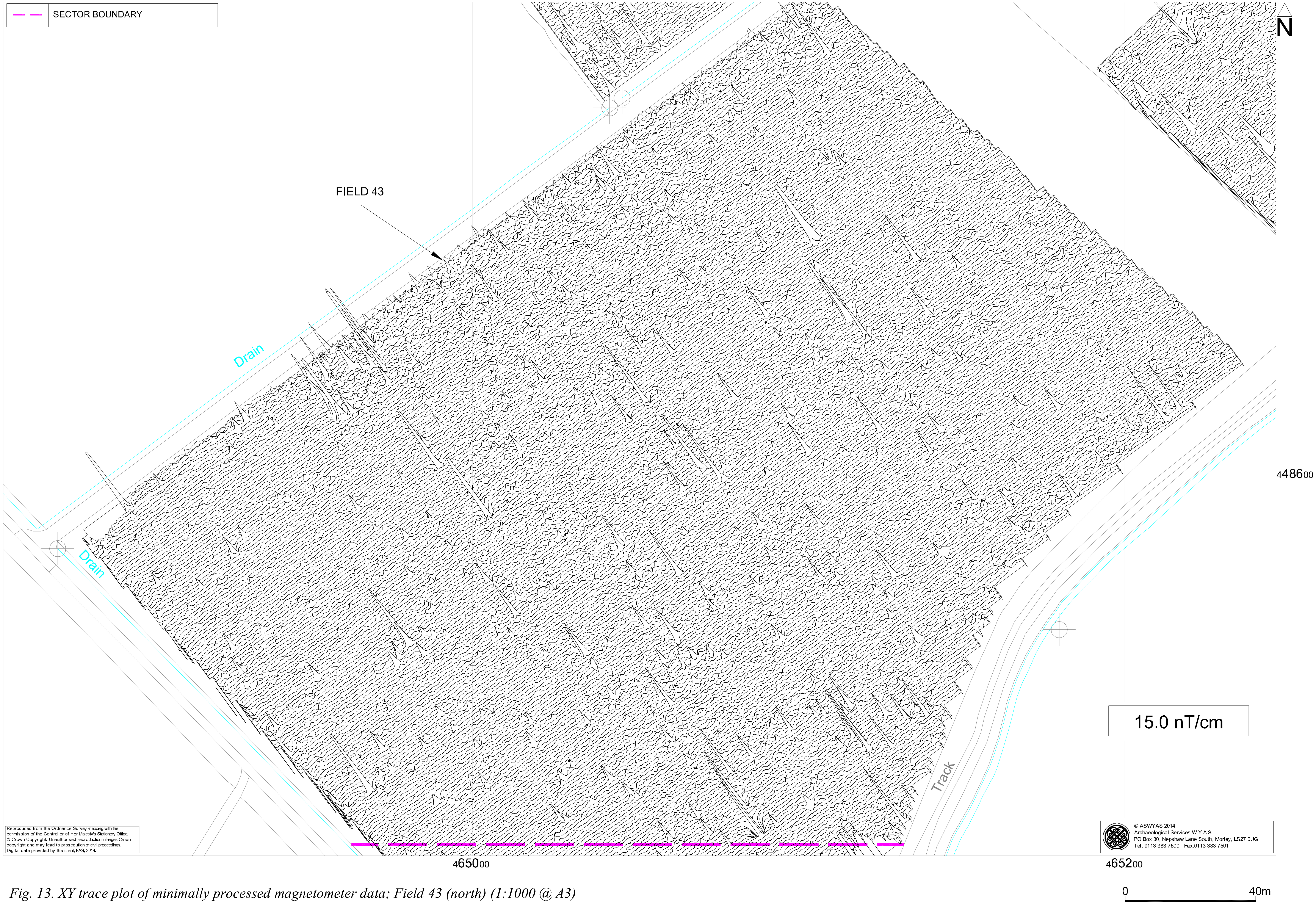


Fig. 13. XY trace plot of minimally processed magnetometer data; Field 43 (north) (1:1000 @ A3)

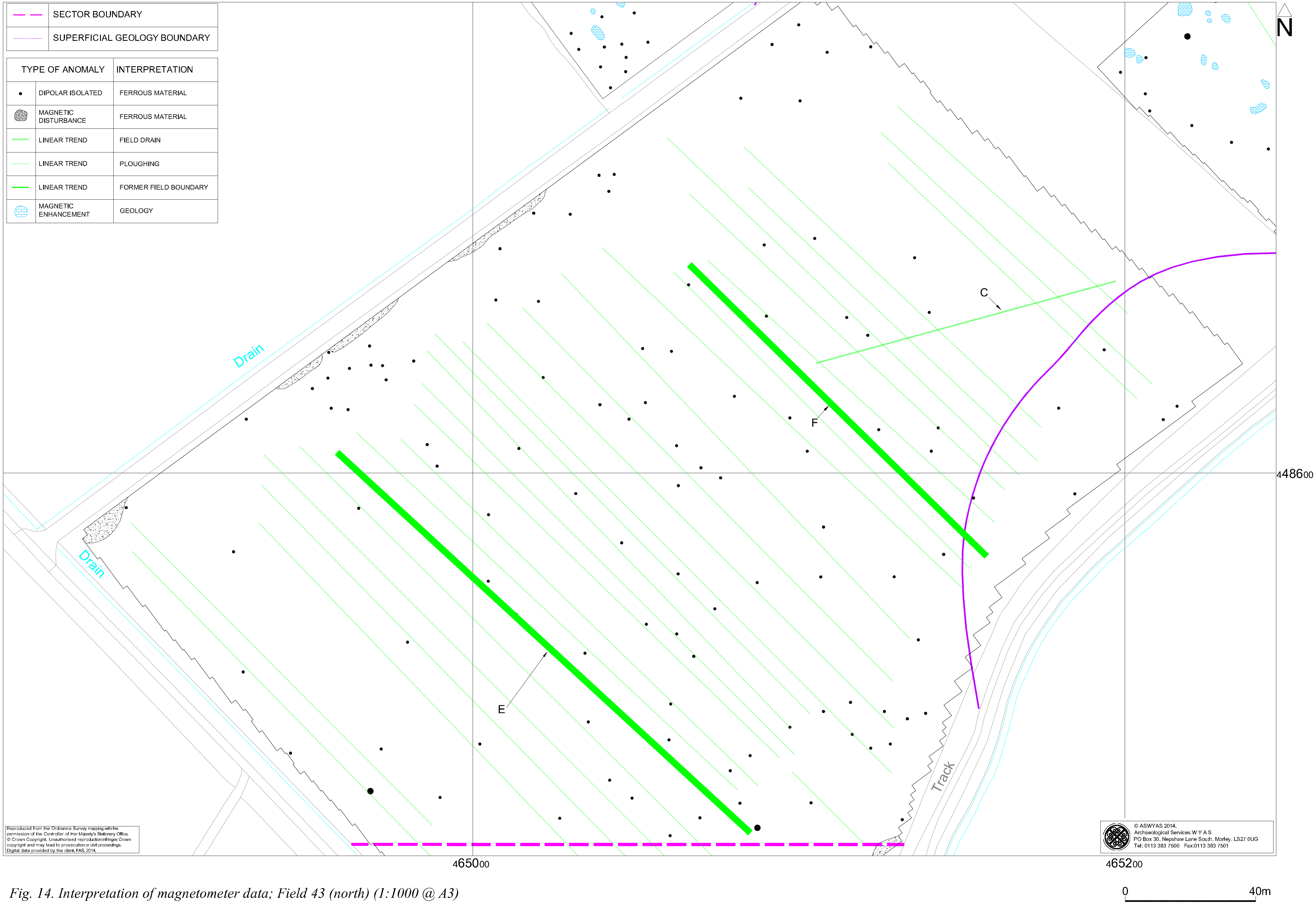


Fig. 14. Interpretation of magnetometer data; Field 43 (north) (1:1000 @ A3)

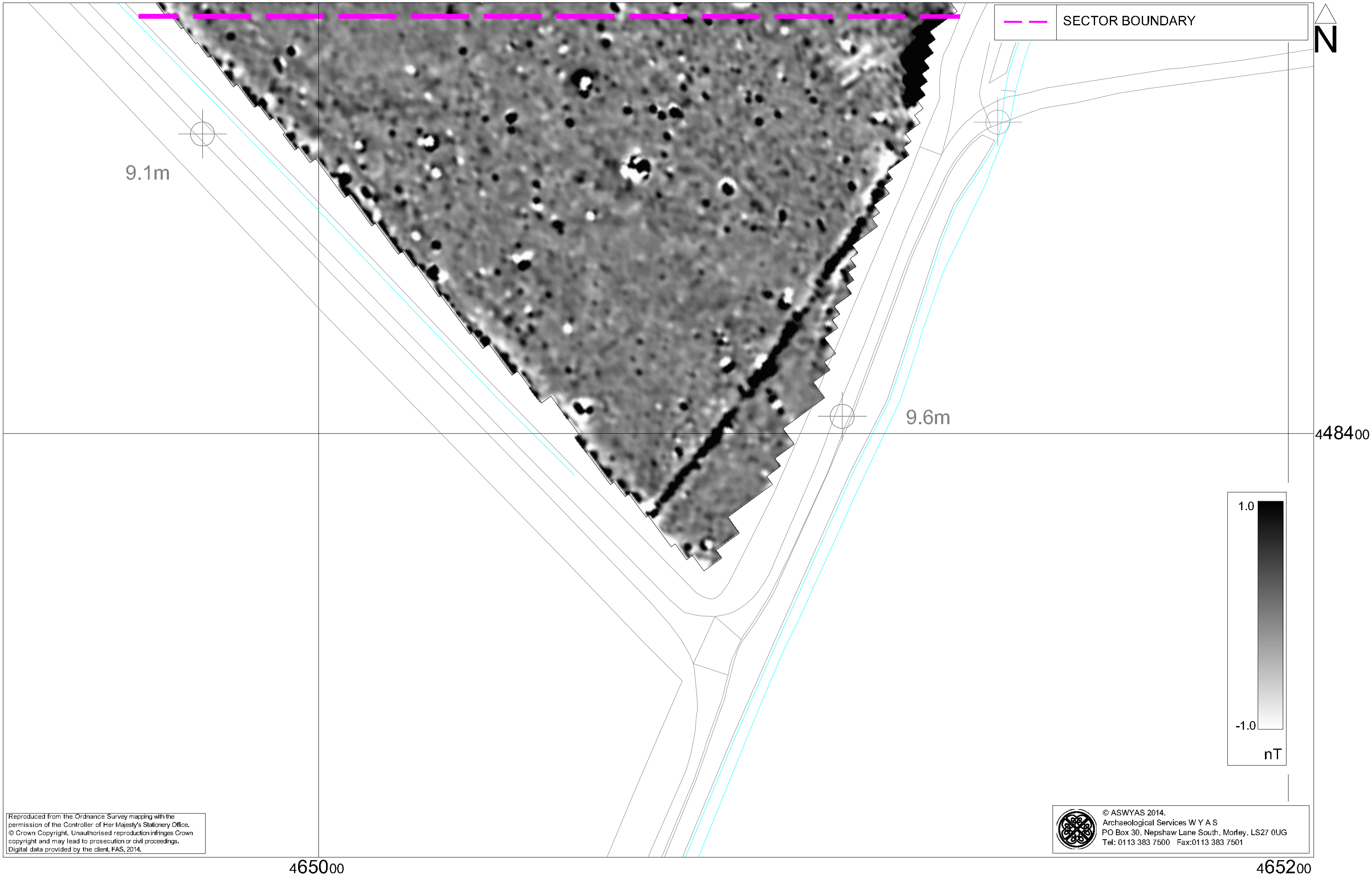


Fig. 15. Processed greyscale magnetometer data; Field 43 (south) (1:1000 @ A4)

0 40m

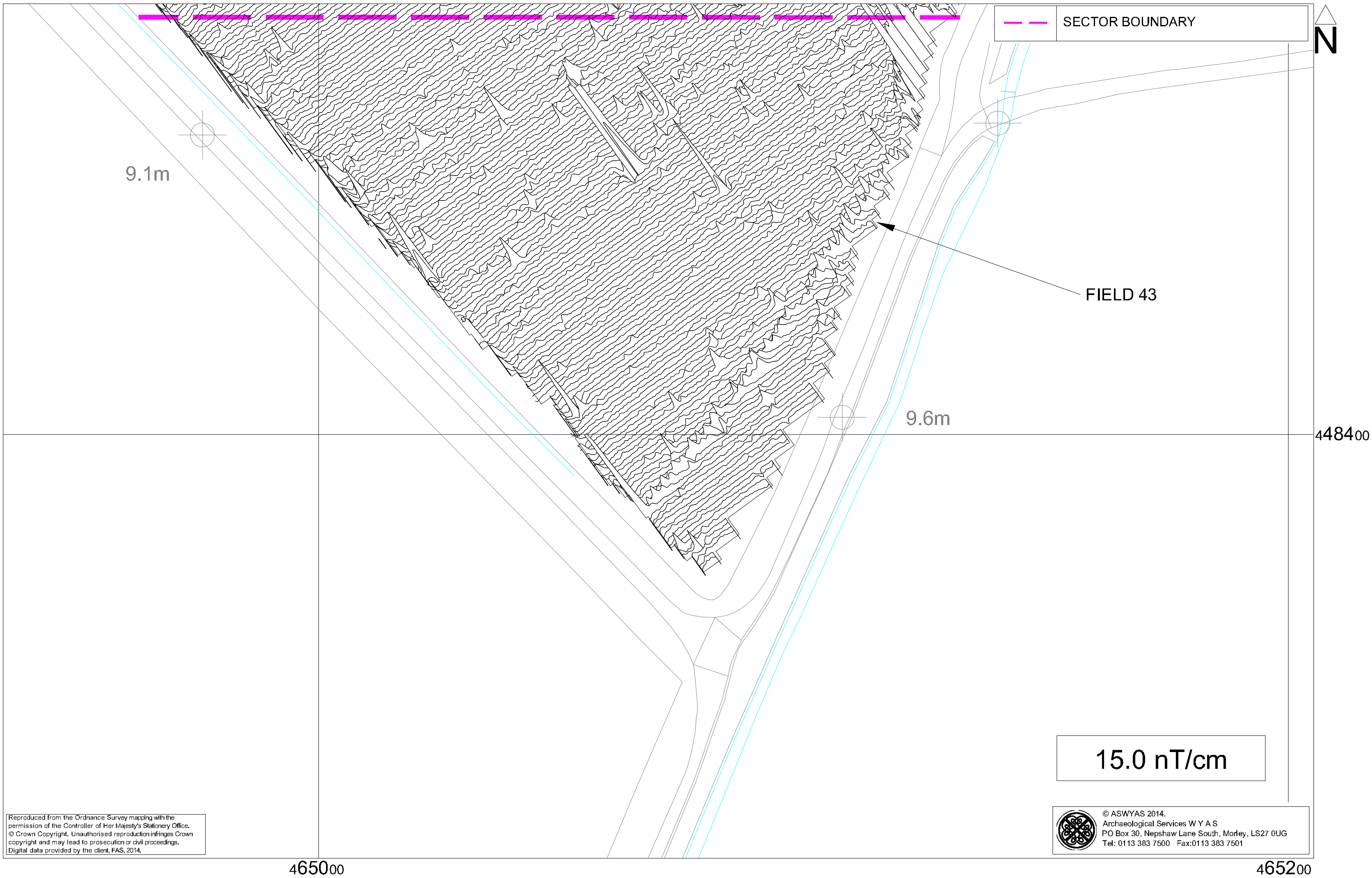


Fig. 16. XY trace plot of minimally processed magnetometer data; Field 43 (south) (1:1000 @ A4)

