ARCHAEOLOGICAL SERVICES WYAS

A9 Dualling: Luncarty to Pass of Birnam

Geophysical Survey

Report no. 2538

November 2013

TRANSPORT SCOTLAND

Client: Jacobs UK Ltd

REGISTERED ORGANISATION IfA

A9 Dualling: Luncarty to Pass of Birnam

Geophysical Survey

Summary

A geophysical (magnetometer) survey was carried out at seven locations either side of the A9 Perth to Inverness road, between Luncarty and the Pass of Birnam, prior to proposed dualling. The survey areas were centred around, or adjacent to, known heritage assets and covered a combined area of 6.7 hectares. The relatively narrow width of the survey areas combined with the effects of variations in the bedrock geology and superficial deposits on the data has made confident interpretation of anomalies difficult. However, an enclosure and possible souterrain have been identified at Northleys Farm (Jacobs UK - Cultural Heritage Asset No. 18), confirming cropmark data. Elsewhere potentially archaeological anomalies have also been identified north of Newmills Farm.

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Report Information

Client:	Jacobs UK Ltd
Address:	95 Bothwell Street, Glasgow, G2 7HX
Report Type:	Geophysical Survey
County:	Perth and Kinross
Grid Reference:	NO 0910 3048 to NO 0830 3275
Period(s) of activity:	Iron Age?
Report Number:	2538
Project Number:	4125
Site Code:	LOP13
OASIS ID:	archaeol11-164900
Planning Application No.:	Pre-application
Museum Accession No.:	n/a
Date of fieldwork:	October 2013
Date of report:	November 2013
Project Management:	David Harrison BA MSc MIfA
Fieldwork:	David Harrison
	Daniel Waterfall BA
Report:	David Harrison
Illustrations:	David Harrison
Photography:	Site Staff
Research:	n/a

Authorisation for distribution: --

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1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Jonathan Dempsey of Jacobs UK, on behalf of their client, Transport Scotland, to undertake a programme of non-intrusive geophysical (magnetometer) survey adjacent to the A9 Perth to Inverness (Luncarty to Pass of Birnam section) trunk road (see Fig. 1). The survey was undertaken in accordance with guidance contained within the Planning Advice Notice (PAN 2/2011), industry guidance (IfA 2011) and in line with current best practice (David *et al* 2008) to provide further information on known heritage assets in advance of the proposed dualling of the road. The survey was carried out between October 21st and October 23rd 2013.

Site location, topography and land-use

The survey focused along a 3km corridor of the A9, to the immediate north of Luncarty, Perth and Kinross, between NGR NO 0910 3048 to the south and NO 0830 3275 to the north (see Fig. 2). The survey blocks (Areas 1 to 6), covering a combined area of 6.7 hectares, are located within an undulating agricultural landscape, cut by the Ordie Burn and its tributaries. Areas 1, 2, 3b, 4 and 6 had recently been harvested of cereal crops. Potatoes had recently been lifted in Area 3a and Area 5 was under permanent pasture (see plates).

Soils and geology

The underlying bedrock geology comprises Cromlix Mudstone to the south and Teith Sandstone Formation to the north (see Fig. 2) overlain by superficial deposits of glaciofluvial gravel, sand and silt. A band of Central Scotland Late Carboniferous Tholelitic Syke Swarm – Quarts-microgabbro, an igneous intrusion, is recorded running east/west to the north of Marlehall Farm (British Geological Survey 2013).

The soils in this area are thought to consist of alluvium adjacent to the watercourses and podzols (Scottish Soils 2013).

2 Archaeological Background

The Cultural Heritage chapter of the Environmental Statement (Jacobs UK – in prep.) for the proposed scheme has identified numerous heritage assets within a 200m wide study area along this section of the scheme. Several of these heritage assets lie within or immediately adjacent to areas proposed for the A9 dualling and this information has been used to determine the location of the survey areas (see Fig. 2). A summary of the known heritage assets pertinent to the survey areas is provided in Table 1 below.

Table 1. Areas of geophysical investigation

Geophysical Survey Area	Cultural Heritage Asset No	Asset Name	SMR Ref.	NGR	Description
1	11	Northleys Palisaded Enclosure	MPK8765	NO 08989 30426	Cropmarks 80m west of Area 1 suggesting a palisaded enclosure, pits, possible round house and ridge and furrow cultivation
2	18	Northleys Cropmarks	MPK6337	NO 08778 31010	Cropmarks suggesting cultivation remains, enclosure and two souterrains
3a	29	Marlehall enclosure	MPK2325	NO 08840 31801	Cropmarks suggesting an enclosure
3b (south)	32	Ladner possible unenclosed settlement	MPK2332	NO 08694 32032	Cropmarks suggesting a possible unenclosed settlement
4	38	Newmills possible settlement and souterrain	MPK2331	NO 08432 32304	Cropmarks suggesting a possible souterrain
5	49	Ring ditch west of Newmills Cottages	MPK6144	NO 08571 32501	Cropmarks suggesting a small ring-ditch
6	59	Newmills Cottages settlement and souterrain	MPK2326	NO 08332 32792	Cropmarks suggesting a possible pit alignment, settlement and souterrain

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of the proposed development on any potential archaeological remains and for mitigation proposals, if appropriate, to be recommended.

The general objectives of the geophysical survey were:

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

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). Bartington Grad601 magnetic gradiometers were used during the survey, taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids, so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 is a large scale (1:8000) survey location plan displaying the processed magnetic data and geology detail. Detailed data plots ('raw' and processed), contour data and full interpretative figures are presented at a scale of 1:1000 in Figures 3 to 26 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 Project Design (Harrison 2013) and guidelines outlined by English Heritage (David *et al* 2008) and by the Institute for Archaeologists (IfA 2011). 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

A variable magnetic background has been recorded across all the survey areas. This is attributed to changes in the composition and depth of the soils and superficial glaciofluvial deposits of gravels, sand and silt allied with changes in the topography. For ease of discussion, the results are described by area.

Area 1 (see Figs 3, 4 and 5; Plate 1)

Area 1 is located to the north of the Shoccie Burn, abutting the western side of the A9, and covers an area 20m wide by 170m in length. A broad area of significantly elevated magnetic enhancement, **A**, dominates the south of the dataset. These elevated readings correspond with the location of a glaciofluvial sheet deposit of sand, silt and gravel which is recorded either side of the Shoccie Burn (British Geological Survey 2013). The anomalous readings are due to magnetic sands and gravels. Several lower magnitude discrete anomalies have also been identified to the north of Area 1. These anomalies are amorphous in appearance and form no obvious pattern. Therefore, these anomalies have also been assigned a geological interpretation, probably being caused by localised variations within the superficial deposits.

Magnetic disturbance identified along the northern edge of Area 1 is due to ferrous material within the adjacent field boundary and is of no archaeological interest. The only other anomalies identified within Area 1 are the ubiquitous dipolar responses caused by ferrous debris in the upper soil horizons.

Area 2 (see Figs 6 to 11; Plate 2)

This area is located to the north-east of Northleys Farm, measures 40m in width and 400m in length and abuts the western edge of the A9. A fragmented circular anomaly, **B**, has been identified (NO 08963 30995) which corresponds with the location of an enclosure and two souterrain's recorded as cropmarks (Jacobs UK – Cultural Heritage Asset No. 18; SMR MPK6337). This cropmark is also visible as a parchmark on satellite imagery. The feature/anomaly is sited on a noticeable rise in the landscape (see Fig. 9). Within the 'enclosure' a number of discrete anomalies are identified, perhaps indicating pits, post-holes and burnt deposits. A sinuous linear anomaly, **C**, extends south from the 'enclosure' for 28m, and may indicate a soil-filled ditch, perhaps a souterrain. If so, it is likely that the anomaly is caused by magnetic sand and gravel filling the passage. Given the clear archaeological potential within this field a number of other high magnitude anomalies, **D**, **E** and **F**, have been assigned a possible archaeological origin. However, with no obvious pattern and within a relatively narrow survey corridor, interpretation of these anomalies is tentative and a geological origin is perhaps equally plausible.

Series of parallel linear trends have been identified on two alignments. Closely spaced trends on a north/south alignment are due to modern ploughing, whereas more widely-spaced linear trends on a north-east/south-west orientation are thought to be caused by land drains.

Numerous amorphous anomalies are ascribed a geological interpretation, probably being caused by localised variations in the soils and sand and gravel superficial deposits. Of particular note is anomaly, **G**, towards the north of Area 2, which is notably higher in magnitude than the other anomalies ascribed a geological origin. However, with no clear archaeological pattern visible, a geological interpretation is preferred.

Magnetic disturbance at the eastern perimeter of the site is due to magnetic material in the adjacent perimeter fencing.

Area 3a (see Figs 12, 13 and 14; Plate 3)

Area 3a is located to the west of Marlehall Farm, on the eastern side of the A9. The most obvious anomaly in this area is the high magnitude anomaly, **H**, aligned broadly north/south at the southern end of the survey area. This anomaly locates a sub-surface culvert depicted on the first edition Ordnance Survey map (1865) and is of no archaeological interest.

A number of broad areas of magnetic disturbance, **I**, can be seen to the west and north of the culvert. These may relate to ground disturbance associated with the construction of the culvert or possibly be caused by magnetic material used to backfill extraction (clay or marl) pits. The first edition Ordnance Survey map shows a 'tile works' and 'brick field' to the north-west of Marlehall Farm (225m to the north of the anomalies) indicating that clay extraction was undertaken locally. A cropmark enclosure (Jacobs UK - Cultural Heritage Asset No. 29) is also recorded at this location. No evidence for an enclosure is visible in the magnetic data although severe magnetic disturbance (see below) makes the confident identification of anomalies in this part of the area difficult.

Series of parallel linear trends are visible throughout Area 3a. The more widely-spaced trends on a north-east/south-west alignment are indicative of the medieval and post-medieval practice of rig and furrow cultivation. The characteristic striped appearance to the data is a result of the magnetic contrast between the now soil-filled furrows and the former rigs. Closely-spaced linear trends on a north-west/south-east alignment, running parallel with the current field boundaries, are due to modern cultivation ridges resulting from the recent potato crop (see Plate 3).

Numerous low magnitude and amorphous anomalies can be seen throughout the dataset. None of these are archaeological in appearance and all are thought to be due to variations in the sand and gravel superficial deposits.

