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ARCHAEOLOGICAL
SERVICES
WYAS

# Carkin Moor Quarry
# Ravensworth
# North Yorkshire

*Geophysical Survey*

*Report No. 1560*

*July 2006*

CLIENT

Northern Archaeological Associates

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# Carkin Moor Quarry

# Ravensworth

# North Yorkshire

## Geophysical Survey

**Contents**




***Summary***

*A geophysical (magnetometer) survey covering approximately 3 hectares was carried out in advance of the proposed expansion of Carkin Moor Quarry, Ravensworth. The survey has identified at least two enclosures of unknown date and function. Other more general areas of enhanced magnetic readings suggest that archaeological activity may have been spread over a more extensive area but that ploughing may have degraded these remains.*


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## 1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned to carry out a geophysical (magnetometer) survey in advance of the proposed extension to a currently disused Victorian quarry at Carkin Moor, by Peter Cardwell of Northern Archaeological Associates. The site, north-east of Ravensworth and south of East Layton (see Fig. 1), was centred at NZ 1608 0820. The irregularly shaped survey area covered approximately 3 hectares and included both the proposed new extraction area and access haul road.

1.2 At the time of survey the majority of the site was set-aside with stubble from the last harvest. However, the south-eastern corner was covered in semi-scrub vegetation that in some parts was too high and dense for survey to be carried out (see Fig. 2). In order to compensate for the unsurveyable parts of the site the survey area was extended to the west following consultation with the client. No other problems were encountered during the fieldwork, which was carried out on July 18th and 19th 2006.

1.3 Topographically the site is thus located upon a low promontory at approximately 170m Above Ordnance Datum. The site slopes down south-westwards to the line of the A66, west towards Carkin Moor fort, and east towards a stream before it rising to Diddersley Hill and gently upwards to the north. The solid geology comprises a Sandstone island surrounded by Brigantian Limestone of the Alston Group (Institute of Geological Sciences 1979). This is overlain by Boulder clay and morainic drift. The soils are classified in the Brickfield 2 association with soils classified in the East Keswick 1 association immediately to the north and the Wick 1 association immediately to the south.

1.4 Prehistoric activity in the area is represented by a possible settlement north-west of the Roman fort but included within the same scheduling (SM 28289). Air photographs have revealed cropmarks suggesting another possible such settlement to the north-east of the proposed quarry (see Fig. 2).

1.5 To the south of the proposed development, the modern A66 is on the line of the Roman road from Scotch Corner to Brougham known as Watling Street. The Roman fort of Carkin Moor is a Scheduled Monument (SM 28289) bisected by the A66 (see Fig. 2).

1.6 The Yorkshire Dales Mapping Programme of 1989–93 has identified several areas of enclosed 'narrow rig' ridge and furrow and more are visible as cropmarks on air photographs, some in the survey area.

1.7 There are both sandstone and limestone quarries (and a lime kiln) to the south of the site, and the proposed development is itself an extension to a 19th century sandstone quarry. The original track to the existing quarry is now only evident as a hedgerow-lined earthwork. It is preserved as a 5m-wide boundary standing up to 1.2m high between fields.

1.8 Trial excavation in the field to the south of the existing quarry in 1999 as part of the A66 upgrade scheme identified a possible furrow base from ridge and furrow, confirming the results of a previous geophysical survey (Bishop 2005).

## 2. Methodology and Presentation of Results

2.1 Prior to the commencement of the survey a methodology for the geophysical survey was produced by Archaeological Services WYAS on behalf of Peter Cardwell of Northern Archaeological Associates.

2.2 The general objectives of the geophysical evaluation were:

- to identify any areas of possible archaeological interest
- to establish the presence, absence, extent and nature of any archaeological features within the defined survey area.

2.3 Detailed magnetometer survey employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on traverses 1m apart. These readings are stored in the memory of the instrument and are later downloaded to computer for processing and interpretation. A Bartington Grad601 magnetic gradiometer was used during the survey with readings being taken at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m grids. The readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation using Geoplot 3 software. Detailed survey allows the visualisation of weaker anomalies that may not have been identifiable by less rigorous techniques such as magnetic scanning or magnetic susceptibility survey.

