ARCHAEOLOGICAL
SERVICES
WYAS

Ripon Quarry Southern Extension
Area of Proposed Soil Storage
North Yorkshire

Geophysical Survey

August 2011

Report No. 2240

CLIENT
Hanson Aggregates

Ripon Quarry Southern Extension
Area of Proposed Soil Storage
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 8 hectares, was carried out in a field to the south of Ripon Quarry, an area on which it is proposed to store topsoil which will be removed as part of the southern expansion of the quarry workings. The location of a square enclosure of presumed late Iron Age or Romano-British date has been identified confirming the cropmark evidence. A possible pit alignment and other linear and discrete anomalies also suggest archaeological activity in the eastern half of the survey area which is assessed as having a locally high archaeological potential. In the western half of the survey area only anomalies due to ploughing, former field boundaries and geological variation have been noted. This part of the site is assessed as having a low archaeological potential.

ARCHAEOLOGICAL
SERVICES
WYAS

Report Information

Client:	Hanson Aggregates
Address:	Clifford House, York Road, Wetherby, LS22 7NS
Report Type:	Geophysical survey
Location:	Ripon Quarry
County:	North Yorkshire
Grid Reference:	SE 298 764
Period(s) of activity: represented	Iron Age/Romano-British?
Report Number:	2240
Project Number:	3753
Site Code:	RIQ11
Planning Application No.:	Pre-determination (Outline)
Museum Accession No.:	n/a
Date of fieldwork:	July 2011
Date of report:	August 2011
Project Management:	Alistair Webb BA MIfA
Fieldwork:	David Harrison BSc MA
	Alex Harrison BSc
Report:	Alistair Webb
Illustrations:	Sam Harrison BSc MSc AIfA
Photography:	David Harrison
Research:	n/a

Authorisation for distribution: --

ISOQAR QUALITY ASSURED ISO 9001 Cert. No. 125

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

REGISTERED IfA ORGANISATION

Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Andrew Josephs Ltd on behalf of their client Hanson Aggregates to carry out a geophysical (magnetometer) survey as part of pre-determination work at Ripon Quarry, near North Stainley (see Fig. 1). The results of the survey (and subsequent trial trenching) will help assess the extent of the archaeological resource and thereby inform the location of soil and overburden storage. This material will be generated by the Phase 3 soil strip, part of the proposed southern extension to the quarry. An Environmental Impact Assessment (EIA) has already been produced for the extension scheme, however, the current area of interest was not initially considered within the EIA, and has been added as a result of the EIA process and design requirements. The scheme of work was undertaken in accordance with the requirements of Planning Policy Statement 5. The survey was undertaken between July 26th to July 28th 2011.

Site location, topography and land-use

The new evaluation area, centred at SE 298 764, comprised a single, triangular-shaped, field of about 9 hectares which is currently under arable cultivation. The field is located approximately 0.8km south of the main quarry facility which is 4km north of Ripon (see Fig. 1) on the river Ure. Topographically the site overlooks the floodplain of the Ure on higher ground gently rising from between 37m aOD on the eastern side of the field to 40m aOD in the west (see Fig. 2). The floodplain below is separated from the site by a steep river bluff, and lies at about 28m aOD. The survey area had recently been harvested of a cereal crop (see Plates 1 and 2) although a strip of maize along part of the western edge of the field (see Plate 3) slightly reduced the overall survey area.

Geology and soils

The underlying bedrock comprises of the Edlington Formation – Calcareous mudstone which is overlain by till (BGS 1992). The soils in this area are classified in the Nercwys soil association, characterised as deep fine loams with slow permeable sub-soils affected by seasonal waterlogging (SSEW 1983).

2 Archaeological background

A scoping report, undertaken on behalf of Hanson by Andrew Josephs Ltd. as part of the southern extension EIA, noted that the extension area lies in the valley of the river Ure, a rich prehistoric landscape, containing prehistoric monuments of national importance, with scheduled henges at Thornborough to the north and Nunwick and Hutton Moor to the south. A pit alignment (MNY13755) lies 100m north of the existing plant site, with a round barrow (MNY24218) a further 300m north-west. An unusual Roman villa with associated defences, Castle Dykes (HER MNY21030), lies 650m to the south-west of the survey area. A possible rectangular enclosure (MNY19916) and other cropmarks have been recorded within the proposed survey area by the National Mapping Programme (see Fig. 3).

Nevertheless, it was noted that the proposed extension area had only a moderate to low archaeological potential due primarily to the fact that the land is low lying adjacent to the river and therefore likely to have been periodically flooded from the prehistoric period until post-medieval times.

A comprehensive geophysical evaluation, covering the proposed southern extension area (ASWYAS 2009), did not identify any anomalies of archaeological potential, although anomalies due to ploughing, drainage features and palaeochannels were identified. A programme of trial trenching subsequently confirmed the low potential of the southern extension area as suggested by the scoping report and geophysical survey.

However, the new evaluation area is on much higher ground thereby increasing the likelihood of archaeological activity. This increased potential is reflected by the presence of a square cropmark, interpreted as a probable enclosure of late Iron Age or Romano-British date, located towards the eastern edge of the proposed soil bund storage areas, with other linear cropmark features noted towards the centre and western sides of the same field (see Fig. 3).