0 40m

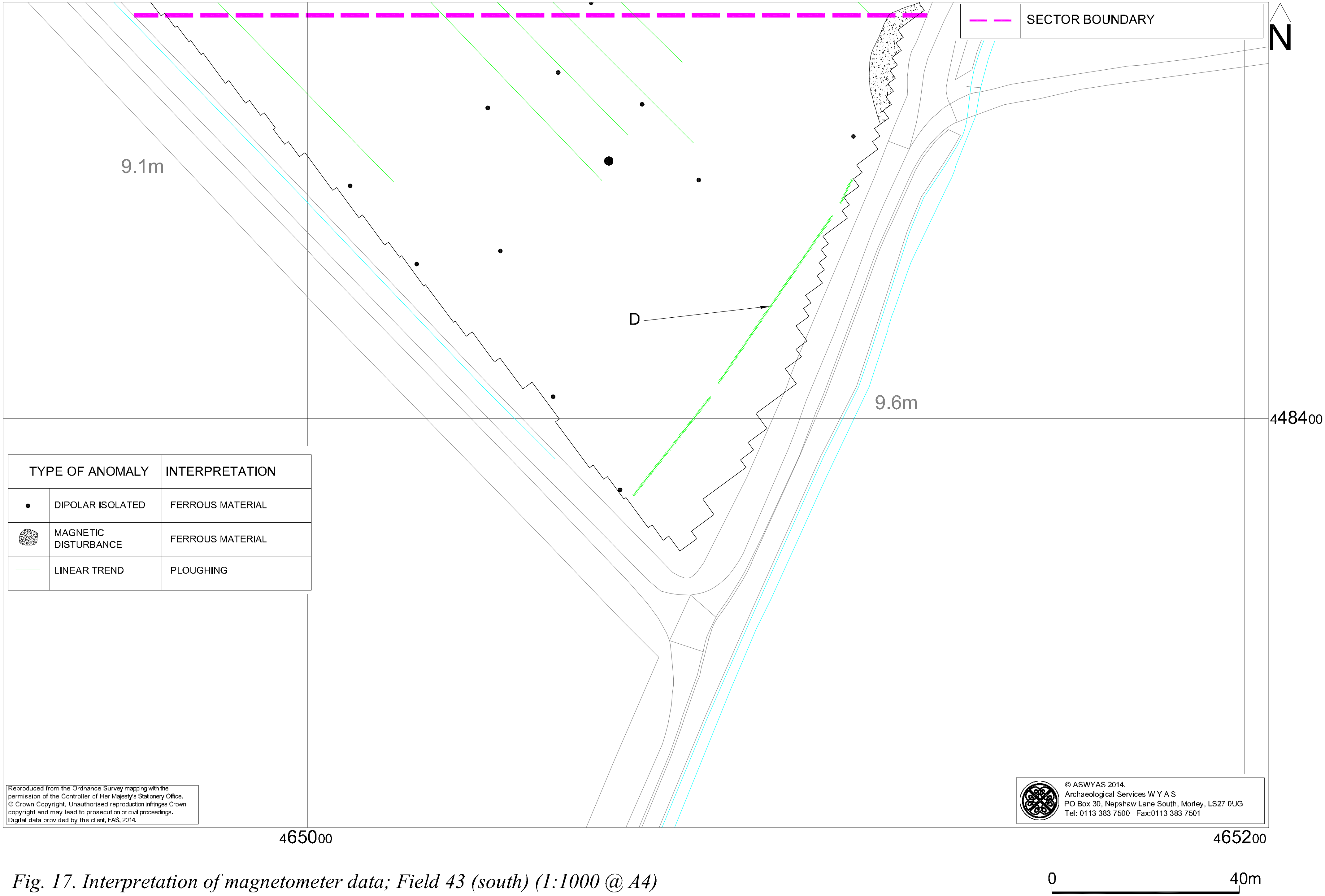


Fig. 17. Interpretation of magnetometer data; Field 43 (south) (1:1000 @ A4)

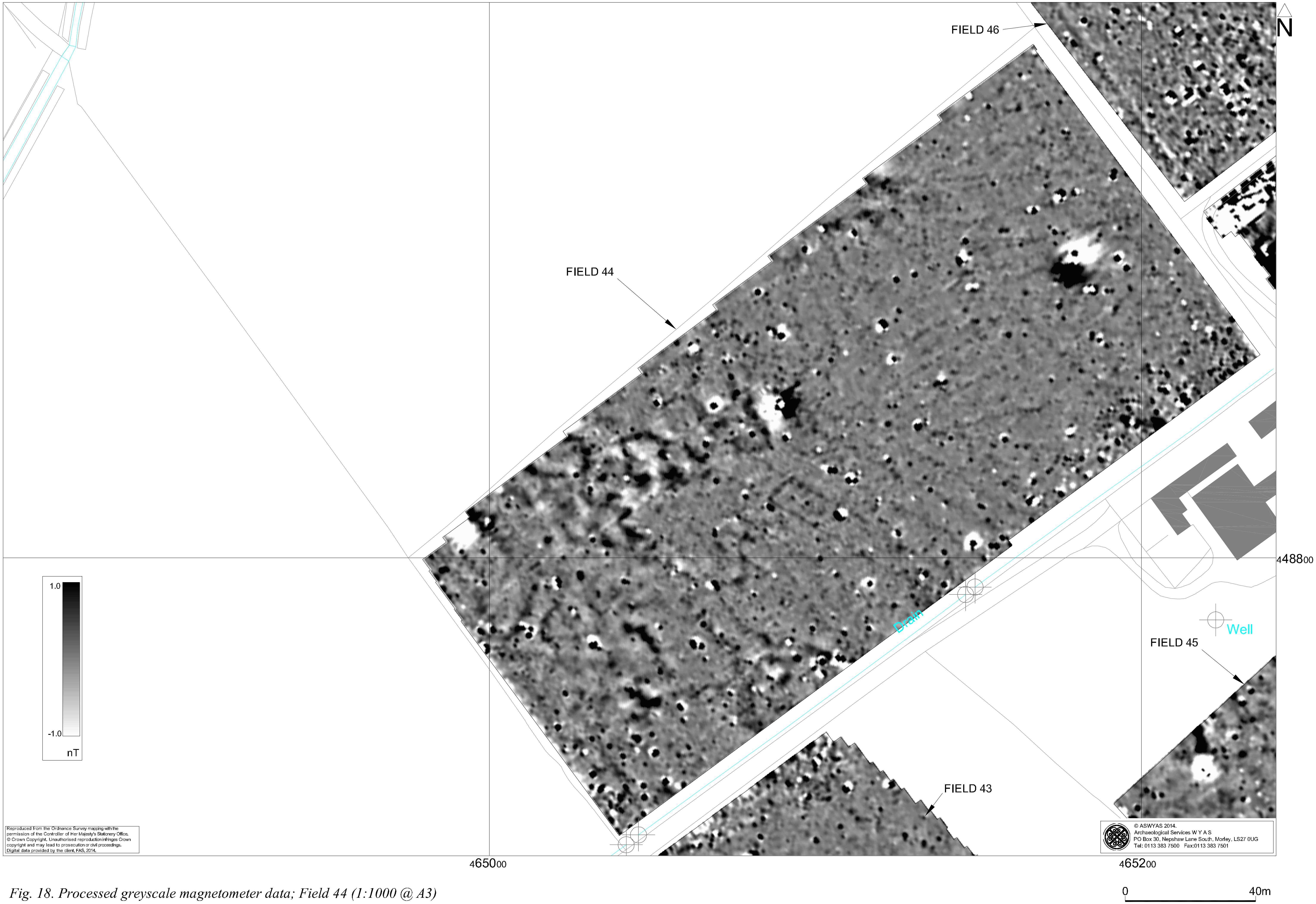


Fig. 18. Processed greyscale magnetometer data; Field 44 (1:1000 @ A3)

Fig. 19. XY trace plot of minimally processed magnetometer data; Field 44 (1:1000 @ A3)

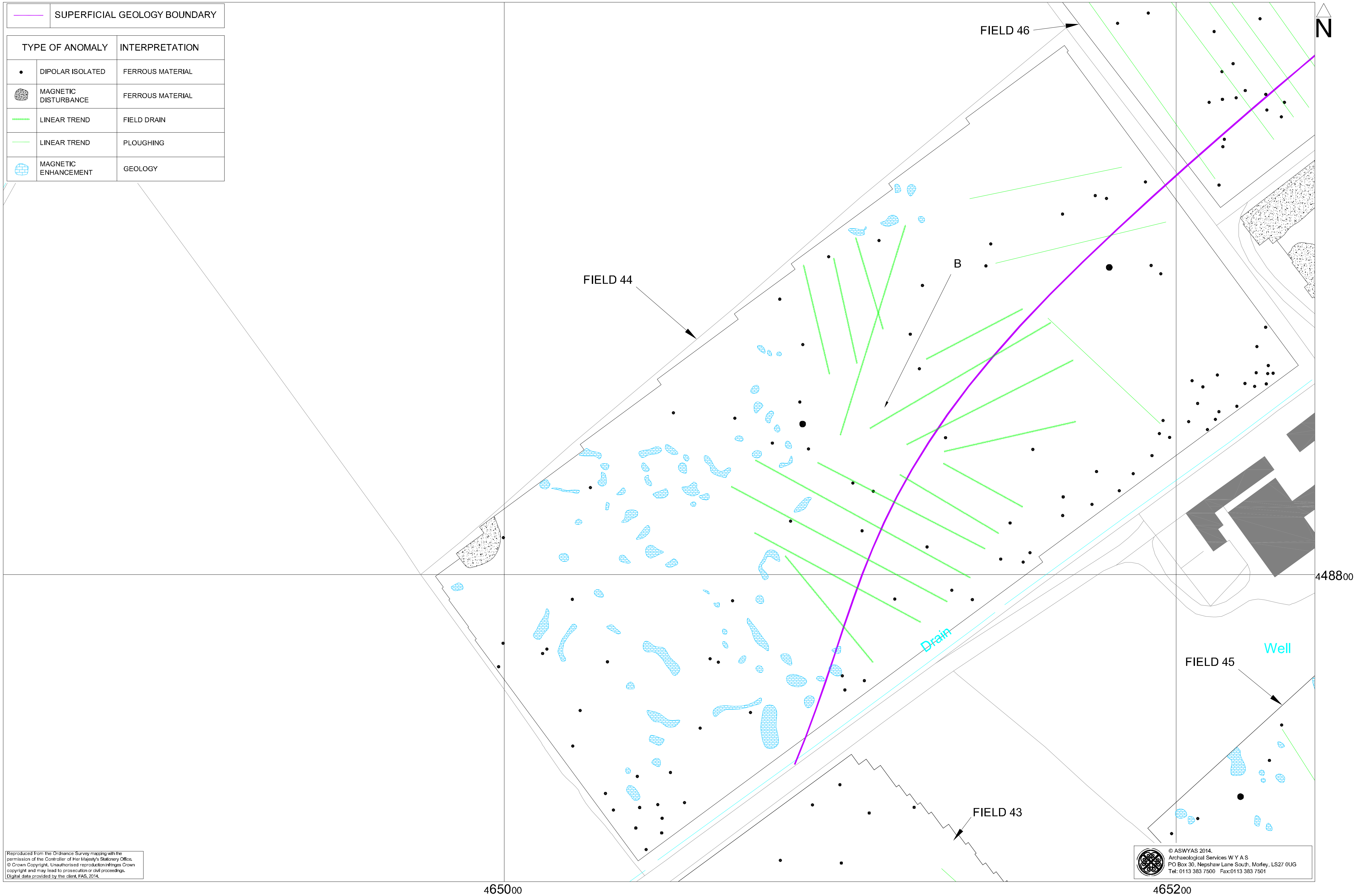


Fig. 20. Interpretation of magnetometer data; Field 44 (1:1000 @ A3)

0 40m

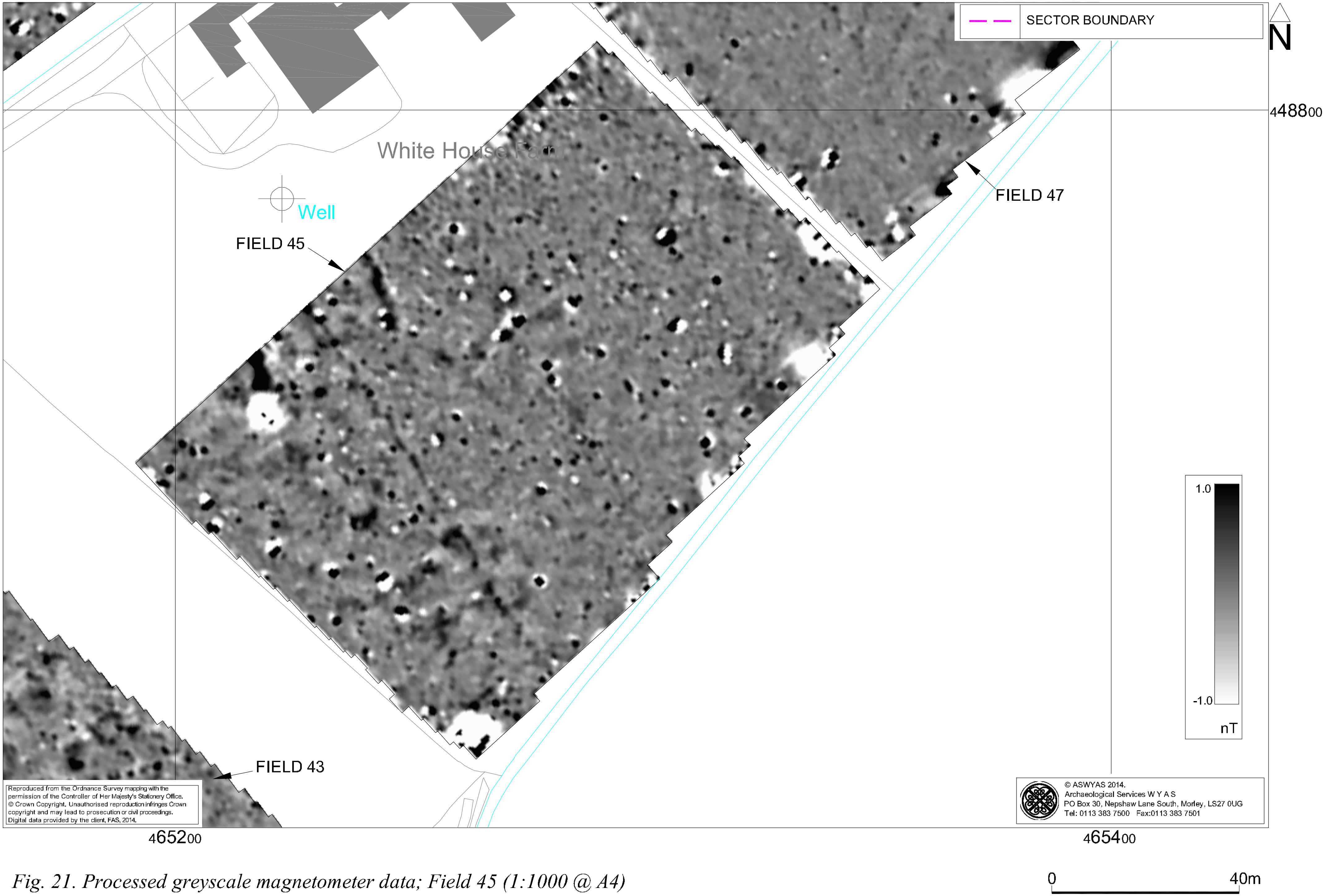


Fig. 21. Processed greyscale magnetometer data; Field 45 (1:1000 @ A4)

