ARCHAEOLOGICAL SERVICES WYAS

Durham Green Business Park
Bowburn
County Durham

Geophysical Survey

November 2008

Report No. 1887

White Young Green

Durham Green Business Park
Bowburn
County Durham

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 18 hectares was undertaken at the proposed site of Durham Green Business Park, Bowburn. Numerous linear anomalies caused by ploughing, field drains, recently removed field boundary ditches and ferrous pipes have been identified. No anomalies due to archaeological activity have been identified. On the basis of the geophysical survey the site is considered to have a low archaeological potential.

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Report Information

Client:	White Young Green Arndale Court, Headingley, Leeds, LS6 2UJ
Report Type:	Geophysical Survey
Location:	Peat Edge Farm, Tursdale Road, Bowburn.
County:	County Durham
Grid Reference:	NZ 305 375
Period(s) of activity represented:	Unknown
Report Number:	1887
Project Number:	3308
Site Code:	DGB08
Planning Application No.:	Pre-determination
Museum Accession No.:	-
Date of fieldwork:	July 2008 and October 2008
Date of report:	November 2008
Project Management:	Sam Harrison BSc MSc AIFA
Fieldwork:	Chris Fisher BSc Alex Harrison BSc Sam Harrison BSc MSc AIFA Emma Watson BSc Ian Wilkins BSc MSc
Report:	Sam Harrison BSc MSc AIFA
Illustrations:	Sam Harrison BSc MSc AIFA
Photography:	-
Research:	-
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1 Introduction and archaeological background

Archaeological Services WYAS (ASWYAS) was commissioned by Kirsten Holland of White Young Green to undertake a geophysical (magnetometer) survey in advance of the proposed development of Durham Green Business Park, Bowburn, County Durham (see Fig. 1).

Site location, land use and topography

The geophysical survey area, centred at NZ 305 375, covered approximately 18 hectares, across eleven separate fields (see Fig. 2). The site, situated approximately 0.5km south of Bowburn, is delimited by Bowburn Beck to the north and west, with fields to the south and the A688 forming the eastern boundary. Peat Edge Farm is situated in the centre of the site.

The geophysical survey was undertaken at two separate times; the pasture fields (Blocks 4, 5, 6, 7, 8 and 11) were surveyed between July 28th 2008 and July 31st 2008 whilst the arable crop fields (Blocks 1, 2, 3, 9 and 10), were surveyed between October 28th 2008 and October 30th 2008 due to a late harvest.

The site gently sloped down to the west and north towards Bowburn Beck, being generally between 75m above Ordnance Datum (aOD) in the west and 90m aOD in the east.

Geology and soils

The solid geology comprises Middle Coal Measures and sandstone (see Fig. 3). The soils are classified in the Dunkeswick association being described as permeable, seasonally waterlogged, fine loams (Survey of England and Wales 1983).

2 Archaeological and Historical Background

A desk-based assessment of the site undertaken by the client prior to the geophysical survey (White Young Green February 2008, revised June 2008) reported that a postulated Roman route way, Cade’s Road, between Great Stainton and Chester-le-Street, passes to the north of the survey area but that no archaeological remains had been identified within the actual survey area.

Extensive ridge and furrow earthworks identified from an earlier aerial survey were found to be no longer extant following the walkover survey undertaken as part of the desk-based assessment and analysis of early Ordnance Survey mapping showed that a number of field boundaries have been removed since the first edition mapping of 1861.

Nevertheless the assessment concluded that there was still a potential for previously unrecorded archaeological remains to survive on the site.

3 Aims and Objectives

The general aims of the geophysical survey were to obtain information that would contribute to an evaluation of the archaeological potential of the site. This information would then enable further evaluation and/or mitigation measures to be designed in advance of the proposed development of the site. These aims were to be achieved by undertaking detailed (recorded) magnetometer survey in the defined locations. Specifically the survey sought to provide information about the nature and possible interpretation of magnetic anomalies identified during the survey and thereby determine the likely extent, presence or absence of any buried archaeological remains in the proposed development area. The survey was undertaken in accordance with a Written Scheme of Investigation agreed following consultation with Lee White from Durham County Council.

4 Methodology

Magnetometer survey

A Bartington Grad601 magnetic gradiometer was used to take 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. Detailed survey allows the visualisation of weaker anomalies that may not have been readily identifiable by evaluation techniques such as magnetometer (magnetic) scanning.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figure 2 shows the processed greyscale magnetometer data, whilst the geology of the survey area is shown in Figure 3, both are at a scale of 1:3000. The processed and 'raw' (unprocessed) magnetometer data from the survey, together with interpretation figures, are presented at a scale of 1:1000 in Figures 4 to 27 inclusive.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the IFA (Gaffney *et al.* 2002). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the survey archive.

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.

5 Results and Discussion

The anomalies from this survey have been divided into three categories.

Ferrous anomalies/magnetic disturbance

Ferrous ('iron spike') anomalies have been located across all parts of the site. These anomalies are indicative of ferrous objects or other magnetic material in the topsoil/subsoil and, although archaeological artefacts may cause them, they are more often caused by modern cultural debris that has been introduced into the topsoil. There are no obvious clusters and therefore these anomalies are not considered to be archaeologically significant. Some of the stronger spike anomalies are caused by man-hole covers and the metal cladding and support stays of telegraph poles.

Concentrations of these anomalies forming distinct areas of magnetic disturbance have been identified in several blocks particularly those surrounding the farm. This disturbance is due to the proximity of fencing, buildings and gates.

In Blocks 1, 6, 7, and 10 there are dipolar linear trend anomalies that are indicative of buried ferrous service pipes. Another pipe leading from Bowburn to the sewage works to the south-west of the site (see Fig. 2) through Blocks 1, 2, 3, 6 and 9 only partially manifests as a dipolar linear anomaly as it nears the sewage works suggesting that the pipe is large, ferrous but deeply buried.

Linear trends

These anomalies may have several causes but all are related, directly or indirectly, to agricultural activity.

Throughout the survey are numerous parallel, linear trend anomalies that are indicative of agricultural activity, primarily ploughing. The weaker and more regularly spaced anomalies are due to recent ploughing regimes while the stronger and slightly curving anomalies, such as those in Block 10 (see Figs 25 - 27), are indicative of the former practice of ridge and furrow ploughing. In this latter case the anomalies are due to the magnetic contrast between the former ridges and infilled furrows.

Six former field boundaries (Blocks 1, 2, 4, 8a and 10) shown on the First Edition Ordnance Survey mapping of 1861 have been identified. These anomalies are generally stronger than the ploughing anomalies; a particular example of this is the anomaly in the centre of Block 10 that aligns with the extant boundary that separates Block 7 and Block 9. It is assumed that this boundary ditch was either backfilled with strongly magnetic material or that a clay drainage pipe was laid in the ditch before backfilling.

In Block 2 and Block 10 (see Figs 7 - 9 and 25 - 27) are weak linear trends that do not align with either ploughing derived anomalies or current or former field boundaries. Particularly curious are the four contour-line type anomalies to the west of Block 2. These are of an unknown origin but it is considered probable that these anomalies are part of a system of field drainage. It is also probable that other linear tends in Block 10 are also due to field drains, although an archaeological origin cannot be completely dismissed.

Magnetic enhancements

Numerous anomalies have been identified, both linear and discrete, that due to their alignment, discontinuous nature and strength of response cannot be easily or confidently interpreted; none correspond with features on the First Edition Ordnance survey map. These 'magnetic enhancements' have been identified in most blocks. Although any could be caused by archaeological features on balance it is considered more likely that they are due to agricultural activity or geological variation.

6 Conclusions

Numerous linear anomalies have been identified across all parts of the site. These are due to ploughing, both recent and ridge and furrow, field drains, former field boundary ditches and ferrous pipes leading to the sewage treatment plant. Other curvilinear anomalies are also considered likely to be caused by a drainage system.

Other short or discontinuous linear anomalies have also been identified which cannot be so easily categorised. Whilst an archaeological interpretation cannot be dismissed it is considered, on balance, that it is more likely these anomalies are also due to recent activity.

The changes in geology across the site appear to have had only a minimal effect on the data with the responses of anomalies on the Middle Coal Measures only slightly weaker than from those on the sandstone.

The responses from the anomalies caused by recent activity suggest that the soils and geology are responsive to magnetic survey and that therefore the lack of identified anomalies attributable to archaeological activity can be seen as an indication of the low archaeological potential of the site.

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.