A very strong magnetic source has resulted in a large area of magnetic interference, **J**, on the eastern edge of the survey area. The exact origin of this interference is unclear as it appears to originate to the east of the survey area. However, the source anomaly is obviously very high in magnitude and it is possible that it is due to near-surface igneous geology; an igneous intrusion is recorded just to the north of this field (see Fig. 2).

Area 3b (see Figs 15, 16 and 17; Plate 4)

A high magnitude anomaly, **K**, is identified in the centre of this survey area located very close to the highest point in the field (see Fig 15). It is possible that this anomaly is caused by an infilled gravel extraction pit, but given its position an archaeological origin should be considered.

Cropmarks identified at the southern end of this area (Jacobs UK – Cultural Heritage Asset No. 32; SMR MPK2332), and interpreted as indicative of unenclosed settlement activity, do not appear to manifest as magnetic anomalies. There is a cluster of anomalies in a vague curvilinear pattern, **L**, at the recorded grid reference but it is considered more likely that this and the other discrete anomalies throughout this area are caused by a combination of geological and topographical factors.

Area 4 (see Figs 18, 19 and 20; Plate 5)

Area 4 is located upon a prominent hilltop immediately north of Newmill Farm and 100m west of the excavated Newmills settlement and souterrain site (Jacobs UK – Cultural Heritage Asset Nos. 42-45). Cropmarks indicative of a possible souterrain have been identified right on the edge of the survey area within this field (Jacobs UK – Cultural Heritage Asset No. 38; SMR MPK2331). No anomalies of obvious archaeological potential have been identified by the geophysical survey at this location although tentatively, two anomalies have been assigned archaeological potential. A vague linear band of anomalies, **M**, may be of archaeological interest, perhaps indicating a ditch, whilst to the south a very faint circular trend, **N**, measuring 15m in diameter, may be due to an enclosure. The vast majority of anomalies identified within this area are thought to be due to variations in the magnetic sand and gravel superficial deposits and it should be noted here that these conditions generally provide poor to average results for the clear identification of anomalies of archaeological potential. Within the east of the dataset, the linear trend running parallel to the field boundary is due to agricultural activity, probably a ploughing headland.

Broad areas of magnetic disturbance along the eastern edge of the field are modern in origin, probably resulting from the construction of the adjacent road.

Area 5 (see Figs 21, 22 and 23; Plate 6)

Aside from the occasional ferrous 'spike' anomalies and discrete anomalies caused by natural variation in the composition of the soils and superficial deposit only a single curving trend anomaly, interpreted as agricultural in origin, has been identified in this area. No anomalies of archaeological potential have been identified although a small cropmark ring ditch is recorded immediately east of the survey area.

Area 6 (see Figs 24 to 25, Plate 7)

Area 6 is the northernmost survey area, located within a waterlogged area at the base of a west-facing gradient on the eastern side of the A9. It measures 40m in width and 185m in length. No obvious archaeological anomalies are visible within the data. Within the south of the field a fragmented curvilinear anomaly, **O**, has been identified. This may indicate a ditch, the function of which is unclear. At the northern extent of the anomaly a broad area of magnetic disturbance, **P**, can be seen. This is similar in size and magnitude to those anomalies observed within Area 3a (see above), and is similarly located within a low-lying area. It is possible, therefore, that this magnetic disturbance is due to the magnetic fill of a former extraction pit. If so, the fragmented linear anomaly, **O**, may be associated.

Elsewhere, anomalies have been identified which are due to geological and pedological variations, modern agriculture and magnetic disturbance from the adjacent field boundaries.

5 Discussion and Conclusions

It is difficult to confidently identify and interpret anomalies of archaeological potential within a relatively narrow survey corridor, especially in an undulating, glaciofluvial landscape where the superficial deposits comprise unsorted sands, gravels and silt. Nevertheless, the geophysical survey has identified a clear area of archaeological potential to the north-west of Northleys Farm (Area 2) where a circular and linear anomaly are thought to locate part of an enclosure and souterrain identified as cropmarks on air photographs recorded by the Royal Commission on the Ancient and Historical Monuments of Scotland (SMR MPK6337). Elsewhere, despite the recording of other cropmark features either within or immediately adjacent to the survey areas, no definite anomalies of archaeological potential have been identified. Several vague anomalies have been ascribed some archaeological potential based on proximity to recorded cropmarks or to advantageous locations in the landscape. However, any of these anomalies could also be just as plausibly interpreted as having a natural (geological or topographical) cause or be due to relatively recent small scale extraction.

On the basis of the geophysical survey, the archaeological potential of the site at Northleys Farm is considered to be fairly high with a moderate to low potential elsewhere.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