Fig. 22. XY trace plot of minimally processed magnetometer data; Field 45 (1:1000 @ A4)

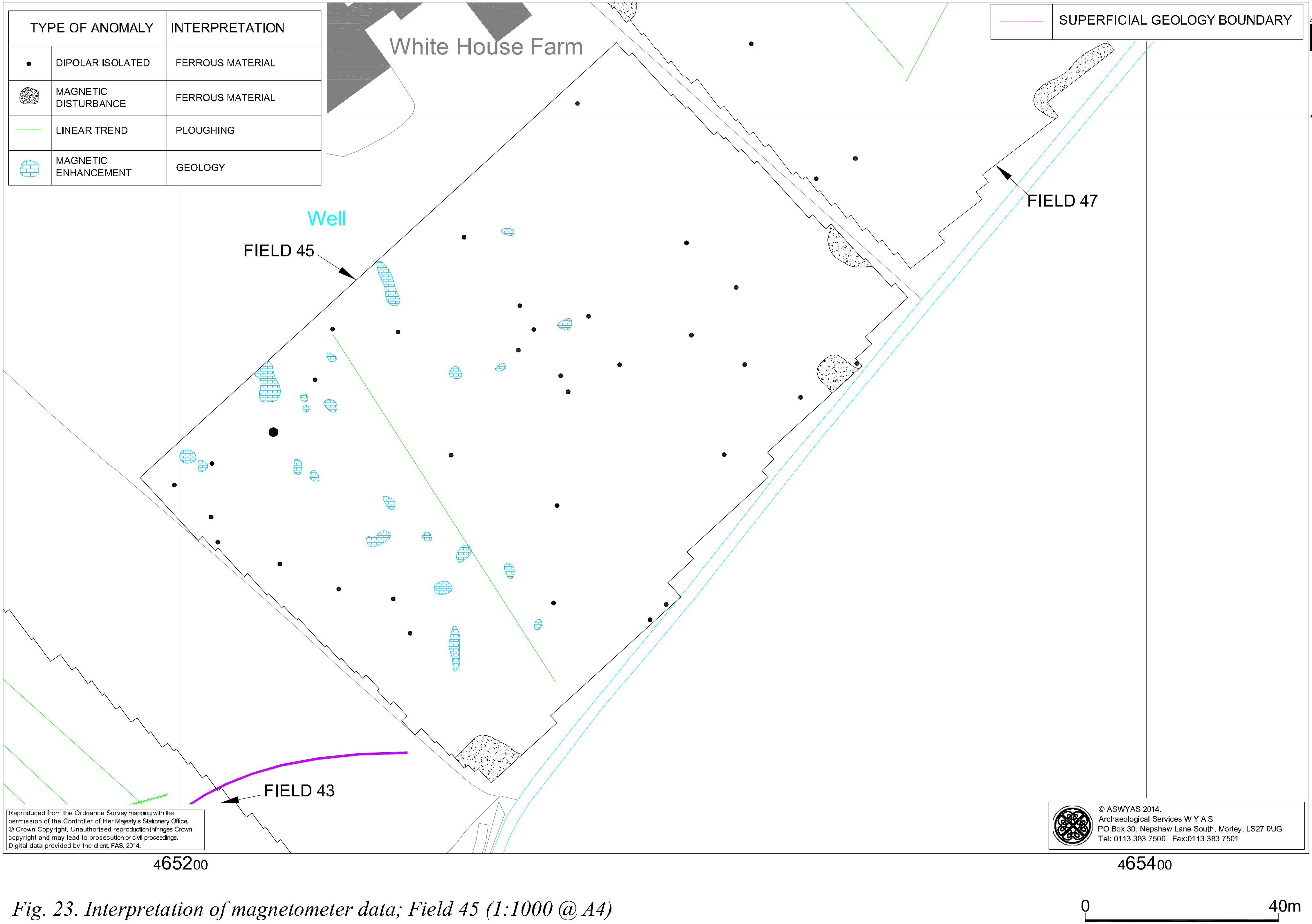
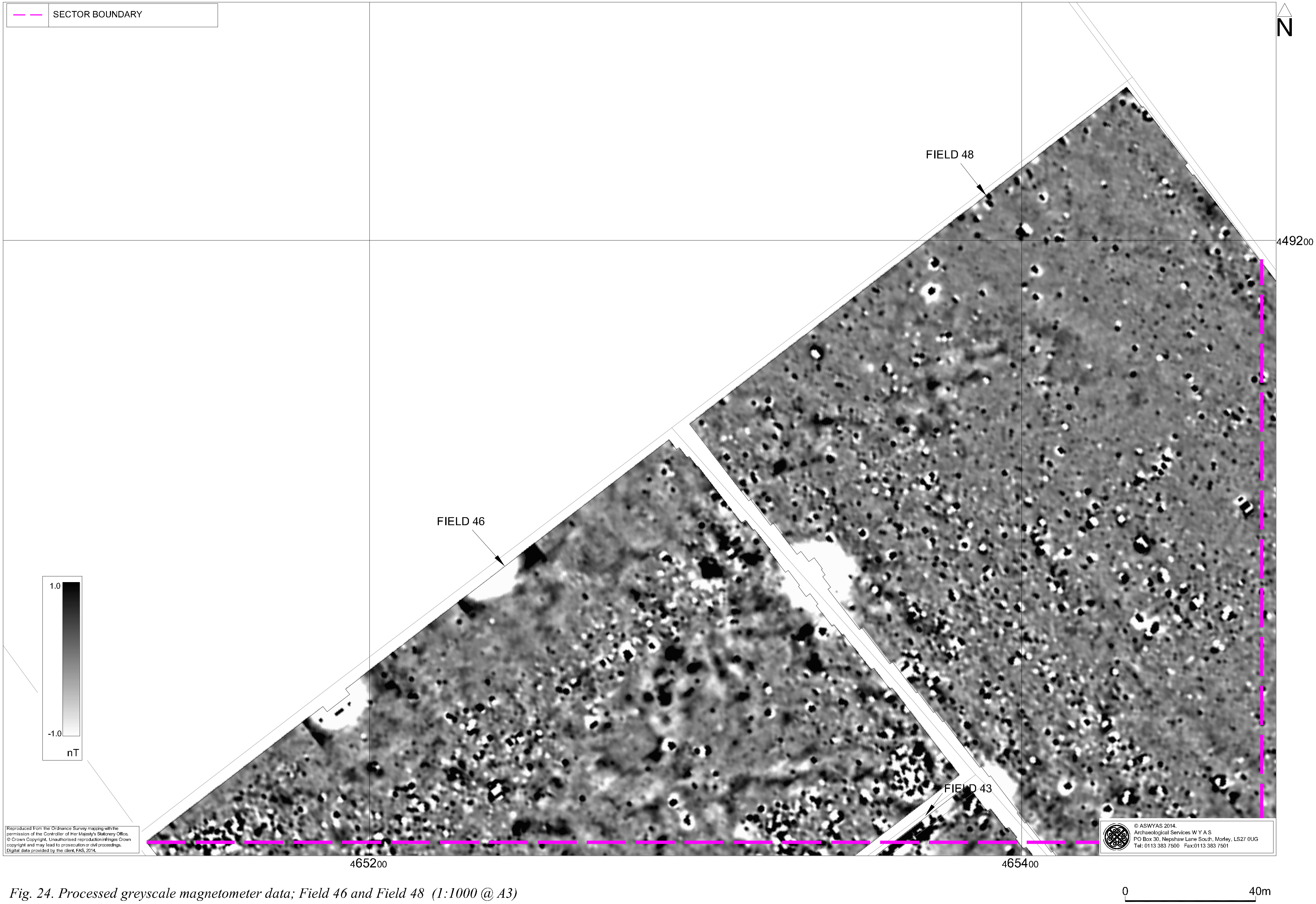


Fig. 23. Interpretation of magnetometer data; Field 45 (1:1000 @ A4)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500   Fax:0113 383 7501

Fig. 24. Processed greyscale magnetometer data; Field 46 and Field 48 (1:1000 @ A3)

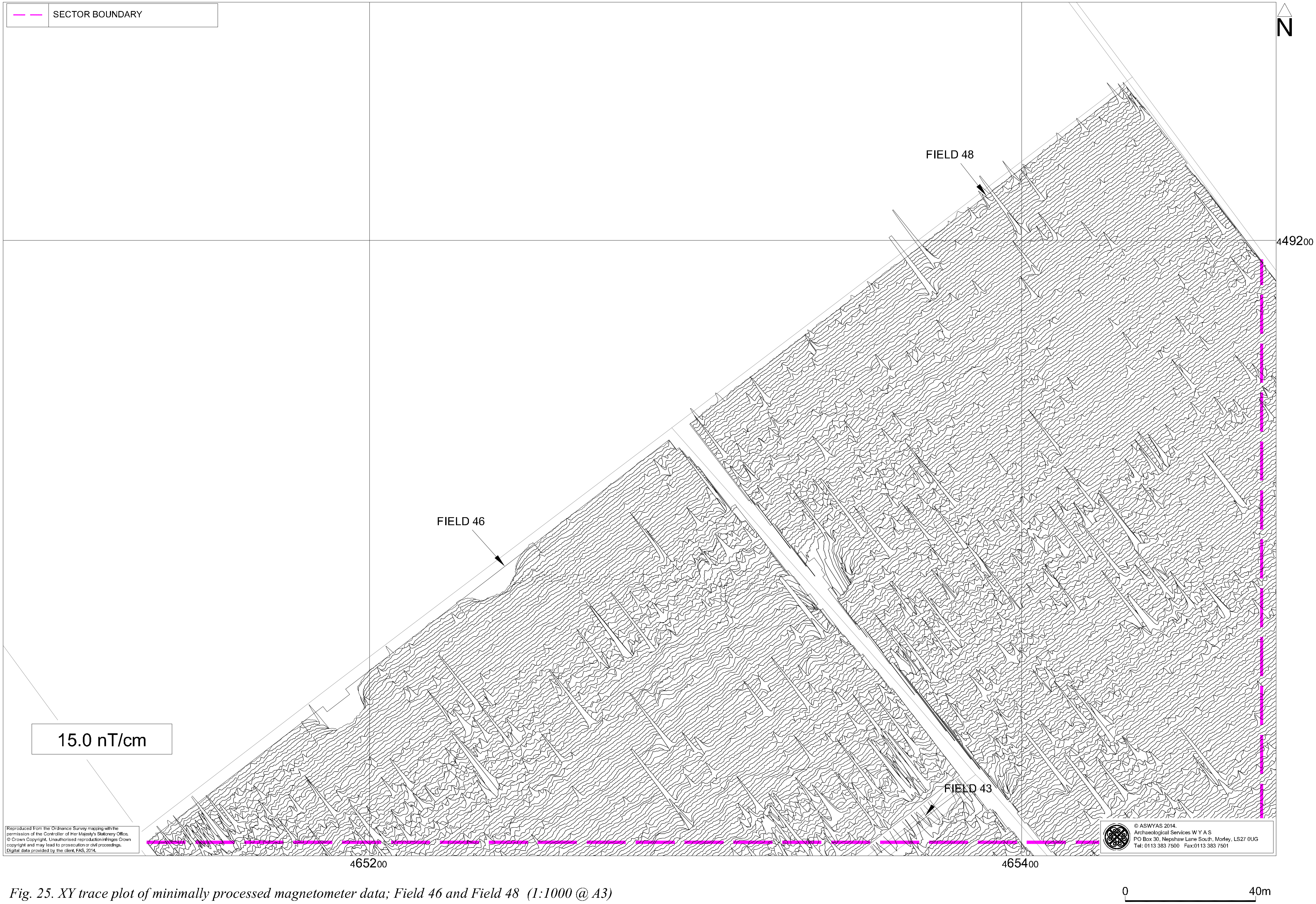


Fig. 25. XY trace plot of minimally processed magnetometer data; Field 46 and Field 48 (1:1000 @ A3)

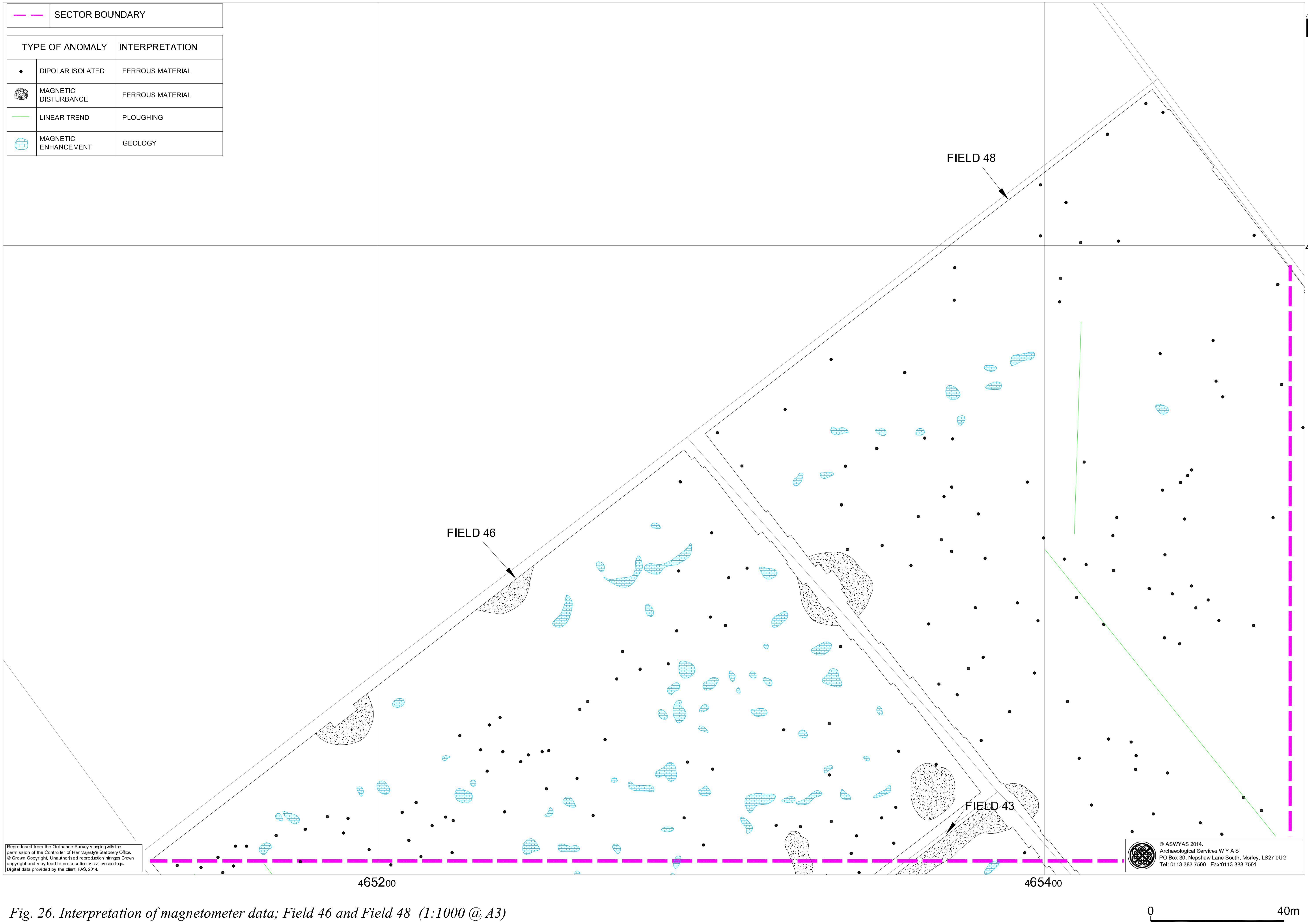


Fig. 26. Interpretation of magnetometer data; Field 46 and Field 48 (1:1000 @ A3)