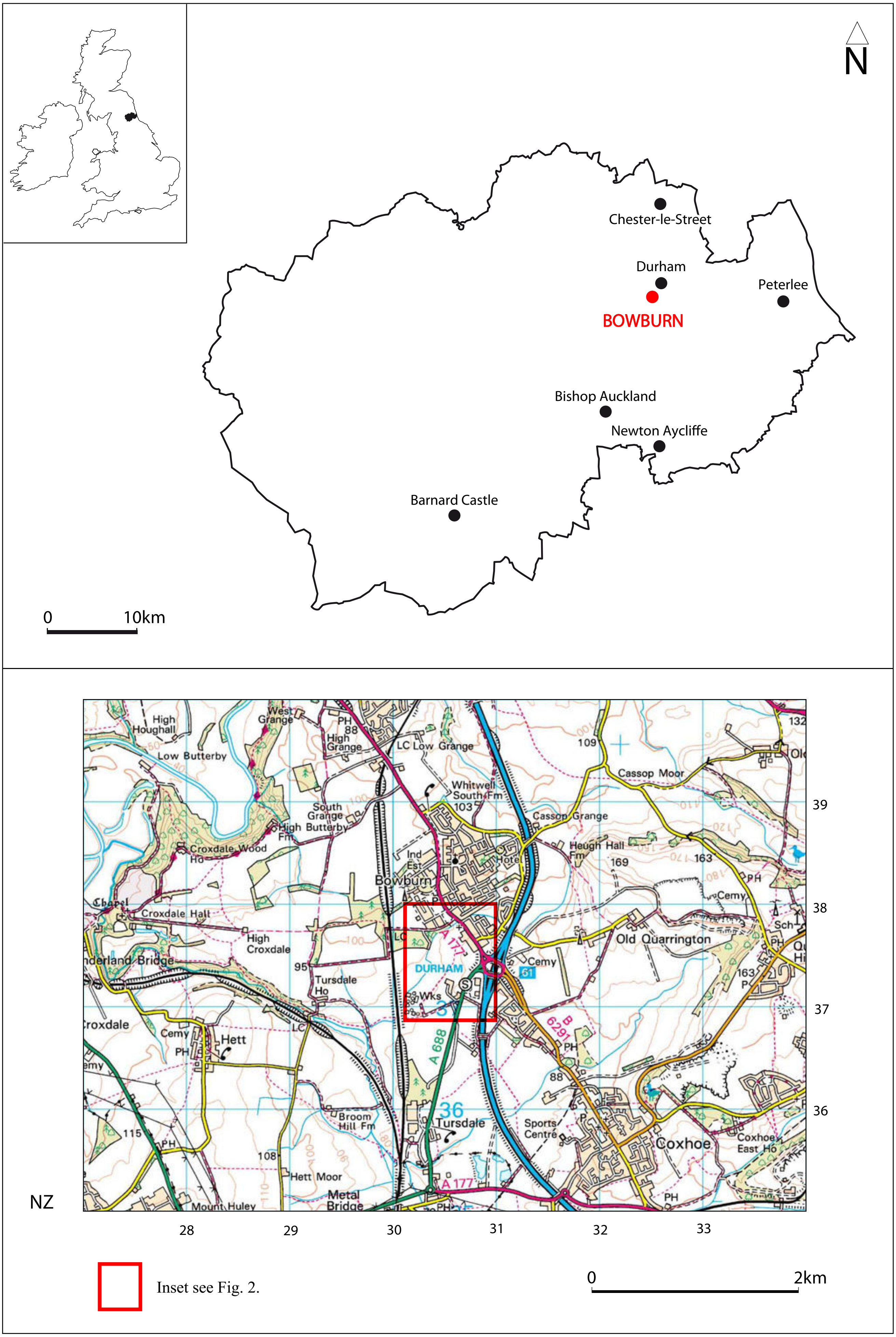

Fig. 1. Site location

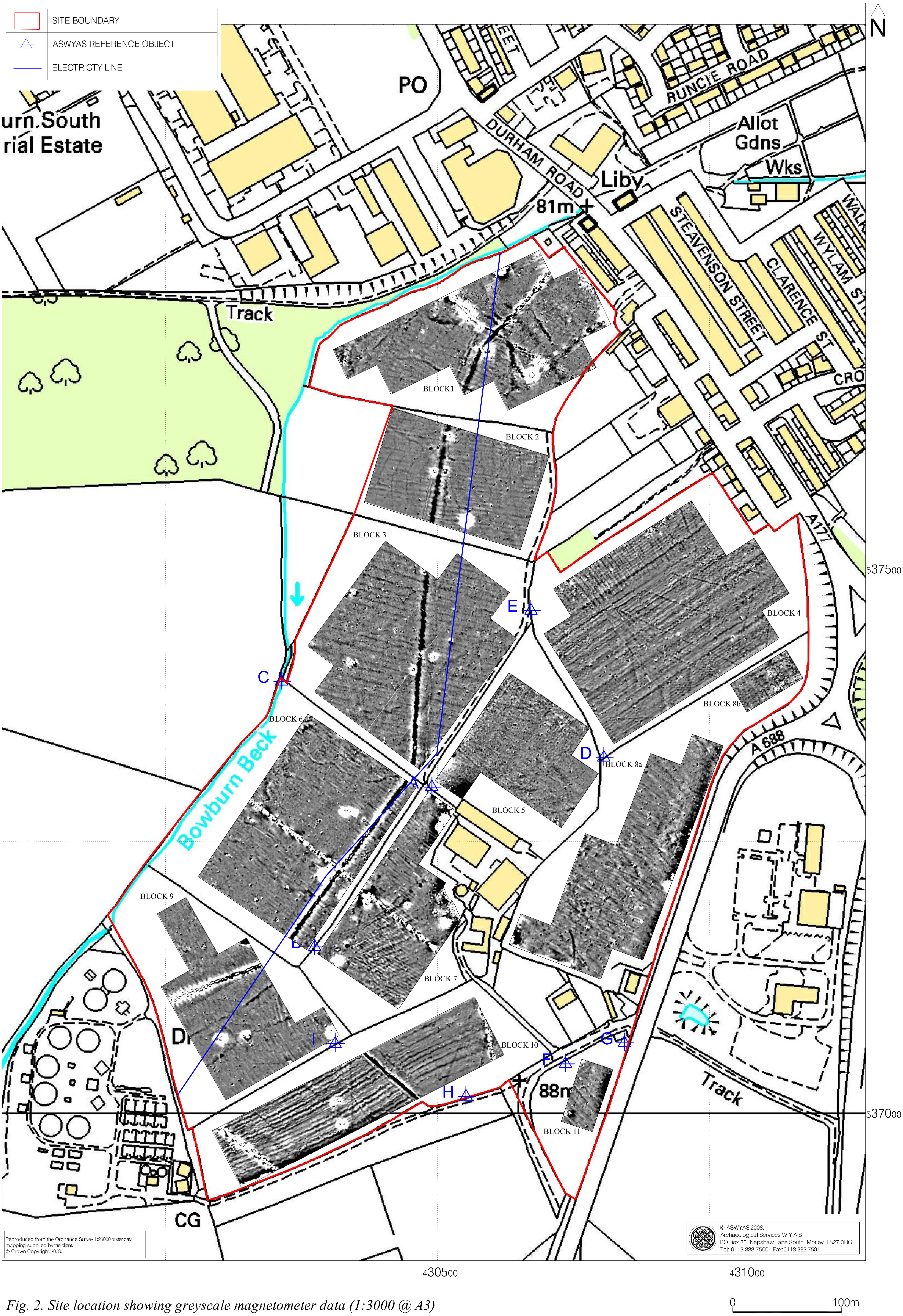

Fig. 2. Site location showing greyscale magnetometer data (1:3000 @ A3)

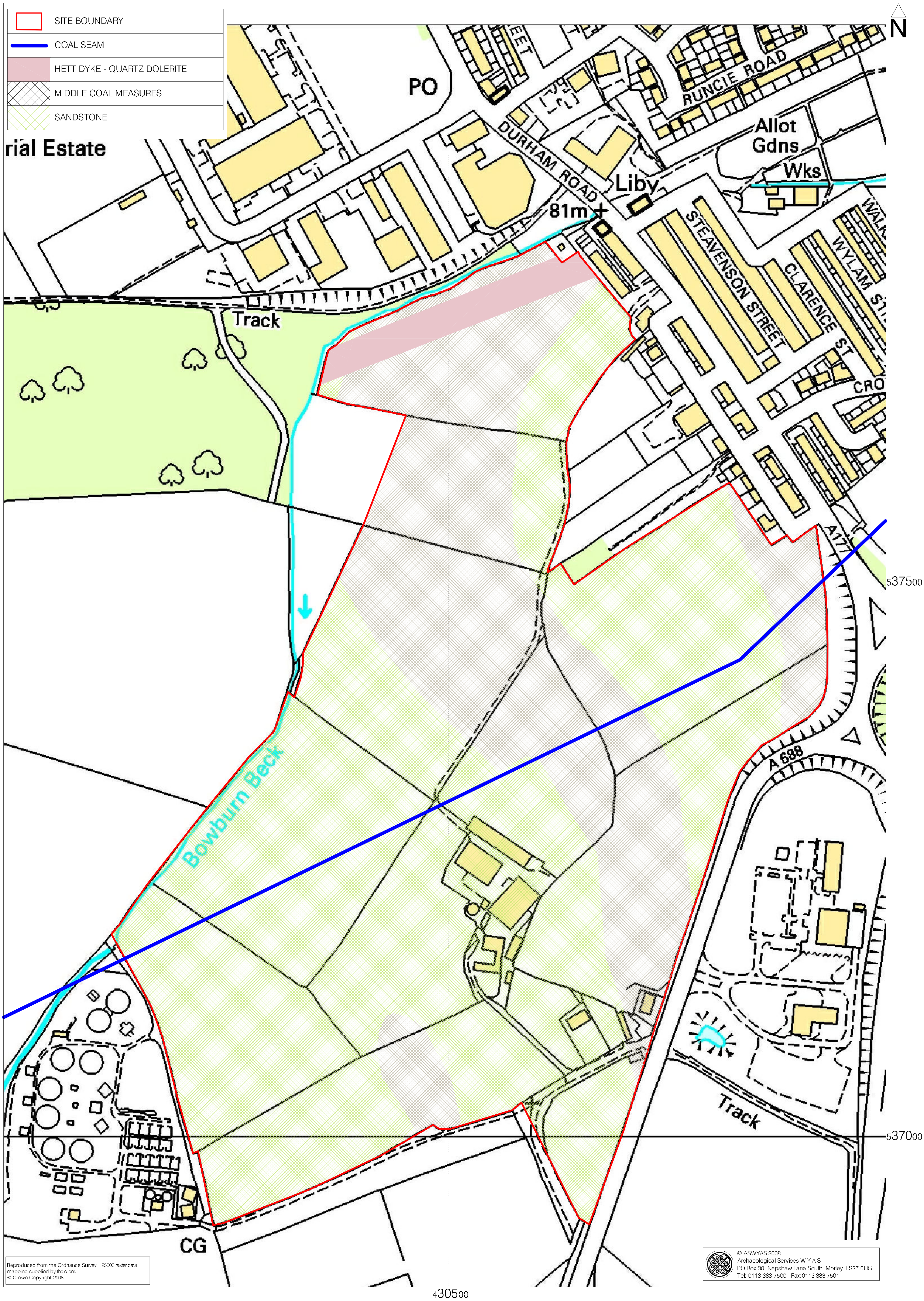

Fig. 3. Site location showing geological data (1:3000 @ A3)

0 100m

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

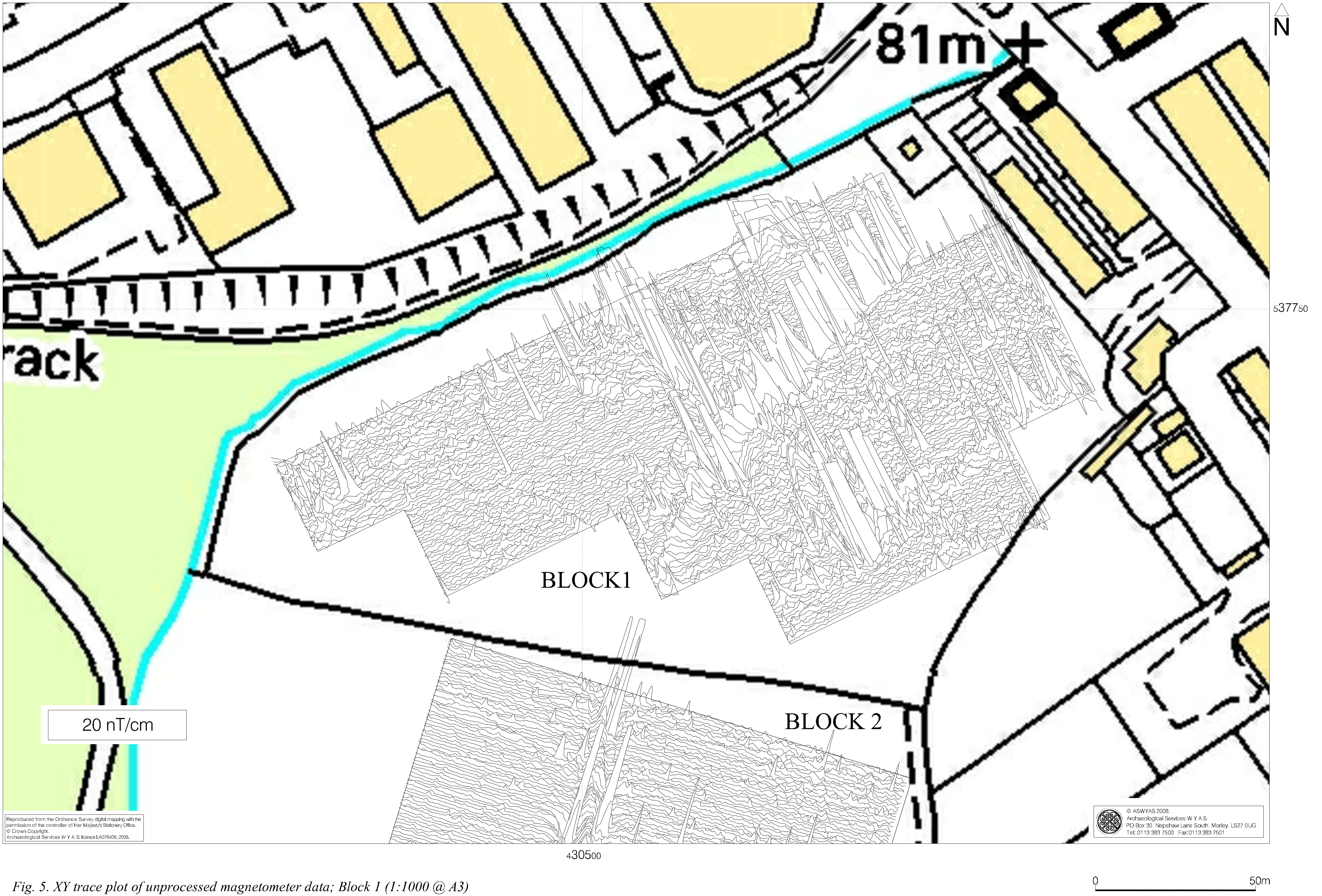

Fig. 5. XY trace plot of unprocessed magnetometer data; Block 1 (1:1000 @ A3)

