GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services

SUMO Group Member

Project name:

Norton Bridge, Staffordshire

Client:

Atkins

November 2013

Job ref:

J3362

Report author:

Thomas Richardson MSc

GEOPHYSICAL SURVEY REPORT

Project name:
Norton Bridge, Staffordshire
Client:
Atkins

Job ref:
J3362

Techniques:
Detailed magnetic survey – Gradiometry

Survey date:
1st-7th August, 27th August - 3rd September, 21st-25th October

Site centred at:
SJ 870 300

Post code:
ST15 0NT

Field team:
Robert Knight BSc(Hons), **John Pykett, Adam Green, Steven Chetwynd, Ben Stevens, Andrew Bateman** BSc(Hons)

Project manager:
Simon Haddrell BEng(Hons) AMBCS PIFA

Report written By:
Thomas Richardson MSc

CAD illustrations by:
Thomas Richardson MSc

Checked by:
David Elks MSc AIFA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 28.1 hectares of mixed agricultural and grassland. The survey identified former field boundaries or enclosures and an area of ridge and furrow cultivation as the only anomalies of probable archaeological origin. A number of possible archaeological anomalies have also been identified; however these are likely to be of agricultural or geological origin. The majority of the anomalies identified are modern, relating to underground services, agricultural activity, land drains, made ground, scattered magnetic debris and fencing.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by Atkins.

2.2 Site location

The site is located to the north west of Stafford at OS ref. SJ 870 300 (Fig. 01).

2.3 Description of site

The survey area is approximately 30.1 hectares of mixed agricultural land, of which 2 hectares could not be accessed. The area is split into 20 parcels (Figs. 01 & 02); Table 01 shows the conditions of the ground at the time of survey and any obstructions.

Table 01. Land use and obstructions

Parcel	Ground	Obstructions
G001	Grassland	None
G002	Recently Sown Crop	None
G003	Cut Crop/Grassland	Area flooded in south
G004	Grassland	None
G005	Cut Crop/Grassland	None
G006	Cut Crop	None
G007	Grassland	None
G008	Cut Crop	None

G009	Grassland	None
G010	Grassland	Wooden frames
G011	N/A	No access arranged
G012	Grassland	Overgrown vegetation across whole area
G013	Grassland	None
G014	Cut Crop	Trench excavated for pipe
G015	Grassland	No access to western area – fenced off
G016	Grassland	None
G017	Grassland	No access to eastern field
G018	Grassland	None
G019	Grassland	Areas of flooding
G020	Grassland	None

2.4 *Geology and soils*

The underlying geology is Mercia Mudstone Group – Mudstone and Halite-stone (British Geological Survey website). The drift geology for parcels G001, G002 and G020 is Glaciofluvial Sheet Deposits, Devensian – Sand and Gravel. Parcels G003, G004 and G005 are covered by Alluvium – Clay, Silt, Sand and Gravel. The remaining parcels have no recorded drift geology (British Geological Survey website).

The overlying soils for all of the parcels except G020 are known as Brockhurst 2, which are typical stagnogley soils. These consist of reddish fine loamy over clayey soils, some reddish clayey alluvial soils. G020 has overlying soils known as Wigton Moor, which are typical cambic gley soils. These consist of fine and coarse loamy soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

The historic background of the site was established by a previous heritage assessment (Temple 2011) summarised below:

There is potential for Palaeolithic deposits to be present within any identified deep gravel deposits, based on precedents recorded elsewhere in Staffordshire and the Midlands. Recent work within the river valleys of the Trent, Tame and Dove highlight the potential for later prehistoric funerary/ ceremonial and settlement remains in similar landscape contexts. Late Neolithic or Early Bronze Age stray finds in the vicinity of the route at Cold Norton may indicate the potential for prehistoric settlement, likely to be ephemeral in nature. A possible later prehistoric bank and ditch at Cold Norton Farm may indicate the potential for settlement of this period in the broader study area. A potential late prehistoric or Romano-British enclosure has been recorded along the route of the Proposed Scheme.

Possible deserted medieval settlements are recorded at Cold Norton and Worston including areas of ridge and furrow cultivation which have been recorded in the broader study area. Post-medieval field boundaries represent agriculture along the route, along with an 18th-19th century water meadow system, identified towards the south of the Proposed Scheme. The historic landscape is characterised by piecemeal enclosure of 16th-18th century date to the west and planned enclosures of 18th or 19th century date to the east.