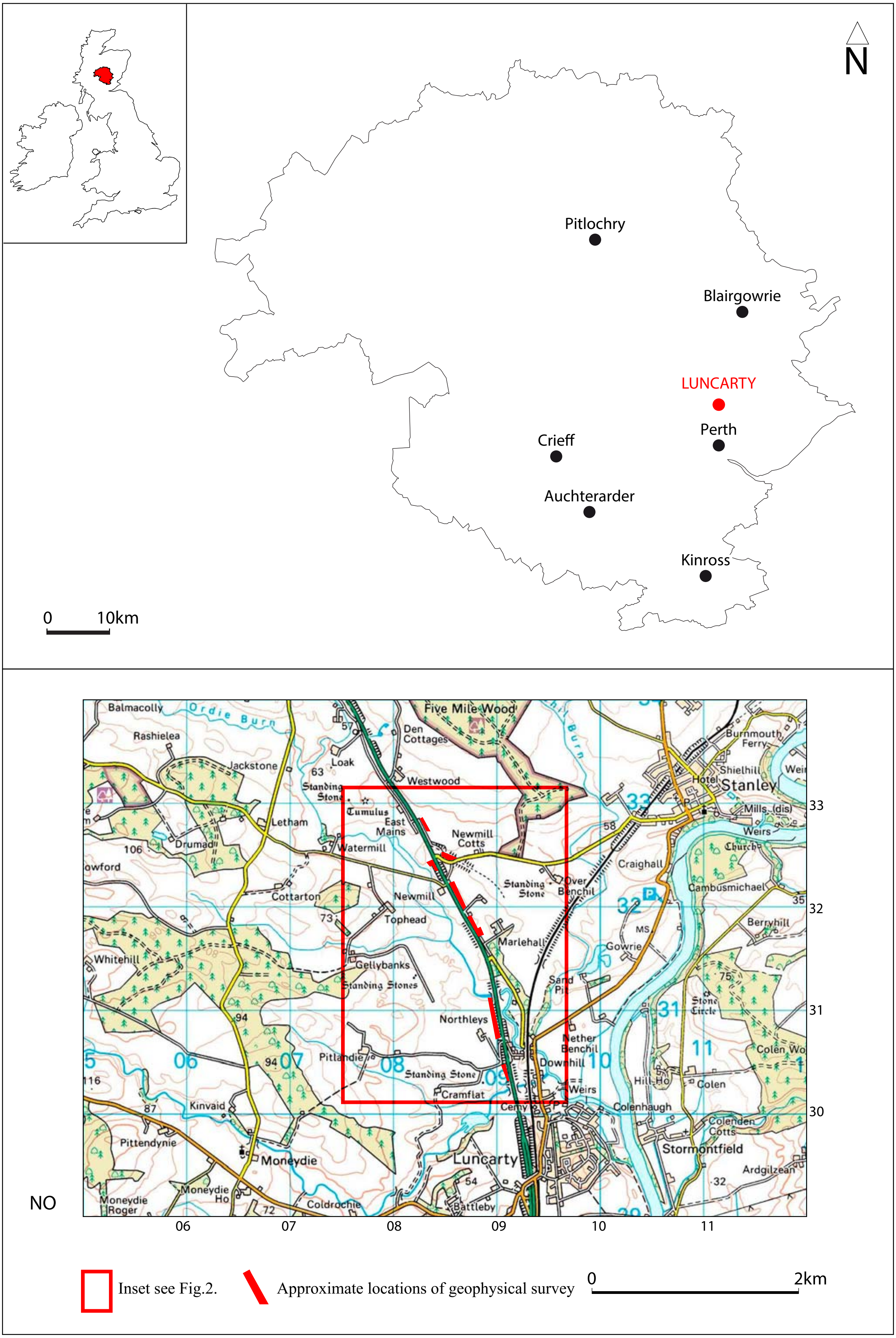

Fig. 1. Site location

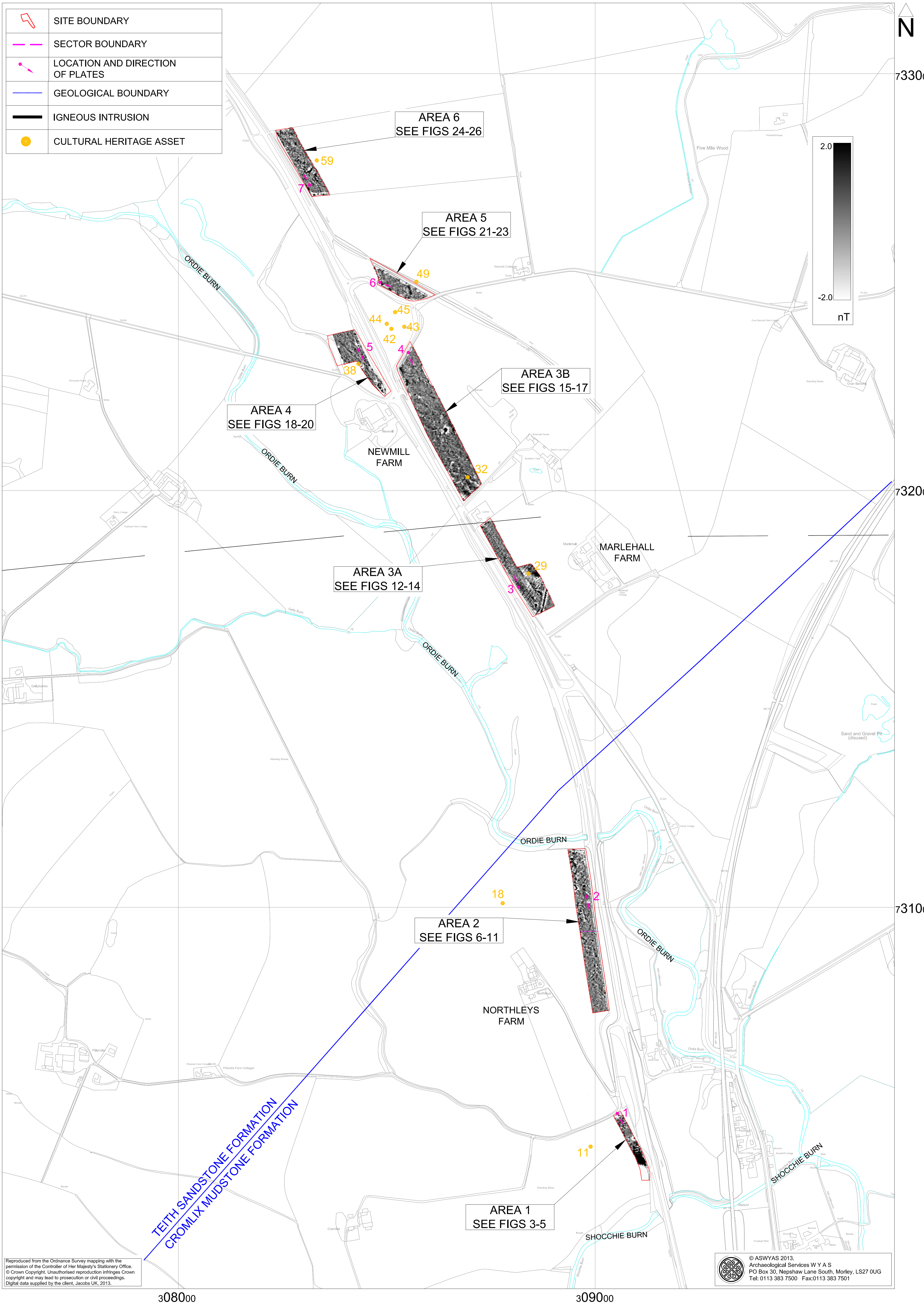

Fig. 2. Survey location showing greyscale magnetometer data and geology detail (1:8000 @ A3)

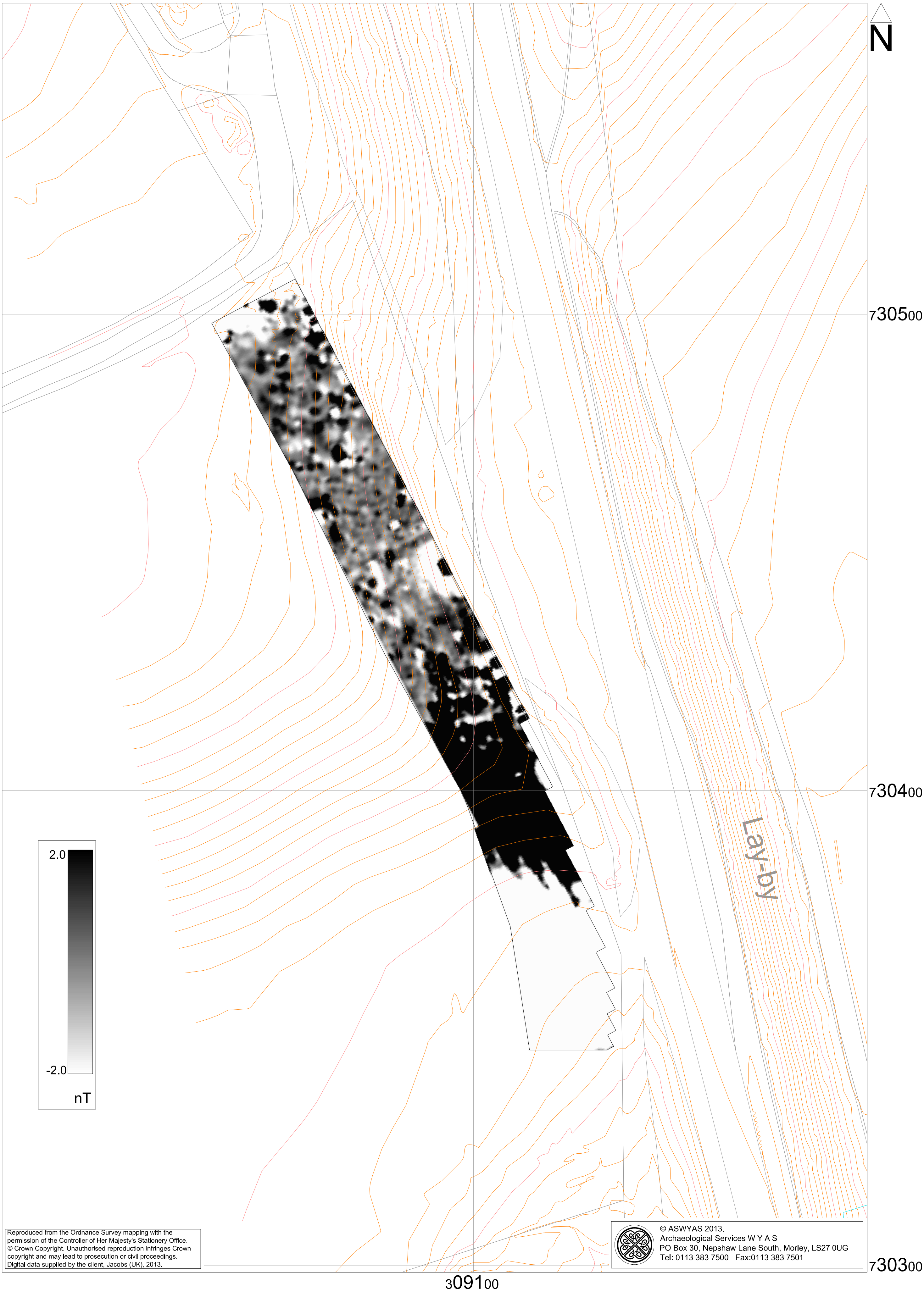

Fig. 3. Processed greyscale magnetometer data; Area 1, showing contour detail (1:1000 @ A4)

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Fig. 4. XY trace plot of minimally processed magnetometer data; Area 1(1:1000 @ A4)

Fig. 5. Interpretation of magnetometer data; Area 1 (1:1000 @ A4)

Fig. 6. Processed greyscale magnetometer data; Area 2 south, showing contour detail (1:1000 @ A4)

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Fig. 7. XY trace plot of minimally processed magnetometer data; Area 2 south (1:1000 @ A4)

Fig. 8. Interpretation of magnetometer data; Area 2 south (1:1000 @ A4)

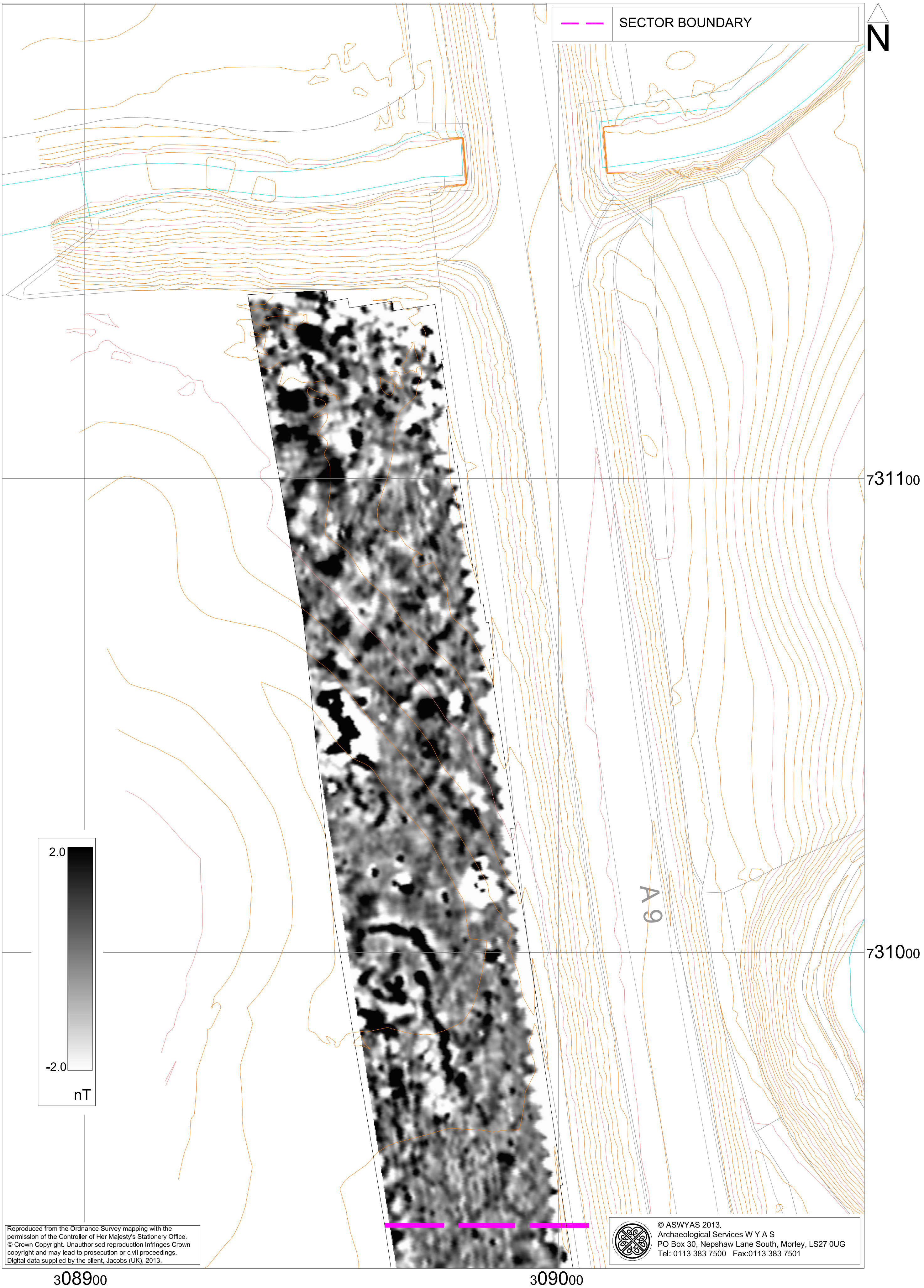

Fig. 9. Processed greyscale magnetometer data; Area 2 north, showing contour detail (1:1000 @ A4)

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Fig. 10. XY trace plot of minimally processed magnetometer data; Area 2 north (1:1000 @ A4)