3 Aims, Methodology and Presentation

The ultimate aim of the evaluation (including the trial trenching) is to enable a decision to be made finalising the location of the soil bunds in areas which will minimise the impact on the archaeological resource.

To achieve this aim the first stage of the evaluation comprised a magnetometer survey to cover the whole of the field where it is proposed to store the soil, an area of approximately 9 hectares; the actual land-take for the soil storage is only approximately 3 hectares.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

Bartington Grad601 magnetic gradiometers were used during the survey taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the Ordnance Survey map, is shown in Figure 1. Figure 2 is a large scale (1:4000) site location plan showing the magnetometer data and southern extension area whilst Figure 3 shows the data, first edition mapping and cropmark detail at 1:2000. Figure 4 presents the overall interpretation of the data also at 1:2000. The data are presented in greyscale, XY trace plot and interpretation formats in Figures 5 to 10 inclusive, all at a scale of 1:1000.

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

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

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

The anomalies identified during the survey can be divided into four categories according to their interpreted origin.

Ferrous Anomalies

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

Agricultural Anomalies

Parallel, linear and curvilinear, trend anomalies can be seen across the whole of the survey area. The very regular, more closely spaced, anomalies aligned north/south, which can be seen predominantly across the central and eastern parts of the field, reflect the orientation of recent agricultural activity. Similarly the curving trends which can be seen around the edge of the field reflect the sinuous nature of the field boundary and the direction of the ploughing/seeding rows taken to maximise the crop yield in an irregularly shaped field.

In the western third of the field the predominant alignment of the trend anomalies is broadly west/east, at right angles to the western field boundary. These trend anomalies are interpreted as being caused by ridge and furrow cultivation. The anomalies are due to the magnetic contrast between the infilled furrows and the former ridges and their extent is defined by the former field boundaries described below.

Linear anomalies, **A**, **B** and **C**, at the western side of the field locate former boundaries that are shown on the first edition Ordnance Survey mapping (see Fig. 3). Interestingly another former boundary that extends across the entire width of the survey area does not, in the main, manifest as an anomaly.

Geological Anomalies

The survey has identified numerous discrete, low magnitude, anomalies (areas of magnetic enhancement) across the whole of the survey area which give the data a speckled appearance. These anomalies are interpreted as geological in origin being due to near-surface geological variation in the composition of the heterogeneous superficial till deposits.

Archaeological? Anomalies

Against this variable magnetic background several anomalies of archaeological potential have been identified. The most distinct is the square-shaped anomaly, **D**, close to the eastern side of the field. This anomaly correlates exactly with the cropmark identified during the National Mapping Programme and is caused by the infilled ditches of an enclosure, approximately $40m^2$. An entrance on the eastern side is clearly visible. Several discrete anomalies within the enclosure have also been identified which could be due to features such as pits or large post-holes, or to areas of burning.

Bisecting the enclosure is a discontinuous linear anomaly, **E**, which extends just over 100m from the northern field edge before turning through 90^{o} about 20m south of **Enclosure D**, and continuing out to the eastern edge of the field. Other discrete anomalies adjacent to this ditch feature are also interpreted as potentially archaeological.

Approximately 70m west of the enclosure a discontinuous, sinuous, anomaly, **F**, aligned north-west/south-east across the full width of the field, is identified. It is not clear whether this anomaly is due to plough damage of a ditch feature or whether it represents a pit alignment, similar to that identified during the evaluation of the northern extension area.

5 Discussion and Conclusions

The geophysical survey has identified several anomalies which have been interpreted as archaeological or potentially archaeological and there is a good correlation between the cropmark data and the magnetic data.

The archaeological activity is focused in the eastern half of the survey area in and around a square enclosure whose presence was already known, being identified as a cropmark on air photographs. It is not clear whether the L-shaped ditch type anomaly which bisects the enclosure and extends to the south and north of it is contemporary with the enclosure or whether it is an earlier or later landscape feature. Other discrete anomalies may hint at settlement activity in and around the enclosure but the number and type of geological anomalies that have also been identified makes a definitive interpretation difficult. A possible pit alignment to the west of the enclosure may mark the western limit of any archaeological activity within the survey area. This feature was also previously identified as a cropmark although the survey has demonstrated that it is more extensive than indicated by the cropmark evidence.

In the western half of the field only anomalies due to ploughing and to former field boundaries have been identified. Discrete anomalies due to geological variation are ubiquitous across the whole of the survey area.

On the basis of the geophysical survey the western half of the field is considered to have a low archaeological potential whereas to the east the potential is high, if localised.

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.