To the south of the proposed scheme a water mill and silk mill has been recorded at Worston, together with a corn mill further south at Great Bridgeford.

There may be potential for archaeological and palaeo-environmental deposits from the prehistoric to the post-medieval periods to be buried beneath alluvial deposits associated with the Meece Brook and its confluence with the River Sow.

The first phase of geophysical survey was conducted by ArcheoPhysica in 2012 (CgMs 2012, Temple 2012) covering two-thirds of the scheme footprint. The survey identified areas of ridge and furrow cultivation and former field boundaries.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological origin in order that they may be assessed prior to development.

2.7 Survey methods

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included and in Appendix A.

2.8 Processing, presentation and interpretation of results

2.8.1 Processing

Processing is performed using bespoke in-house software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all minimally processed gradiometer data used in this report:

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)

2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

2.8.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the minimally processed data both as a colour plot showing extreme magnetic values (Figs 3-6) and a greyscale plot (Figs. 7-10). Magnetic anomalies have been identified and plotted onto the Interpretation drawings for the site (Figs 11-14).

3 RESULTS

The detailed magnetic gradiometer survey conducted at Norton Bridge has identified a number of anomalies that have been characterised as being either of a *probable* or *possible* archaeological origin.

The difference between *probable* and *possible* archaeological origin is a confidence rating. Features identified within the dataset that form recognisable archaeological patterns or seem to be related to a deliberate historical act have been interpreted as being of a probable archaeological origin.

Features of possible archaeological origin tend to be more amorphous anomalies which may have similar magnetic attributes in terms of strength or polarity but are difficult to classify as being archaeological or natural.

The following list of numbered anomalies refers to numerical labels on the interpretation plots (Figs. 11-14).

3.1 *Probable Archaeology*

1 Positive linear anomalies in G002. These are indicative of former cut features and may be related to field boundaries or enclosures. It is possible that these relate to Anomaly 20 in the report by ArcheoPhysica(CgMs 2012, Temple 2012). (Fig.11)

2 Widely spaced curving parallel linear anomalies in G009. These are indicative of ridge and furrow cultivation. (Fig.13)

3.2 *Possible Archaeology*

3 Positive linear anomalies across much of the site. These are indicative of former cut features and may be of archaeological origin; however an agricultural origin would be likely for the majority. (Figs. 11-14)

4 Negative linear anomalies in G018 and G020. These anomalies are indicative of former bank or earthwork features and may be of archaeological origin; however an agricultural origin would be likely. (Fig. 14)

5 A positive linear anomaly with an associated negative response in G019. This is indicative of a former banked ditch feature and may be related to a former field boundary. However it is not possible to discount the possibility of a geological origin. (Fig 14)

3.3 *Other Anomalies*

6 Closely spaced parallel linear anomalies in G006 and G010. These are related to modern agricultural activity, such as ploughing. (Figs. 12-13)

7 Areas of magnetic variance in G003, G004, G005 and G017. These anomalies are likely to be of geological or pedological origin. (Figs. 11, 12 & 14)

8 Moderate strength bipolar linear anomalies in G002. These anomalies are related to land drains. (Fig. 11)

9 High amplitude bipolar linear anomalies across several areas. These are indicative of underground services. (Figs. 11-13)

10 Areas of high amplitude dipolar responses in G003, G018 and G019. These are indicative of modern made ground. (Figs. 11 & 14)

11 Areas of scattered magnetic debris in G002, G008, G009 and G010. These are likely to be of modern origin. (Figs. 11-13)

12 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences. These effects can mask weaker archaeological anomalies. (Figs 11-14)

13 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish. (Figs. 11-14)

4 CONCLUSION

The survey at Norton Bridge identified little in the way of archaeology, with an area of former field boundaries or enclosures and an area of ridge and furrow cultivation being the only probable archaeological features. A number of possible archaeological anomalies have also been identified; however the majority of these are likely to be of agricultural or natural origin.

The remaining anomalies are all of modern or geological origin, with much of the centre of the site covered by underground services and associated magnetic disturbance. It is possible that this disturbance is masking weaker archaeological anomalies. The other modern anomalies identified on the site relate to agricultural activity, land drains, made ground, scattered magnetic debris and fencing.