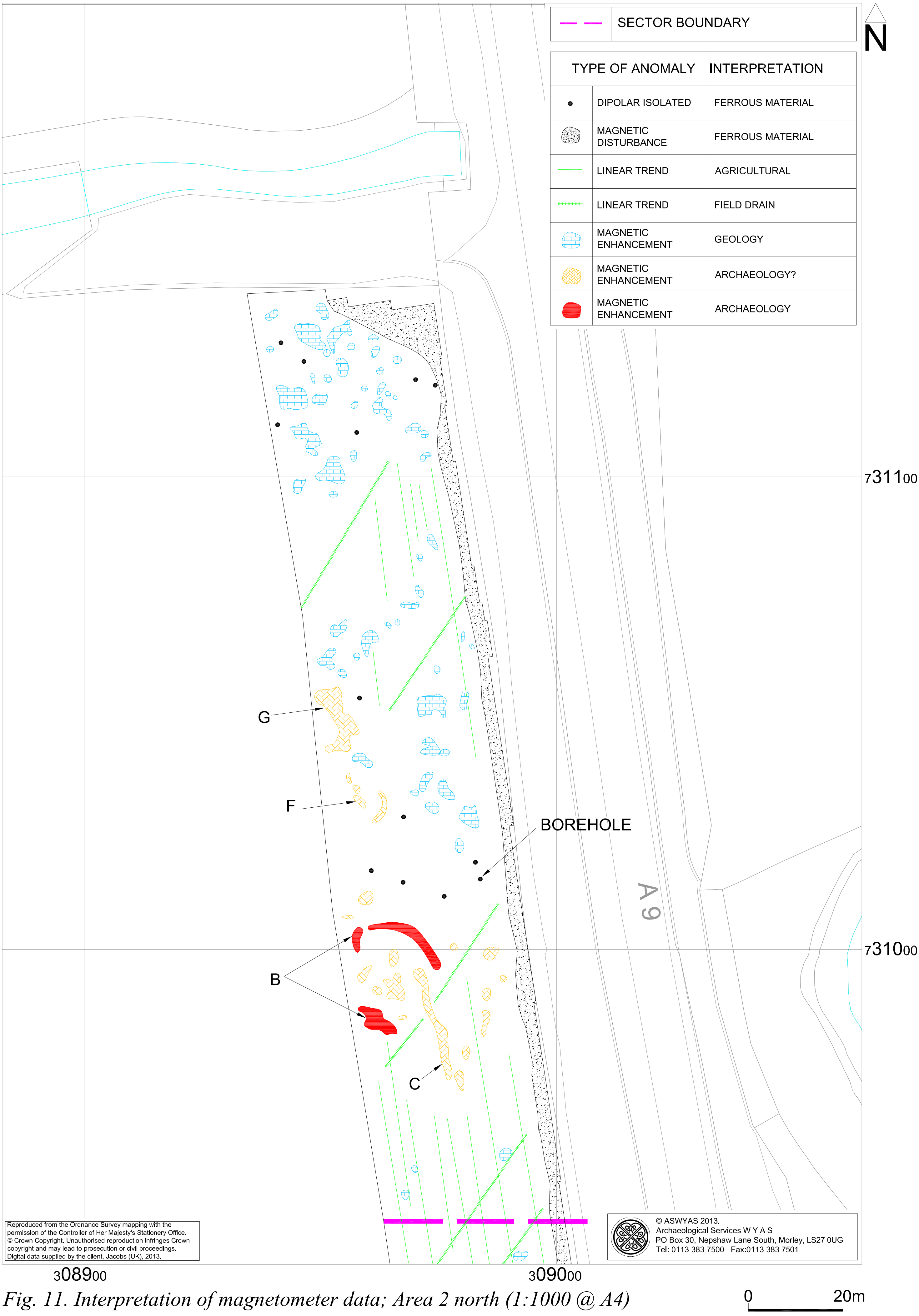

Fig. 11. Interpretation of magnetometer data; Area 2 north (1:1000 @ A4)

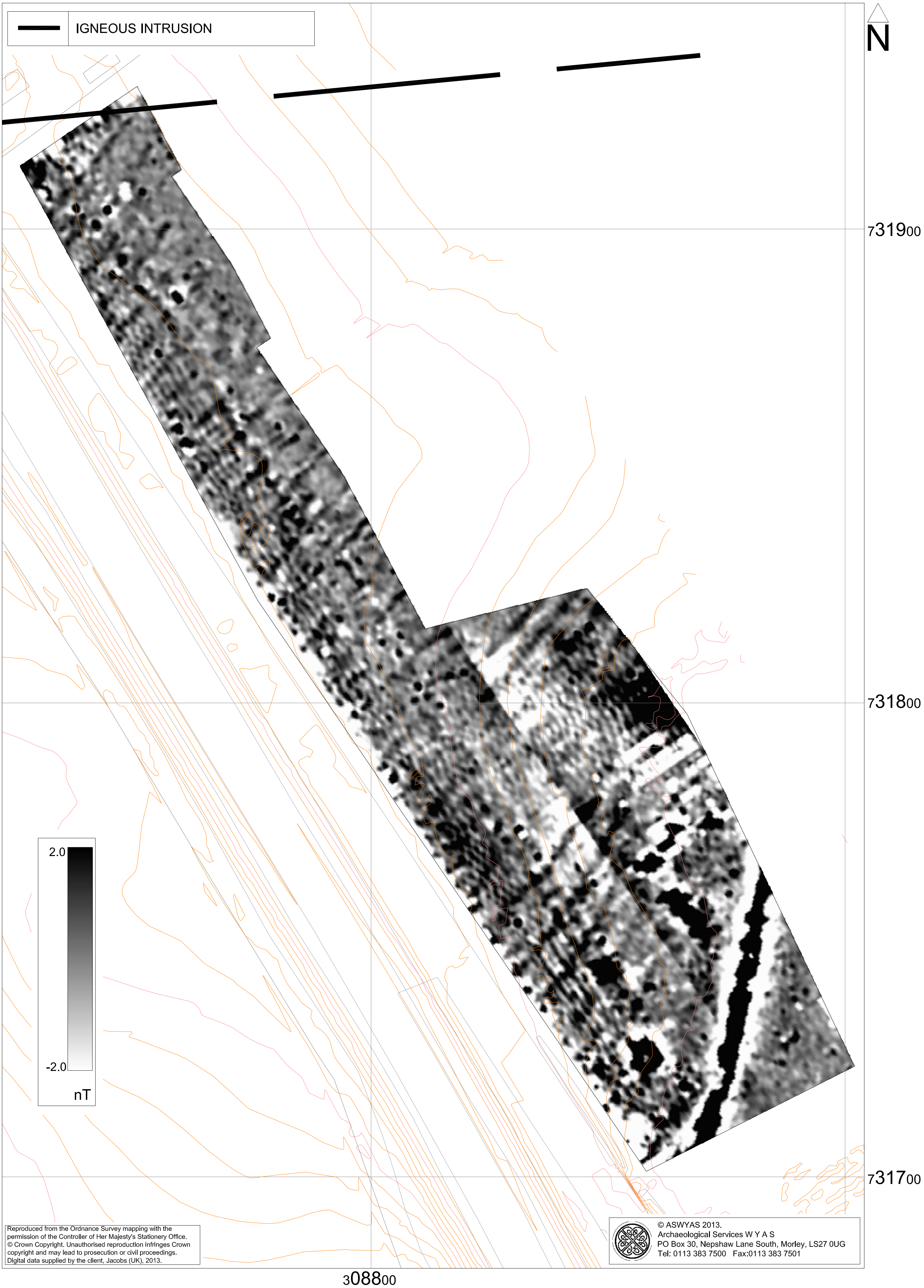

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Fig. 12. Processed greyscale magnetometer data; Area 3a, showing contour detail (1:1000 @ A4)

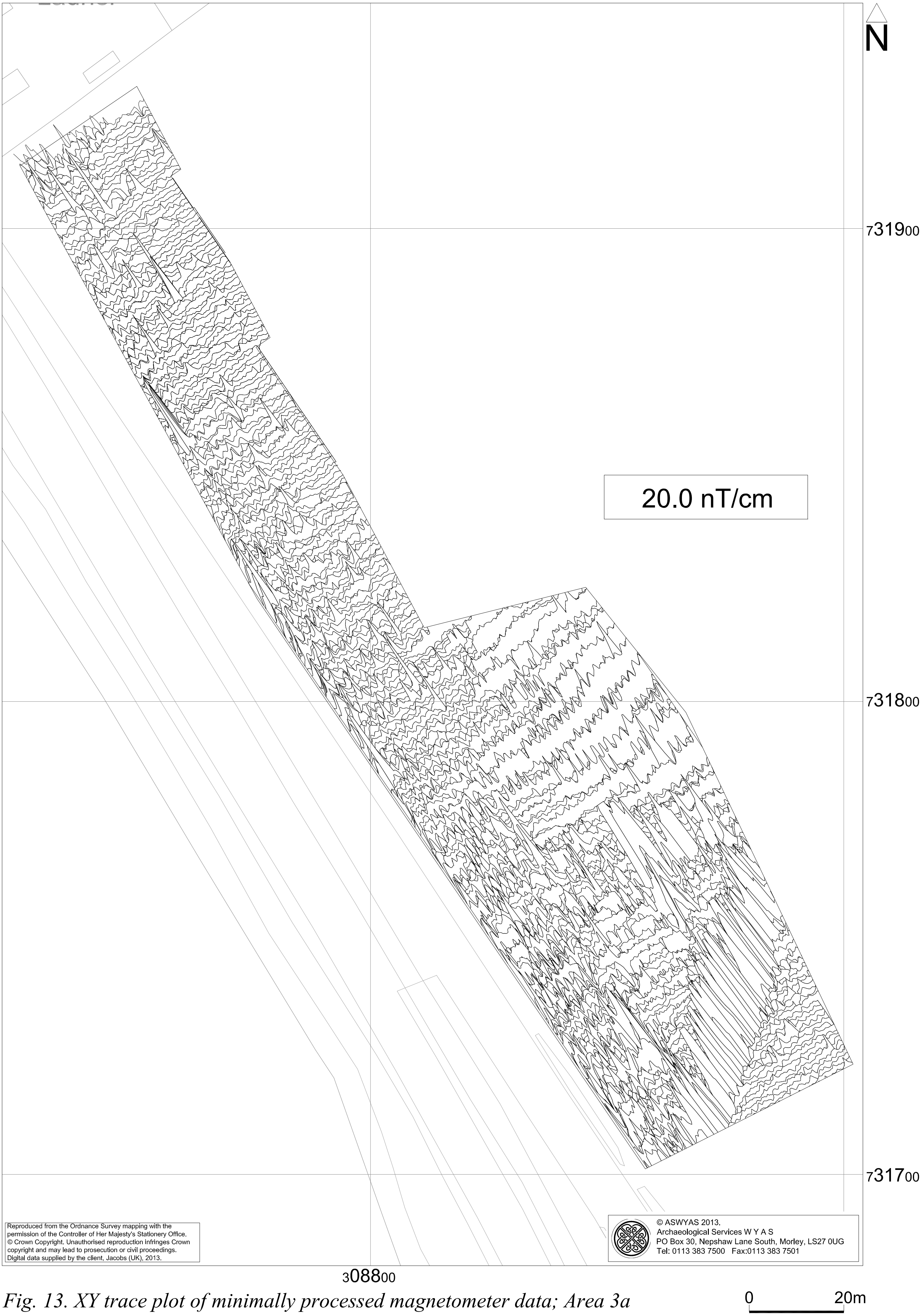

Fig. 13. XY trace plot of minimally processed magnetometer data; Area 3a (1:1000 @ A4)