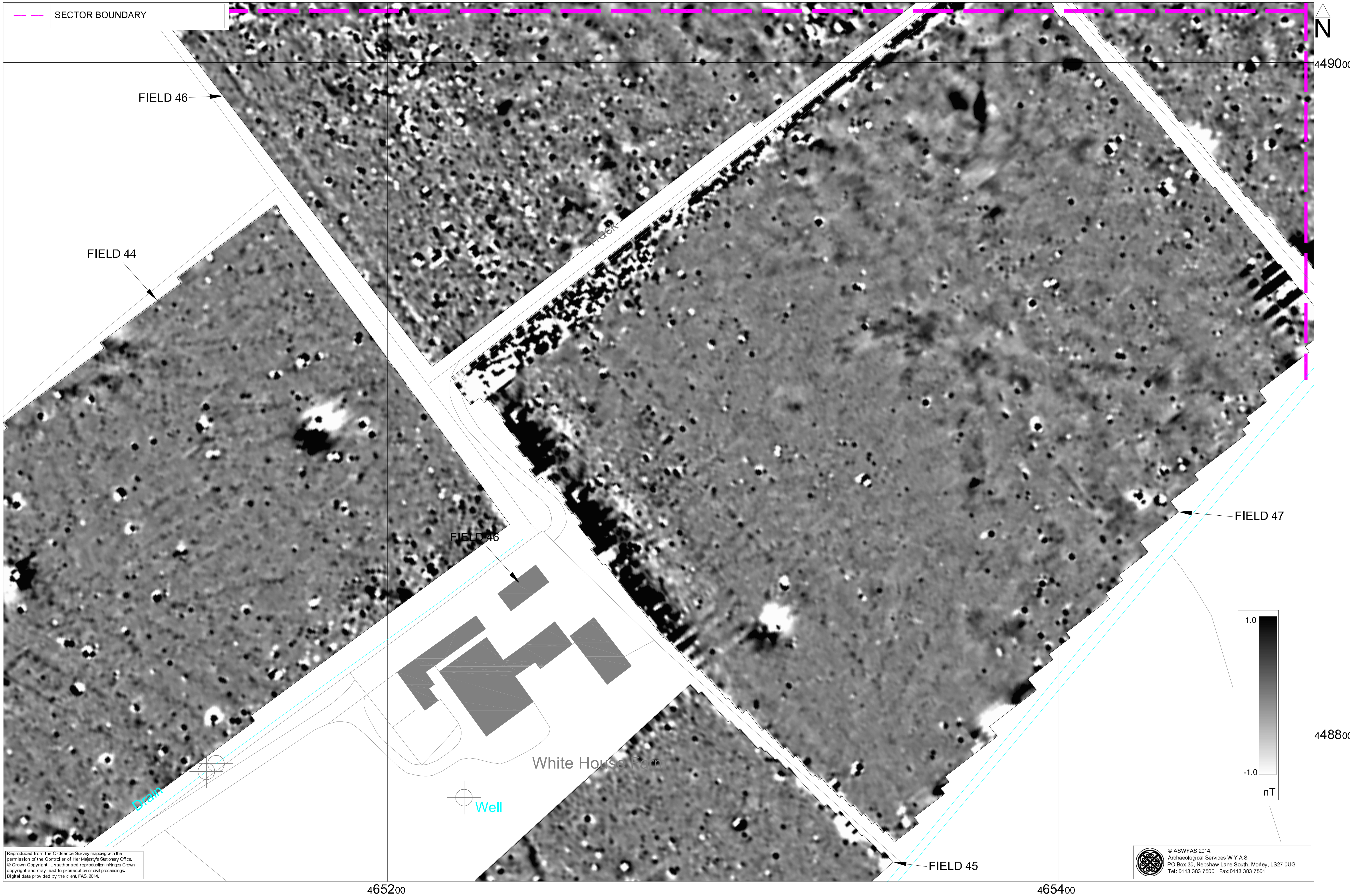


Fig. 27. Processed greyscale magnetometer data; Field 46 and Field 47 (1:1000 @ A3)

0 40m

Fig. 28. XY trace plot of minimally processed magnetometer data; Field 46 and Field 47 (1:1000 @ A3)

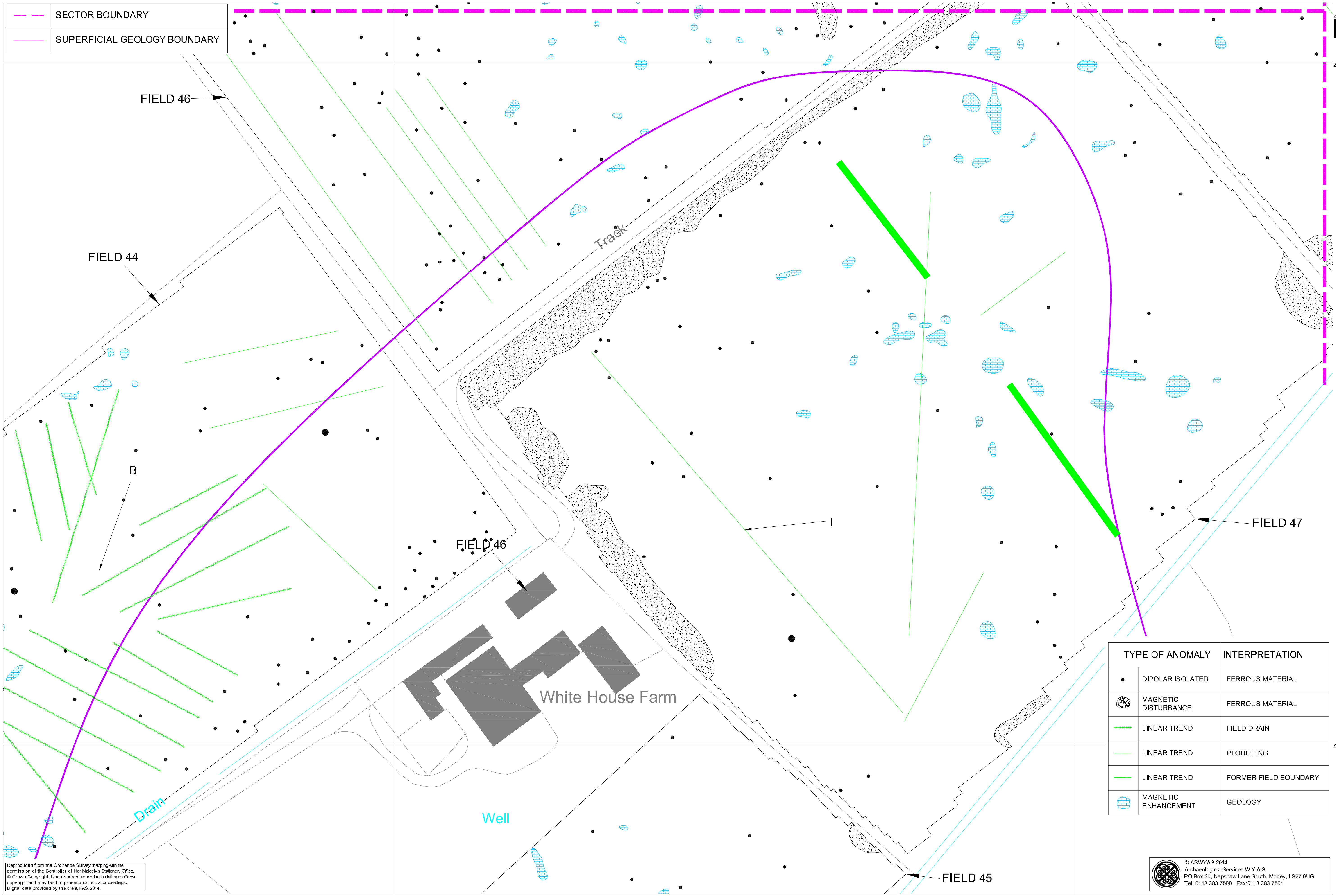


Fig. 29. Interpretation of magnetometer data; Field 46 and Field 47 (1:1000 @ A3)

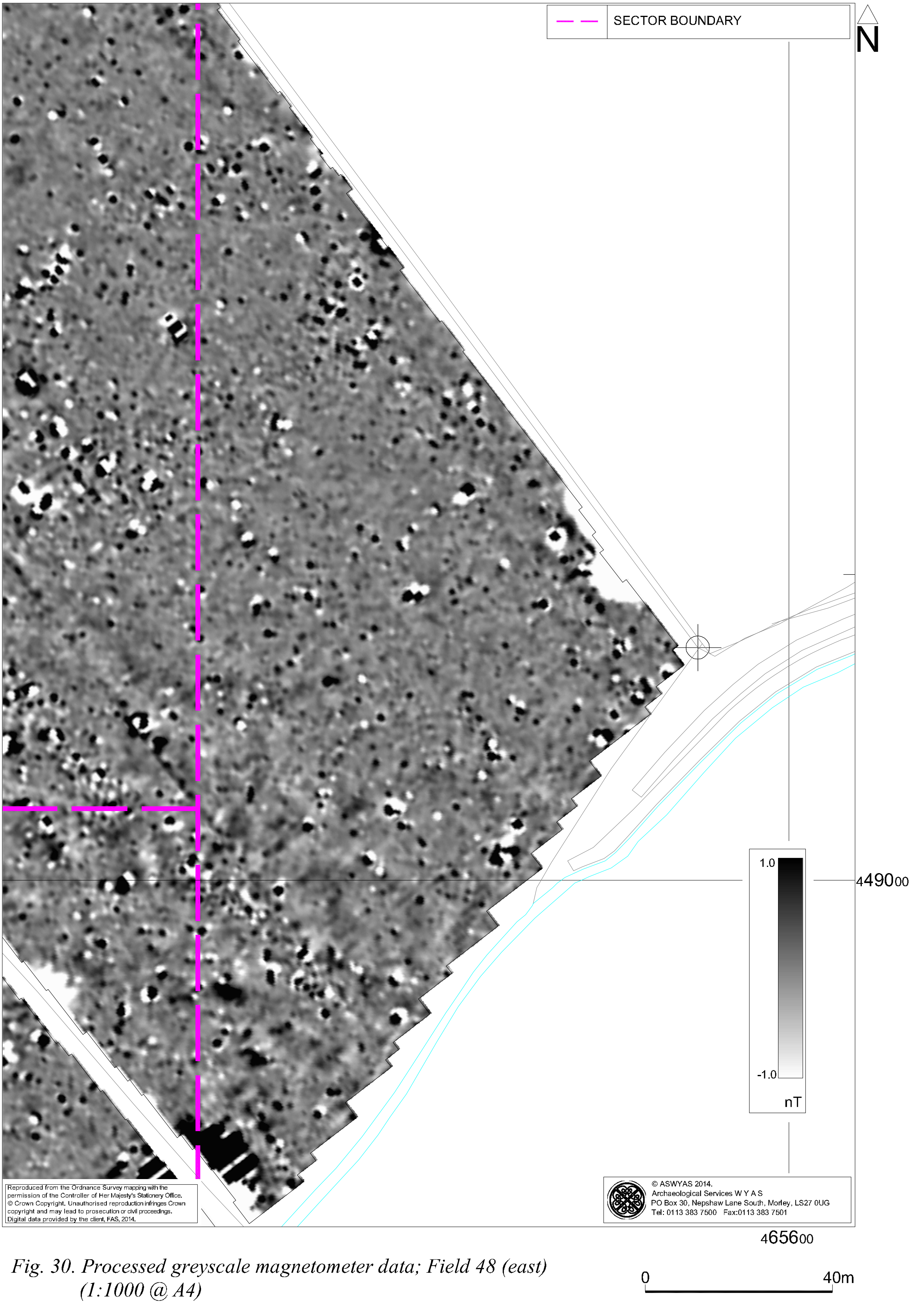


Fig. 30. Processed greyscale magnetometer data; Field 48 (east) (1:1000 @ A4)

