North Doncaster Technology College
Adwick-le-Street
Doncaster

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering approximately 6.3 hectares was undertaken on playing fields at North Doncaster Technology College, Adwick-le-Street, as part of pre-determination evaluation works to accompany a planning application. Large areas of high magnetic disturbance have been identified throughout the survey area due to the nature of land use and the close proximity of school buildings and fencing. However, linear anomalies on the same alignment as cropmarks to the north of the site have been identified less than 100m from an area in which Saxon burials have recently been uncovered.

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Report Information

Client:	Faber Maunsell, 2 City Walk, Leeds, LS11 9AR
Report Type:	Geophysical survey
Location:	North Doncaster Technology College, Adwick-le-Street
County:	South Yorkshire
Grid Reference:	SE 536 083
Period(s) of activity represented:	Unknown
Report Number:	1945
Project Number:	3410
Site Code:	DOS09
Planning Application No.:	Pre-determination
Museum Accession No.:	-
Date of fieldwork:	March 2009
Date of report:	April 2009
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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Matthew Parker of Faber Maunsell on behalf of their clients Cyril Sweet Ltd. to undertake a geophysical (magnetometer) survey on playing fields at North Doncaster Technology College (see Fig. 1), as part of pre-determination evaluation works to accompany a planning application.

Site location and topography

The survey covered approximately 6.3 hectares across generally flat playing fields surrounding the school (see Fig. 2), centred at SE 536 083. Area A was located to the south-west of the current school buildings although part of the area was unsuitable for survey due to ongoing building works (see Fig. 2). Areas B and C were to the east of the school located on the sports field. Area D comprised an all weather pitch.

Soils, geology and land-use

The geology of the area consists of the Brotherton Formation in the Upper Magnesian Limestone group (BGS 1976). The soils in this area are classified as unsurveyed (Soil Survey of England and Wales 1983).

At the time of survey the site comprised grassed and man-made playing surfaces.

2 Archaeological and Historical Background

An archaeological desk-based assessment undertaken for the proposed development identified 55 archaeological sites within the 1km study area of which two are located within the site boundary (see Fig. 2). Most significantly a number of Saxon burials dating from the 5th to the 9th centuries were discovered during construction work at SE 5356 0821 in the area immediately east of Area A. A Roman coin has also been found at SE 5350 0830 to the north of the site (Faber Maunsell 2008).

3 Aims and Objectives

The general aim of the geophysical survey was to establish and clarify the potential of archaeological features within the survey boundary as part of pre-determination evaluation works to accompany a planning application.

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 those areas identified for survey.

These aims were to be achieved by undertaking detailed (recorded) magnetometer survey over all the playing fields surrounding North Doncaster Technology College.

4 Methodology

Magnetometer survey

A Bartington Grad601 magnetic gradiometer was used to take readings at 0.25m intervals on zig-zag (east-west) 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 (recorded) 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 and the location of the recent archaeological discoveries in relation to the survey areas. The processed and 'raw' (unprocessed) magnetometer data from the survey, together with interpretations of the identified magnetic anomalies, are presented at a scale of 1:1000 in Figures 3 to 8 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

Area A (Figs 3, 4 and 5)

Running through Area A, aligned north-north-west/south-south-east is a strong linear dipolar anomaly caused by a ferrous service pipe. There are several other large areas of magnetic disturbance either caused by ferrous material within the topsoil/subsoil and/or the proximity of school buildings and boundary perimeter fences.

Several other discrete dipolar ‘iron spike’ anomalies are seen throughout all the survey areas. These are indicative of ferrous objects or other magnetic material in the topsoil/subsoil. Although archaeological artefacts may cause them, they are more often caused by modern cultural debris that has been introduced into the topsoil. At the northern end of the area the magnetic background is extremely variable, giving the data a characteristically speckled or mottled appearance. It is considered possible that this is due to the presence of magnetic material in imported topsoil although it might be due to natural variations in the composition of the soils.

Four discontinuous linear anomalies have been identified in Area A. At the northern end of the area two possibly intersecting anomalies, **A** and **B** can be seen. Anomaly **B** is aligned south-west/north-east with Anomaly **A** perpendicular to this.

At the southern end of the area two further anomalies are also present. Anomaly **C** is on the same alignment as Anomaly **A**. Twenty five metres to the south is a curvilinear anomaly, **D**. All four anomalies are interpreted as potentially archaeological being caused by infilled ditch features. The proximity of the Saxon burials gives added confidence to an archaeological interpretation. All four anomalies appear to continue beyond the site boundary both to the east and west. Anomalies **B** and **C** are on the same alignment as cropmarks to the north of the site (see Fig. 2).

Several discrete areas of magnetic enhancement can be seen throughout the site. Whilst these anomalies are probably due to variations or inclusions within the topsoil/subsoil an archaeological interpretation cannot be dismissed particularly due to the proximity of the Saxon graves.

Three linear responses, probably agricultural in nature have been identified to the south-west of the survey area.

Area B and Area C (Figs 6, 7 and 8)

In Area B numerous areas of strong magnetic disturbance have been identified throughout the survey area. All are due either to sports equipment (goalposts, concrete cricket wickets, long jump pit), ferrous perimeter fencing and the proximity of school buildings.

Several linear anomalies cross the area. However, with the exception of three, **E, F** and **G**, all are interpreted as modern in origin being related to drainage or services. Anomaly **E** broadly aligns with Anomaly **B** in Area A and it is perpendicular to Anomaly **F** which runs north-west/south-east about 25m to the east. On the same alignment as **F** to the south-west is Anomaly **G.**

Only strong magnetic disturbance due to the close proximity of surrounding buildings/fences can be discerned in Area C.

Area D (see Fig. 2)

At the request of the client this area was rapidly scanned but again only strong ferrous responses could be identified.

6 Discussion and Conclusions

Several anomalies of possible archaeological significance have been identified within the survey areas, particularly in Area A, adjacent to the location of the recorded Saxon burials. Two linear anomalies in Area B might also be archaeological in nature but here the interpretations should be viewed as more tentative.

Given the proximity of archaeological remains and the possible archaeological anomalies identified in the magnetometer survey it is considered that this area has a fairly high archaeological potential.

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

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

Station	Easting	Northing
A	453614.1	408088.0
B	453663.7	408123.9
C	453609.1	408117.1
D	453867.2	408284.6

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 CS 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).

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