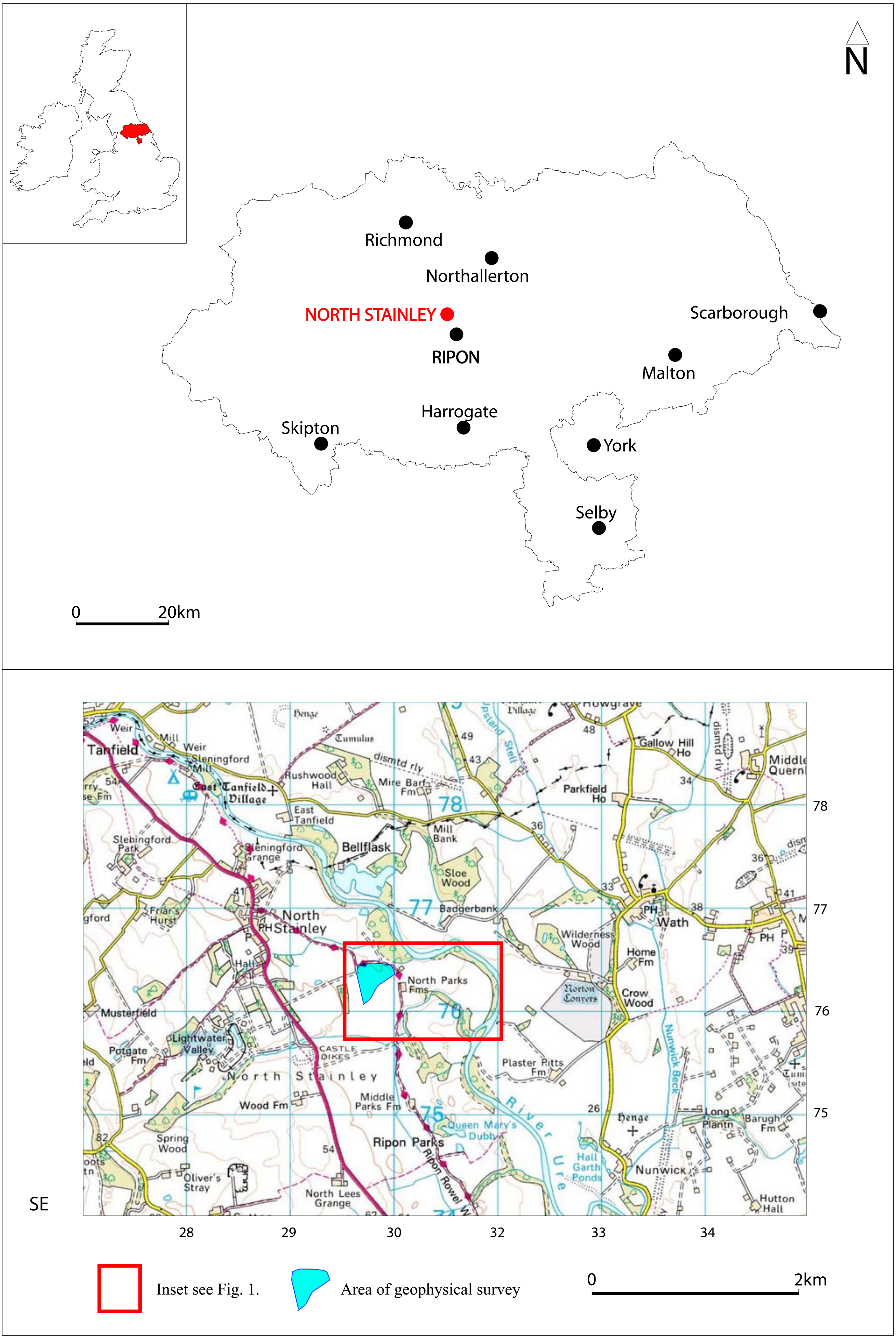


Fig. 1. Site location

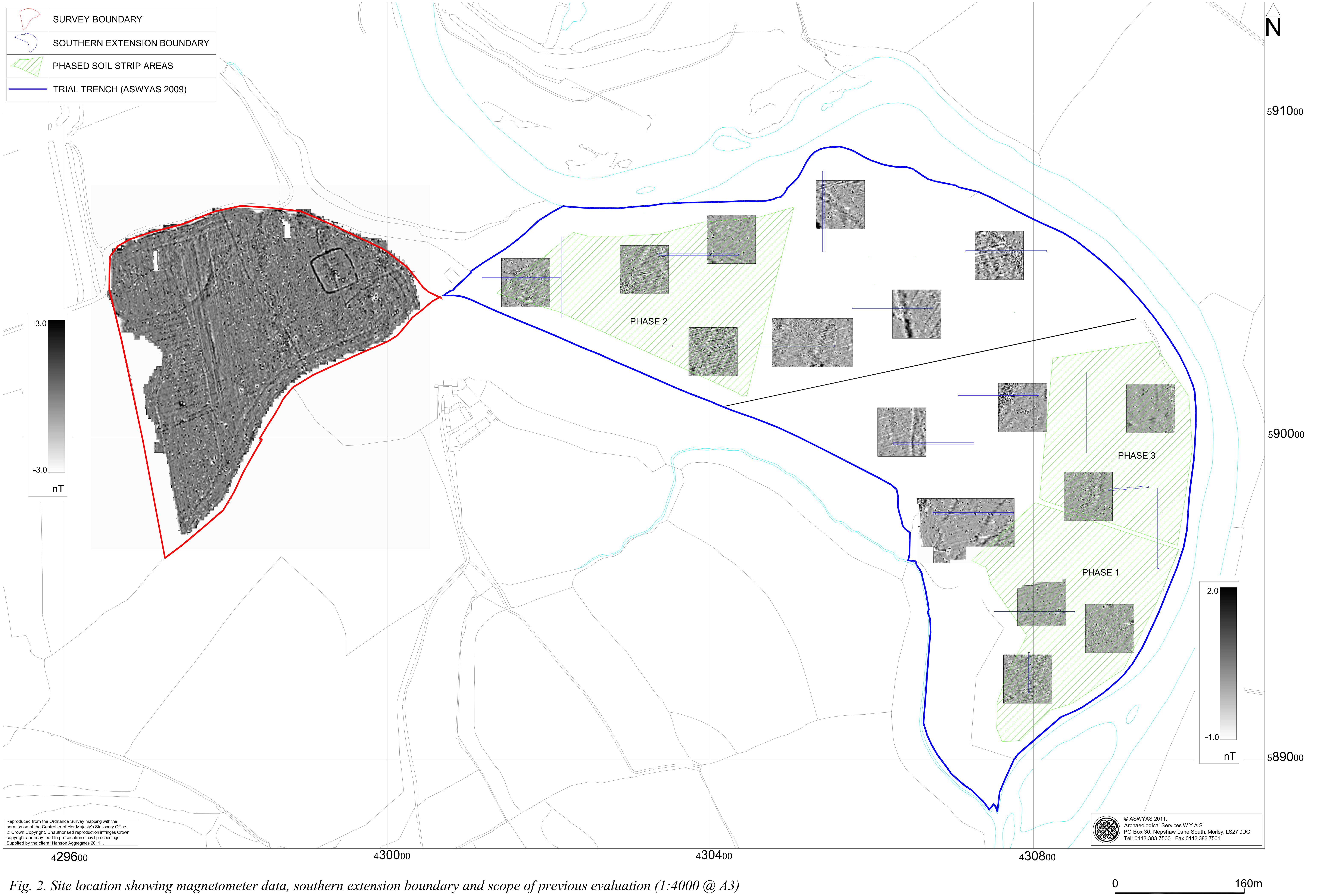


Fig. 2. Site location showing magnetometer data, southern extension boundary and scope of previous evaluation (1:4000 @ A3)