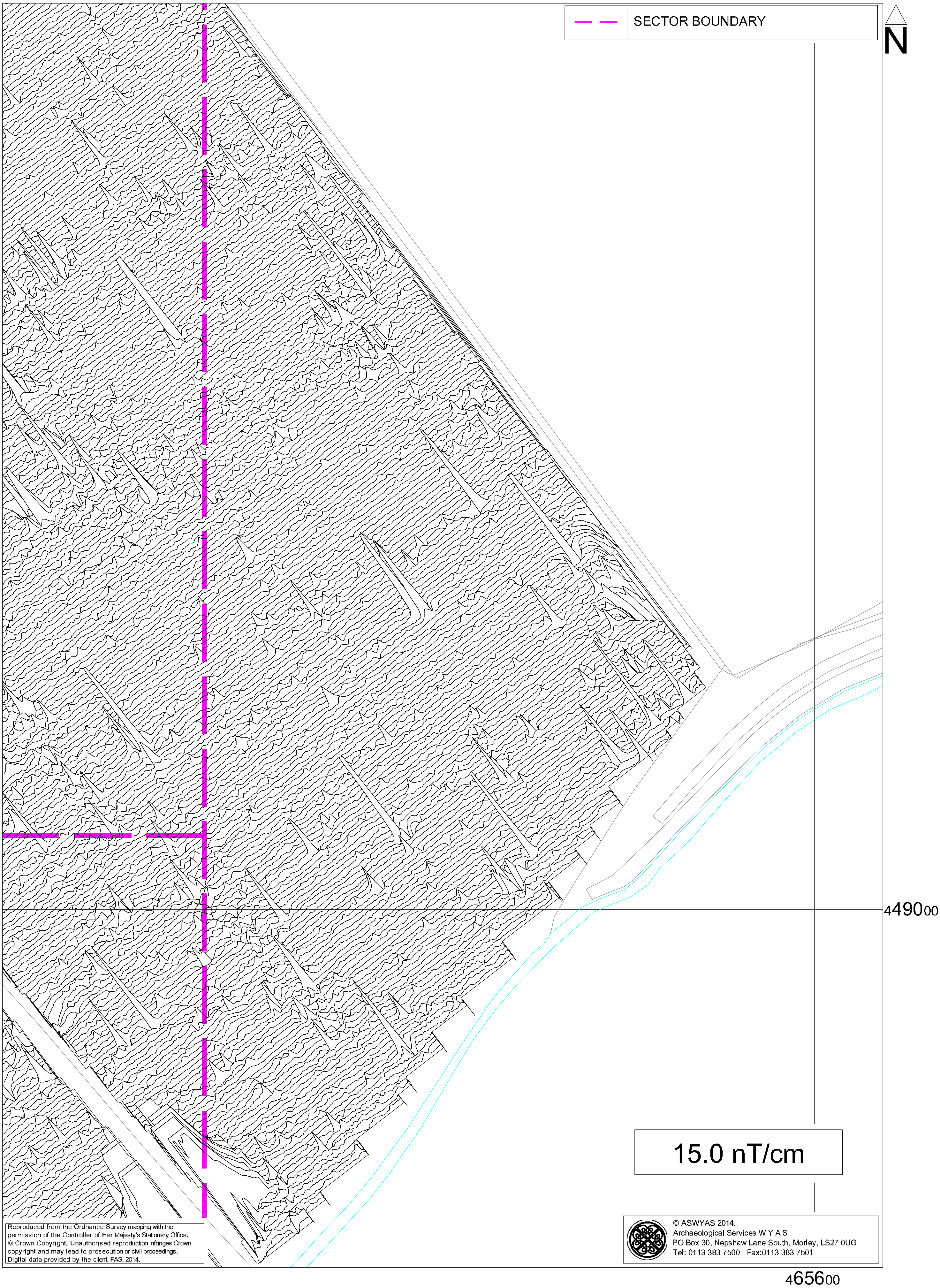
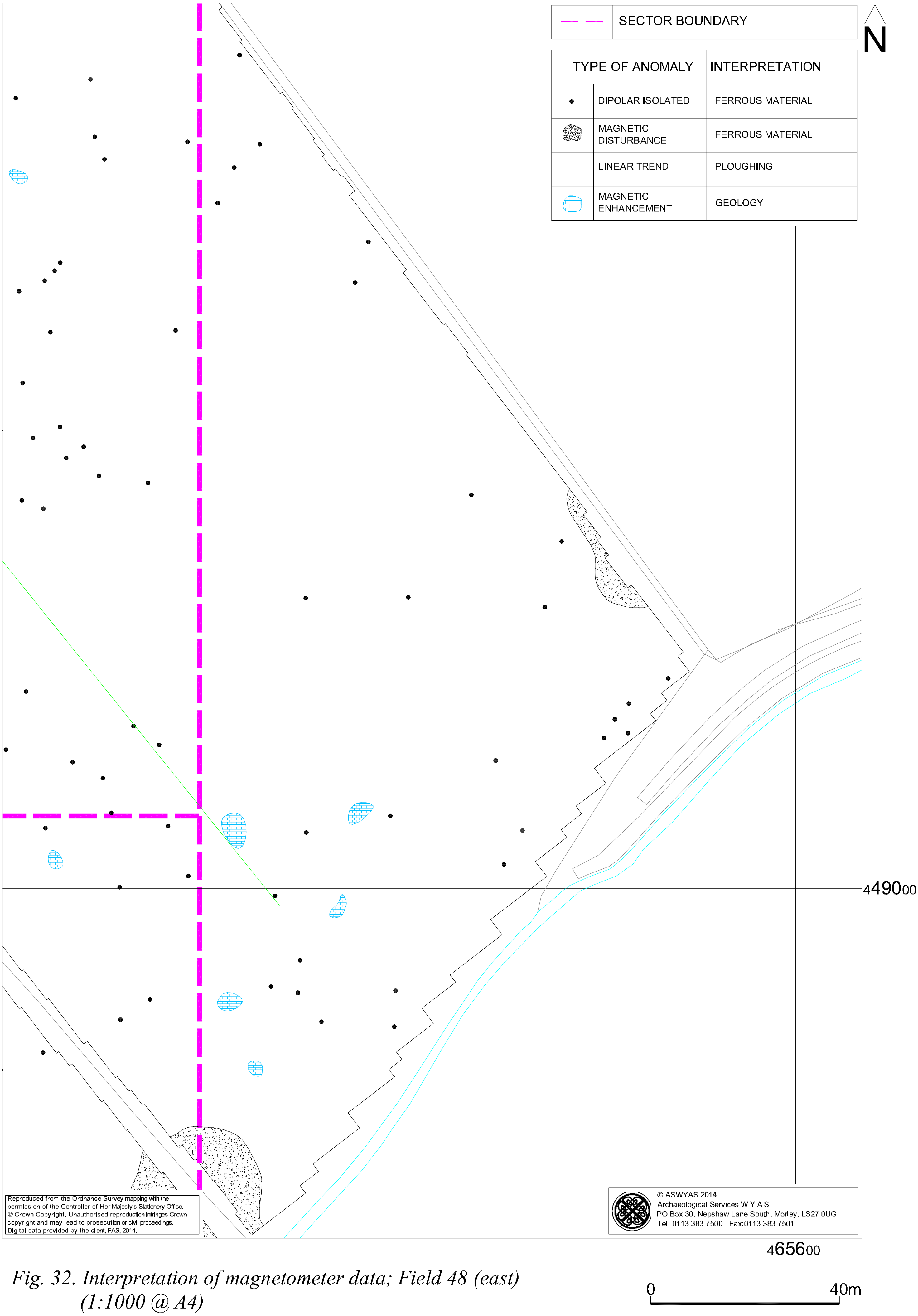


Fig. 31. XY trace plot of minimally processed magnetometer data; Field 48 (east) (1:1000 @ A4)

0 40m



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 32. Interpretation of magnetometer data; Field 48 (east) (1:1000 @ A4)

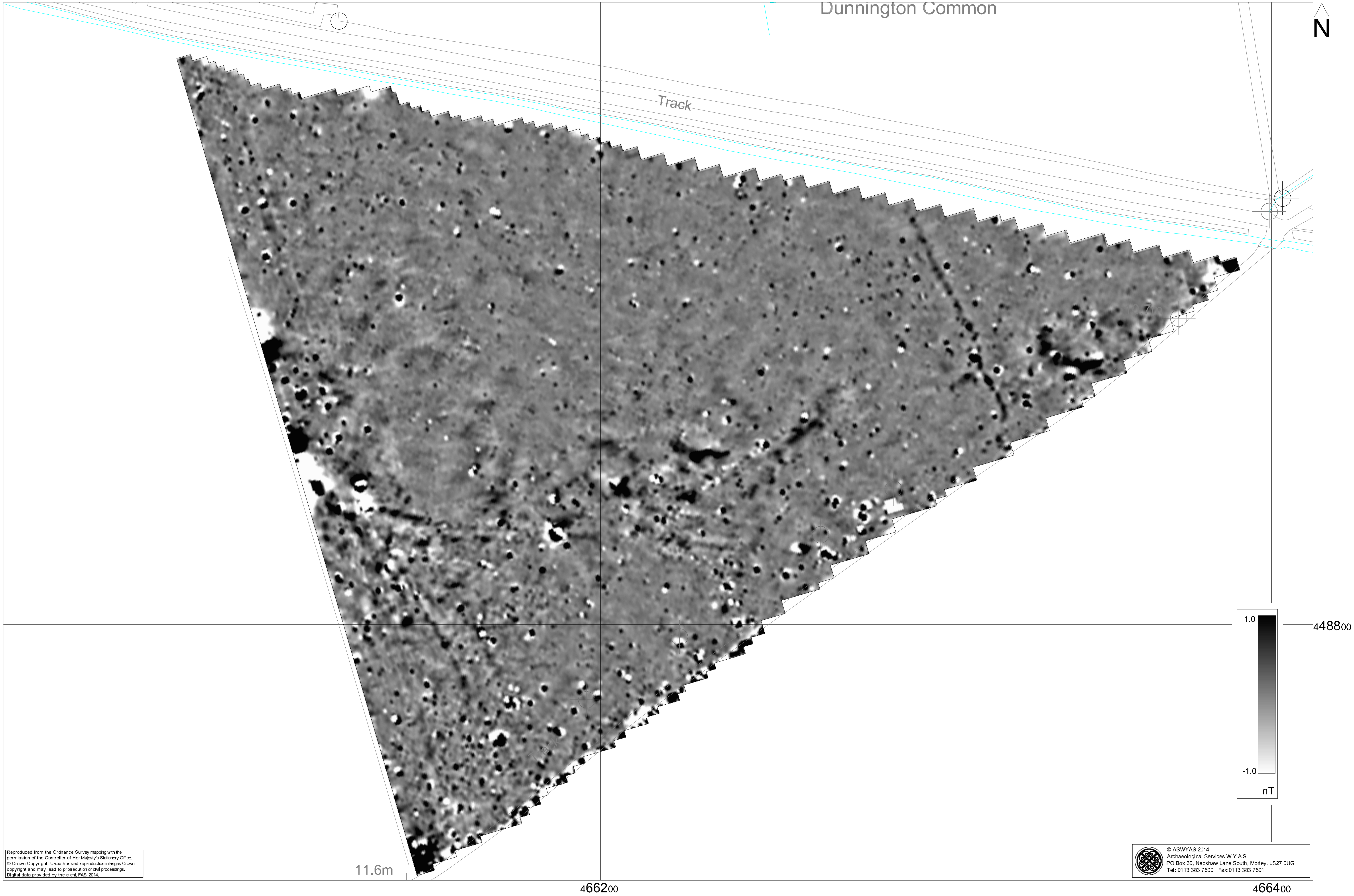
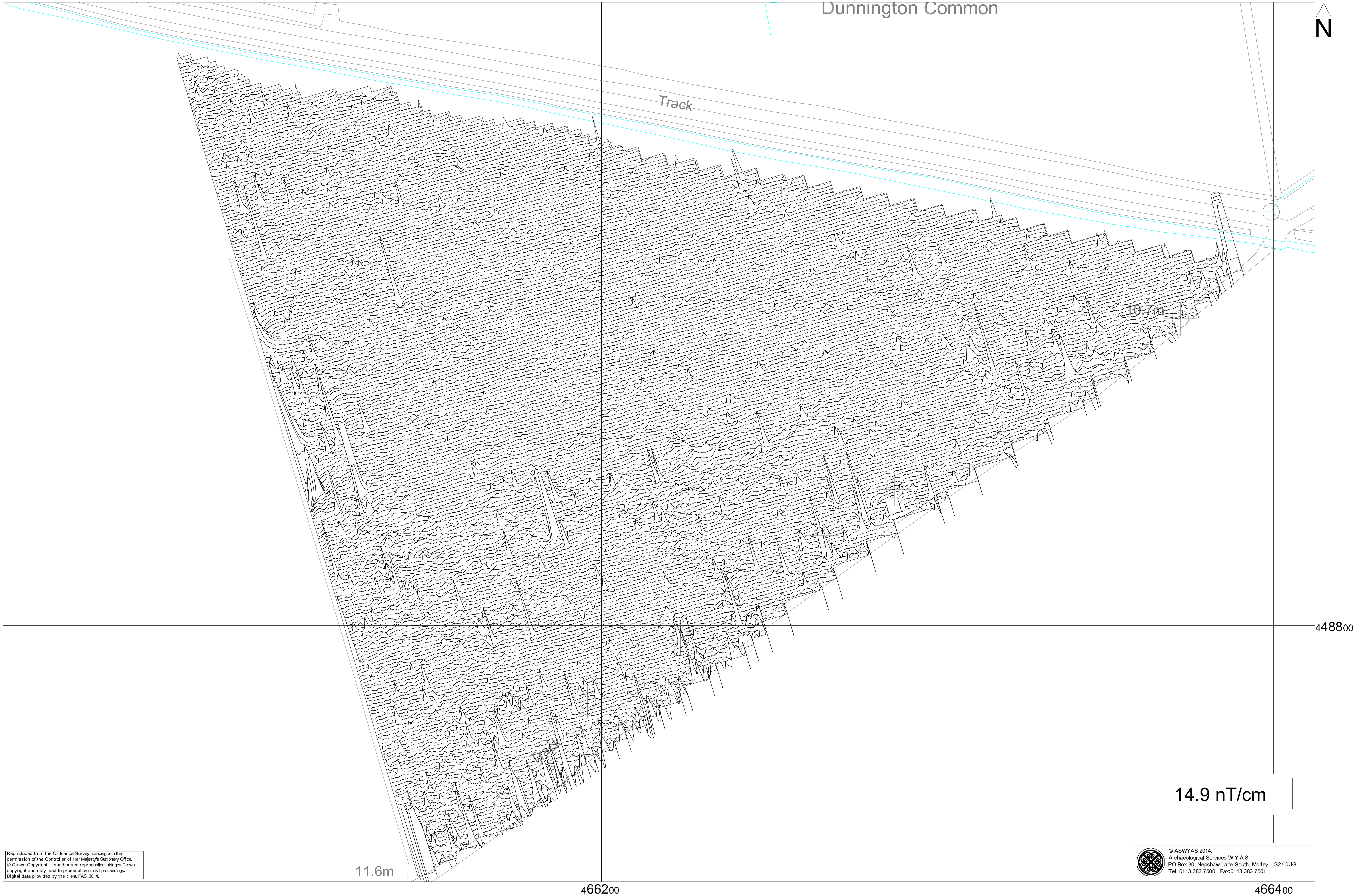


Fig. 33. Processed greyscale magnetometer data; Field 52 (1:1000 @ A3)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 34. XY trace plot of minimally processed magnetometer data; Field 52 (1:1000 @ A3)

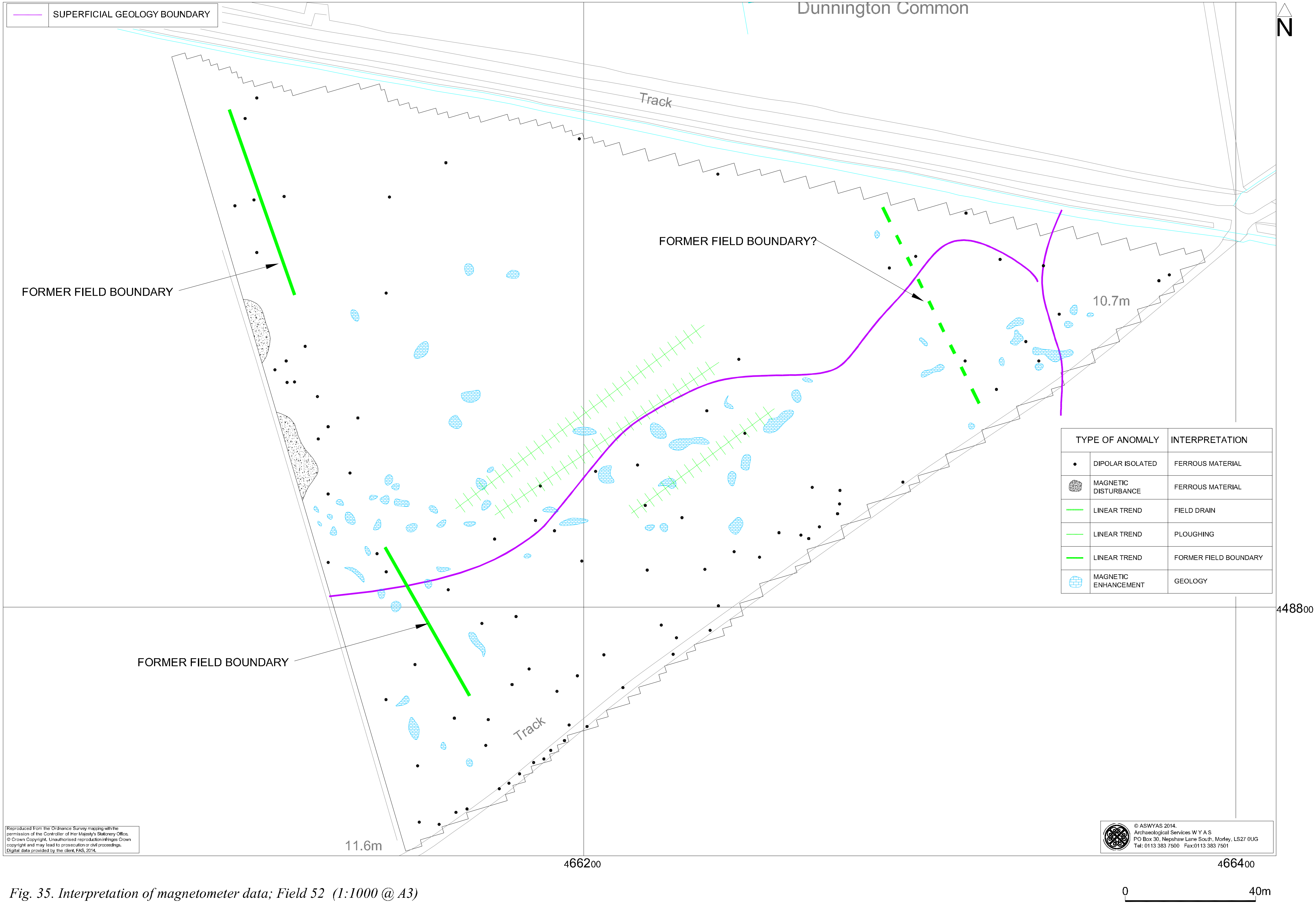


Fig. 35. Interpretation of magnetometer data; Field 52 (1:1000 @ A3)