2.4 The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David 1995) and by the IFA (Gaffney, Gater and Ovenden 2002). All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty's Stationery Office. © Crown copyright.

2.5 A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figure 2 shows the processed magnetometer data superimposed onto a digital map base at a scale of 1:5000. Figures 3 and 4 show the processed (greyscale) and unprocessed (XY trace plot) data whilst Figure 5 is an interpretation of the results. These three figures are all at a scale of 1:1000.

2.6 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 site 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.***

## 3. Results and Discussion (Figs 3, 4 and 5)

3.1 Numerous isolated dipolar anomalies ('iron spikes' - see Appendix 1) have been identified 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 often as a consequence of manuring. An area of magnetic disturbance is visible along the southern boundary of the survey. This is caused by wire fencing surrounding the quarry edge.

3.2 Several linear trend anomalies have been identified running in a north-west to south-east direction. The linearity and spacing between these anomalies suggests they are due to relatively modern ploughing rather than ridge and furrow ploughing. A former field boundary can also be seen in the data running in the same direction as the ploughing. Although this is no longer an extant boundary it does mark the physical boundary between the area of rough grazing and the area of set-aside.

3.3 Two enclosures have been identified within the survey area. Enclosure **A** is directly north of the quarry and is rectangular in shape being approximately 50m by 35m, the long axis being aligned from north-east to south-west. The enclosure is divided into two unequal parts, the southern compartment being the smaller. Immediately south of the main body of the enclosure an area of variable magnetic readings could be caused by magnetic material being ploughed out of the enclosure ditch. Indeed the absence of a continuous response from the ditch along the south-eastern edge of the enclosure is further evidence that there may have been substantial plough damage to the archaeology in this part of the site.

3.4 On the same basic alignment as Enclosure **A** and 80m to the south-east is Enclosure **B** which is located immediately north-east of the current quarry edge. The enclosure appears to be square in shape being approximately 25m by 25m, but the 19$^{th}$ century quarrying has destroyed much of the south-western corner of the enclosure. Discrete anomalies both within and immediately outside the enclosure to the north-east might also be indicative of archaeological features such as pits or small areas of burning.

3.5 Between the two enclosures a linear anomaly, **C**, again on the same basic alignment has been identified. To the south-east of this anomaly is a second large area where the magnetic background is extremely variable. Again it is possible that this variability is caused by the destruction of archaeological features by ploughing and the subsequent spreading of magnetically enhanced material. It should be noted that natural changes in the soils and geology may also account for the observed variability.

3.6 Throughout the survey area there are several small areas of magnetic enhancement as well as short linear anomalies, particularly to the north-western edge of the survey area. These anomalies might also be due to underlying archaeological features such as pits or ditches, especially given the proximity of more obviously archaeologically features. However, natural geological variation might also account for the anomalies.

3.7 To the south-east of the site a broad curvilinear anomaly can be seen. This anomaly is located at the base of a small slope and the strong readings obtained are thought to be due to the build-up of colluvium at the base of the slope. Other broad anomalies in this area are also thought to be due to geological variation.

## 4. Conclusions

4.1 The geophysical survey has demonstrated that at least two enclosures of unknown date and function are present on site although some of the archaeological activity may be outside the proposed extraction area. Other more general areas of enhanced magnetic readings suggest that archaeological activity may have been spread over a more extensive area but that ploughing may have degraded these remains. The focus of this activity seems to on the highest point of the site.

4.2 On the basis of the magnetometer survey the archaeological potential of the area of proposed extraction is quite high. The archaeological potential along the route of the haul road is considered to be low.