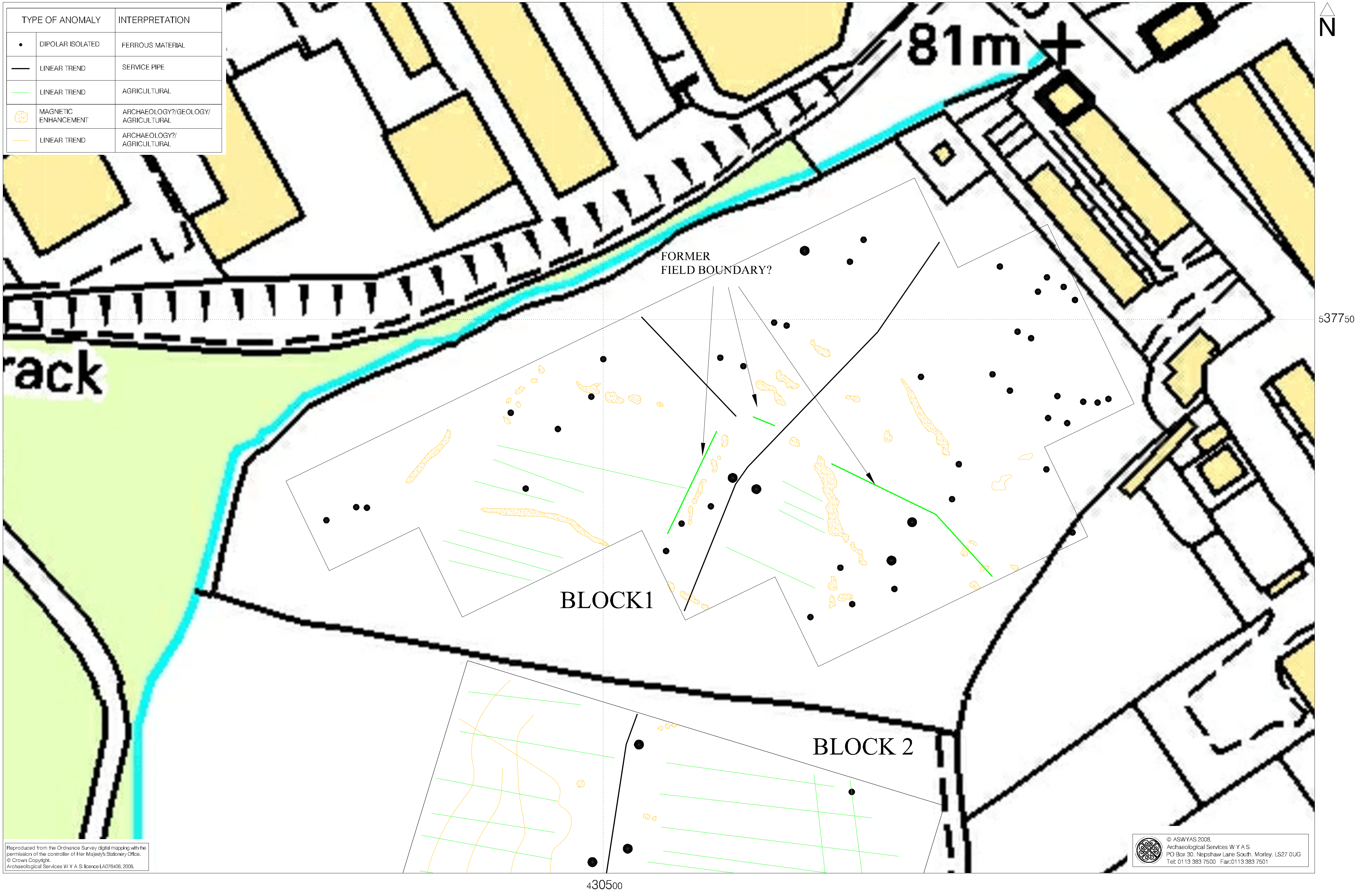

Fig. 6. Interpretation of magnetometer data; Block 1 (1:1000 @ A3)

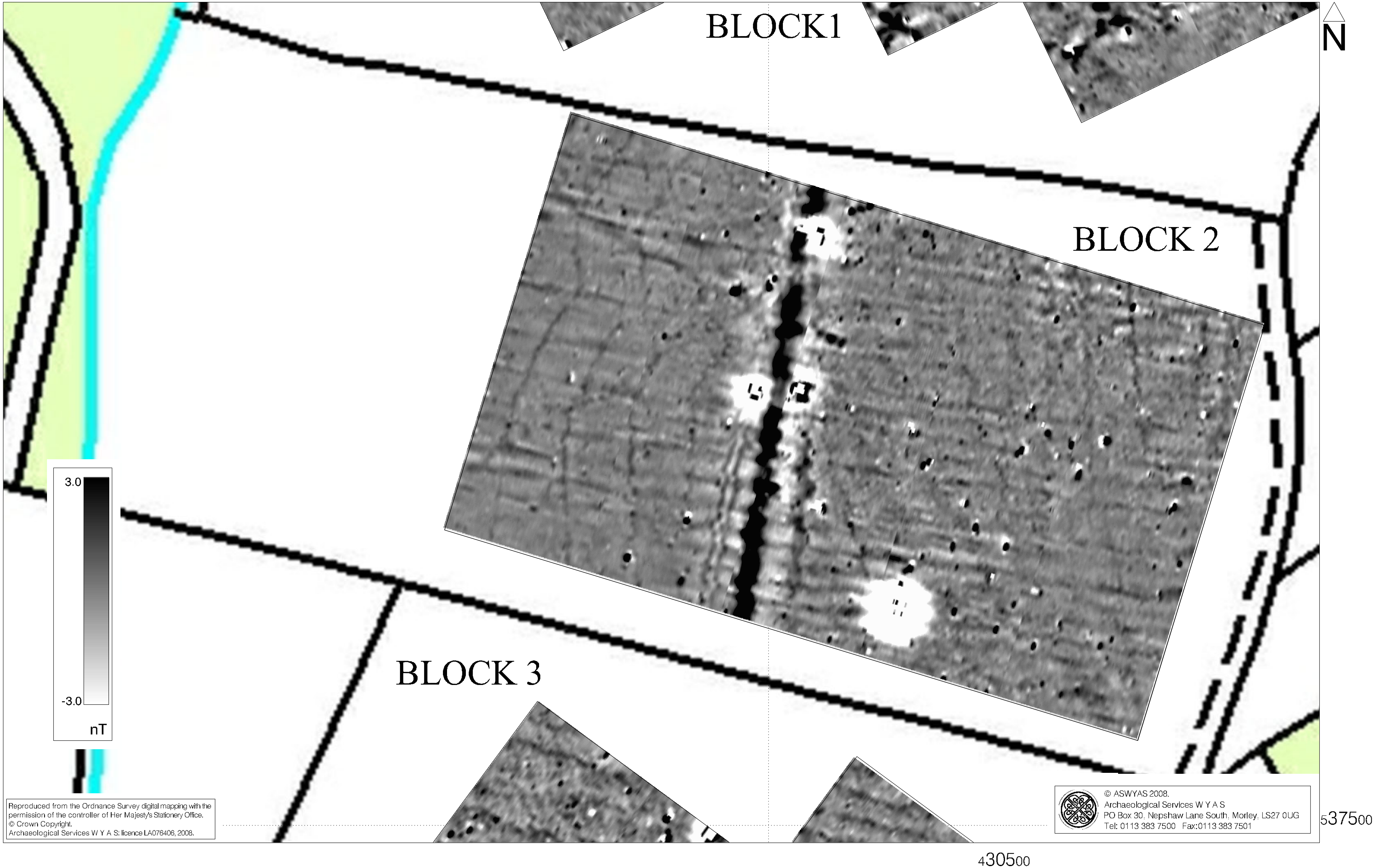

Fig. 7. Processed greyscale magnetometer data; Block 2 (1:1000 @ A4)

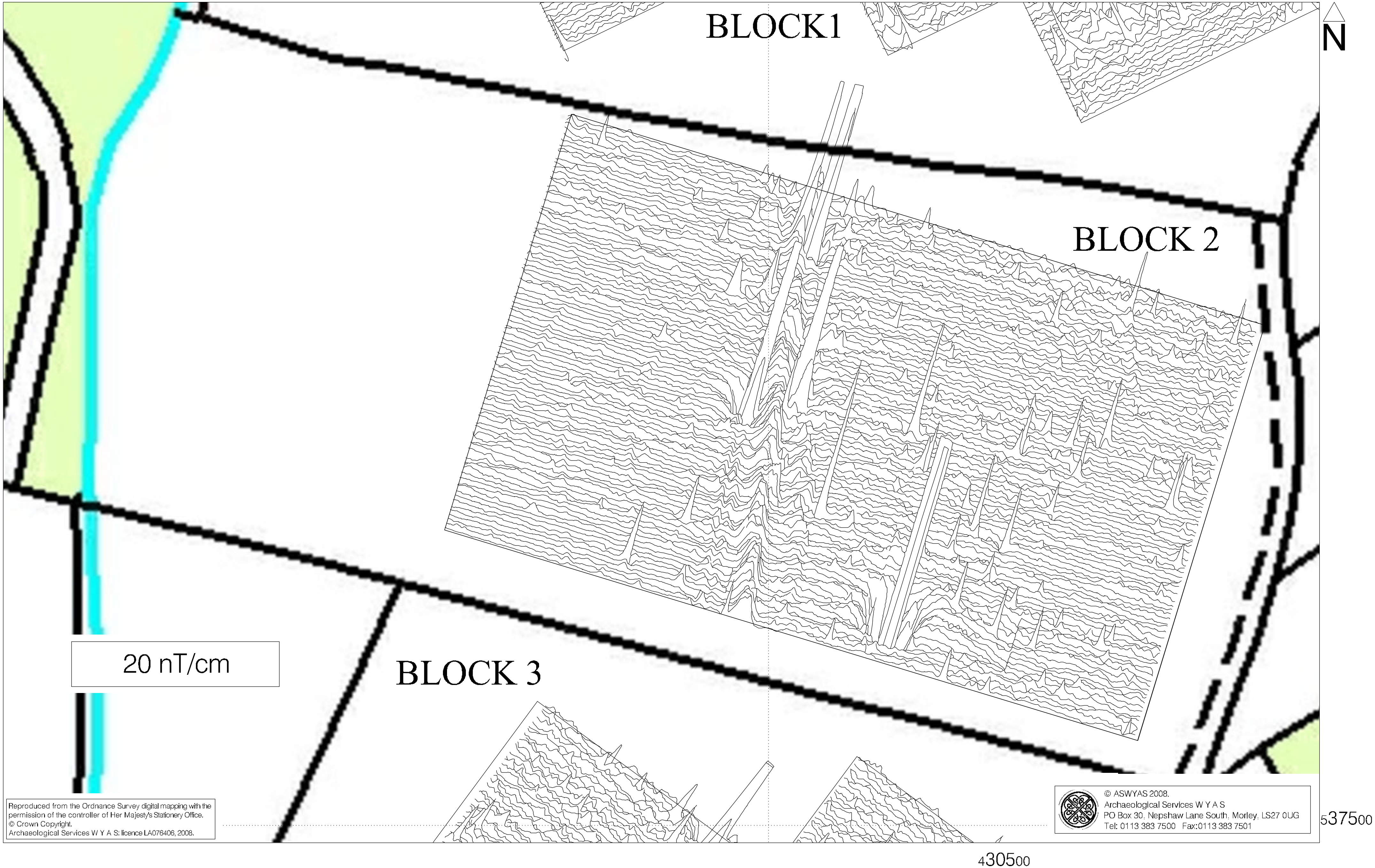

Fig. 8. XY trace plot of unprocessed magnetometer data; Block 2 (1:1000 @ A3)

