ARCHAEOLOGICAL SERVICES WYAS

Ripon Quarry Proposed Southern Extension North Yorkshire

Geophysical Survey

August 2009

Report No. 1978

Hanson Aggregates

Ripon Quarry Proposed Southern Extension
North Yorkshire

Geophysical Survey

Summary

A geophysical survey comprising magnetic scanning followed by selected detailed magnetometer survey was carried out at the location of the proposed southern extension to Ripon Quarry. The scanning covered the whole of the available area (29 hectares) and the detailed survey 6.5 hectares. Anomalies caused by ploughing and field drains as well as those due to natural features such as palaeochannels and bands of river gravels and more general pedological variation have been identified. No anomalies of probable archaeological potential have been identified. Former field boundaries and cropmarks identified from air photograph analysis have not been identified as magnetic anomalies. The results of the geophysical evaluation confirm the view put forward in an archaeological assessment that this area has a moderate to low archaeological potential.

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Report Information

Client:	Hanson Aggregates
Report Type:	Geophysical survey
Location:	Ripon
County:	North Yorkshire
Grid Reference:	SE 305 764
Period(s) of activity represented:	n/a
Report Number:	1978
Project Number:	3465
Site Code:	RIQ09
Planning Application No.:	n/a
Museum Accession No.:	-
Date of fieldwork:	August 2009
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Contents

List of Figures

1 Introduction

Archaeological Services WYAS was commissioned by Hanson Aggregates via their consultant Andrew Josephs to carry out a program of non-intrusive geophysical evaluation (magnetometer survey) at the location of the proposed southern extension to Ripon Quarry (see Fig. 1). The proposed extension covers 33 hectares although not all was suitable for survey (see below).

The geophysical survey is the first element of a staged programme of archaeological evaluation that will inform the Environmental Impact Assessment and allow North Yorkshire County Council to make an informed decision on any planning application. The aim of the evaluation is to determine the nature, extent and significance of the archaeological resource and provide sufficient detail to allow the scope of mitigation to be designed with confidence.

Site location, topography and land use

The proposed southern extension area (a similar programme of archaeological work is planned for the proposed northern extension) is located approximately 1km south-east of the current plant site and is centred at SE 305 764. The land is generally flat and low lying at between 28m and 29m aOD rising gently to the north-west at about 30m aOD and is located on the flood plain on the western bank of the River Ure. At the time of survey the fields were all in agricultural production having recently been harvested of a wheat crop. No problems were encountered during the survey which was undertaken in early August 2009. Two bands of oil seed rape and maize aligned broadly east/west, used as cover for pheasants, sub-divided the site and an area of overgrown vegetation along the south-western edge of the site (see Fig. 2) reduced the area suitable for survey to 29 hectares.

Geology and soils

The solid geology comprises Middle Marl with evaporates of the Edlington Formation but with superficial (drift) deposits of alluvium. The soils derived from the river alluvium are classified in the Alun association comprising deep, stoneless, permeable, coarse loams over gravel in places.

2 Archaeological background

A review of the known archaeological resource of the site and the surrounding area undertaken on behalf of the client by Andrew Josephs Ltd. and submitted as a scoping report to North Yorkshire County Council concluded that although the site lies in the valley of the River Ure, a rich Prehistoric landscape of national importance, the whole of this southern extension would have been under water or regularly flooded during the early prehistoric period. It was also considered probable that this area would have been marginal land, due to the risk of flooding, until the post-medieval period.

There is limited cropmark evidence and those that have been identified by the NMP do not appear to correlate with any boundaries shown on the first edition Ordnance Survey mapping (see Fig. 3). Consequently the archaeological potential of the southern extension was assessed as moderate to low based on the currently available evidence.

3 Aims, Methodology and Presentation

The general aim of the geophysical survey was to obtain information that would evaluate the archaeological potential of the site. This information would then enable further evaluation and/or mitigation measures to be designed as appropriate.

Specifically the aims were:

- To interpret any geophysical anomalies identified by the survey and thereby
- To determine (so far as is possible) the presence and extent or absence of buried archaeological remains in the proposed extension area

These aims were to be achieved by undertaking magnetometer (unrecorded) scanning across all of the proposed extension that was suitable for survey followed by detailed (recorded) magnetometer survey at selected locations.

All the survey areas were set out using a Trimble VRS dGPS system and superimposed onto a digital Ordnance Survey map base supplied by the client.

Magnetometer scanning

There are two methods of using the magnetometer (fluxgate gradiometer) for archaeological evaluations. The first method is referred to as 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 with bamboo canes and the position recorded using a Gekko hand-held GPS. Scanning is particularly useful as a means of rapidly identifying areas of archaeological potential so that detailed survey can be focused to best effect.

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 also not be detected. These drawbacks mean that 'negative' scanning results (***i.e.*** in areas where few or no anomalies are identified) should be validated with an agreed amount of detailed magnetic survey. Geoscan FM36 fluxgate gradiometers were used for the scanning.

Magnetometer survey

For the detailed survey Bartington Grad601 instruments were used to take readings at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m grids so that 1600 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. Detailed survey allows the visualisation of weaker anomalies that may not have been readily identifiable by magnetometer (magnetic) scanning.

The detailed survey blocks were positioned to satisfy at least one of the criteria below:-

- To target anomalies identified during scanning
- To cover cropmarks or first edition boundaries
- To ensure coverage across all parts of the site
- To cover topographically favourable locations
- To sample and validate apparently 'blank' areas.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey mapping is shown in Figure 1. Figure 2 shows the scanning results and the sample blocks whilst Figure 3 shows the magnetometer data and cropmarks. The processed greyscale data, the 'raw' XY trace plot data and interpretation figures are presented at a scale of 1:1000 in Figures 4 to 18 inclusive.

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 survey methodology, report and any recommendations comply with the Methodology (Archaeological Services 2009) and guidelines outlined by English Heritage (David *et al* 2008) and by the IfA (Gaffney, Gater and Ovenden 2002). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright – OS Licence No. 100023320).

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

Magnetometer Scanning

Magnetic scanning was undertaken across all the extension area that was amenable for survey. The direction of scanning was chosen to be perpendicular to identified cropmarks and previous field boundaries to maximise the number of traverses that would potentially cross the alignment of the former feature and thereby increase the chance of locating them.

During the scanning the background of the site varied little being between ±1nT. Iron ‘spike’ anomalies when encountered were investigated further to see if these were in clusters or part of a wider area of anomalies. The majority of these anomalies were isolated and were ignored being assigned a modern agricultural origin.

Palaeochannels were also prevalent throughout the survey area. These were identified on the ground but were not focussed on as the purpose of the survey was to identify archaeological remains. The responses from the palaeochannels varied from broad weak linear anomalies to very disturbed linear trends (see Fig. 2).

The majority of the scanning ‘hits’ identified in the survey were discrete anomalies that did not occur in any identifiable pattern or as part of a cluster. These anomalies were usually between +2nT and +4nT in strength. This type of anomaly can be indicative of features such as pits but on this occasion it was expected, especially given the absence of any linear anomalies (see below) and the prevailing soils and superficial geology, that these anomalies are due to natural variations in the soil and by the presence of magnetic river gravels.

Linear anomalies due to former field boundaries were not readily identified by the scanning although very subtle variation in the magnetic background was noted either side of an ‘invisible’ boundary.

A strongly magnetic linear response locates a high pressure gas main that crosses the centre of the of the site aligned south-south-west/north-north-east (see Figs 2 and 3).

Magnetometer Survey

The types of anomaly identified on this site can be divided into three categories.

Discrete ferrous, dipolar anomalies

These anomalies are typically caused by ferrous (magnetic) material, either on the ground surface or in the topsoil, which causes rapid variations in the magnetic readings giving a characteristic ‘spiky’ XY trace. Unless there is supporting evidence for an archaeological interpretation, little importance is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring or tipping/infilling. Iron spike anomalies are present in all survey blocks and there is no obvious pattern or clustering to their distribution to suggest anything other than random ferrous debris in the ploughsoil.

Anomalies due to soils or geology

These geological anomalies can be categorised in two distinct types. The first are vague, sinuous and discontinuous anomalies characterised as broad, low level areas of magnetic enhancement such as those interpreted in Blocks 3, 9, 11 and 14. It is not clear whether these anomalies are true palaeochannels – it is perhaps more likely that they are due to minor variations in the composition of the alluvial deposits, perhaps as a consequence of material being deposited in drifts following a period of inundation rather than former stream courses.

A more obvious broad linear anomaly is visible in Block 4. This is considered more likely to be a palaeochannel. Weaker anomalies identified in Block 3 to the north and Block 7 to the south probably locate the continuation of this feature.

Clusters of strongly magnetic anomaly are prominent in Blocks 1, 6 and 8. These clusters are thought to be caused by bands or pockets of magnetic river gravels.

Linear trends

Linear trend anomalies on varying alignment are present in several of the blocks, particularly those to the north of the site. These anomalies reflect the orientation of recent agricultural regimes.

Those linear anomalies in Block 4, aligned south-west/north-east are slightly more prominent than the other vague trends and are thought may be due to a system of field drains. These anomalies all seem to terminate along an edge. It is considered probable that this 'inferred' boundary locates the field division shown on the first edition Ordnance Survey mapping (see Fig. 2) even though it does not manifest as a magnetic anomaly – none of the other former boundaries show up as magnetic anomalies either. This is considered to be a reflection of the deep, stoneless, loamy nature of the soils – in effect the fill of the boundary ditch will comprise essentially the same loamy material into which the ditch has been cut. This results in an absence of magnetic contrast between the fill of the feature and the surrounding material, as a consequence making infilled cut features difficult to identify.

The linear trend anomaly aligned south-west/north-east in Block 3 marks the boundary between an area of arable crop (to the south) and a grassed area (to the north).