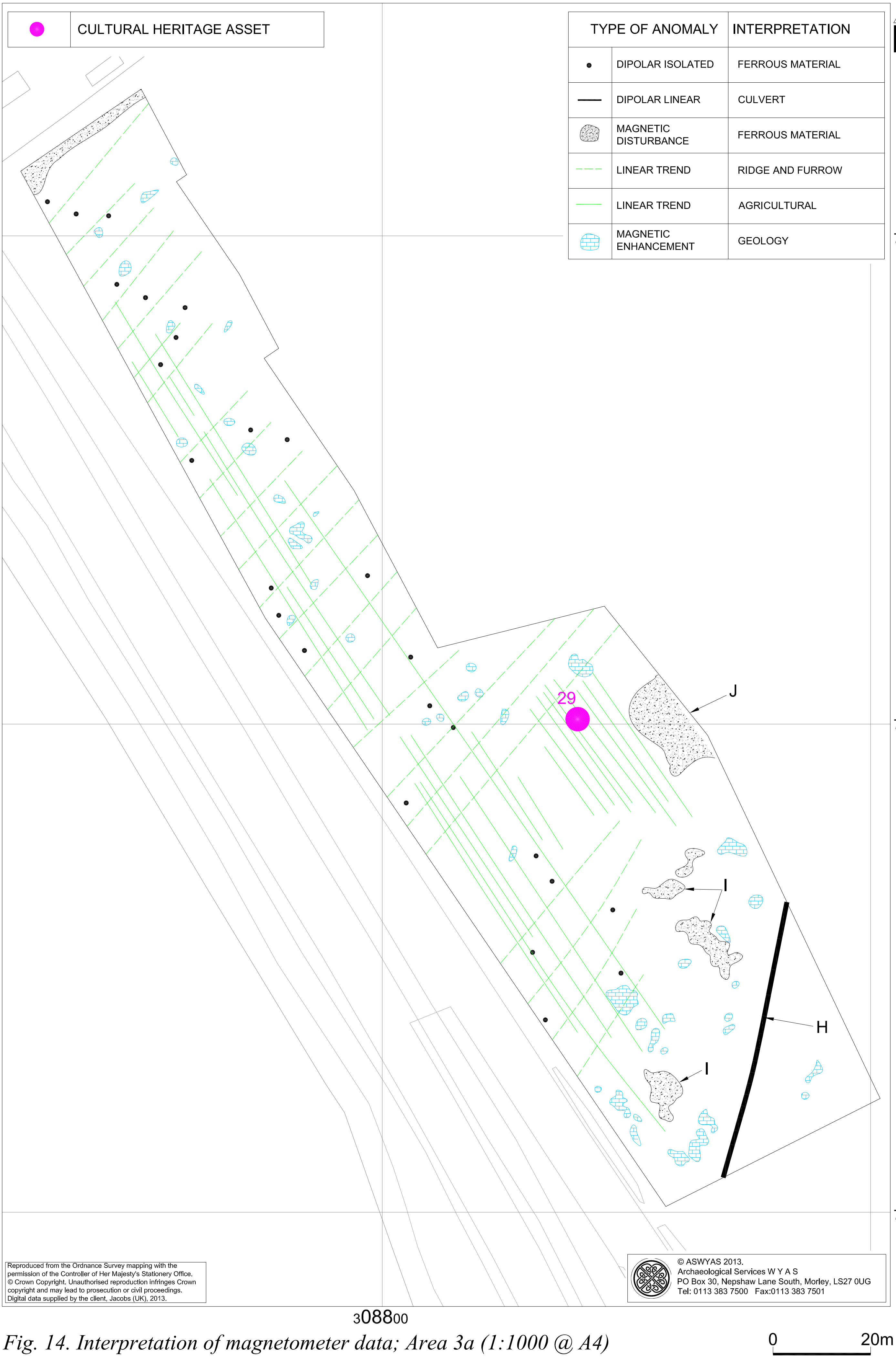

Fig. 14. Interpretation of magnetometer data; Area 3a (1:1000 @ A4)

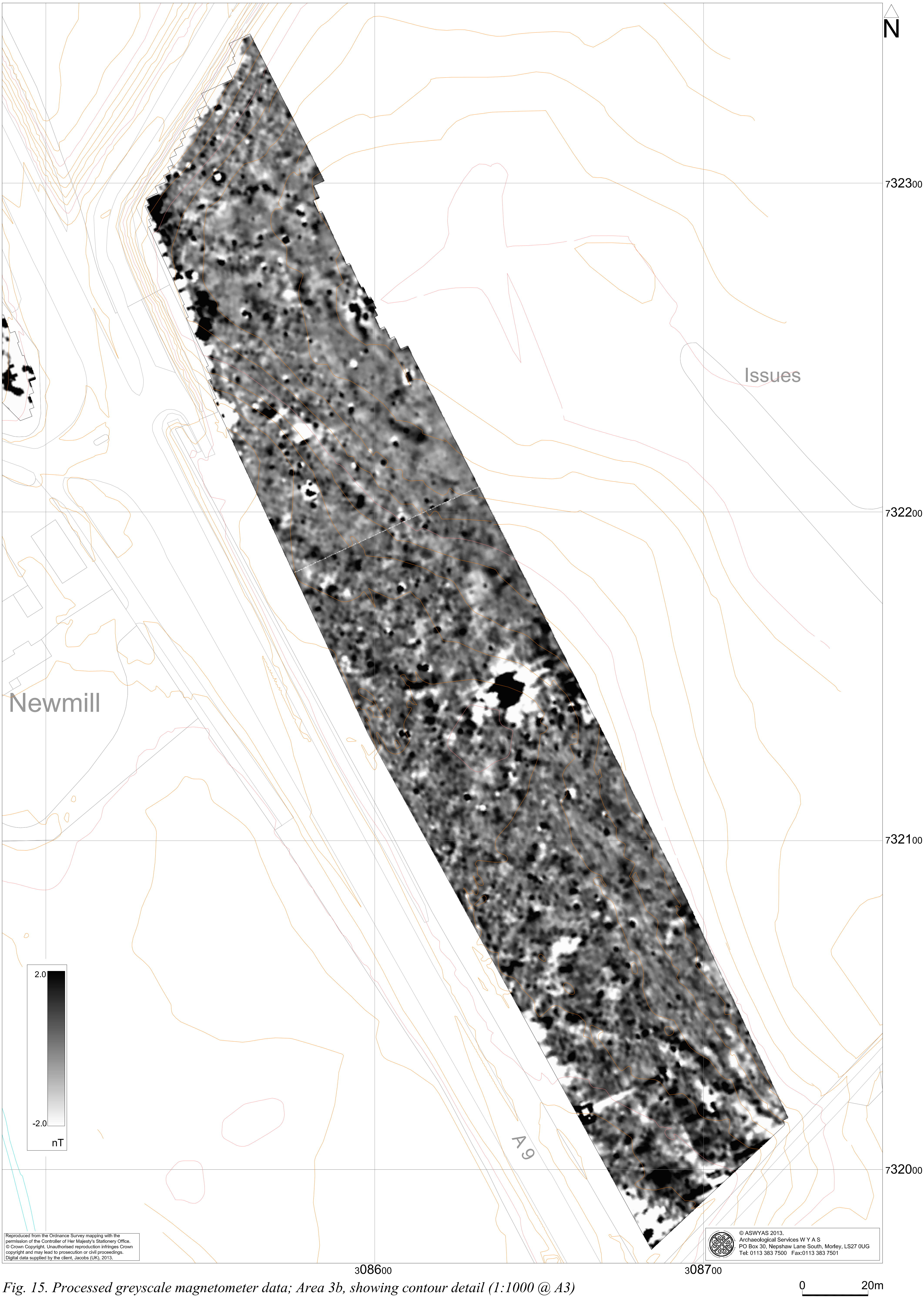

Fig. 15. Processed greyscale magnetometer data; Area 3b, showing contour detail (1:1000 @ A3)

Fig. 16. XY trace plot of minimally processed magnetometer data; Area 3b (1:1000 @ A3)