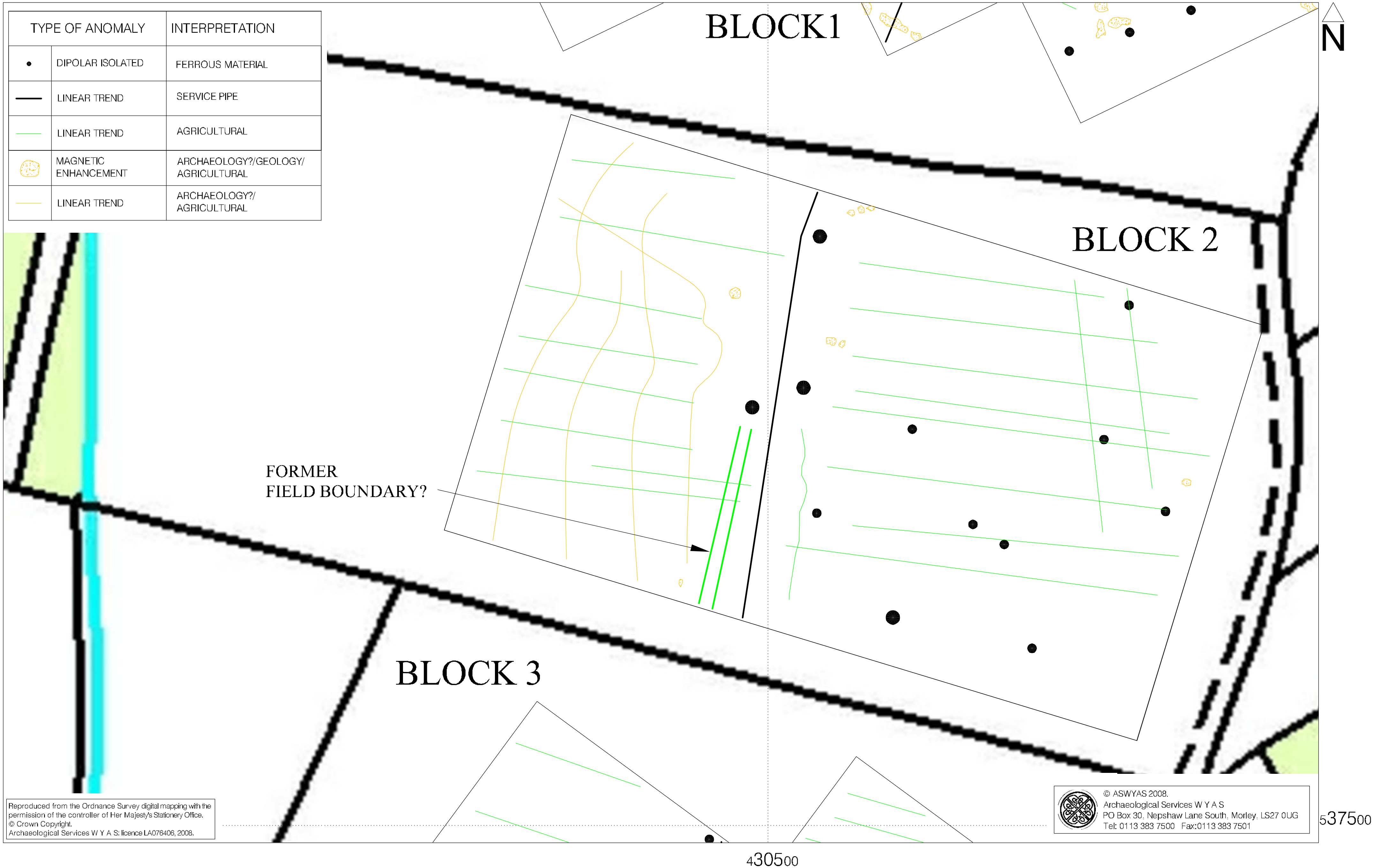

Fig. 9. Interpretation of magnetometer data; Block 2 (1:1000 @ A3)

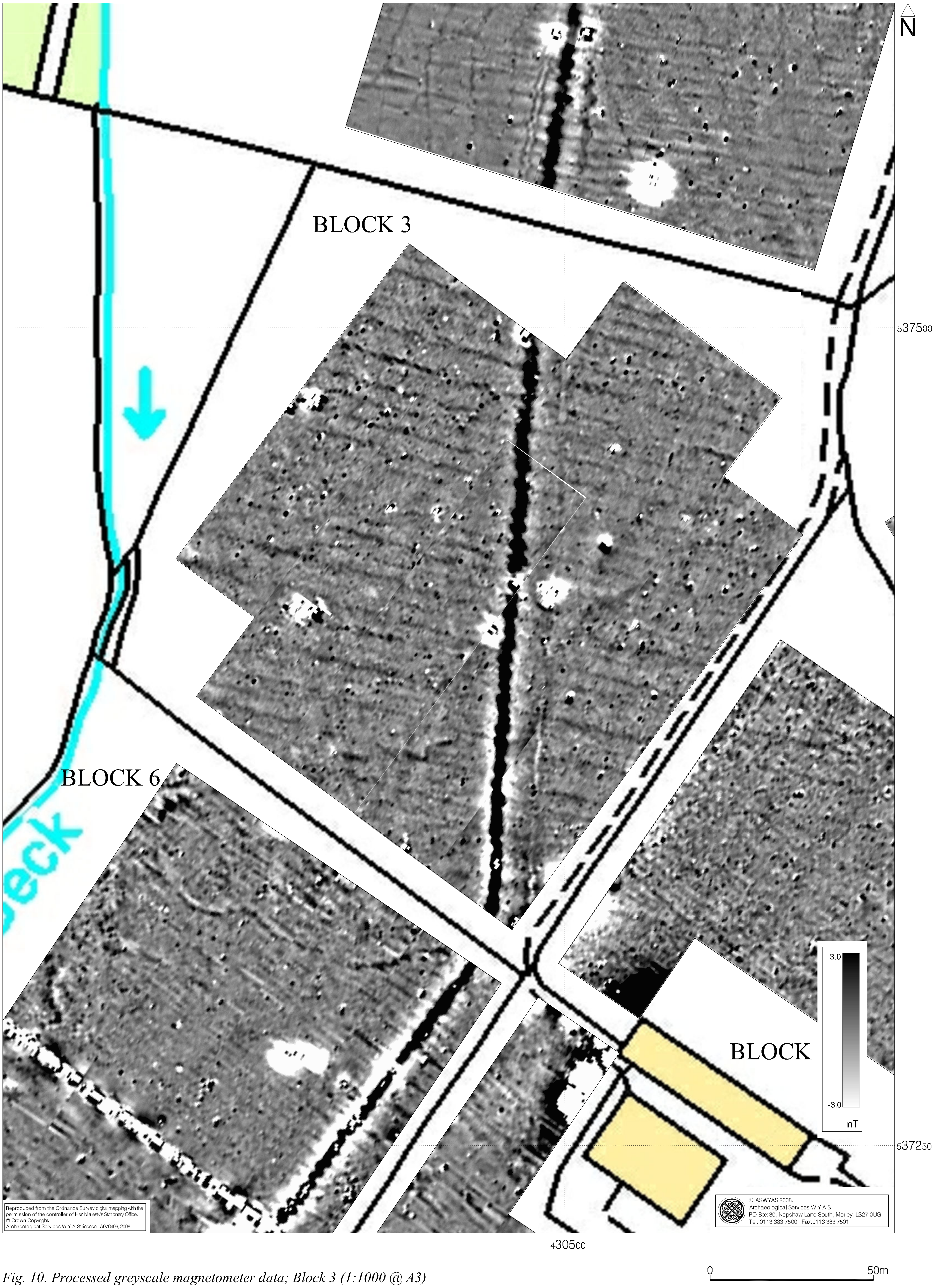

Fig. 10. Processed greyscale magnetometer data; Block 3 (1:1000 @ A3)

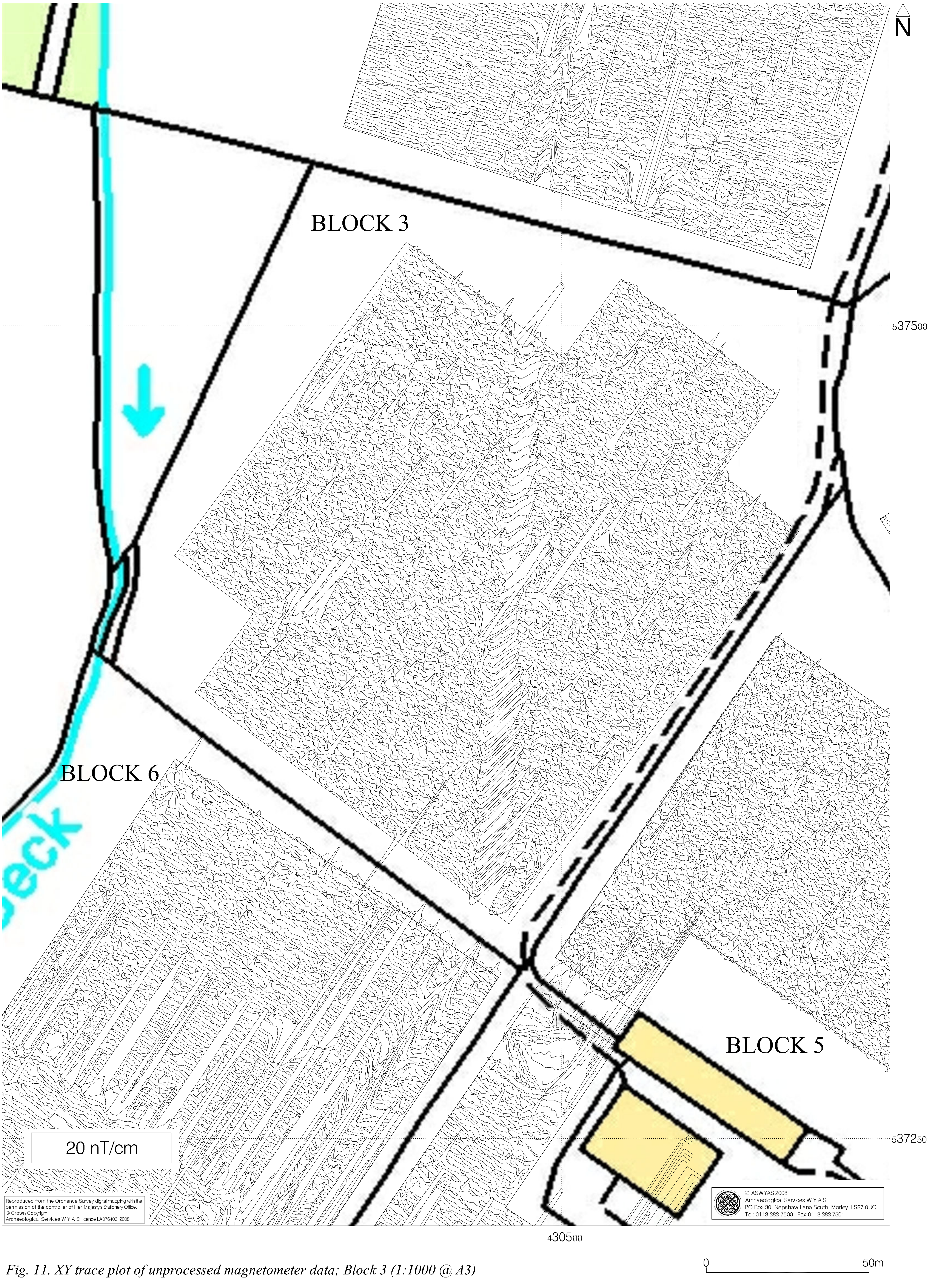

Fig. 11. XY trace plot of unprocessed magnetometer data; Block 3 (1:1000 @ A3)