5 Discussion and Conclusions

A comprehensive geophysical evaluation has been undertaken across all of the proposed extraction area that was suitable for survey. No anomalies of probable archaeological potential have been identified although anomalies due to agricultural practice and to natural features and variation in the superficial (drift) deposits have been identified.

Although the deep, loamy, alluvial soils are not necessarily the most favourable of geologies on which to undertake magnetometer surveys the fact that ploughing anomalies have been identified suggests that if there had been any major archaeological activity at this site that it would have been possible to identify it with the methodologies employed.

Whilst the absence of archaeological features should not dismissed completely due to the attenuating effect of the deep soils on balance it is considered that the absence of archaeological anomalies identified on this site is a reflection of the absence of underlying archaeological features or deposits rather than an inability of the technique to identify any such activity.

In conclusion the geophysical evaluation has added corroborative (negative) evidence to the assertion previously reported that this particular part of the Ure valley has a moderate to low archaeological potential, having from the prehistoric period until the post-medieval period been periodically inundated, marginal land, unfit for settlement.

The next stage of evaluation will be a programme of trial trenching that will confirm or refute this 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.

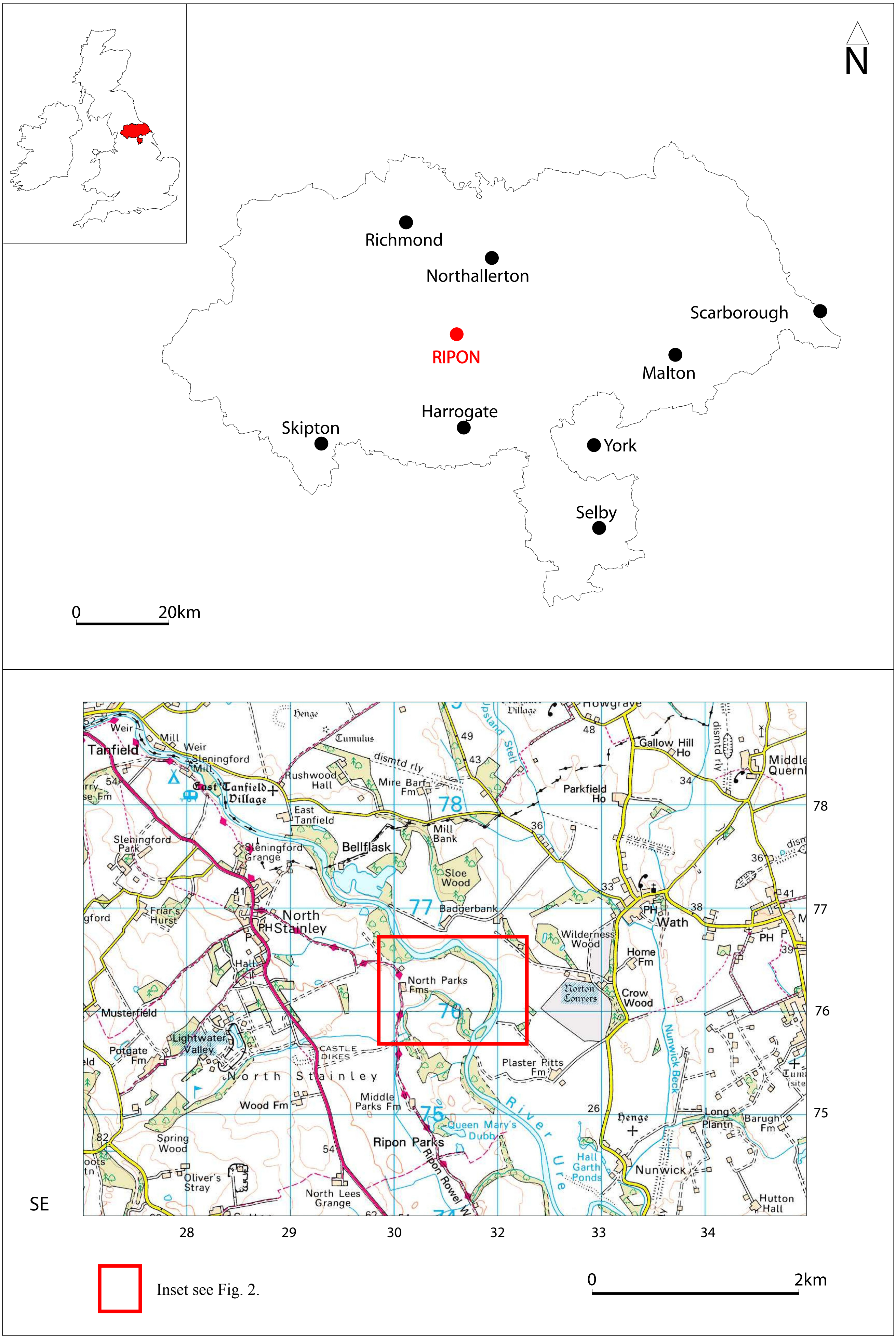

Fig. 1. Site location

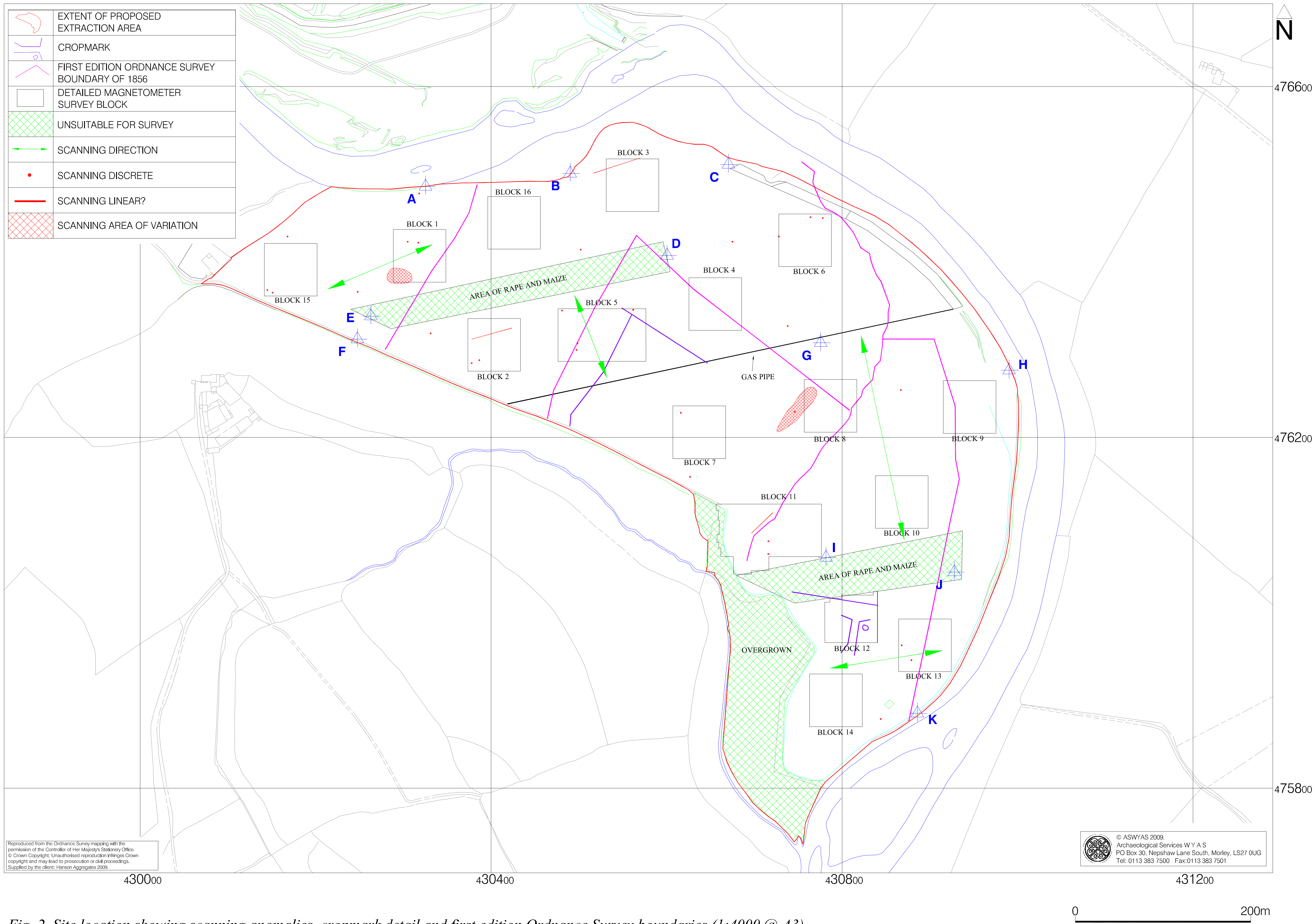

Fig. 2. Site location showing scanning anomalies, cropmark detail and first edition Ordnance Survey boundaries (1:4000 @ A3)

Fig. 3. Site location showing greyscale magnetometer blocks (1:4000 @ A3)