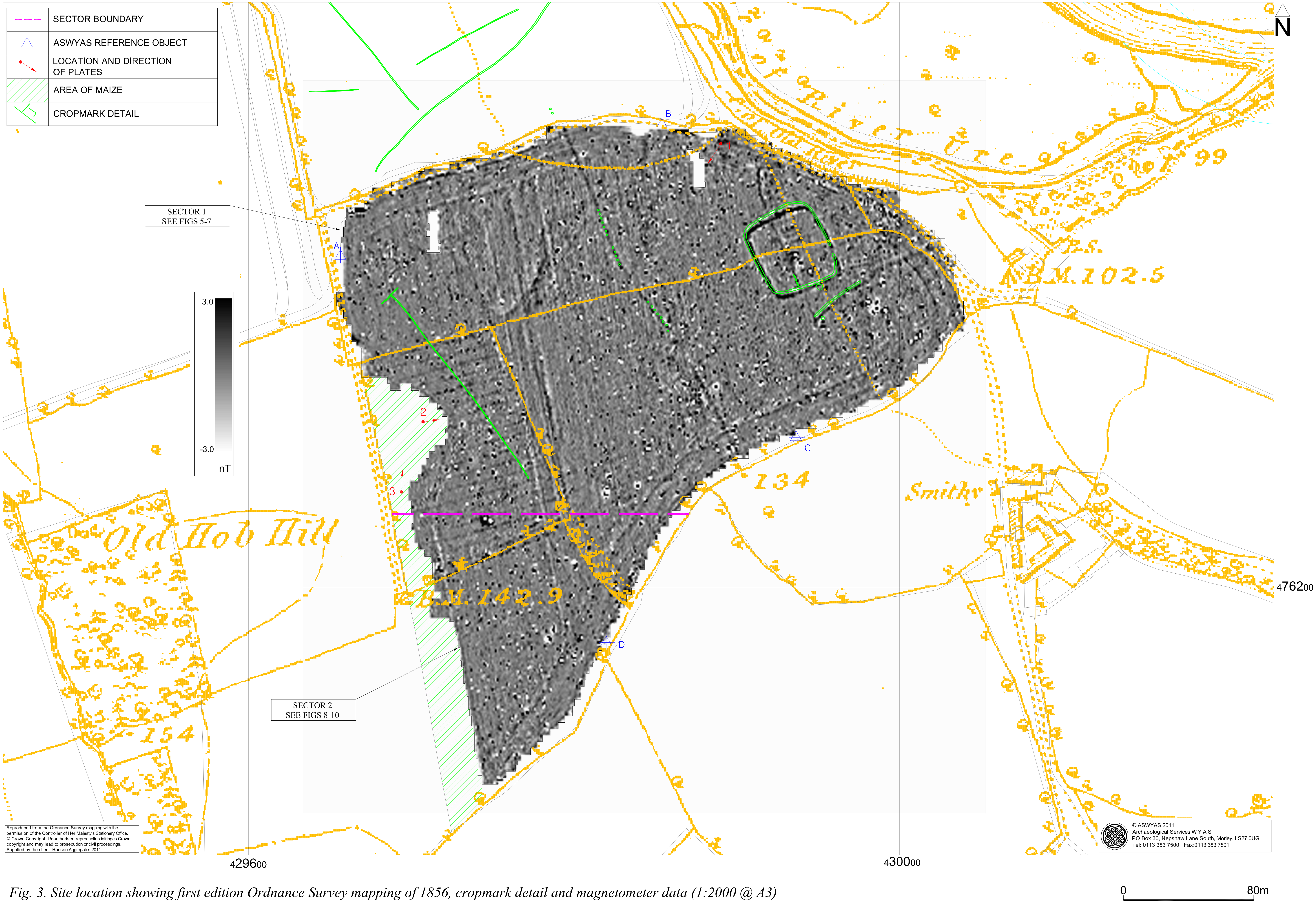


Fig. 3. Site location showing first edition Ordnance Survey mapping of 1856, cropmark detail and magnetometer data (1:2000 @ A3)