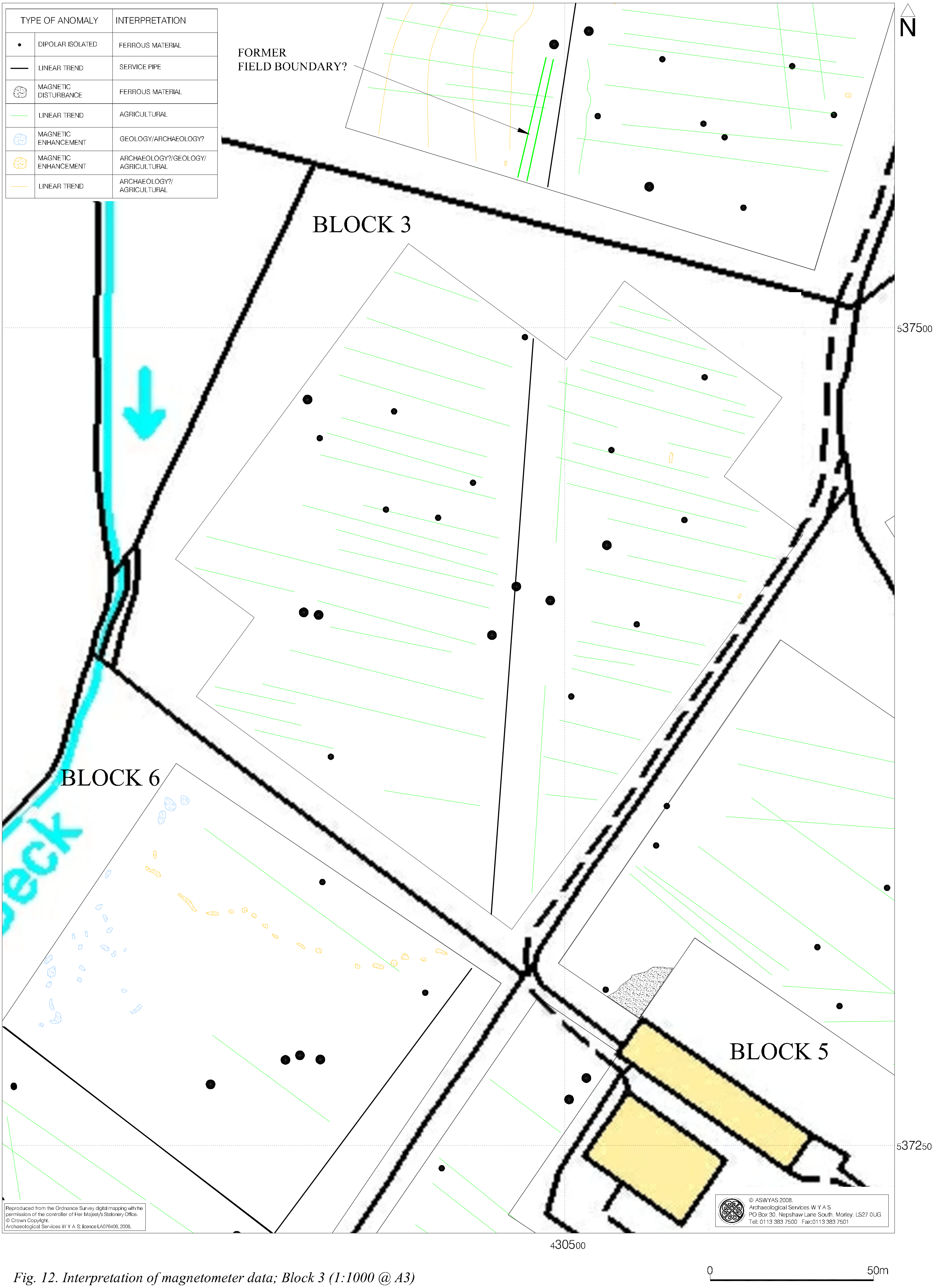

Fig. 12. Interpretation of magnetometer data; Block 3 (1:1000 @ A3)

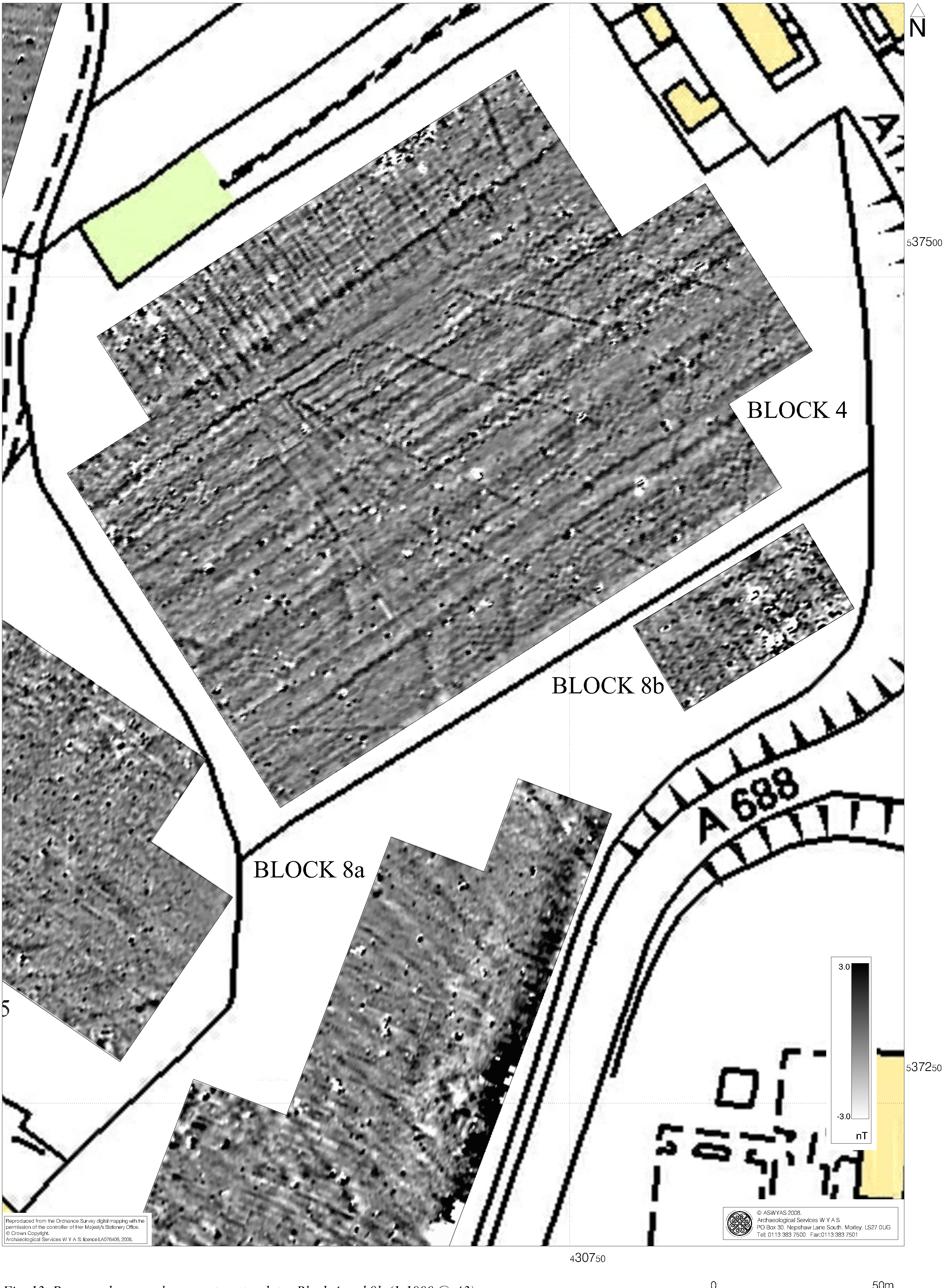

Fig. 13. Processed greyscale magnetometer data; Block 4 and 8b (1:1000 @ A3)

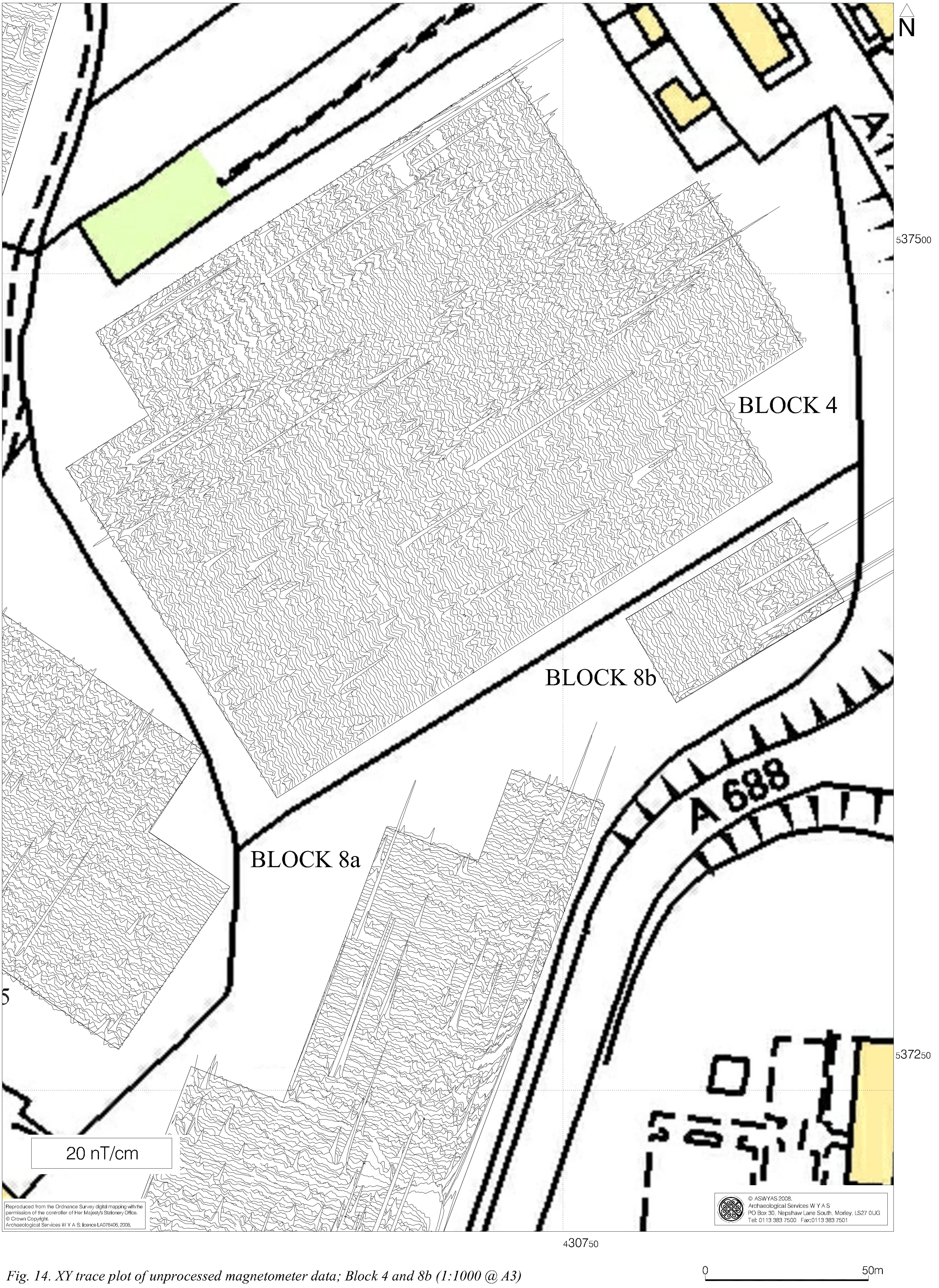

Fig. 14. XY trace plot of unprocessed magnetometer data; Block 4 and 8b (1:1000 @ A3)