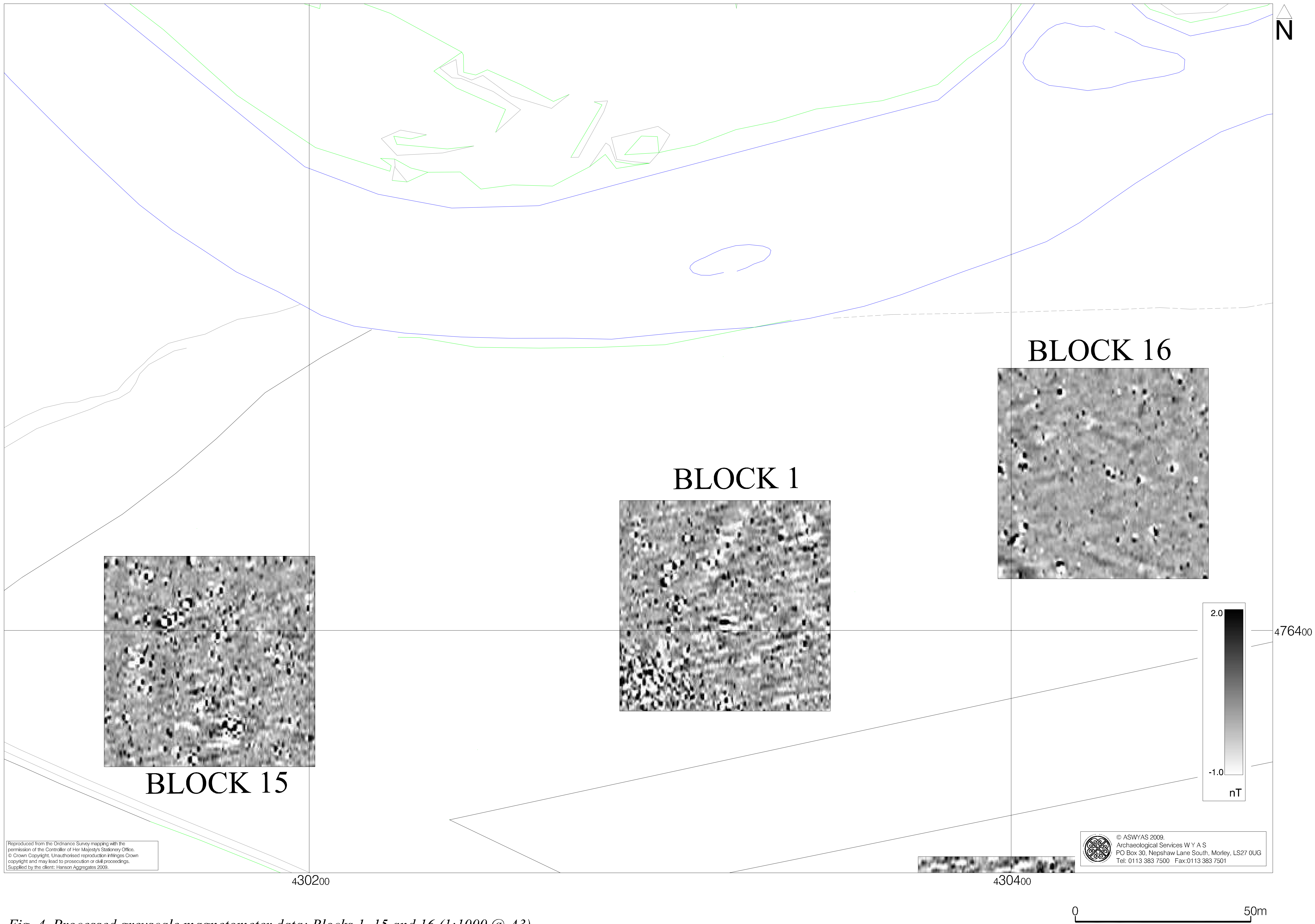

Fig. 4. Processed greyscale magnetometer data; Blocks 1, 15 and 16 (1:1000 @ A3)

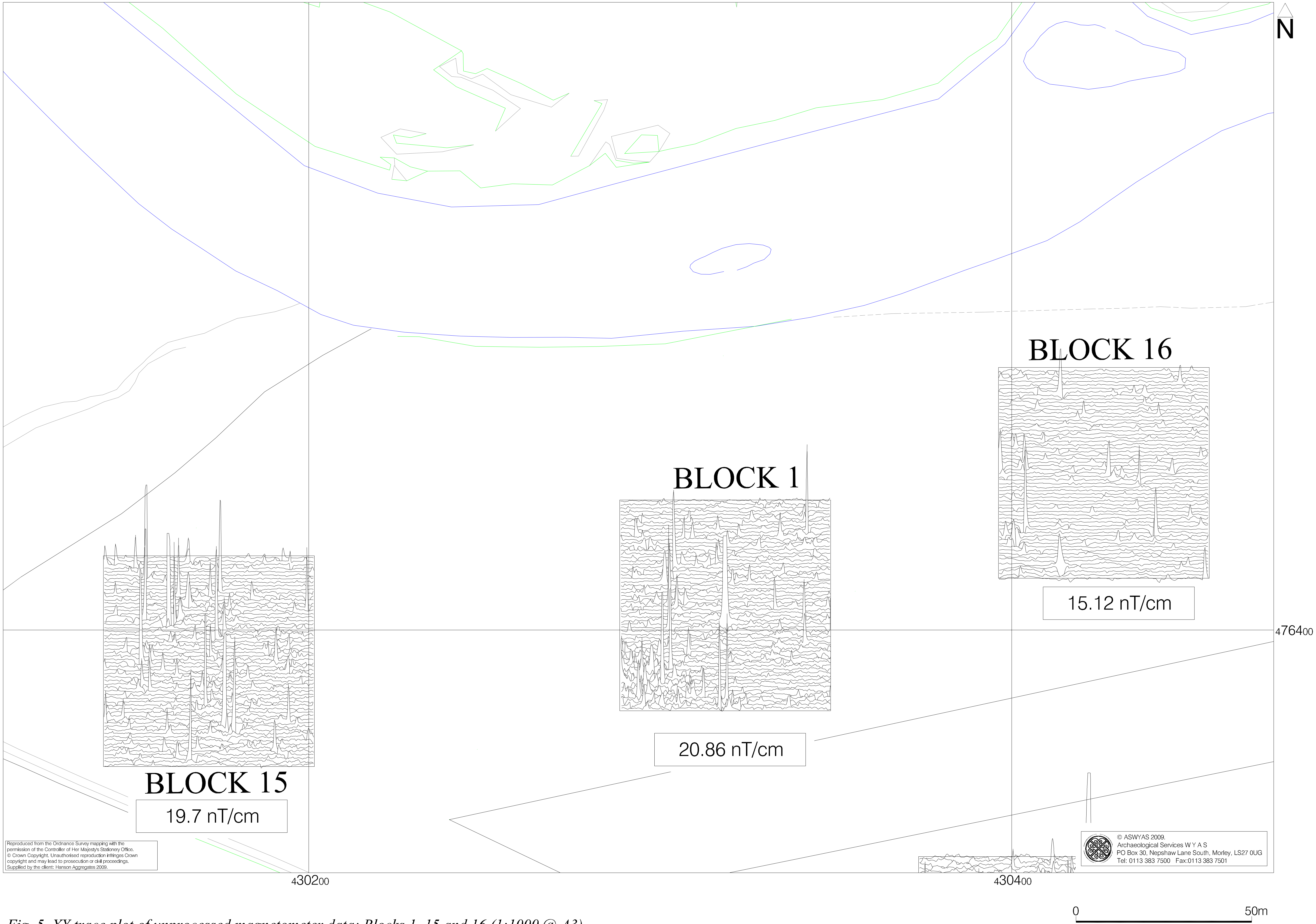

Fig. 5. XY trace plot of unprocessed magnetometer data; Blocks 1, 15 and 16 (1:1000 @ A3)

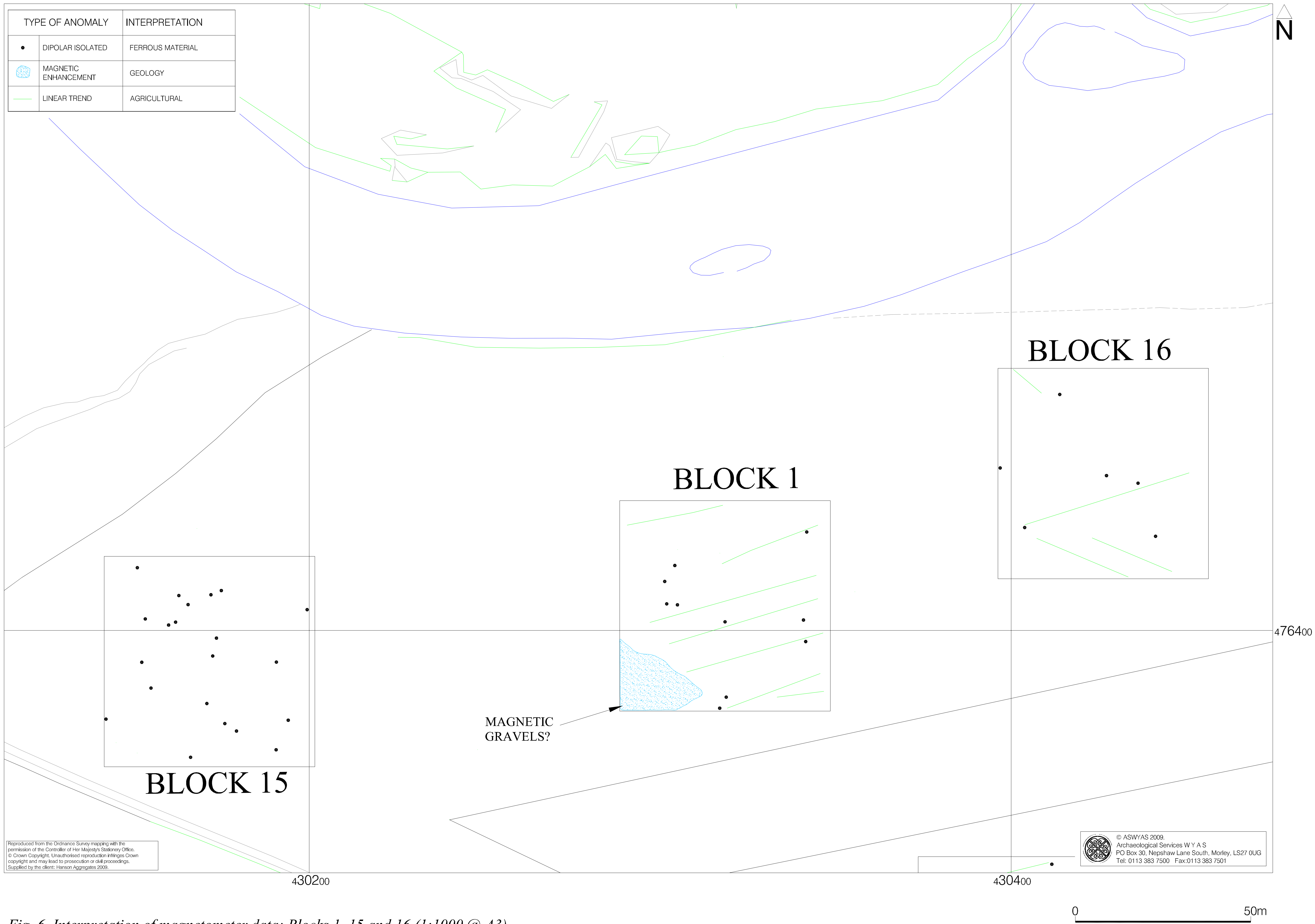

Fig. 6. Interpretation of magnetometer data; Blocks 1, 15 and 16 (1:1000 @ A3)