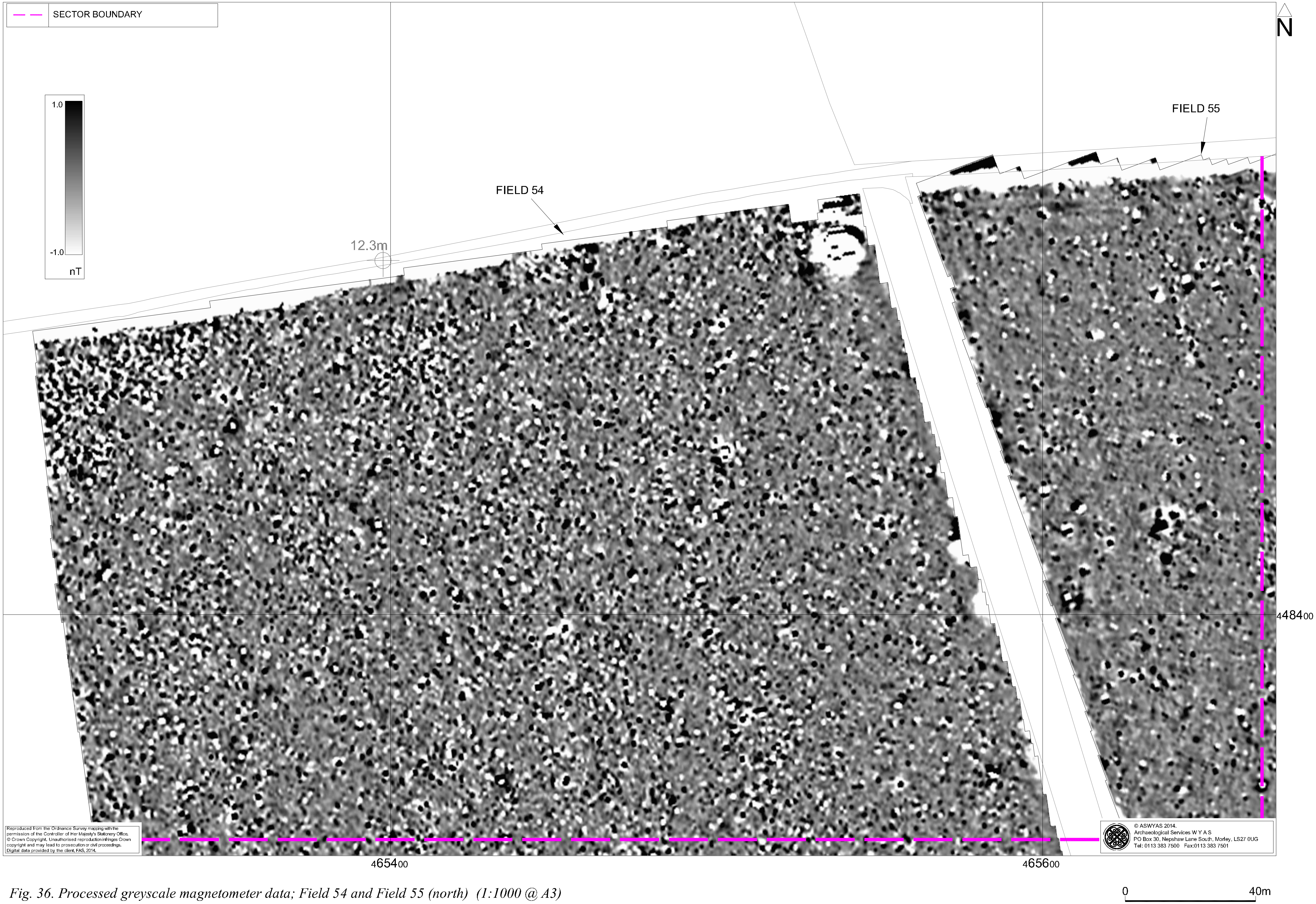
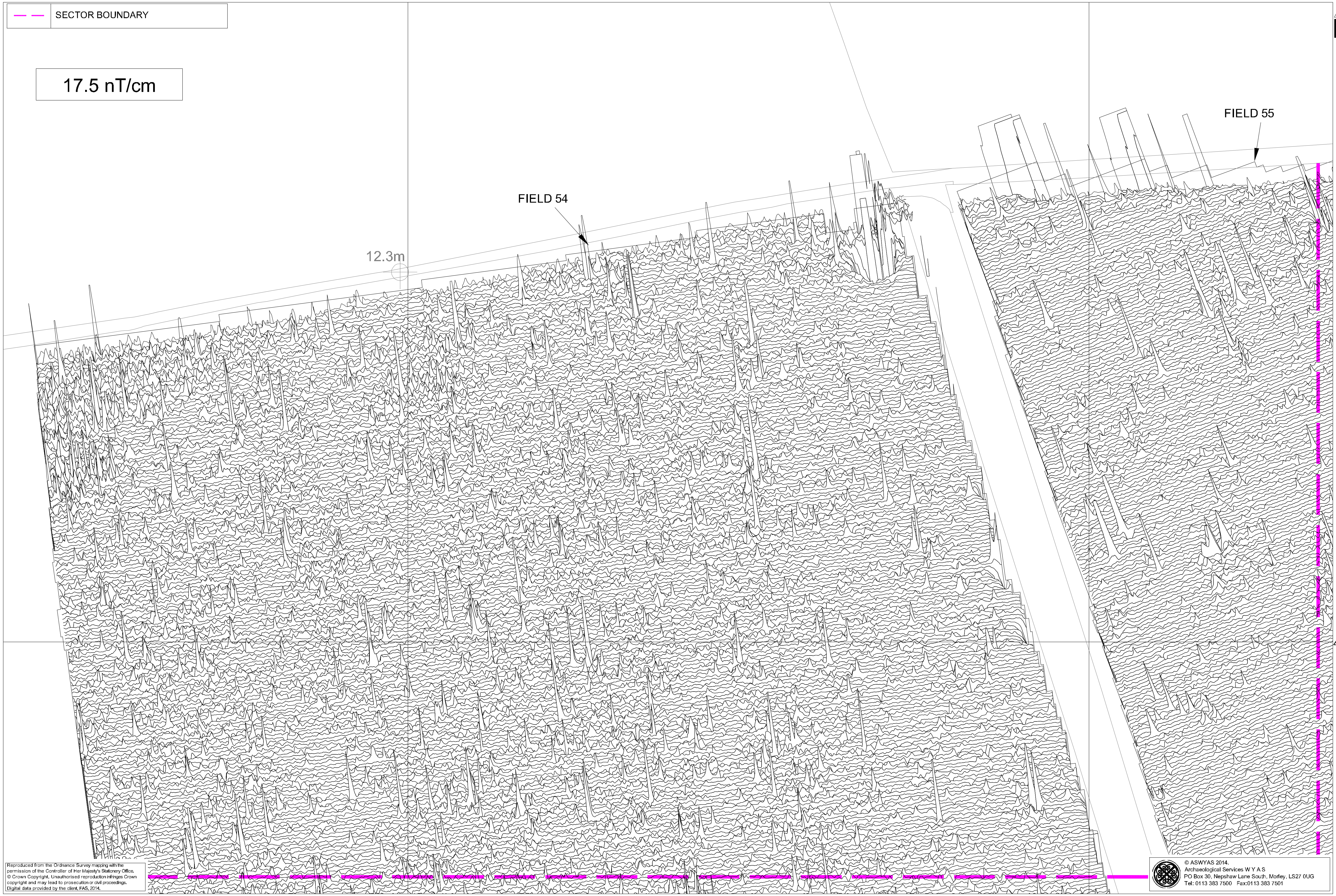


Fig. 36. Processed greyscale magnetometer data; Field 54 and Field 55 (north) (1:1000 @ A3)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 37. XY trace plot of minimally processed magnetometer data; Field 54 and Field 55 (north) (1:1000 @ A3)

Fig. 38. Interpretation of magnetometer data; Field 54 and Field 55 (north) (1:1000 @ A3)

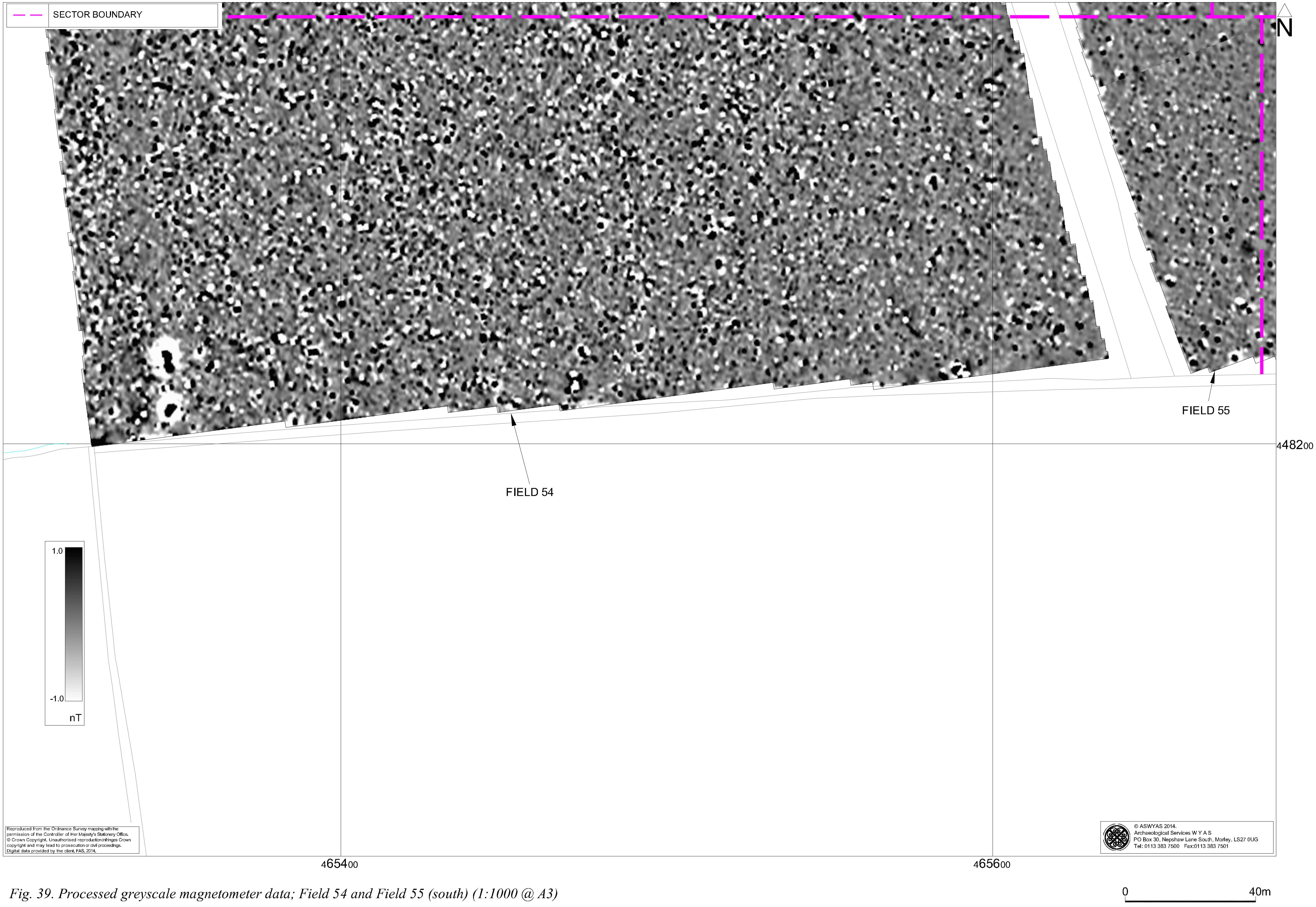


Fig. 39. Processed greyscale magnetometer data; Field 54 and Field 55 (south) (1:1000 @ A3)