Fig. 15. Interpretation of magnetometer data; Block 4 and 8b (1:1000 @ A3)

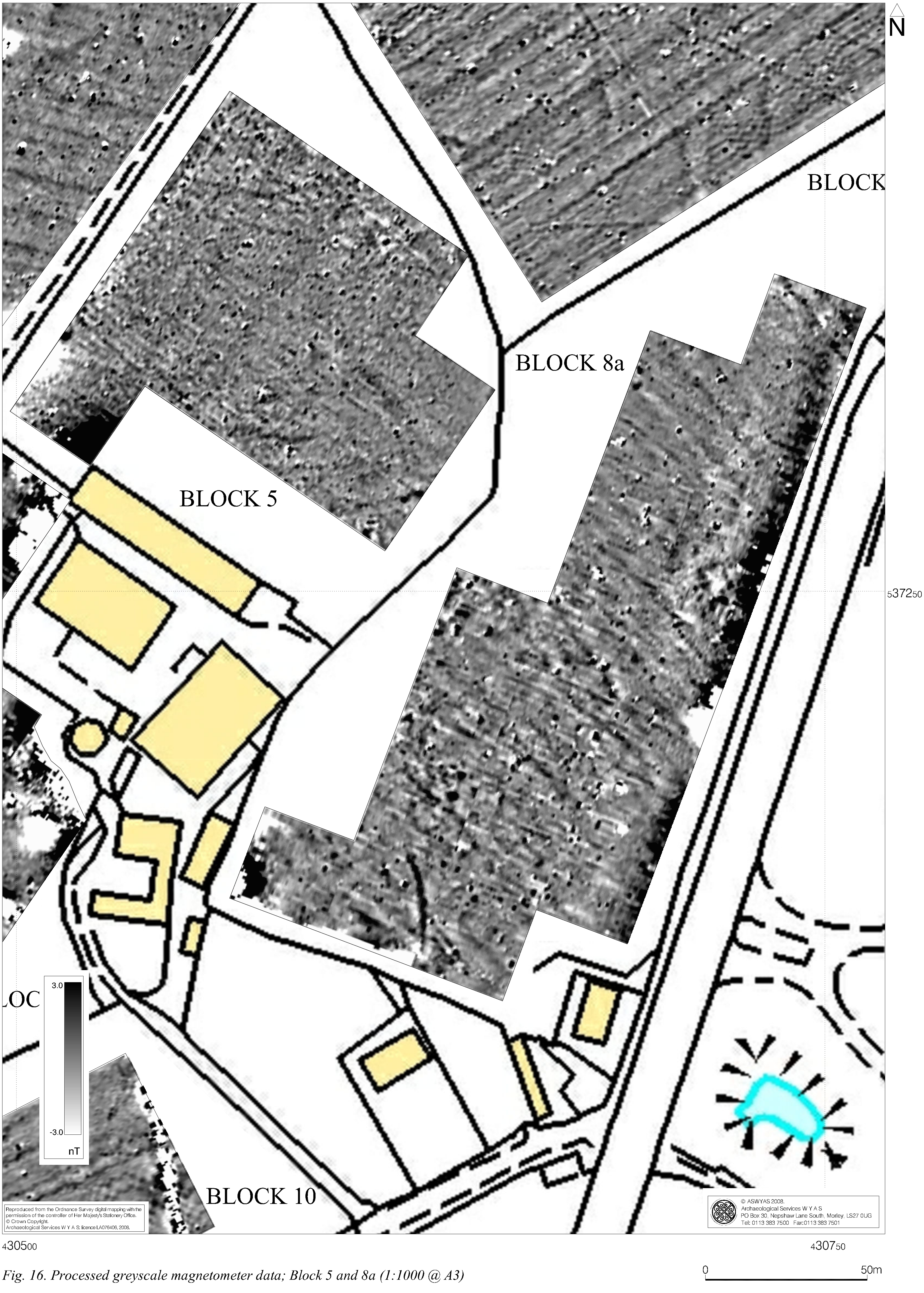

Fig. 16. Processed greyscale magnetometer data; Block 5 and 8a (1:1000 @ A3)

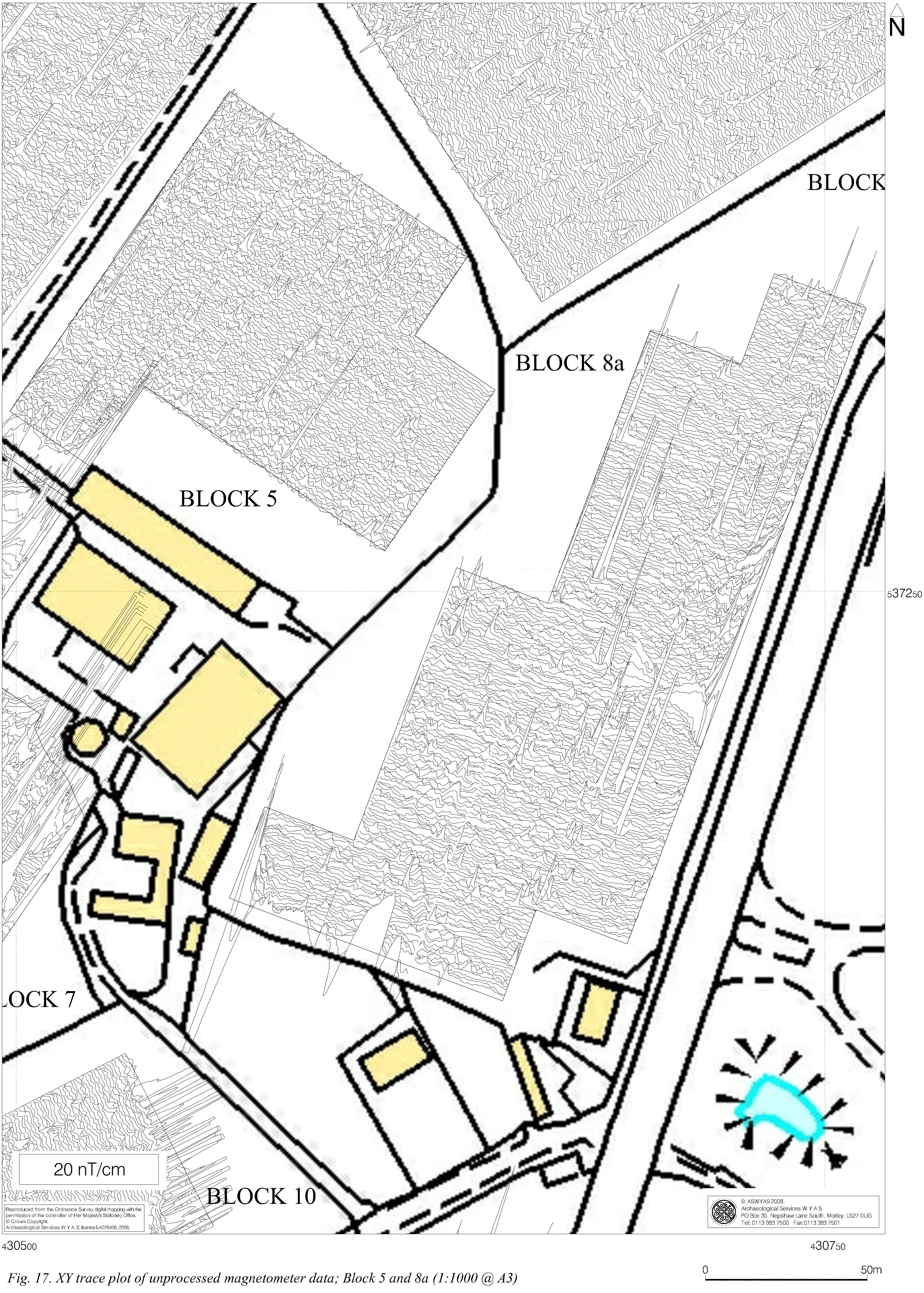

Fig. 17. XY trace plot of unprocessed magnetometer data; Block 5 and 8a (1:1000 @ A3)