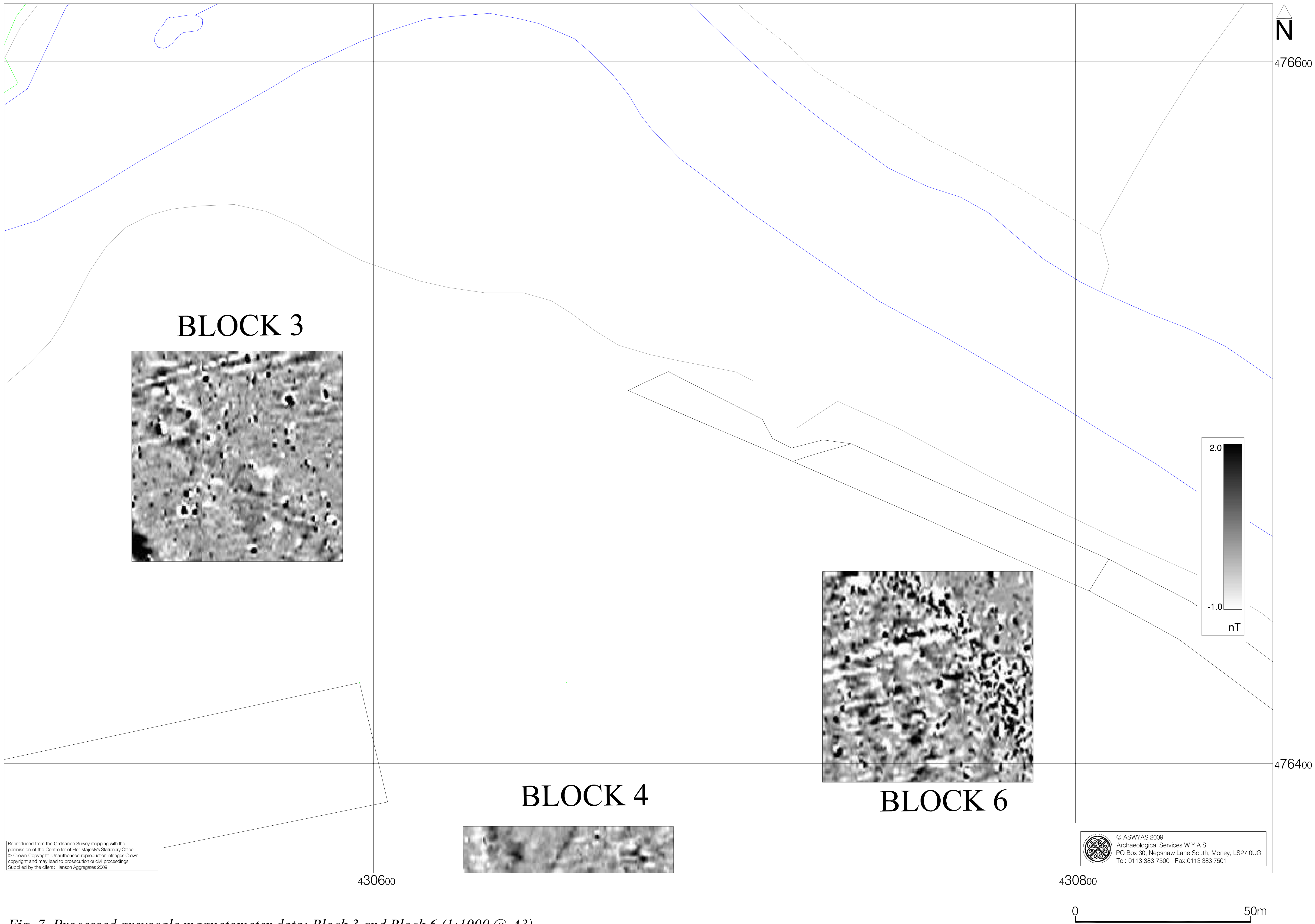

Fig. 7. Processed greyscale magnetometer data; Block 3 and Block 6 (1:1000 @ A3)

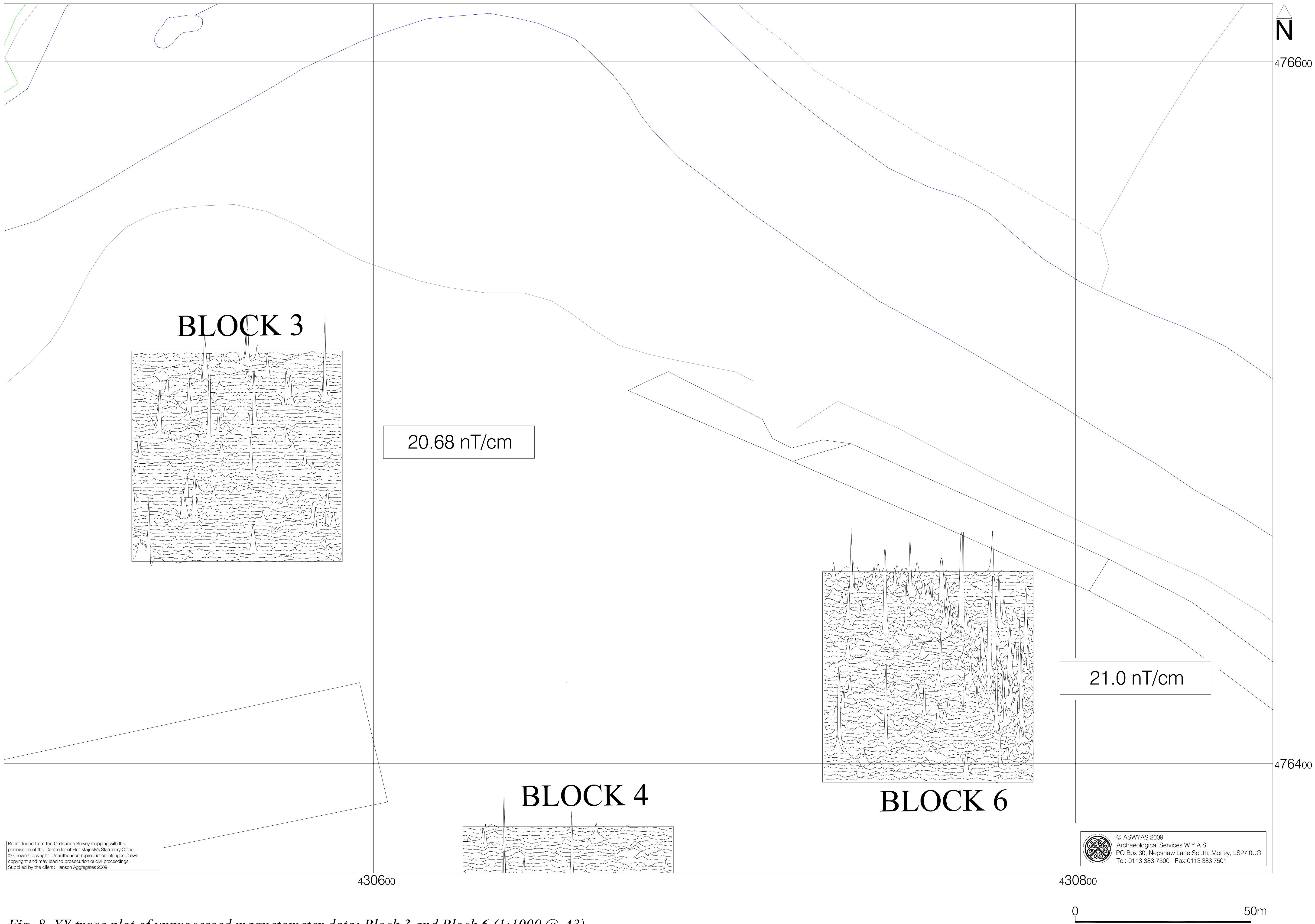

Fig. 8. XY trace plot of unprocessed magnetometer data; Block 3 and Block 6 (1:1000 @ A3)