***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.***

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## Acknowledgements

### Project Management

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### Fieldwork

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### Report

T. S. Harrison

### Graphics

K. Munster

## Figures



## Appendices

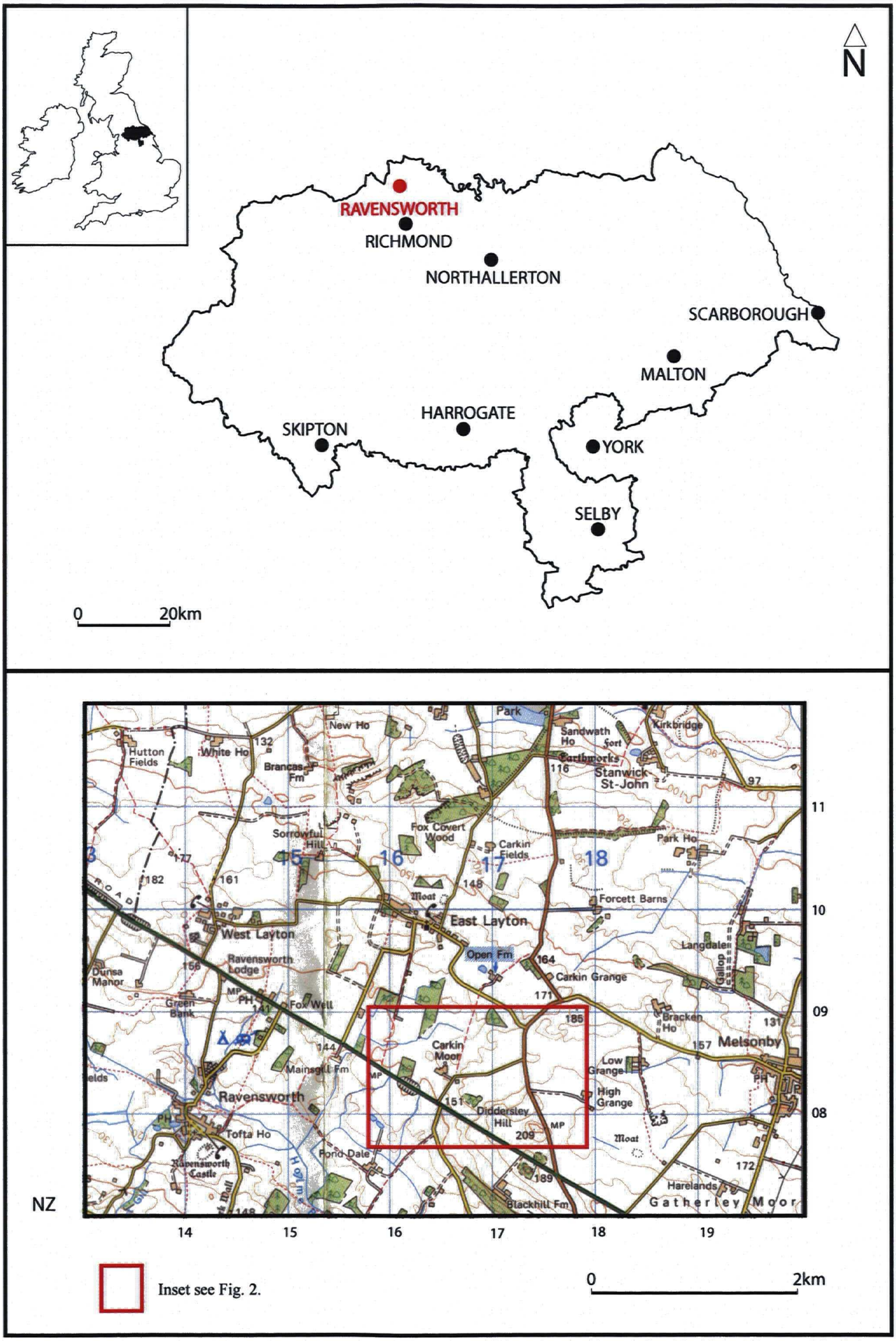


*Fig. 1. Site location*


*Fig. 2. Site location showing greyscale magnetometer data (1:5000 @ A3)*

0 200m


*Fig. 3. Processed greyscale magnetometer data (1:1000 @ A3)*


*Fig. 4. XY trace plot of unprocessed magnetometer data (1:1000 @ A3)*

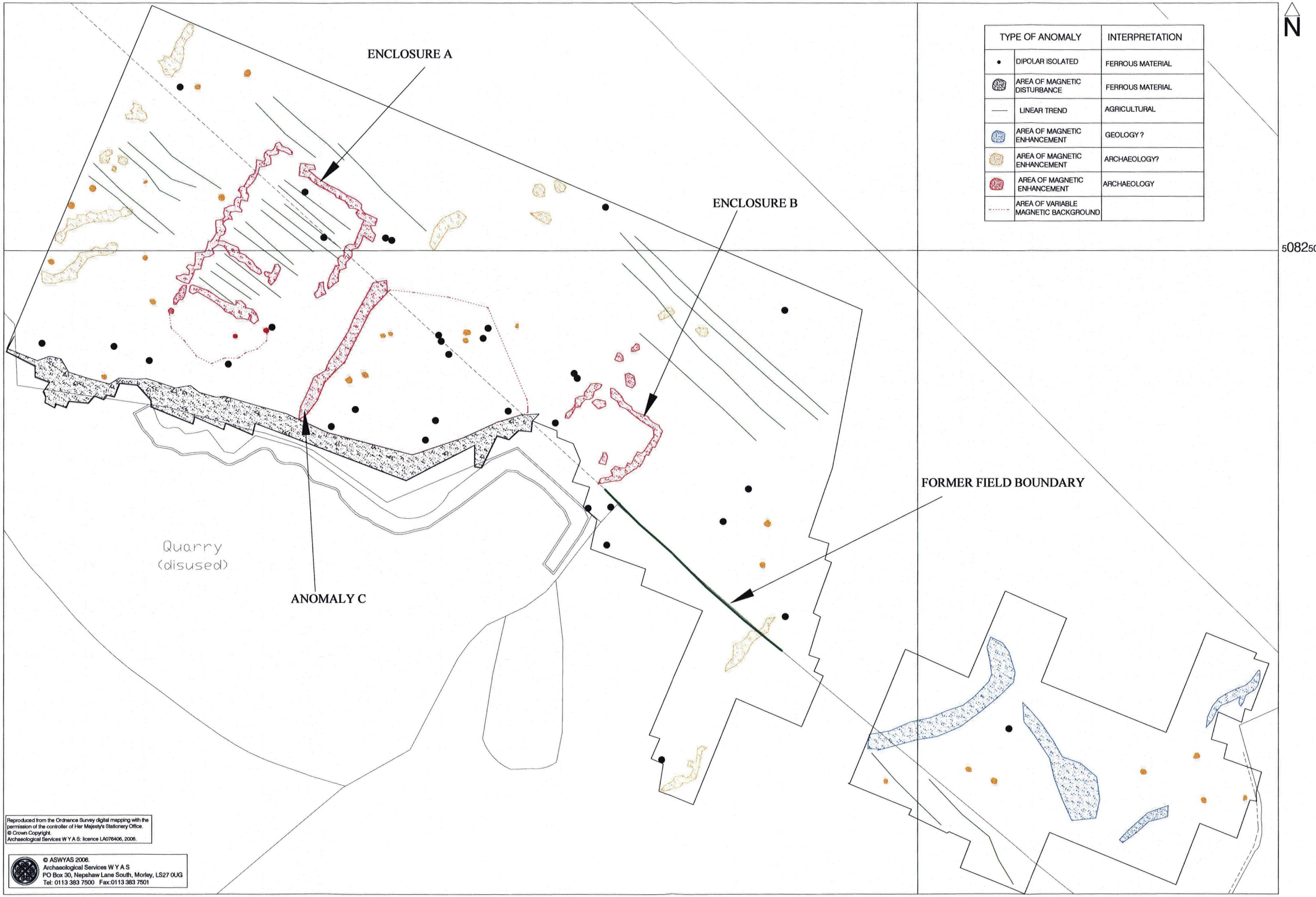


*Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)*

# *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 negative results from magnetic scanning should be checked with at least a 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 0.5m or 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 field gradiometer was used. Readings were taken, on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m square grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

**Data Processing and Presentation**

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been selectively filtered.

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 at 10nT. 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 1600 readings were obtained for each 20m by 20m 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 permanent structures. The survey grids were then superimposed onto an Ordnance Survey digital map base using common boundary walls and other fixed points. 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 ±1.0m. 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. Local grid co-ordinates can be supplied if required.

| Station | Easting | Northing |
|---|---|---|
| A | 416904.372 | 508331.563 |
| B | 417100.519 | 508137.611 |
| C | 416816.898 | 508194.995 |

***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 (Word 2000), and graphics files (CorelDraw6 and AutoCAD 2000) 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).