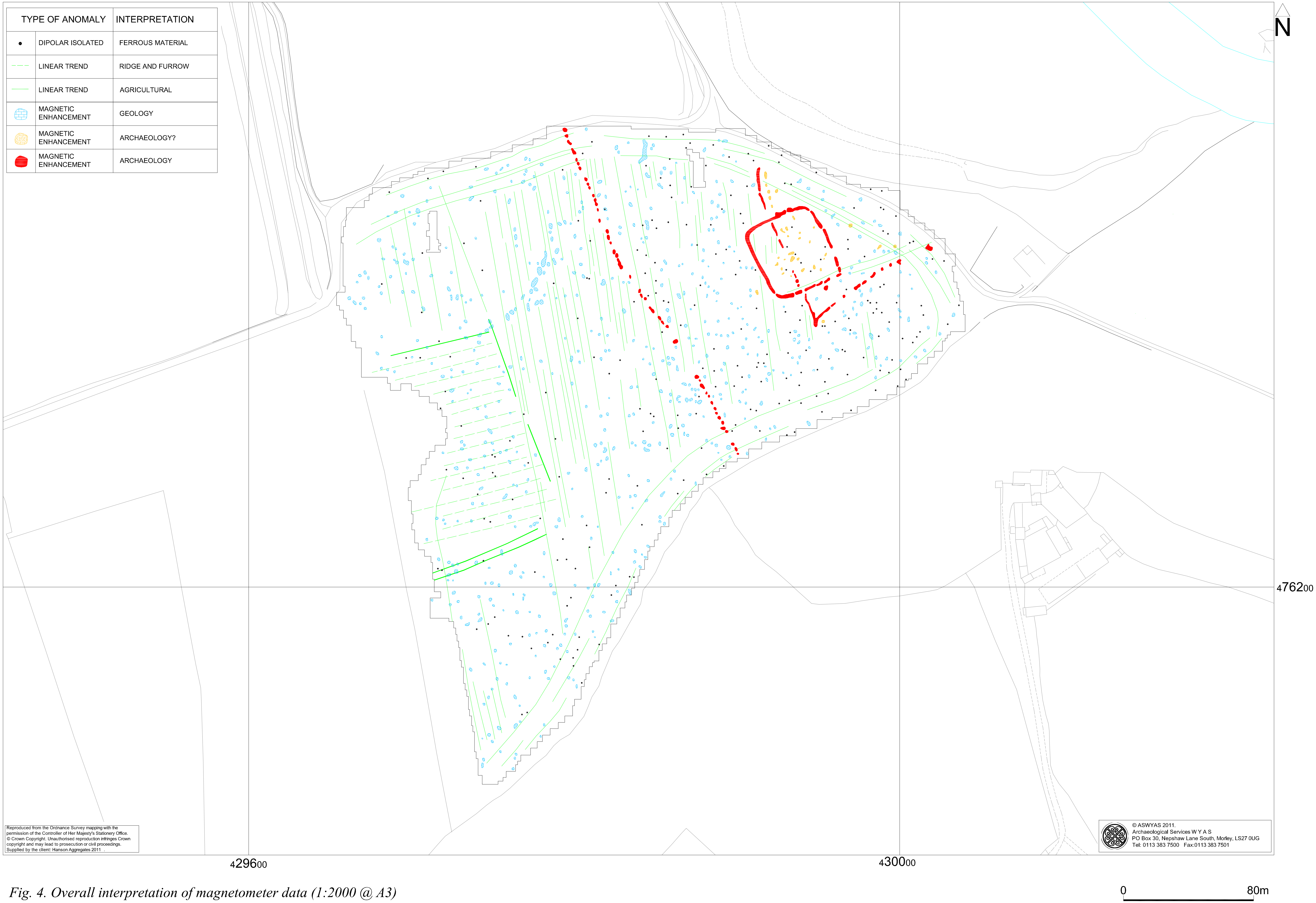


Fig. 4. Overall interpretation of magnetometer data (1:2000 @ A3)

Fig. 5. Processed greyscale magnetometer data; Sector 1 (1:1000 @ A3)