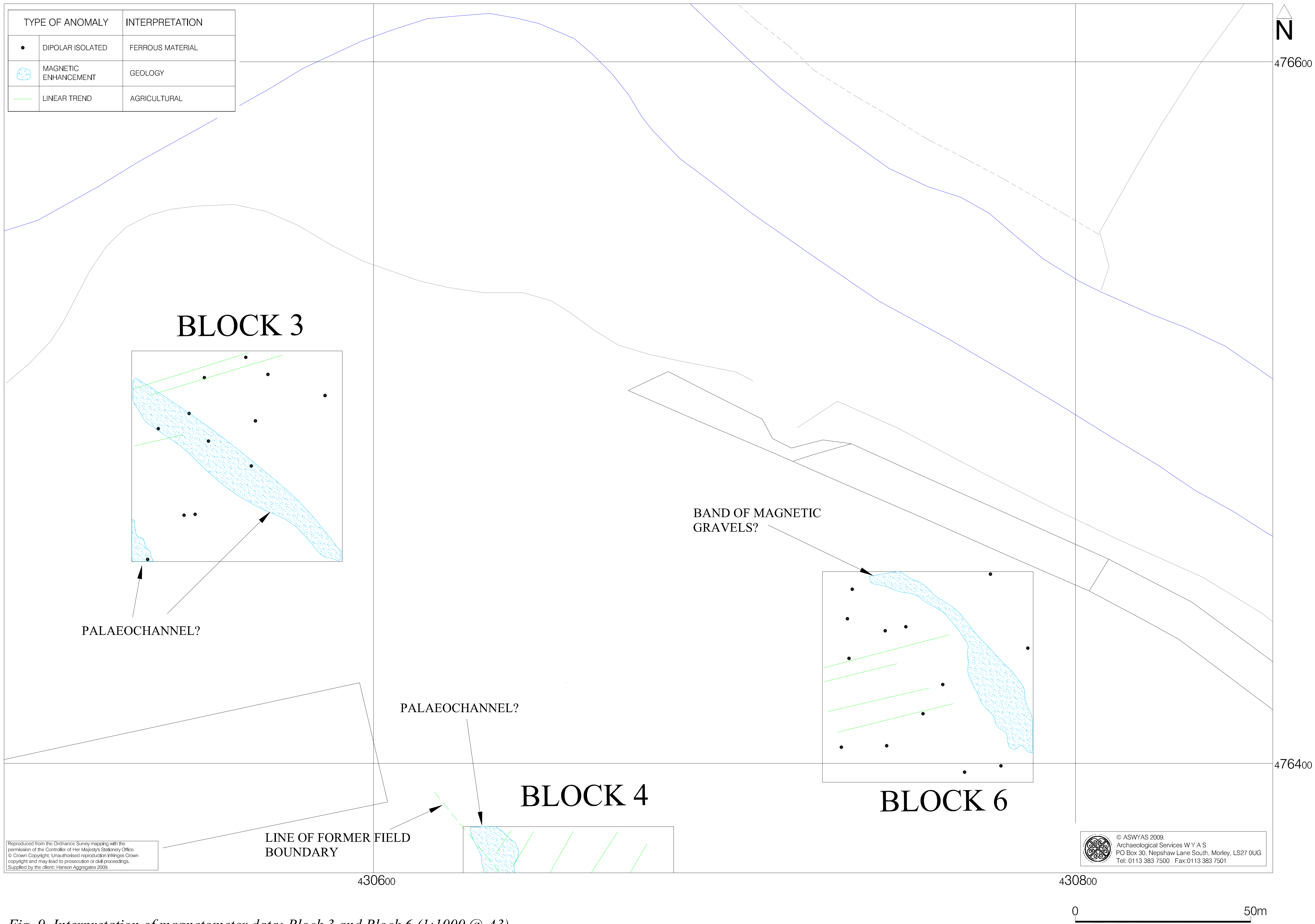

Fig. 9. Interpretation of magnetometer data; Block 3 and Block 6 (1:1000 @ A3)

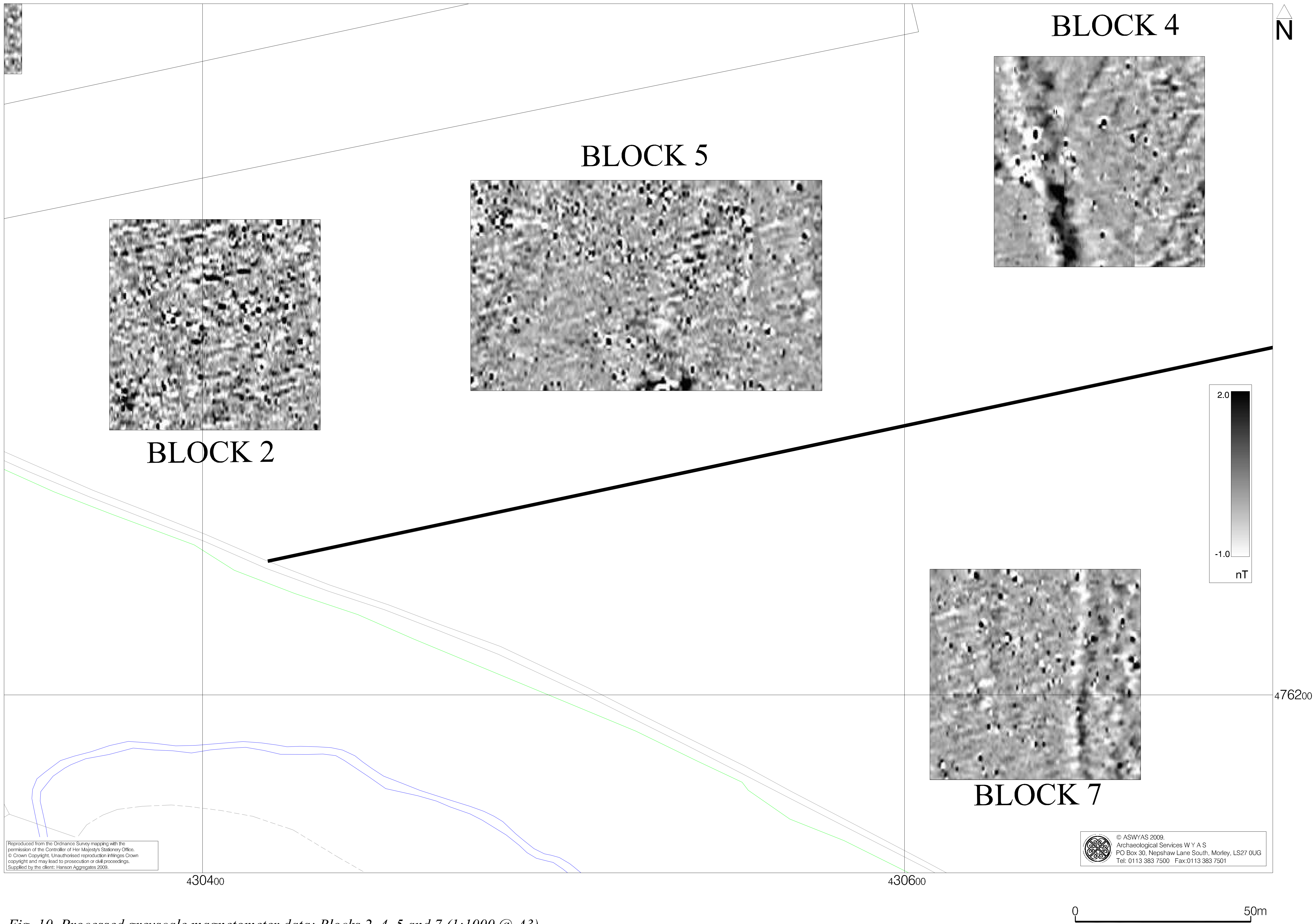

Fig. 10. Processed greyscale magnetometer data; Blocks 2, 4, 5 and 7 (1:1000 @ A3)

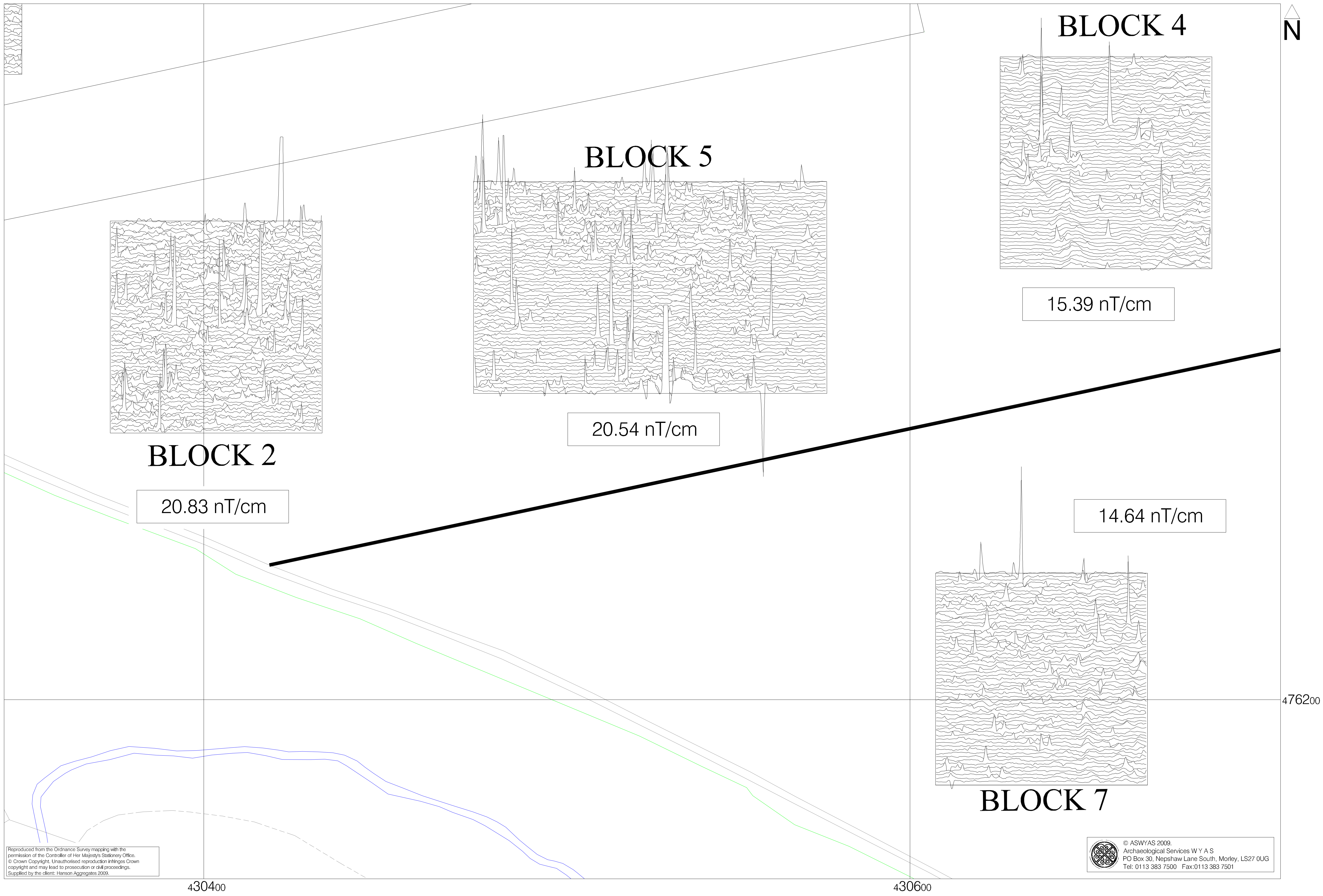

Fig. 11. XY trace plot of unprocessed magnetometer data; Blocks 2, 4, 5 and 7 (1:1000 @ A3)