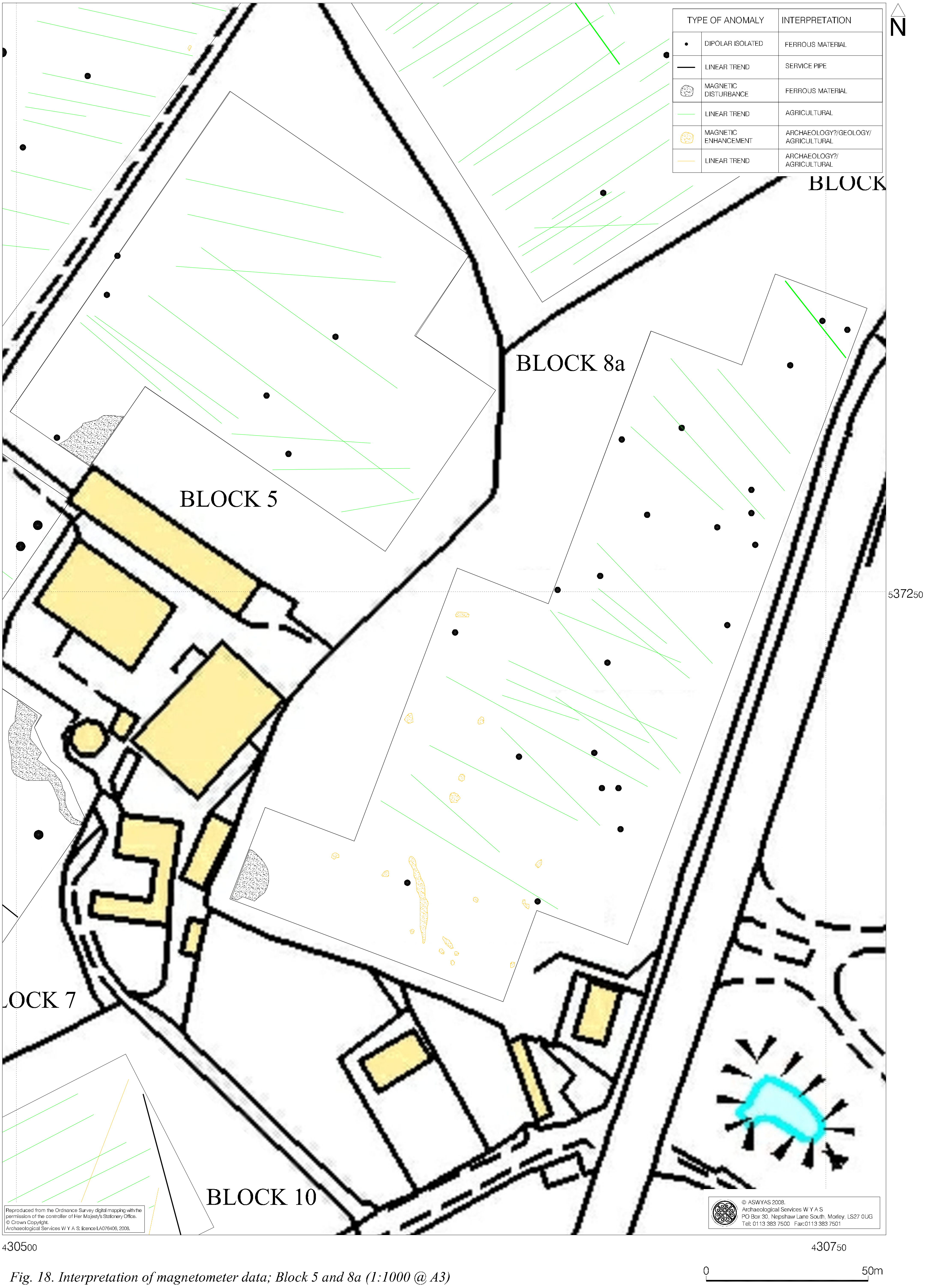

Fig. 18. Interpretation of magnetometer data; Block 5 and 8a (1:1000 @ A3)

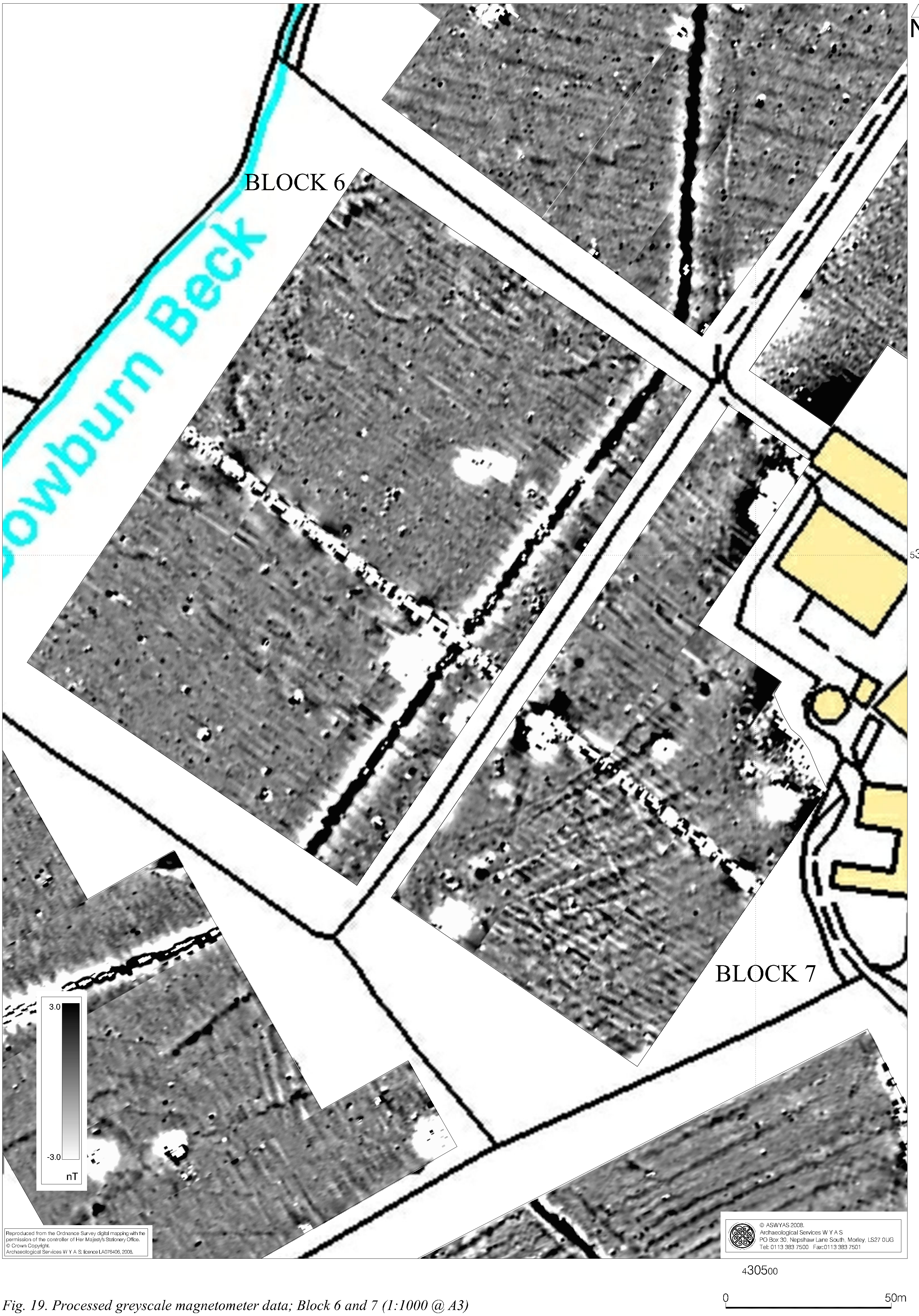

Fig. 19. Processed greyscale magnetometer data; Block 6 and 7 (1:1000 @ A3)

Fig. 20. XY trace plot of unprocessed magnetometer data; Block 6 and 7 (1:1000 @ A3)

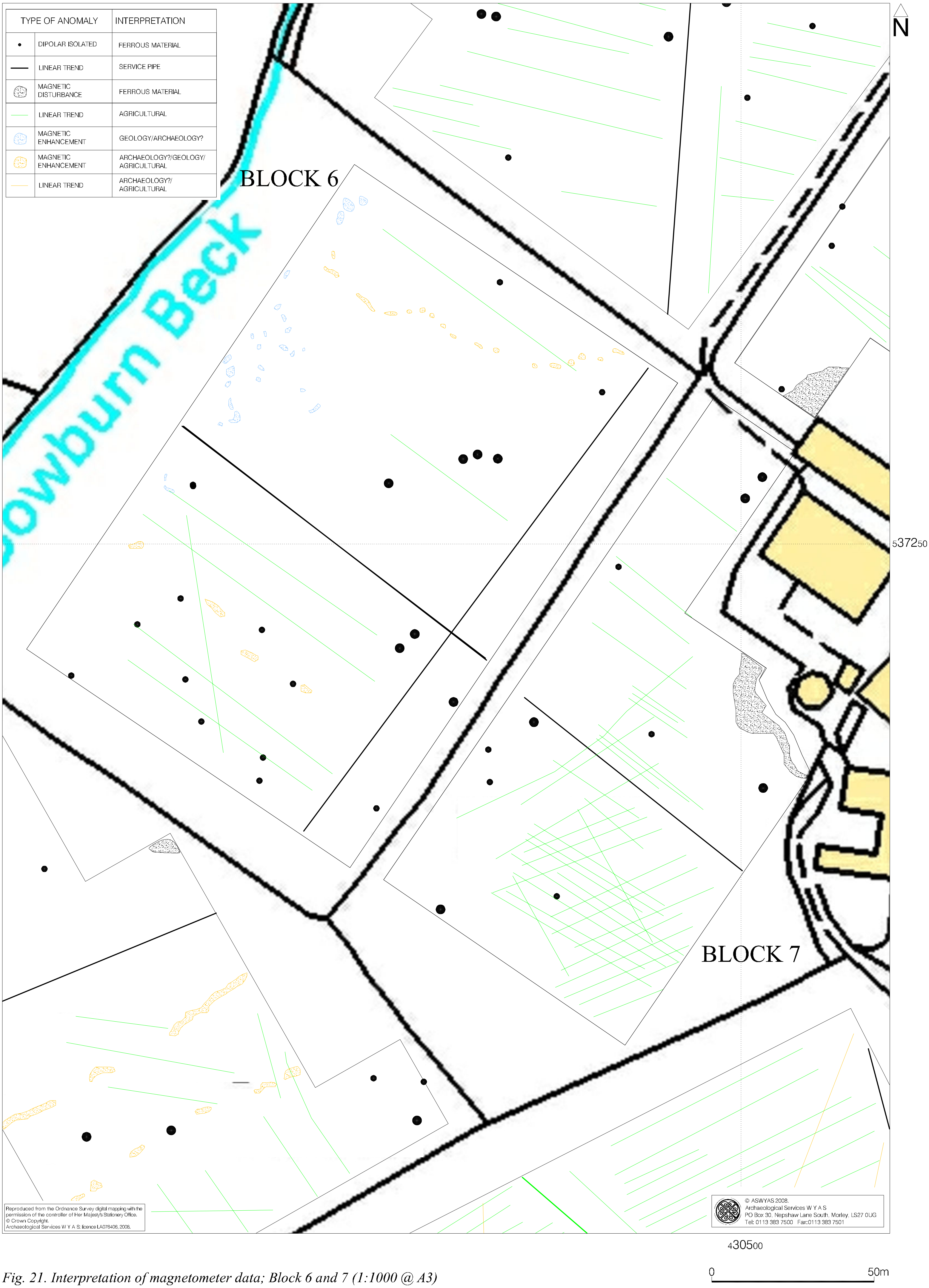

Fig. 21. Interpretation of magnetometer data; Block 6 and 7 (1:1000 @ A3)