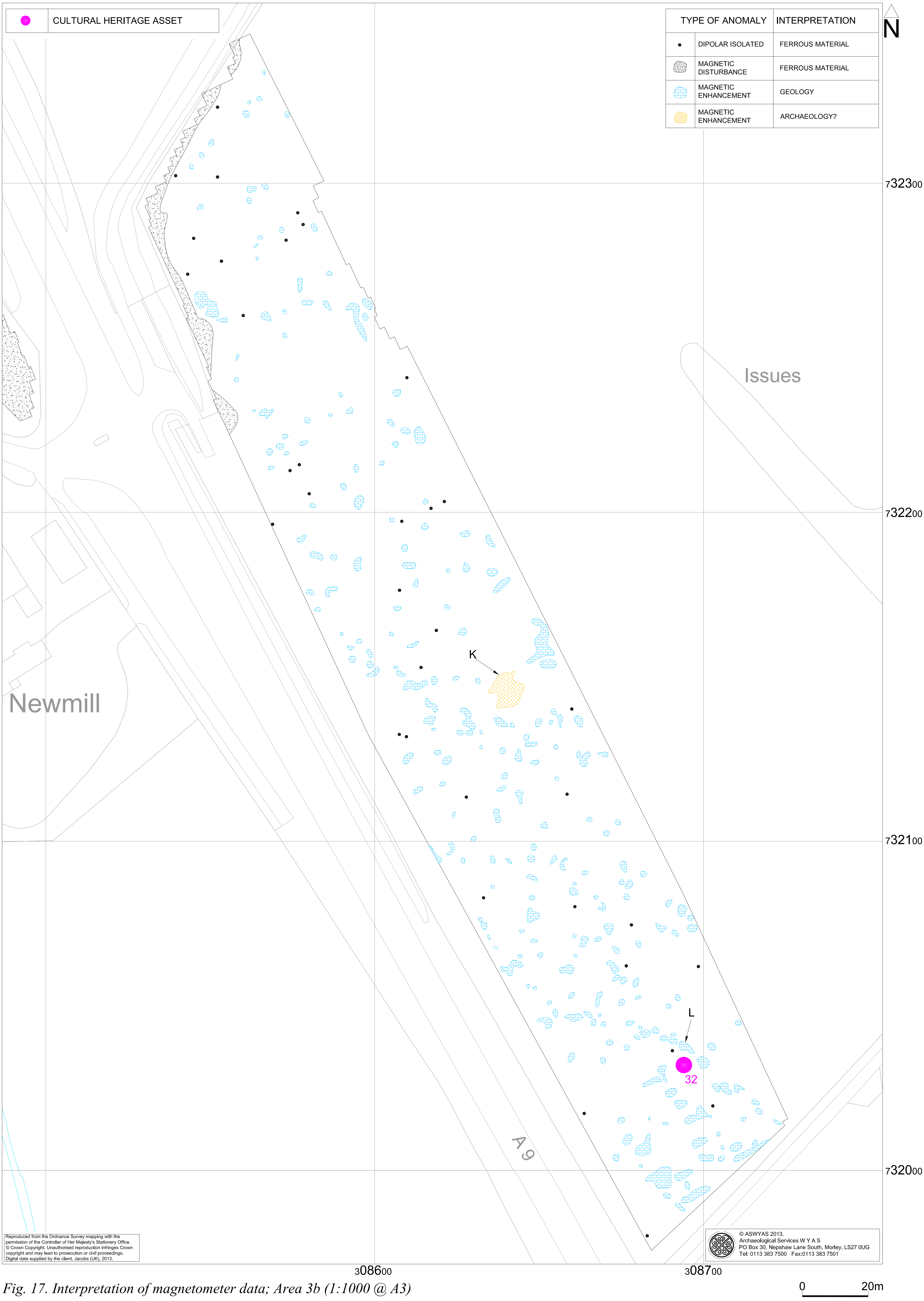

Fig. 17. Interpretation of magnetometer data; Area 3b (1:1000 @ A3)

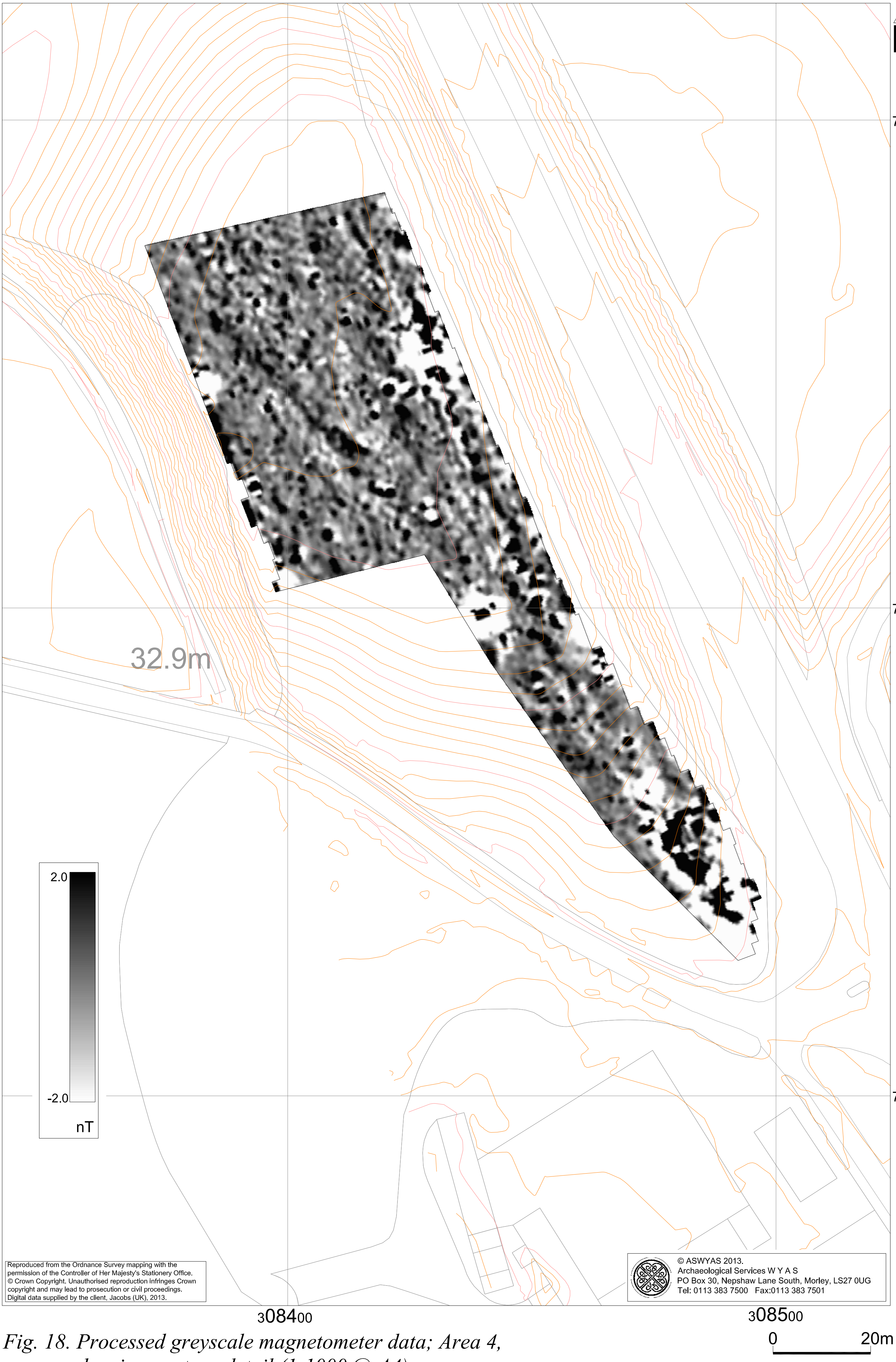

Fig. 18. Processed greyscale magnetometer data; Area 4, showing contour detail (1:1000 @ A4)

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Fig. 19. XY trace plot of minimally processed magnetometer data; Area 4 (1:1000 @ A4)

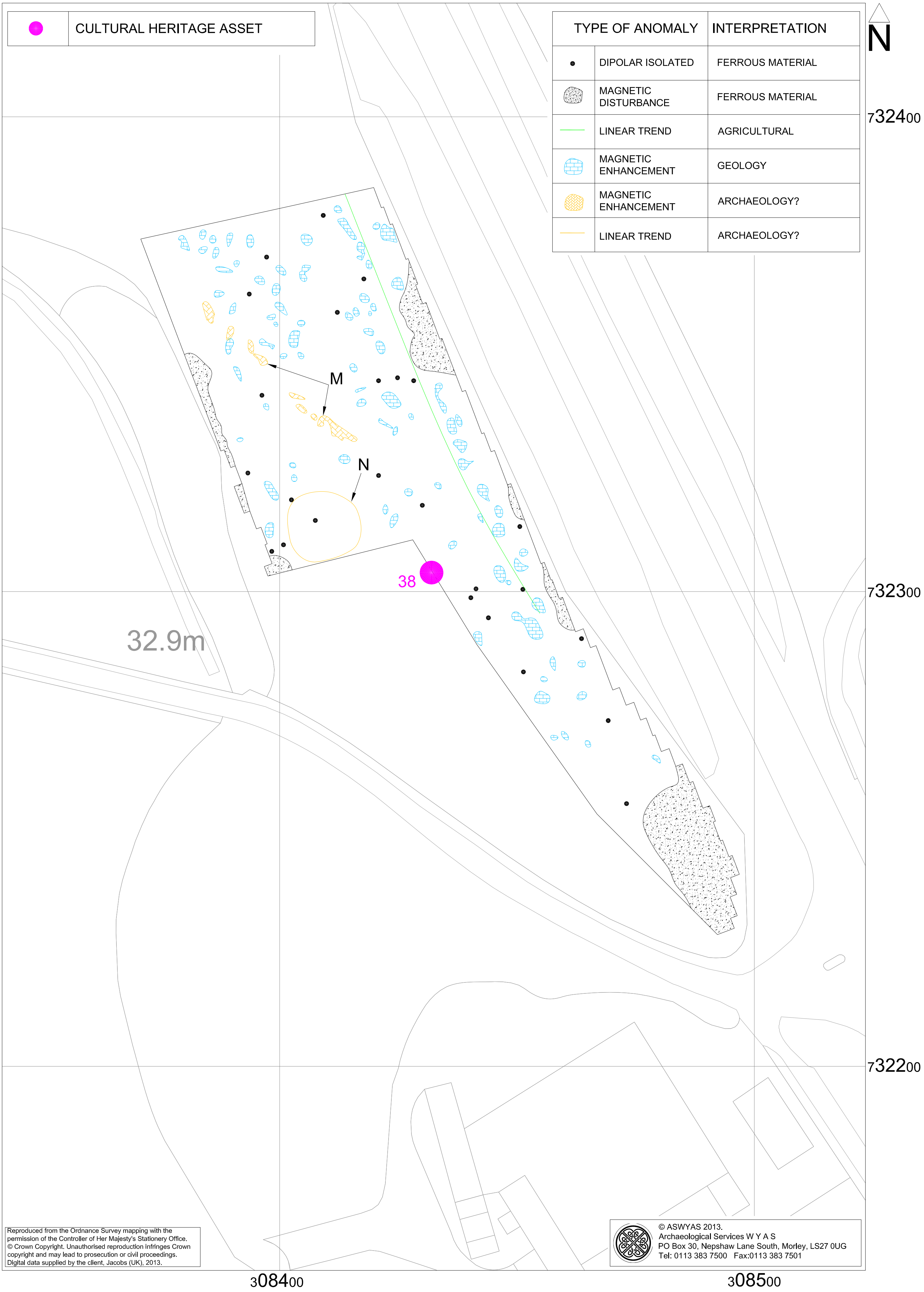

Fig. 20. Interpretation of magnetometer data; Area 4 (1:1000 @ A4)