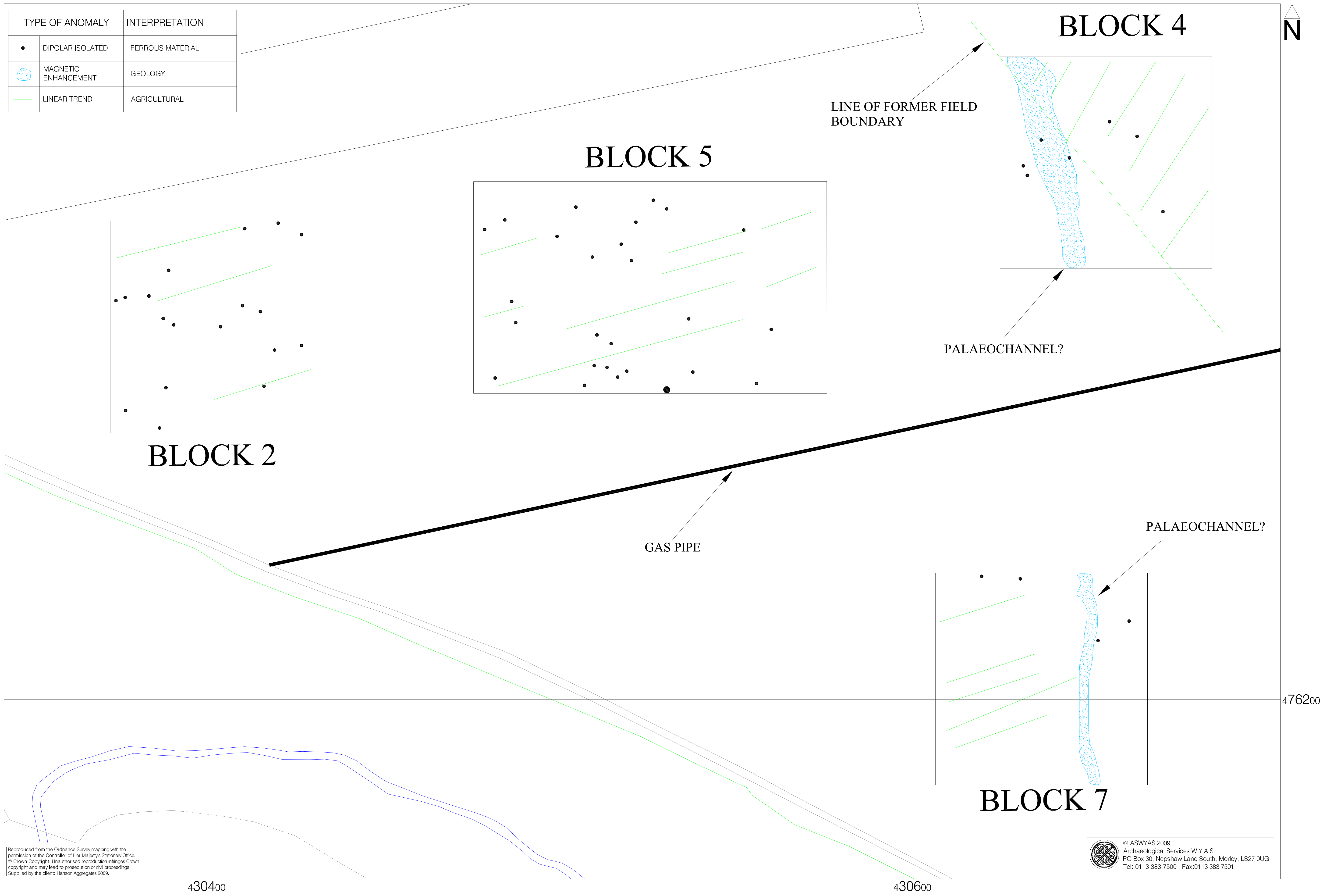

Fig. 12. Interpretation of magnetometer data; Blocks 2, 4, 5 and 7 (1:1000 @ A3)

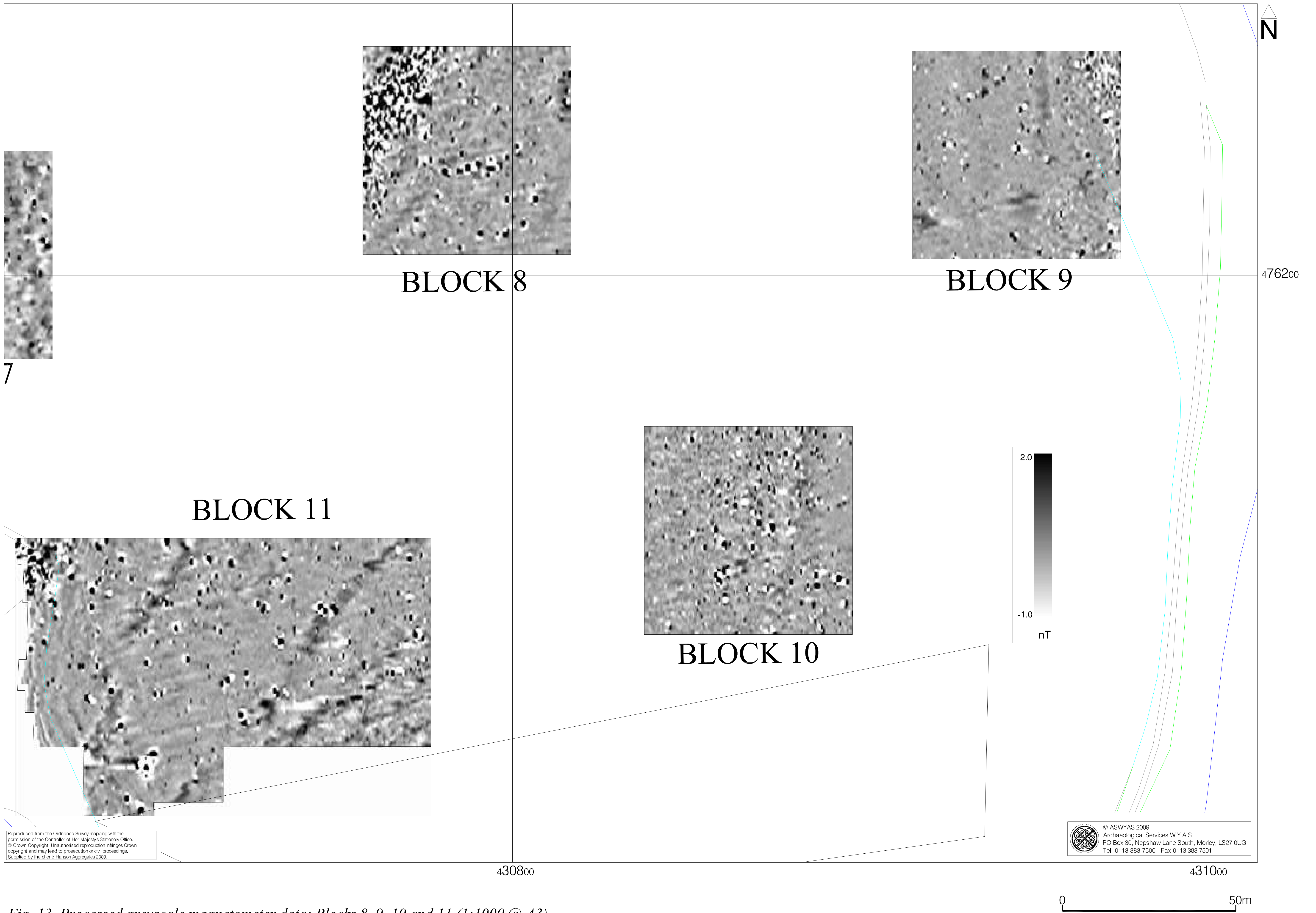

Fig. 13. Processed greyscale magnetometer data; Blocks 8, 9, 10 and 11 (1:1000 @ A3)