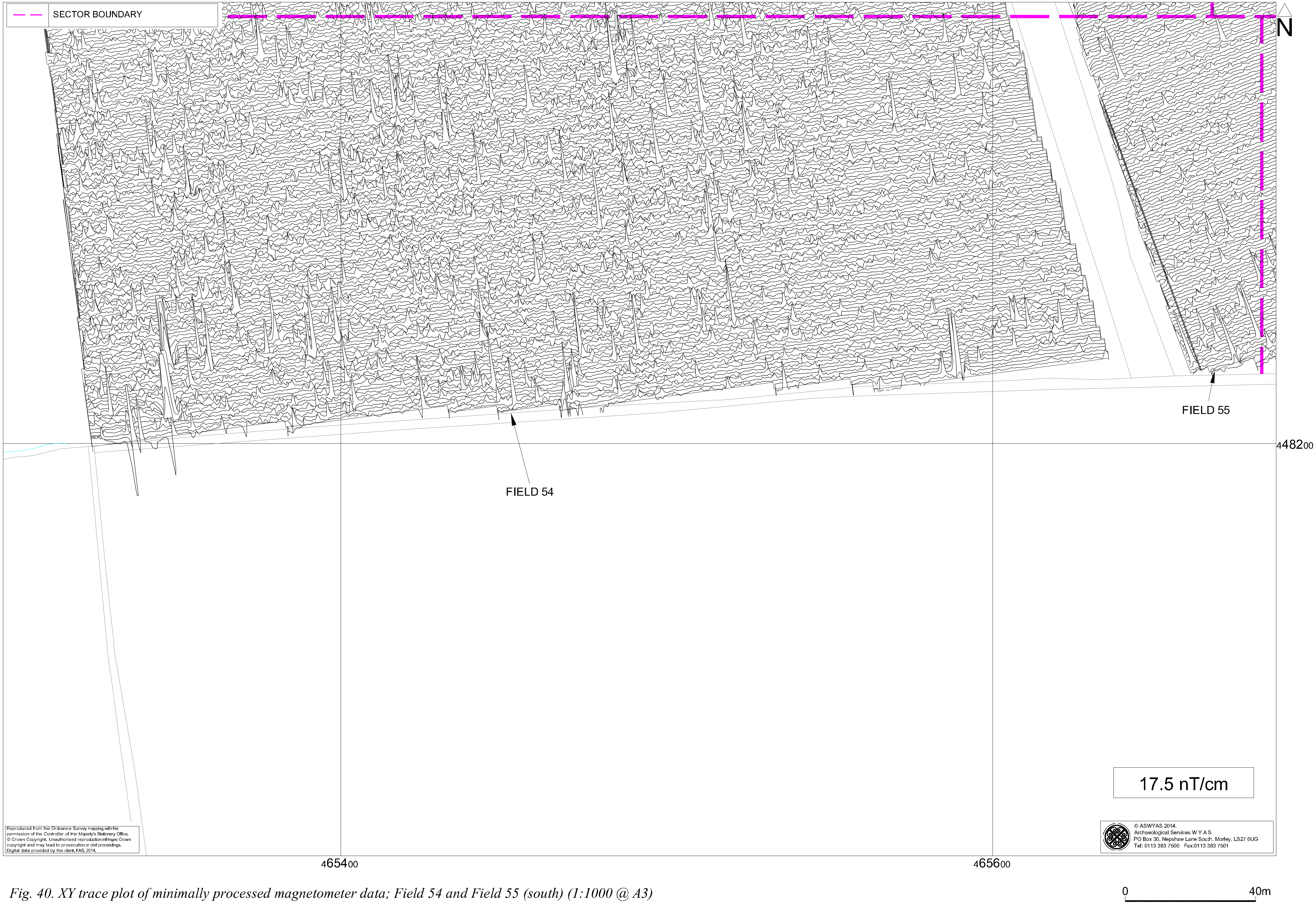


Fig. 40. XY trace plot of minimally processed magnetometer data; Field 54 and Field 55 (south) (1:1000 @ A3)

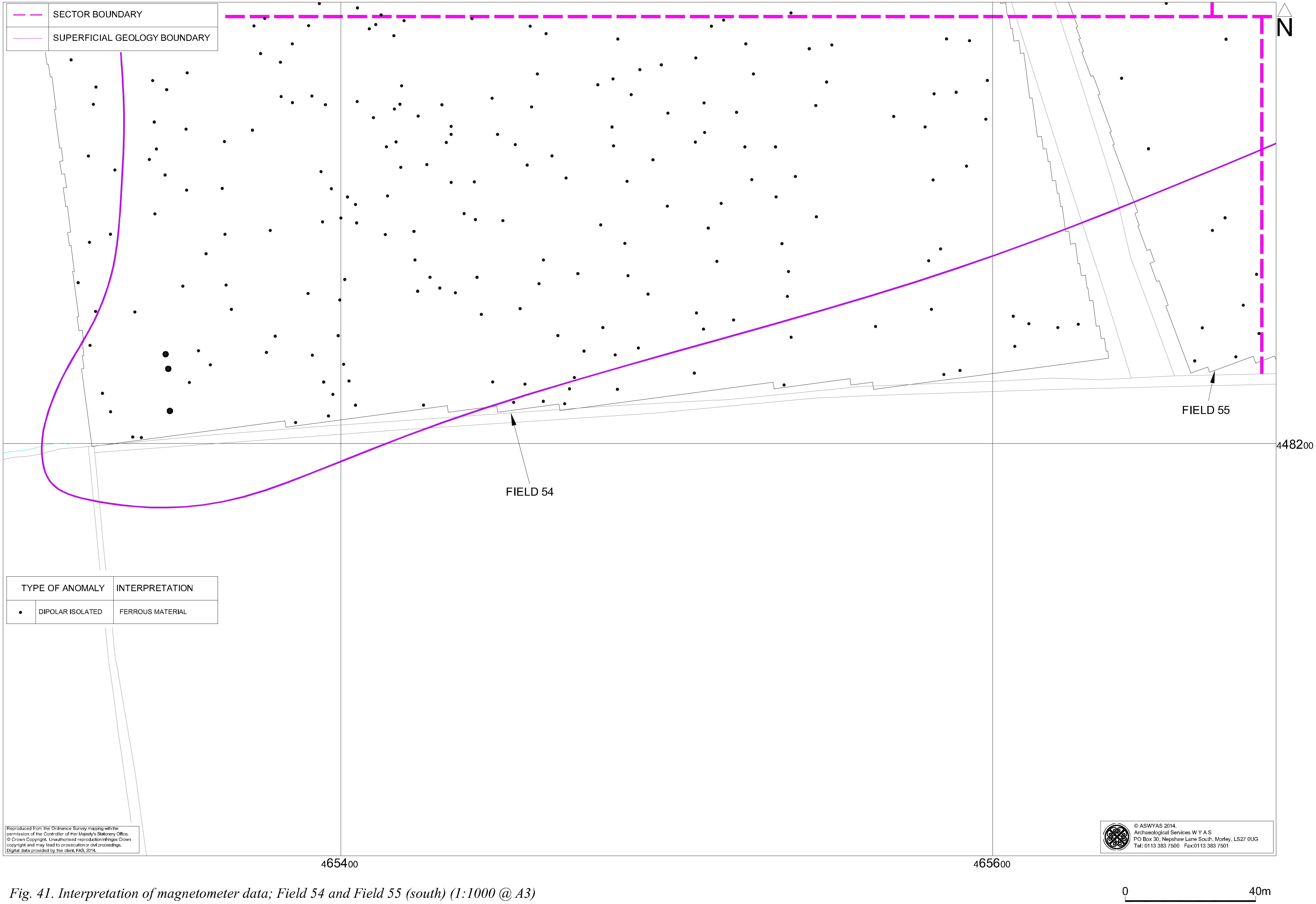


Fig. 41. Interpretation of magnetometer data; Field 54 and Field 55 (south) (1:1000 @ A3)

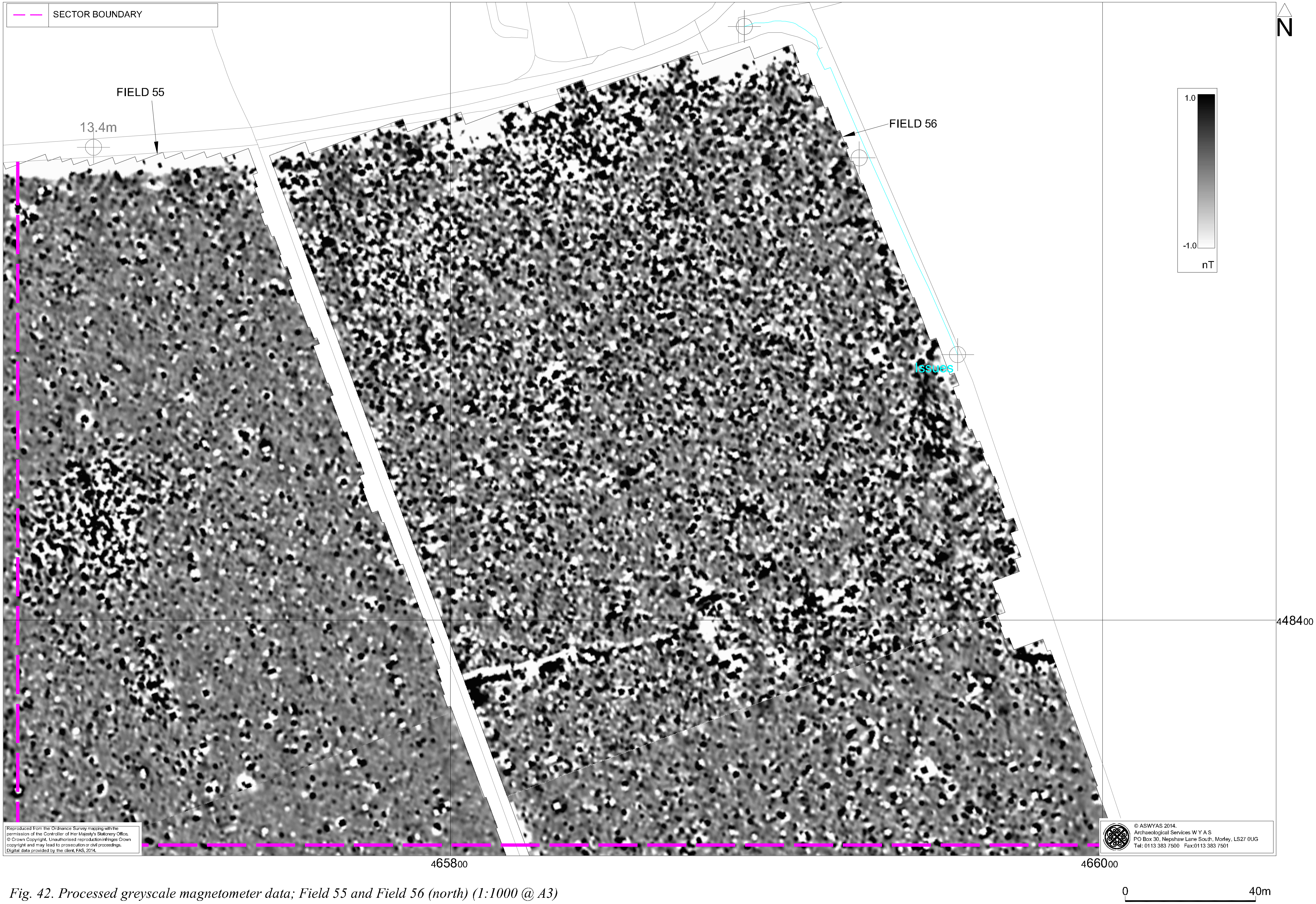


Fig. 42. Processed greyscale magnetometer data; Field 55 and Field 56 (north) (1:1000 @ A3)

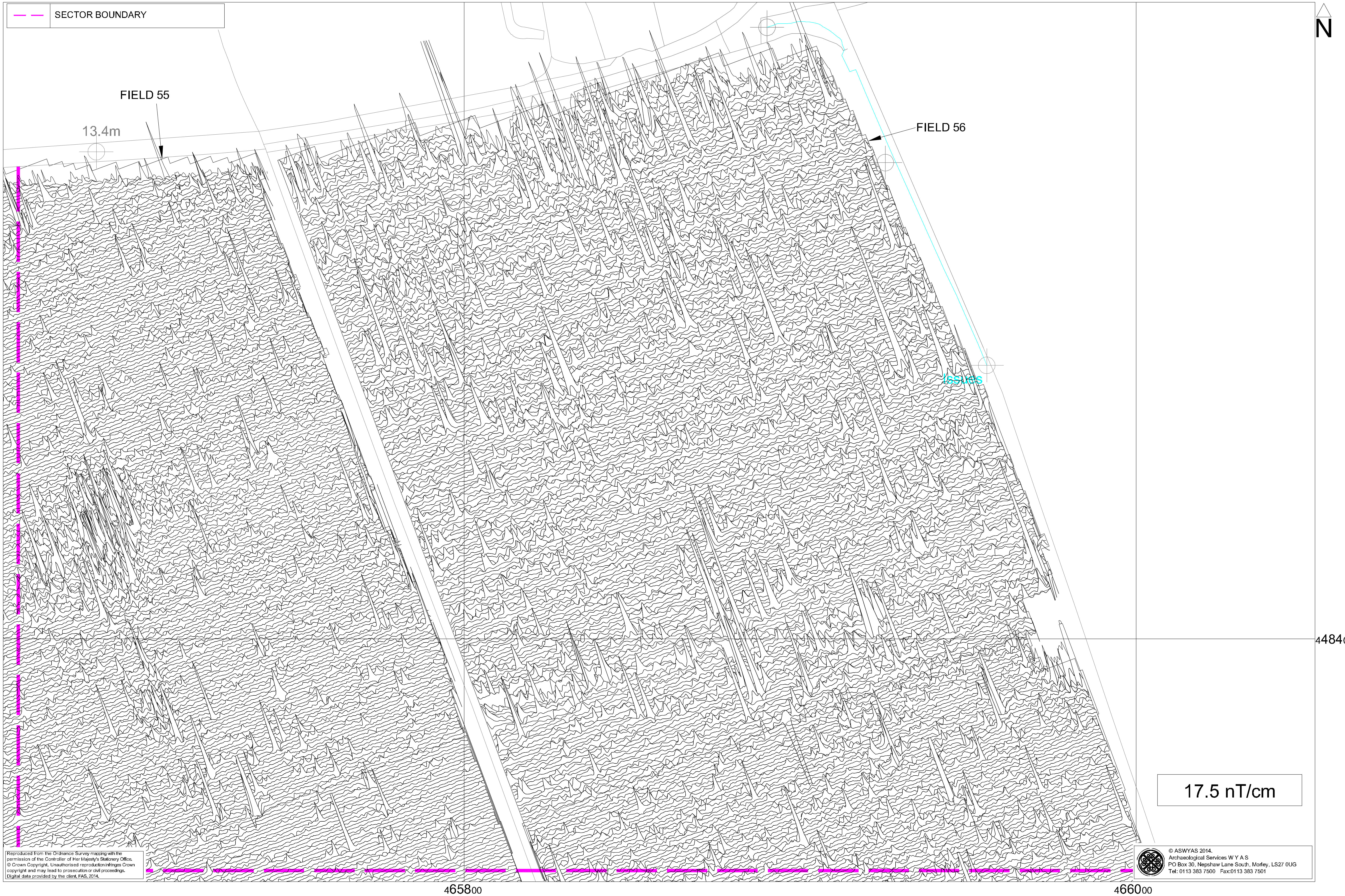


Fig. 43. XY trace plot of minimally processed magnetometer data; Field 55 and Field 56 (north) (1:1000 @ A3)