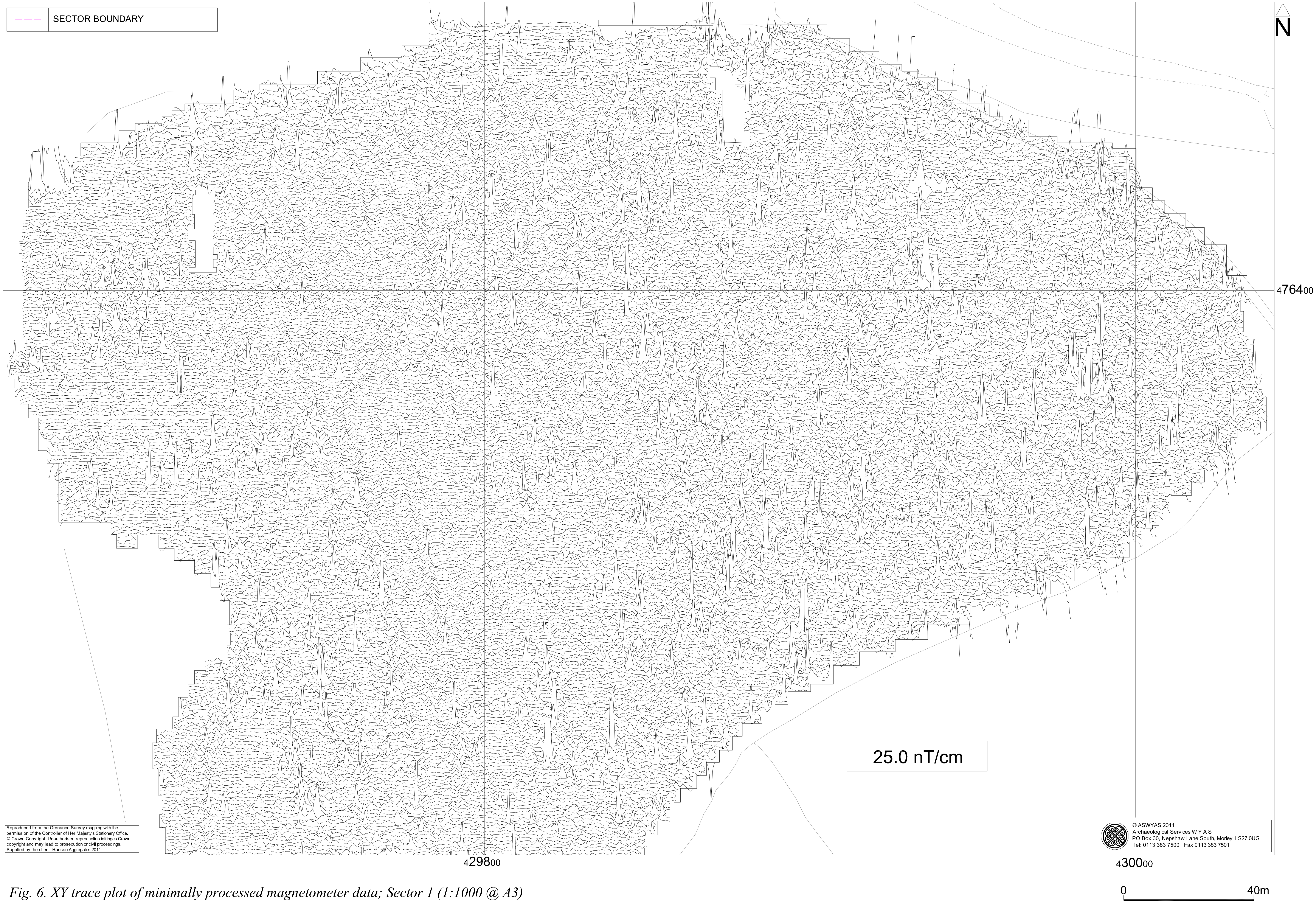


Fig. 6. XY trace plot of minimally processed magnetometer data; Sector 1 (1:1000 @ A3)