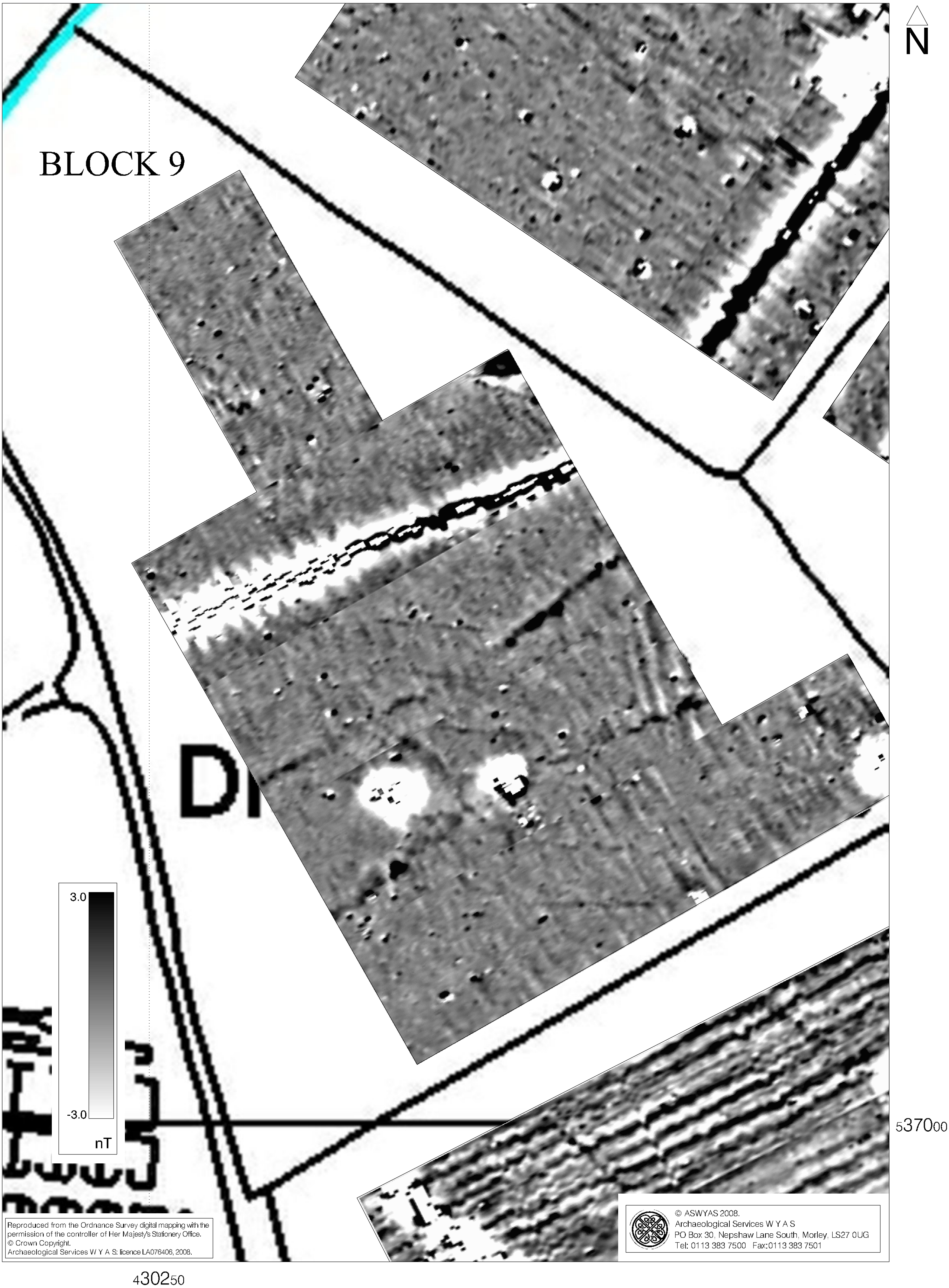

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Fig. 22. Processed greyscale magnetometer data; Block 9 (1:1000 @ A4)

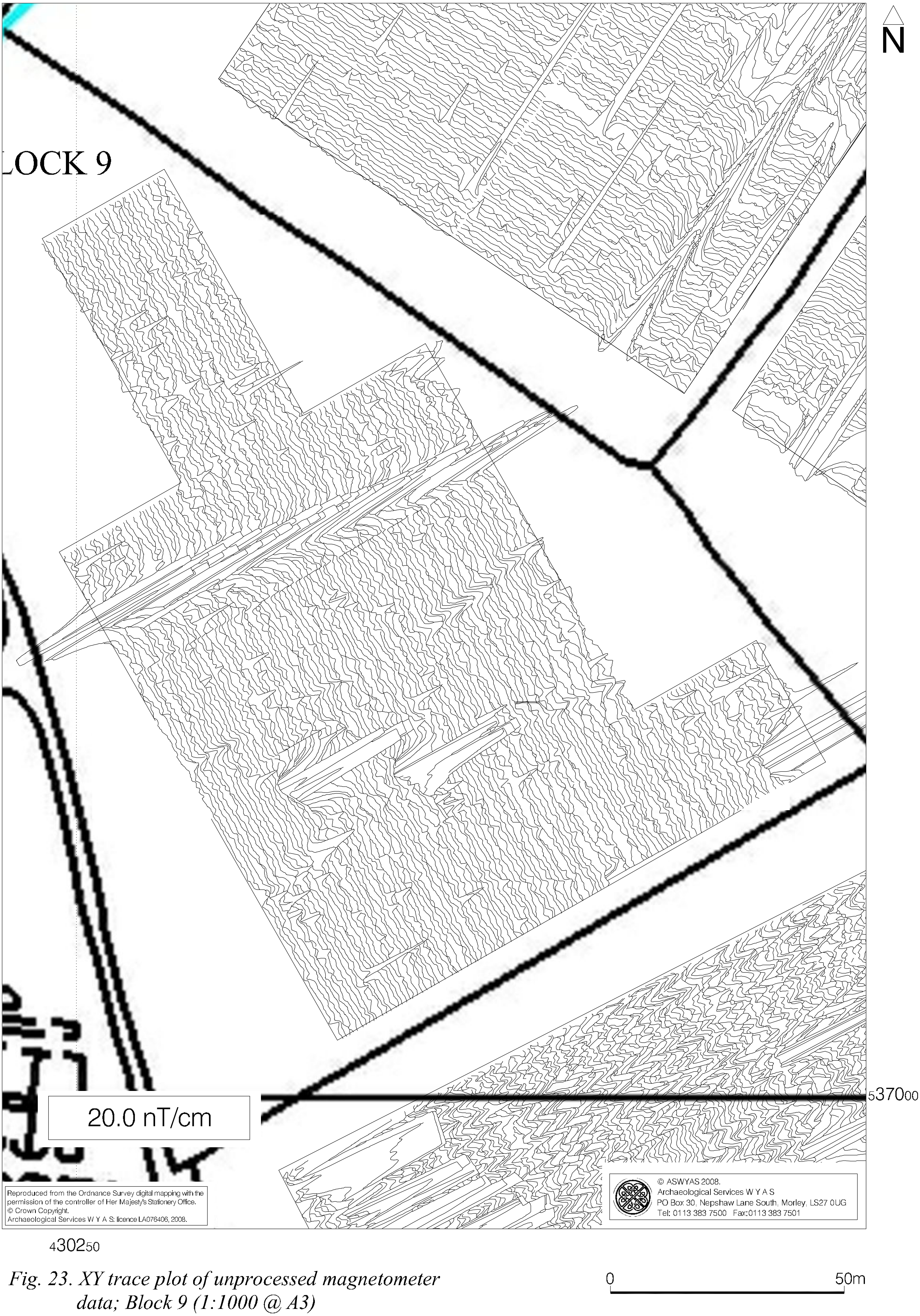

Fig. 23. XY trace plot of unprocessed magnetometer data; Block 9 (1:1000 @ A3)

Fig. 24. Interpretation of magnetometer data; Block 9 (1:1000 @ A3)

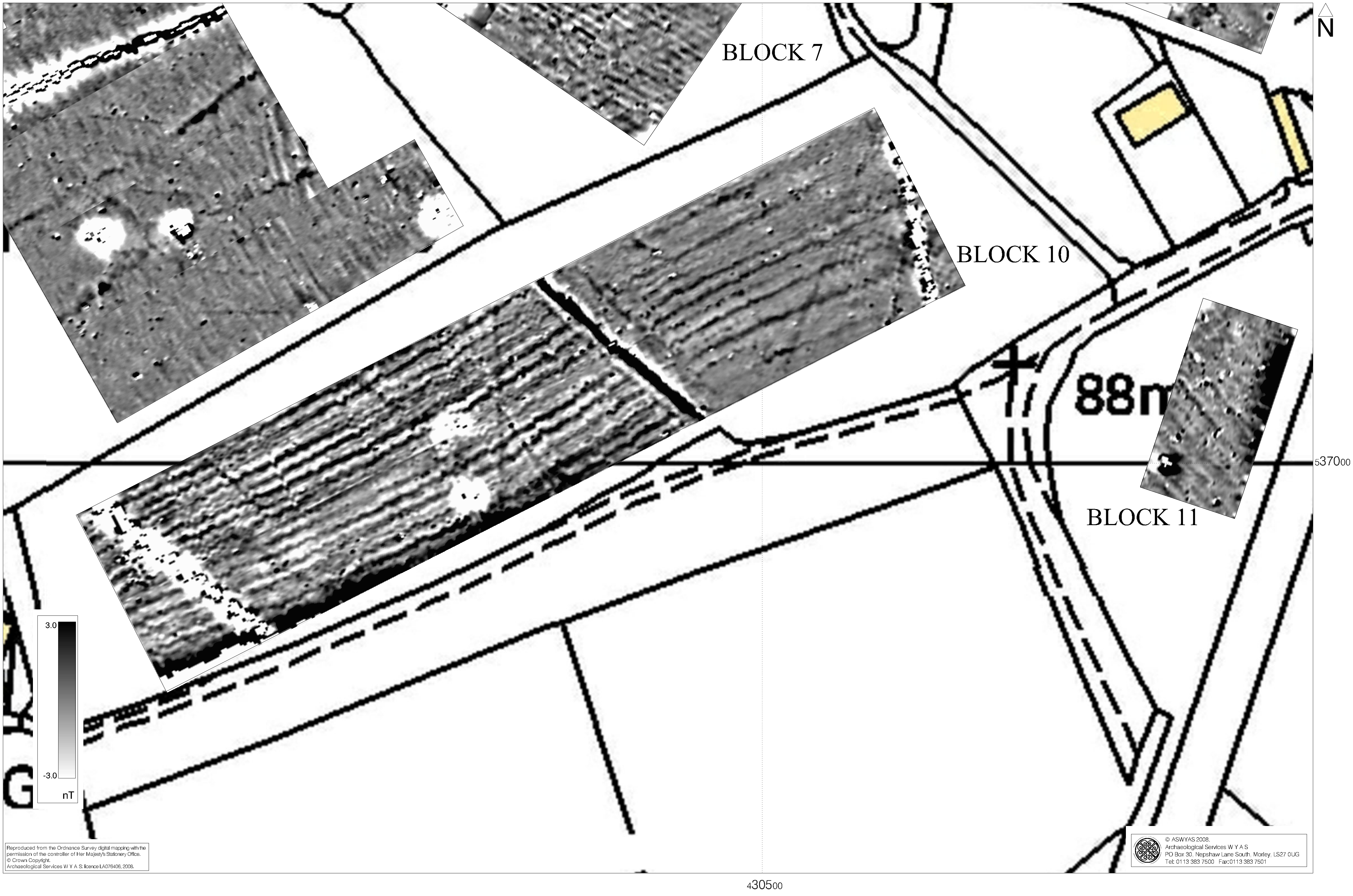

Fig. 25. Processed greyscale magnetometer data; Block 10 and 11 (1:1000@ A3)

Fig. 26. XY trace plot of unprocessed magnetometer data; Block 10 (1:1000 @ A3)

Fig. 27. Interpretation of magnetometer data; Block 10 and 11(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. Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

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. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geological substrates.

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. An agricultural origin, either ploughing or land drains is 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. 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 Geodimeter 600s total station theodolite and tied in to the corners of buildings and other permanent landscape features and to temporary reference points (survey marker stakes) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points are shown on Figure 2 and the Ordnance Survey grid co-ordinates tabulated below. The internal accuracy of the survey grid relative to these markers is better than 0.05m. The survey grids were then superimposed onto a map base provided by the client as a 'best fit' to produce the displayed block locations. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.5m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes.

Station	**Easting**	**Northing**
A	430495.0916	537299.7959
B	430387.4330	537153.0518
C	430356.8161	537396.7090
D	430653.1098	537326.8248
E	430586.2229	537461.8882
F	430617.9418	537045.5198
G	430671.9310	537064.7834
H	430526.4836	537015.6608
I	430406.3092	537064.2250

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

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 2007) 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).

Appendix 4: OASIS form

Bibliography

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Soil Survey of England and Wales. 1983, 'Soils of Northern England. (Sheet 1) Scale 1:250,000 (map and legend)'

White Young Green, 2008. *Cultural Heritage Desk Based Assessment. Durham Green Business Park, Bowburn, County Durham*. White Young Green Report