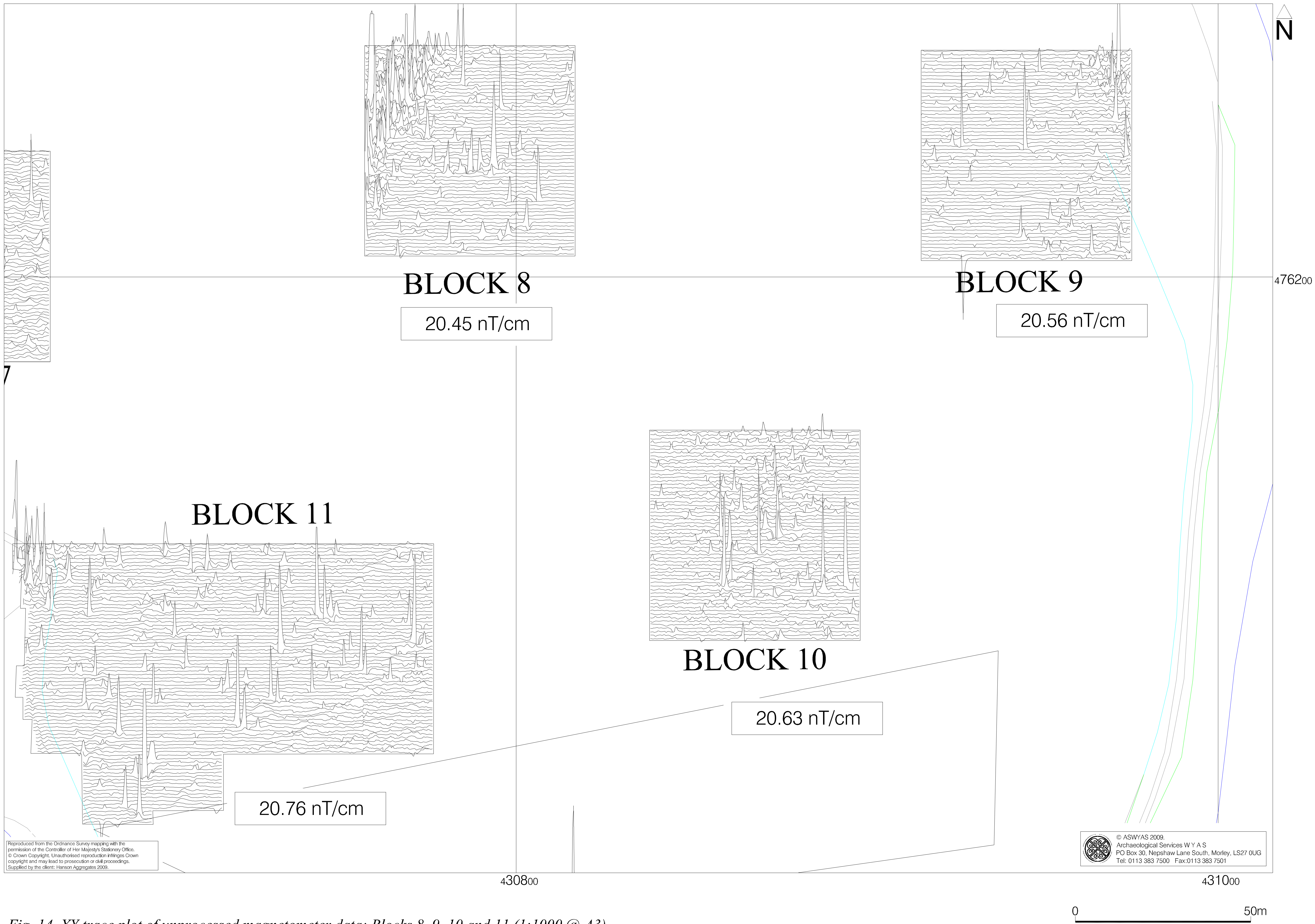

Fig. 14. XY trace plot of unprocessed magnetometer data; Blocks 8, 9, 10 and 11 (1:1000 @ A3)

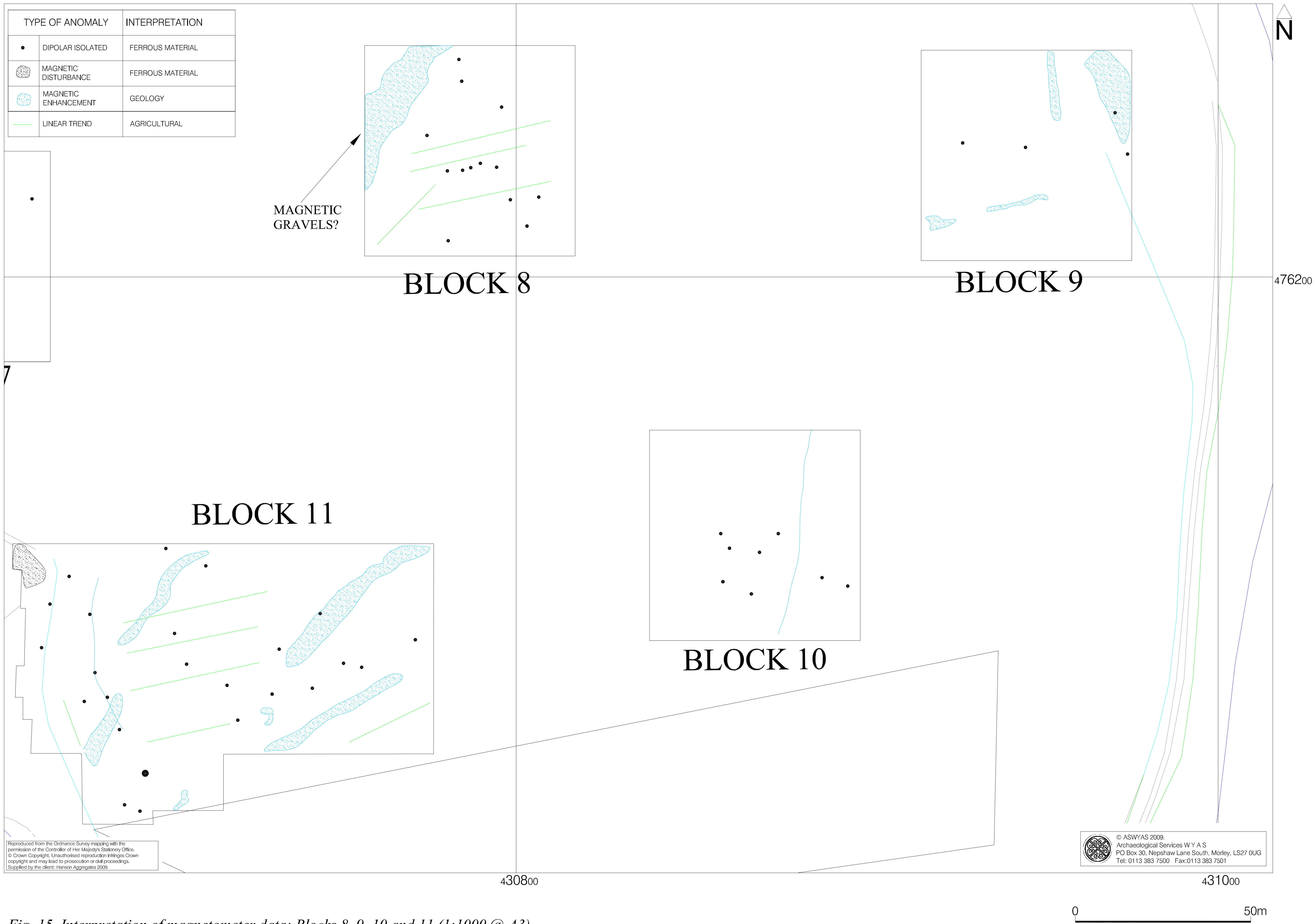

Fig. 15. Interpretation of magnetometer data; Blocks 8, 9, 10 and 11 (1:1000 @ A3)

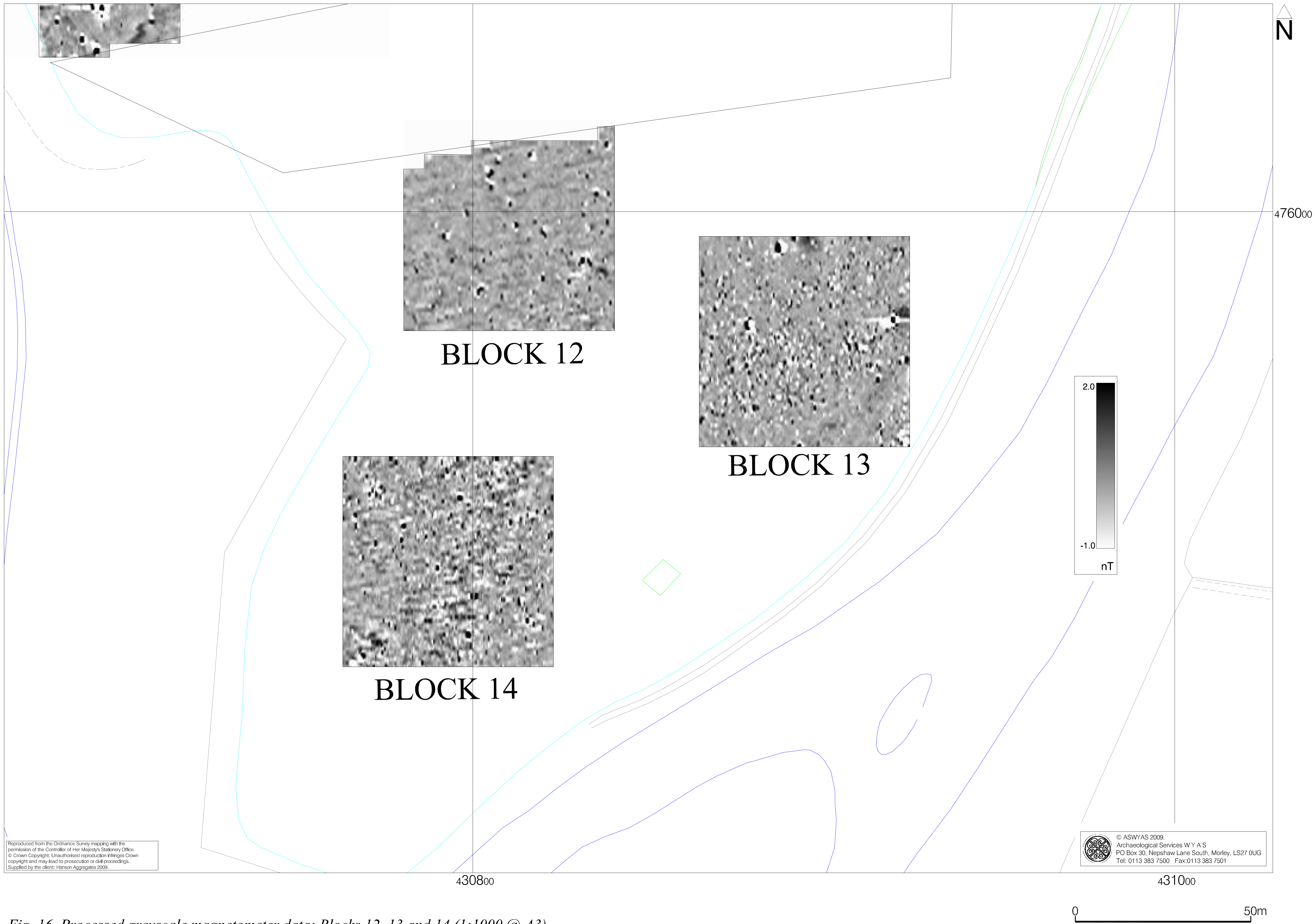

Fig. 16. Processed greyscale magnetometer data; Blocks 12, 13 and 14 (1:1000 @ A3)