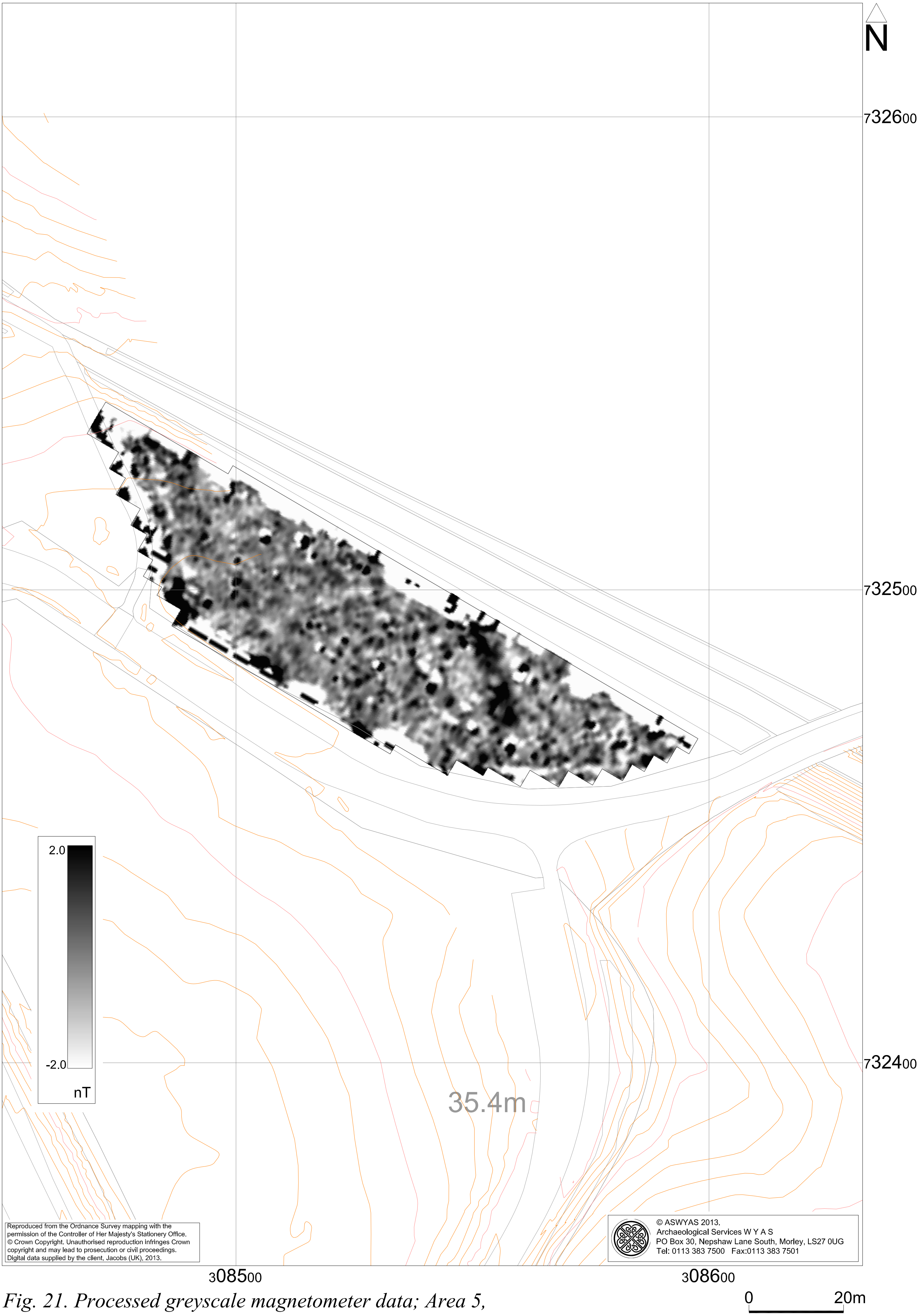

Fig. 21. Processed greyscale magnetometer data; Area 5, showing contour detail (1:1000 @ A4)

Fig. 22. XY trace plot of minimally processed magnetometer data; Area 5 (1:1000 @ A4)

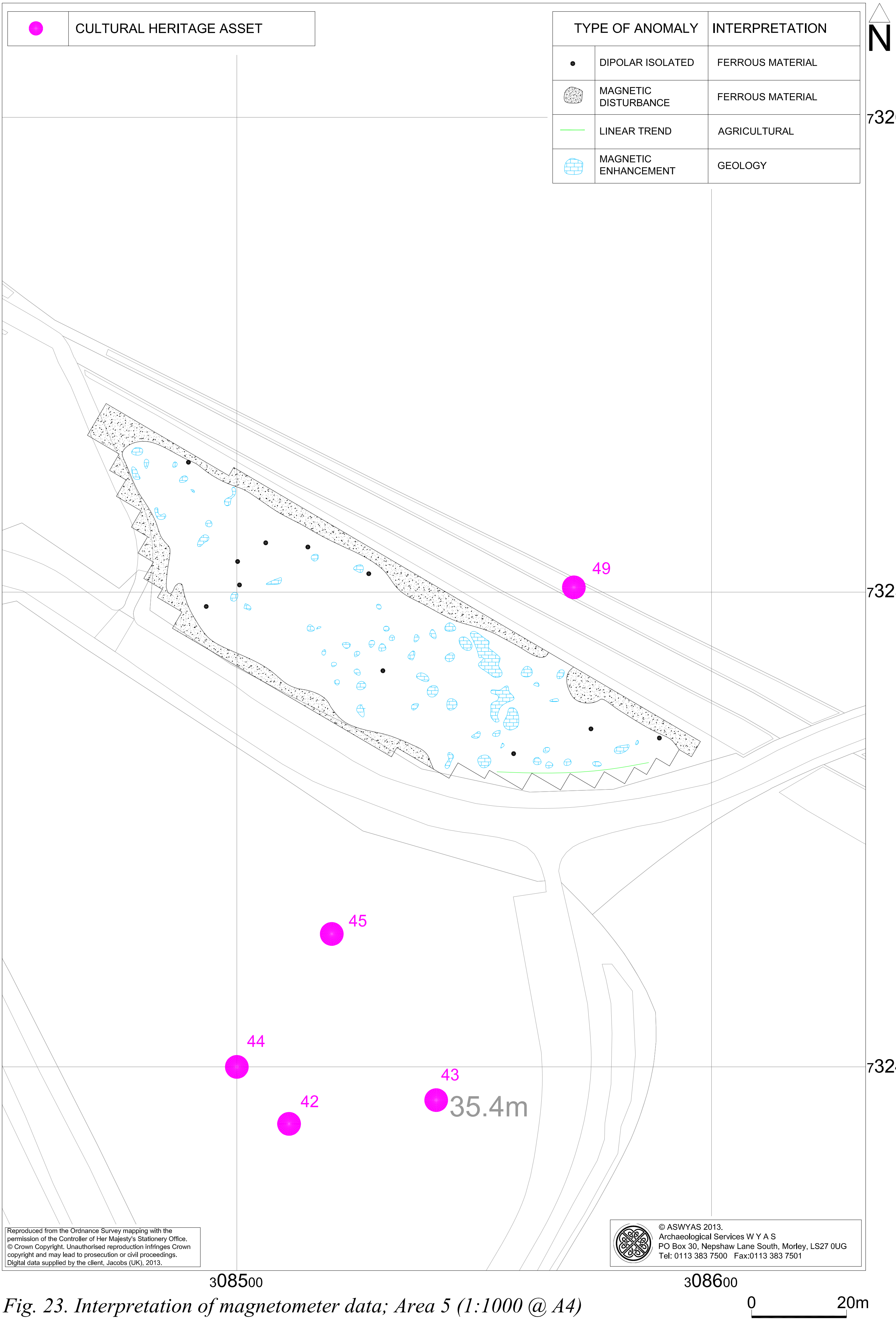

Fig. 23. Interpretation of magnetometer data; Area 5 (1:1000 @ A4)