0 40m

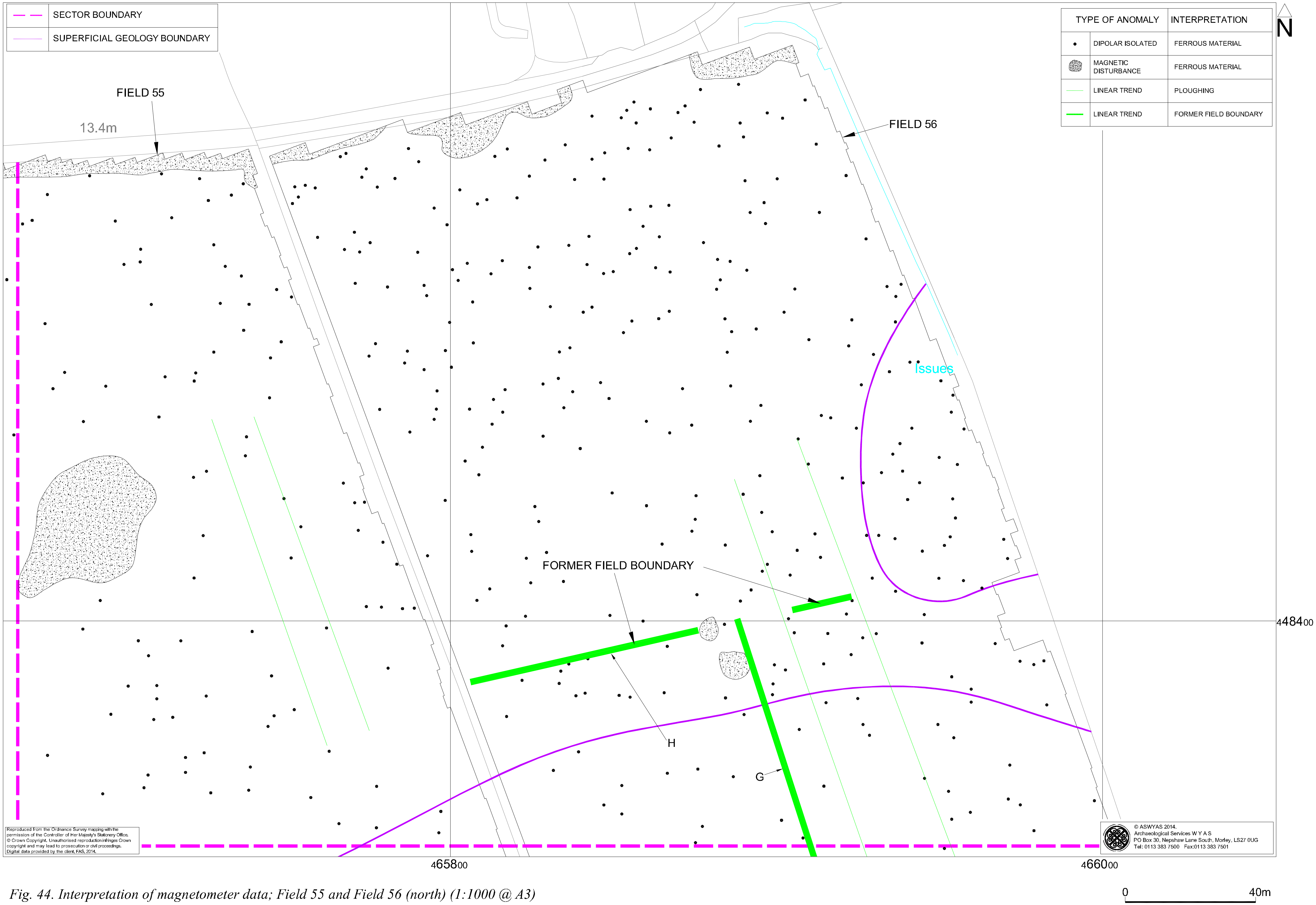
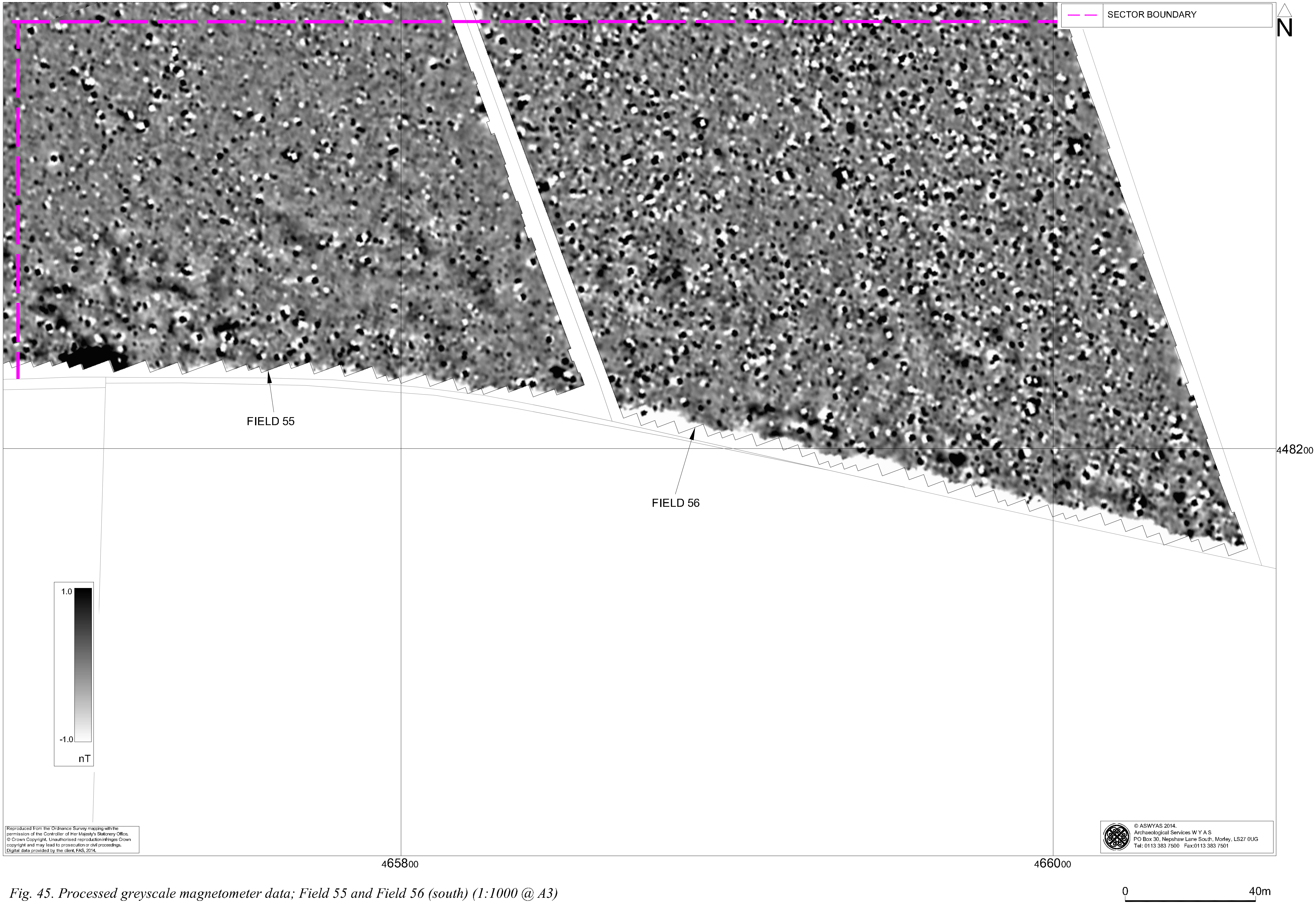


Fig. 44. Interpretation of magnetometer data; Field 55 and Field 56 (north) (1:1000 @ A3)



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel: 0113 383 7500 Fax:0113 383 7501

Fig. 45. Processed greyscale magnetometer data; Field 55 and Field 56 (south) (1:1000 @ A3)

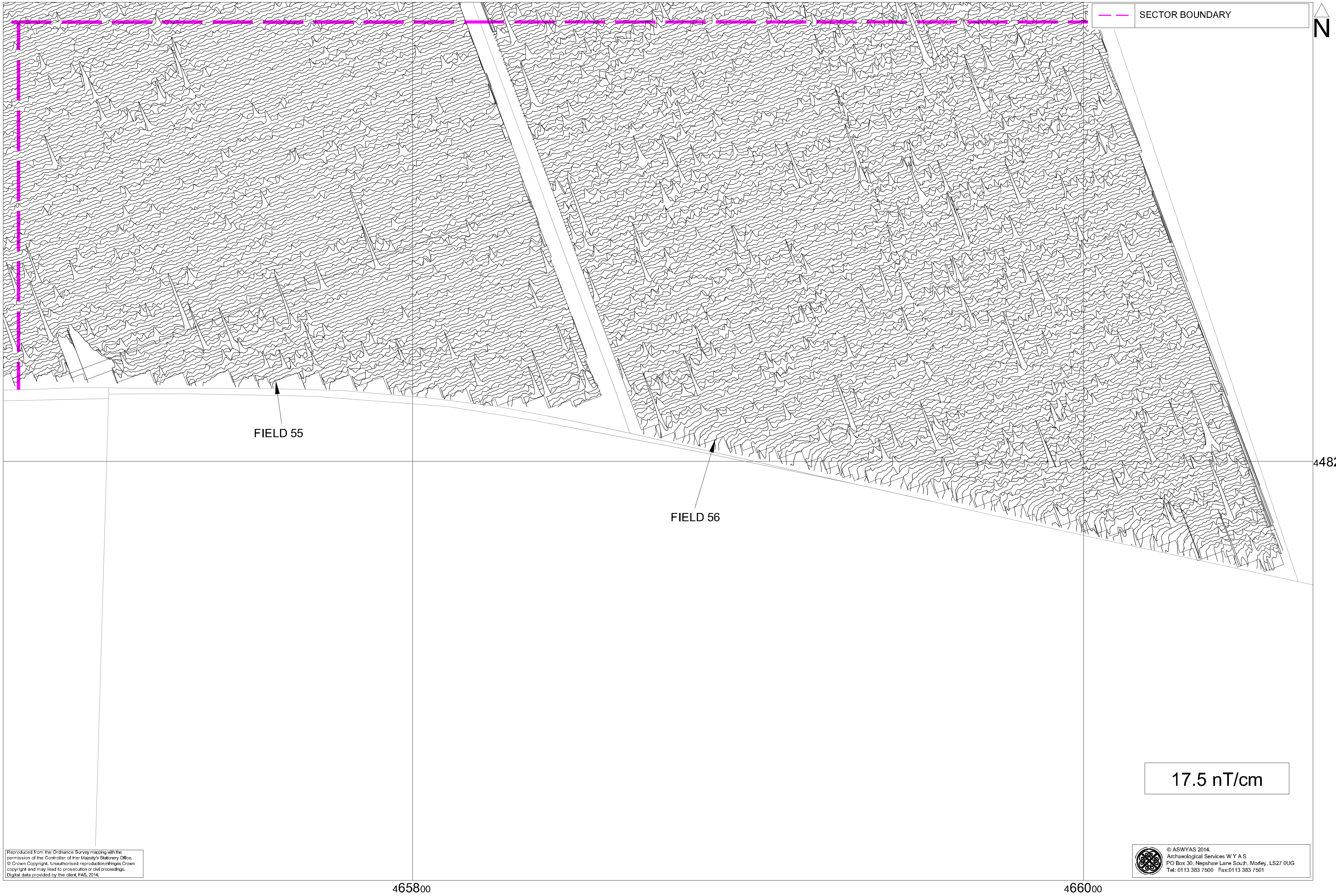


Fig. 46. XY trace plot of minimally processed magnetometer data; Field 55 and Field 56 (south) (1:1000 @ A3)

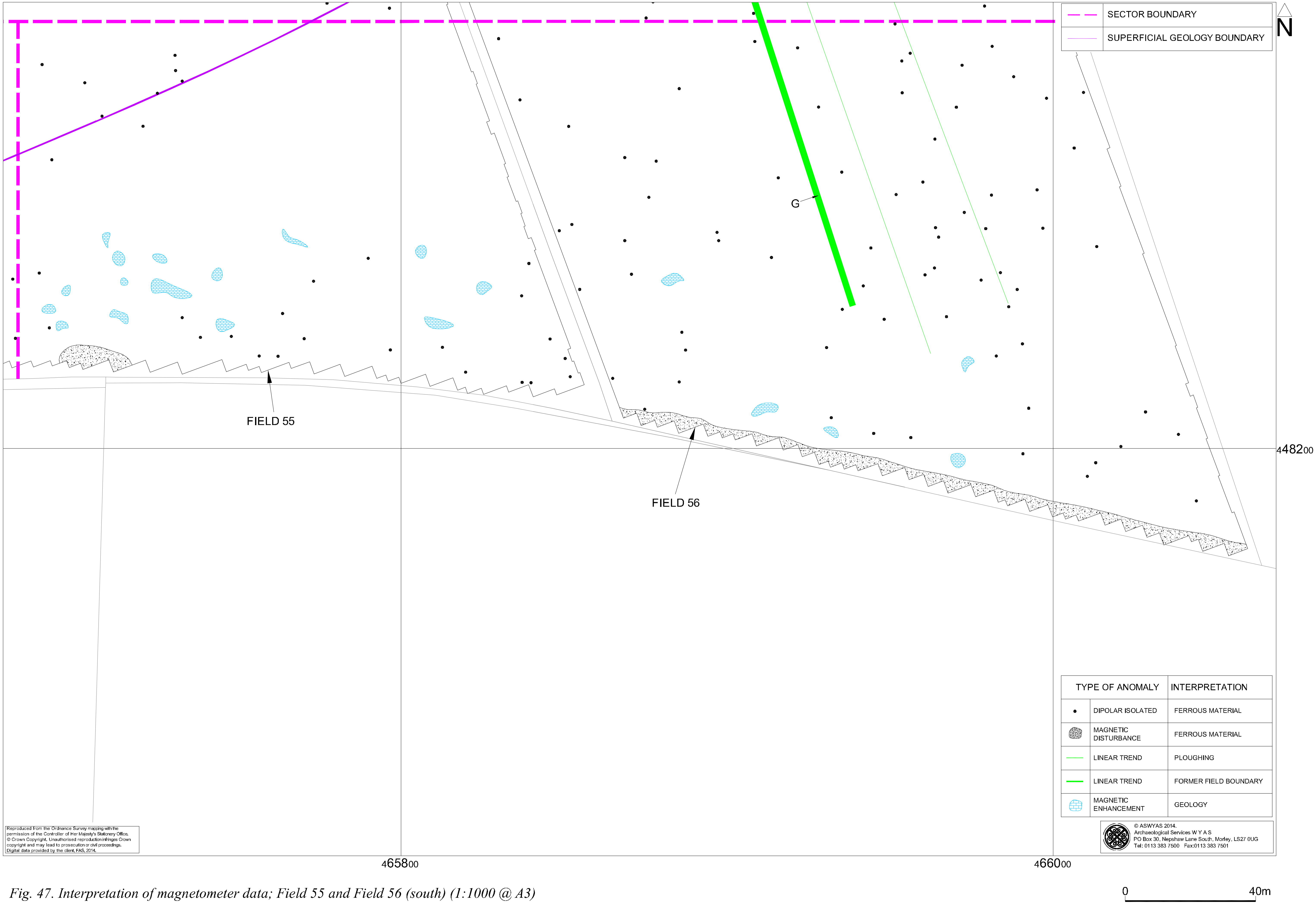


Fig. 47. Interpretation of magnetometer data; Field 55 and Field 56 (south) (1:1000 @ A3)

Plate 1. General view of Field 38, looking north-west

Plate 2. General view of Field 39, looking north-west

Plate 3. General view of Field 43, looking west

Plate 4. General view of Field 44, looking south-west

Plate 5. General view of Field 45, looking north-west

Plate 6. General view of Field 46, looking north-east

Plate 7. General view of Field 47, looking north

Plate 8. General view of Field 48, looking north

Plate 9. General view of Field 52, looking west

Plate 10. General view of Field 54, looking south-west

Plate 11. General view of Field 55, looking south-west

Plate 12. General view of Field 56, looking south-east

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 City of York Historic Environment Record).

Bibliography

British Geological Survey, 2014. www.bgs.ac.uk/discoveringGeology/geology OfBritain/viewer.html . (Viewed June 9th 2014)

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, 2013. *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 1

Toop, N. 2014. *Whinthorpe, York: Desk-based Archaeological Assessment.* Unpublished Client Report Ref. FAS2014 570 YW/T250