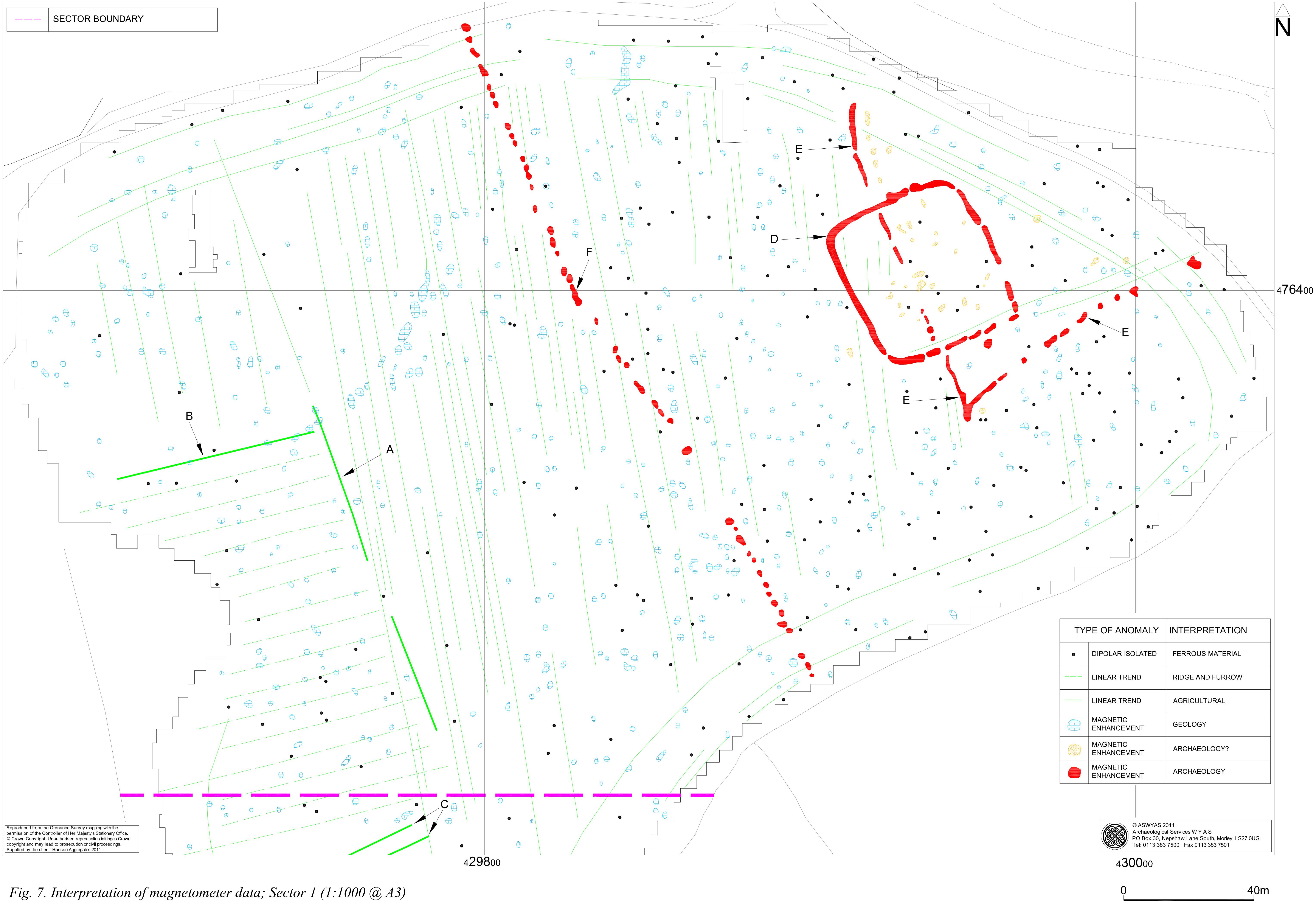
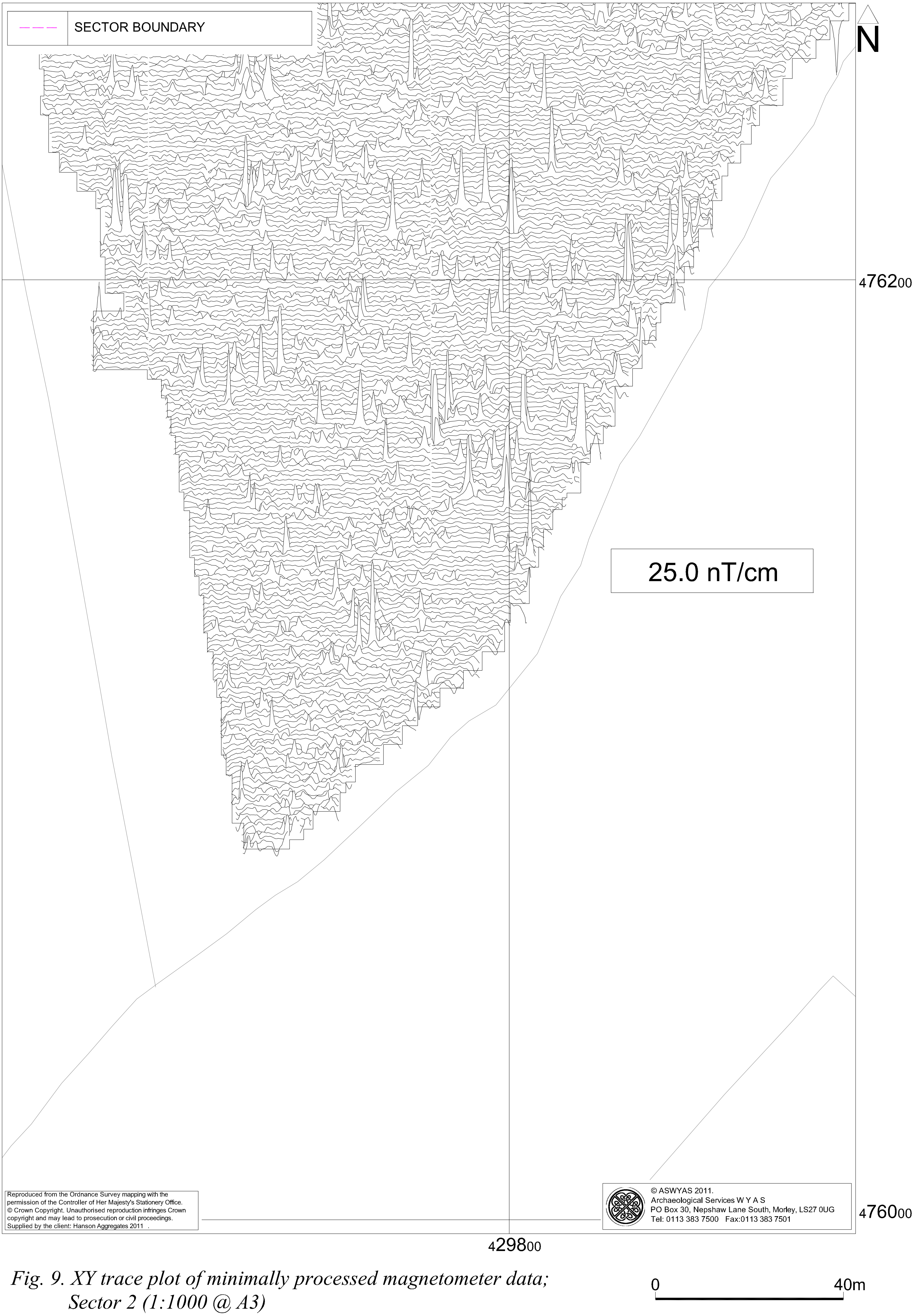