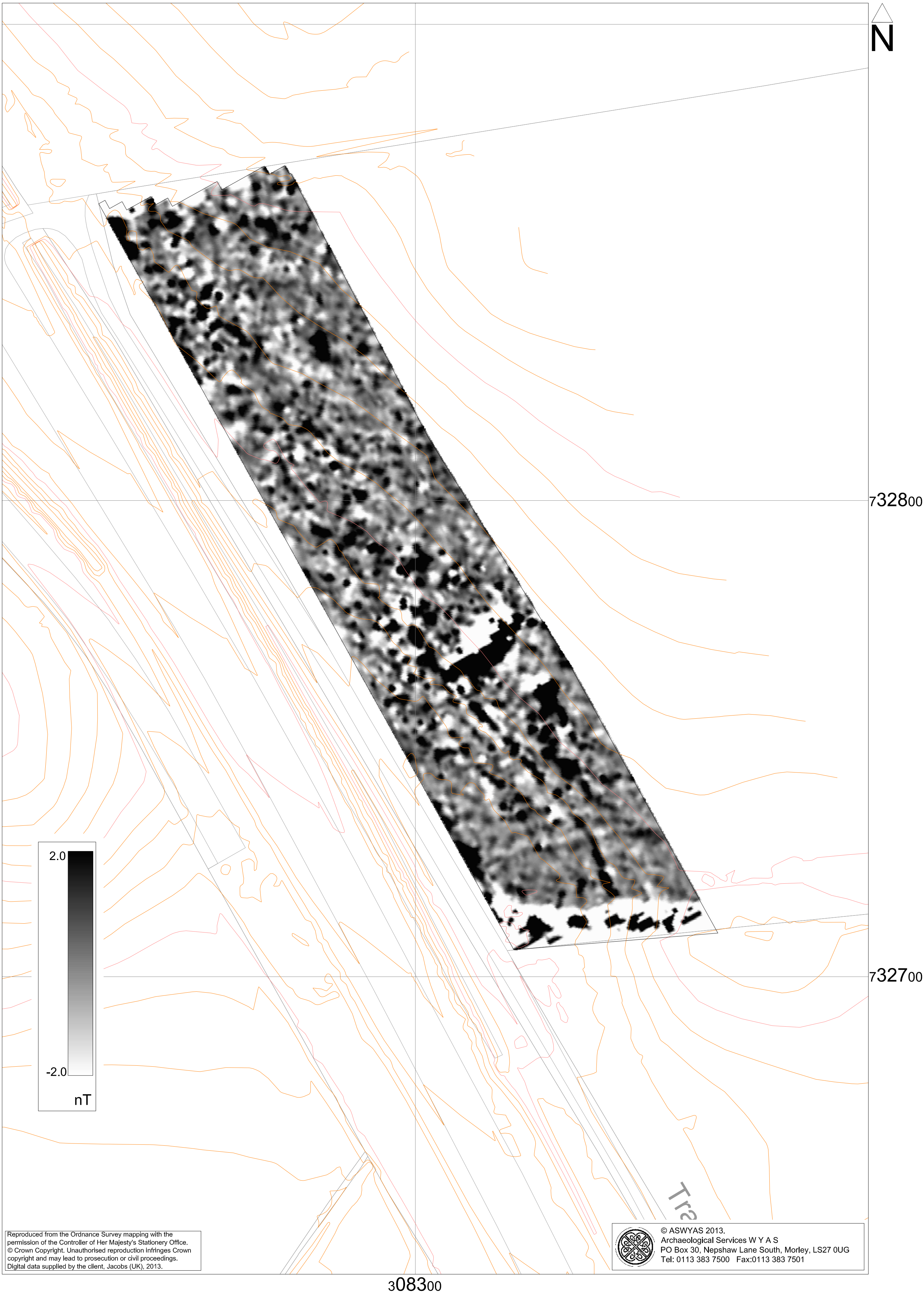

Fig. 24. Processed greyscale magnetometer data; Area 6, showing contour detail (1:1000 @ A4)

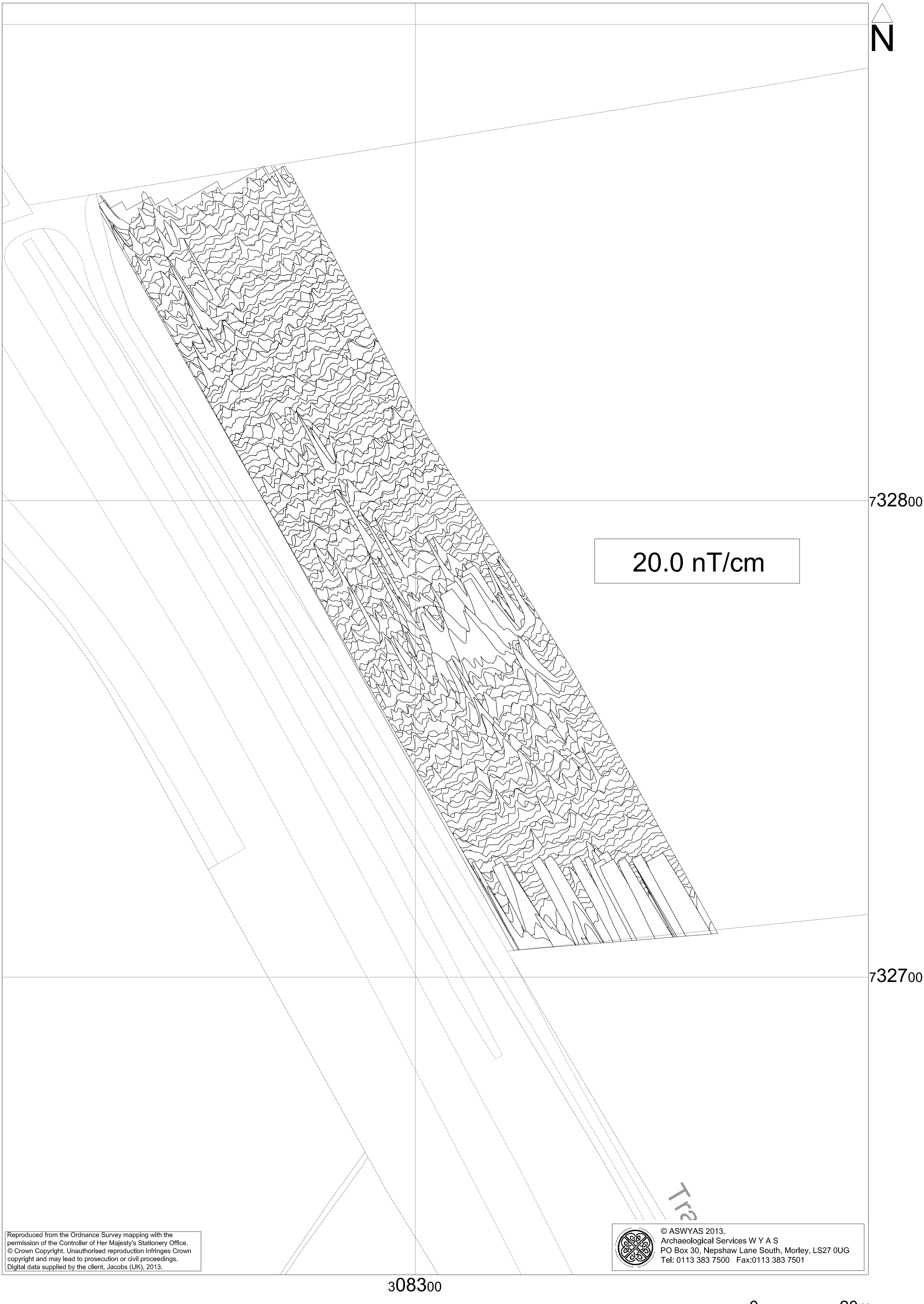

Fig. 25. XY trace plot of minimally processed magnetometer data; Area 6 (1:1000 @ A4)

0 20m

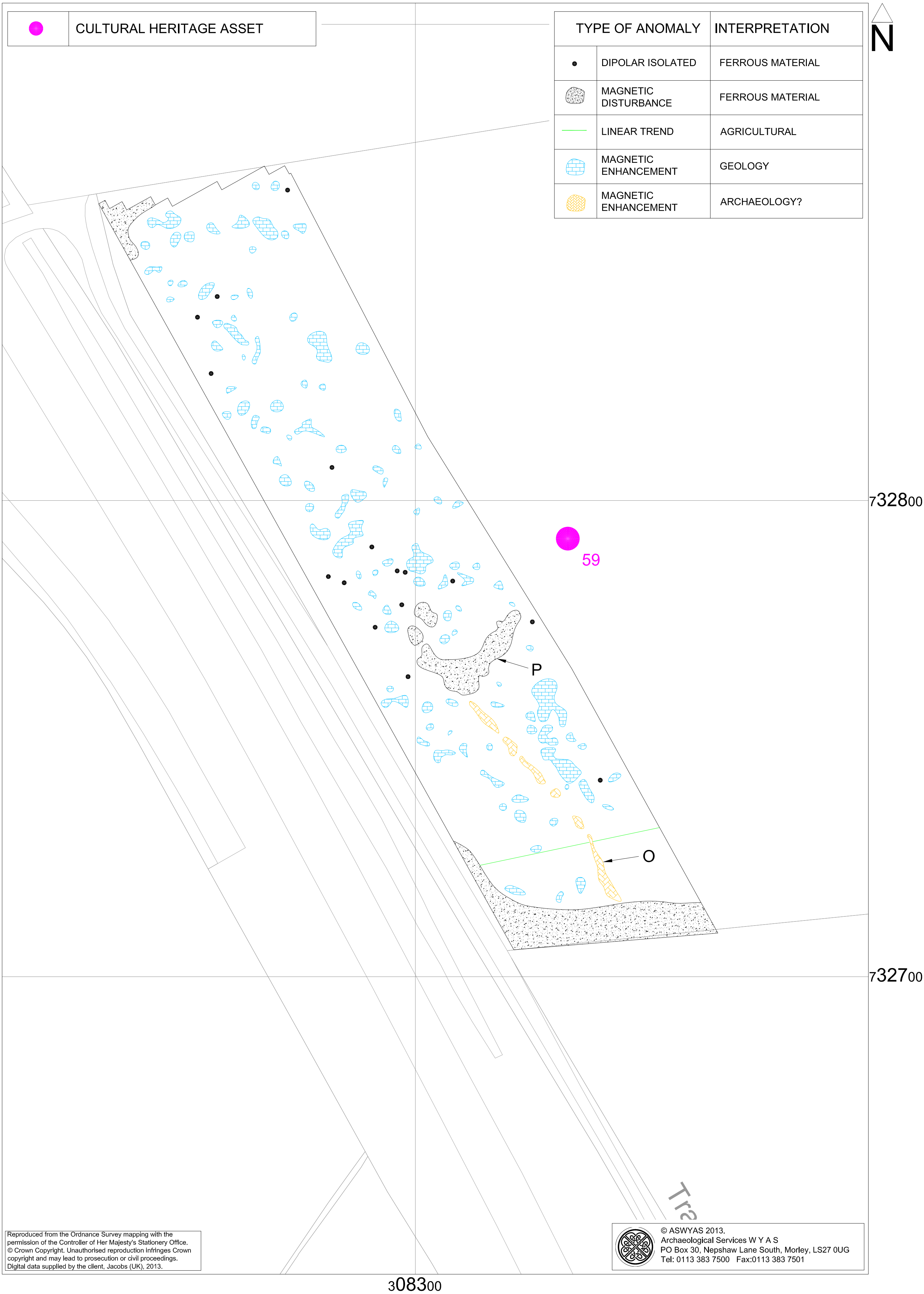

Fig. 26. Interpretation of magnetometer data; Area 6 (1:1000 @ A4)

Plate 1. General view of Area 1, looking south

Plate 2. General view of Area 2, looking south

Plate 3. General view of Area 3a, looking north

Plate 4. General view of Area 3b, looking south

Plate 5. General view of Area 4, looking south

Plate 6. General view of Area 5, looking south-east

Plate 7. General view of Area 6, 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 survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

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

Appendix 3: Geophysical archive

The geophysical archive comprises:-

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

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

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