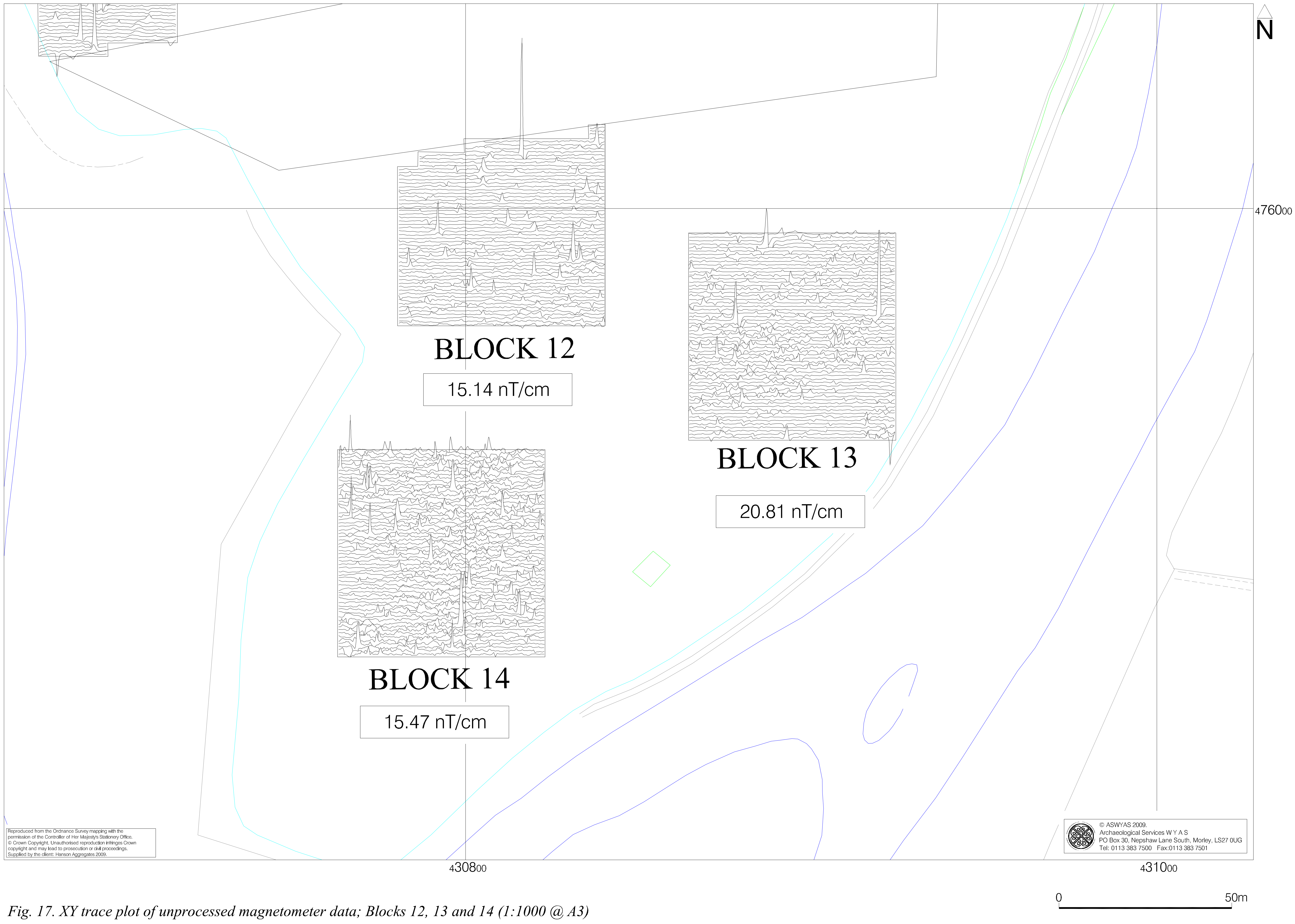

Fig. 17. XY trace plot of unprocessed magnetometer data; Blocks 12, 13 and 14 (1:1000 @ A3)

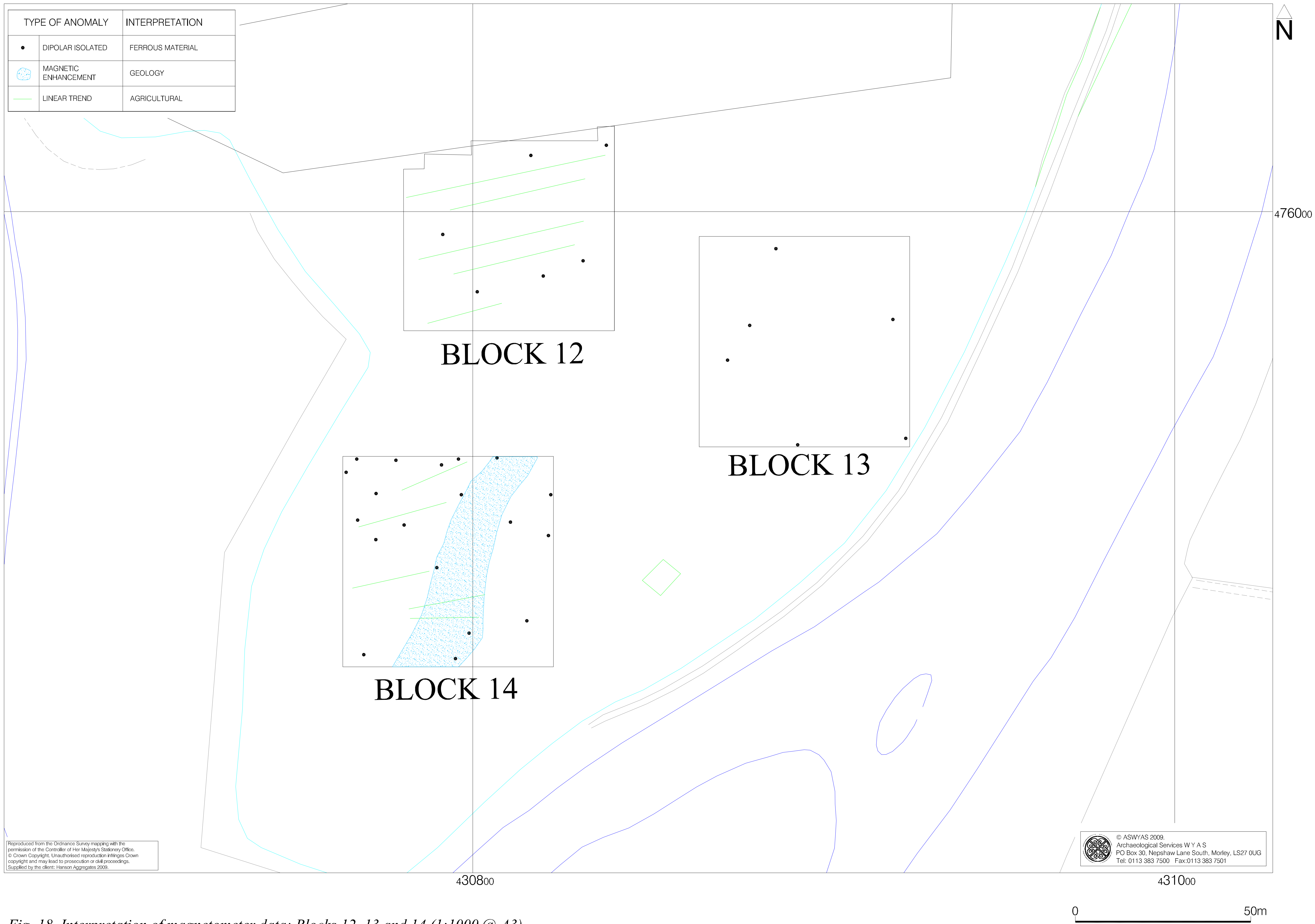

Fig. 18. Interpretation of magnetometer data; Blocks 12, 13 and 14 (1:1000 @ A3)

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 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 20m by 20m 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 dual frequency Global Positioning System (GPS) with two Rovers (Trimble 5800 models) working in real-time kinetic mode. The accuracy of such equipment was better then 0.02m. 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 for relocation purposes.

Temporary reference objects were left on site (see Fig. 2). The Ordnance Survey reference points are listed below.

Station	Easting	Northing
A	430325.32	476486.05
B	430490.15	476500.86
C	430670.44	476511.10
D	430600.55	476407.25
E	430263.07	476338.16
F	430247.56	476311.95
G	430775.53	476307.78
H	430990.30	476276.51
I	430781.75	476063.05
J	430927.97	476046.38
K	430885.87	475885.43

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 Sites and Monument Record Office).

Bibliography

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