Fig. 7. Interpretation of magnetometer data; Sector 1 (1:1000 @ A3)

Fig. 8. Processed greyscale magnetometer data; Sector 2 (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. 9. XY trace plot of minimally processed magnetometer data; Sector 2 (1:1000 @ A3)

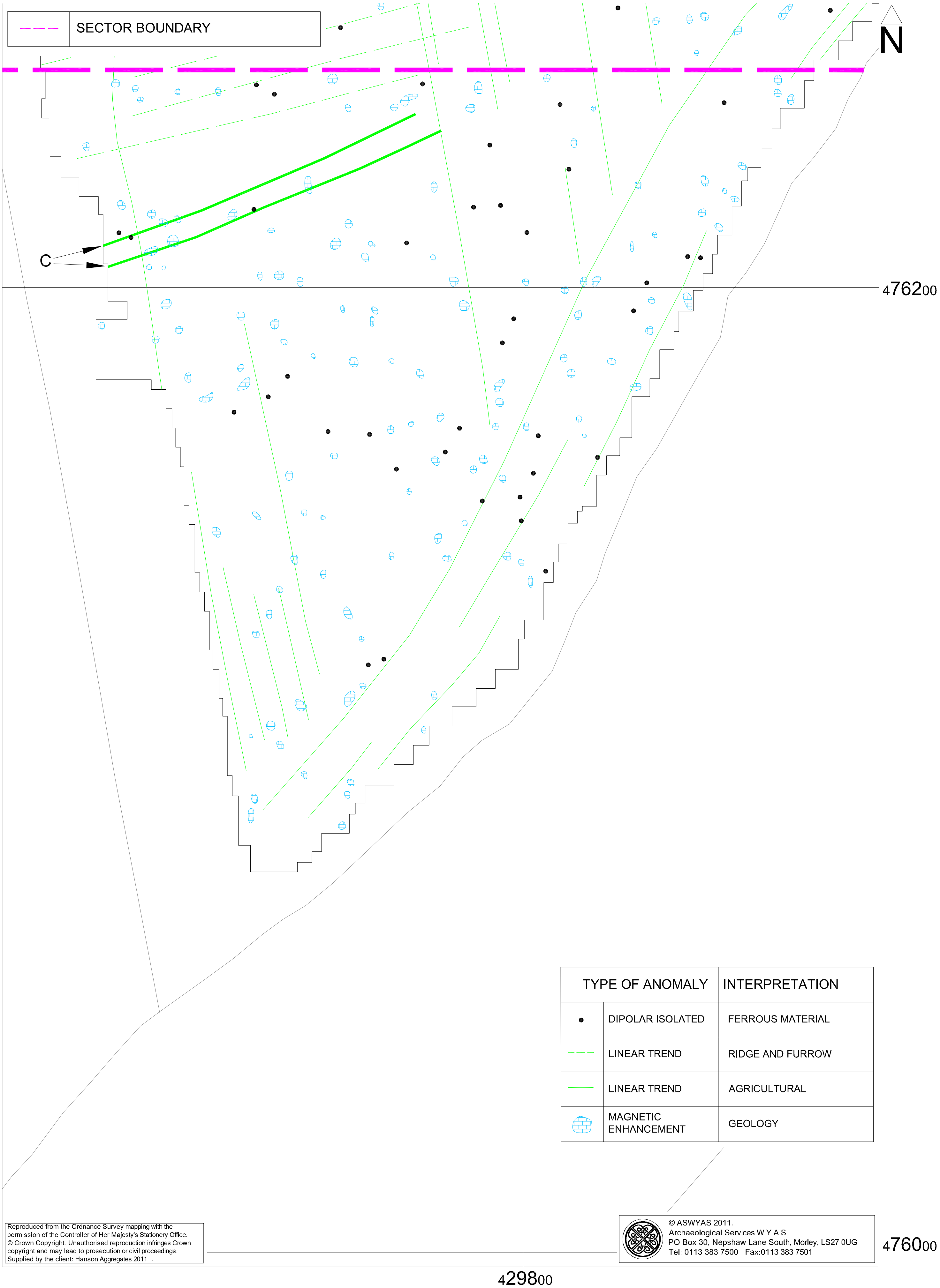


Fig. 10. Interpretation of magnetometer data; Sector 2 (1:1000 @ A3)

0 40m

Plate 1. General view of survey area, looking south-west

Plate 2. General view of survey area, looking east

Plate 3. General view of maize within west of survey area, looking north

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 locations of the temporary reference points left on site are shown on Figure 3 and the Ordnance Survey grid co-ordinates tabulated below. The internal accuracy of these markers is better than 0.01m. The survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Station	**Easting**	**Northing**	**Elevation (aOD)**
A	429656.3460	476403.3340	39.80m
B	429853.9820	476483.9420	37.76m
C	429936.3030	476292.0680	40.40m
D	429819.7050	476166.0090	42.67m

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files.
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the relevant Historic Environment Record).

Bibliography

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

Gaffney, C., Gater, J. and Ovenden, S. 2002. *The Use of Geophysical Techniques in Archaeological Evaluations*. IFA Technical Paper No. 6