5 REFERENCES

British Geological Survey South Sheet, 1977. *Geological Survey Ten Mile Map, South Sheet First Edition* (*Quaternary).* Institute of Geological Sciences.

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid)*. British Geological Society.

British Geological Survey, n.d., *website*: (http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps) Geology of Britain viewer.

CgMs, 2012. Stafford Area Rail Improvement Scheme: geophysical survey report

Temple, 2011. *Stafford Area Improvements, Norton Bridge Grade separation Scheme: heritage assessment*

Temple, 2012. *The Network Rail (Norton Bridge Area Improvements) Order, Environmental Statement Vol 3, Report 12: archaeology and cultural heritage technical report*

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 3 Midland and Western England*.

English Heritage, 2008. *Geophysical Survey in Archaeological Field Evaluation.*

Institute For Archaeologists. *Standard and Guidance for Archaeological Geophysical Survey.* http://www.archaeologists.net/sites/default/files/nodefiles/Geophysics2010.pdf

APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or a Leica Smart Rover RTK GPS.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

Data capture

The readings are logged consecutively into the data logger which in turn is daily down- loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

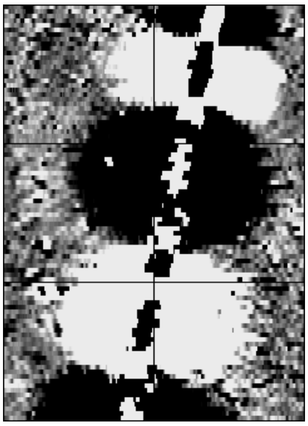
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

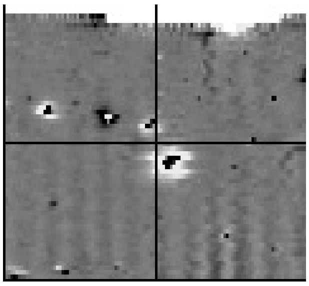
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

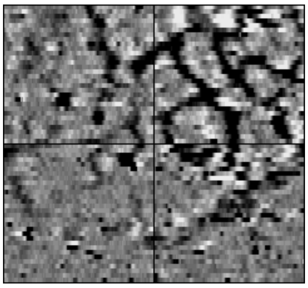


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

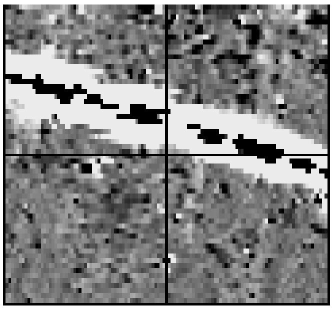
See bipolar and dipolar.

Positive linear



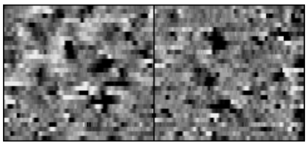
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



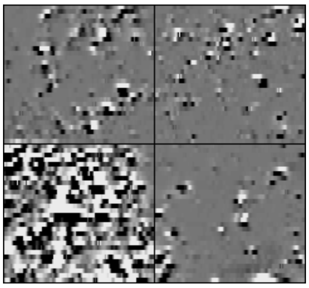
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



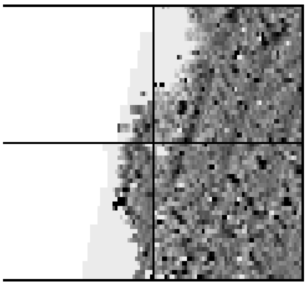
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



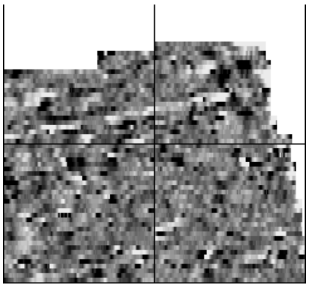
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

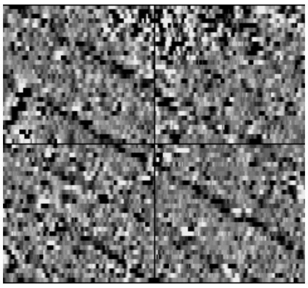


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing, clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

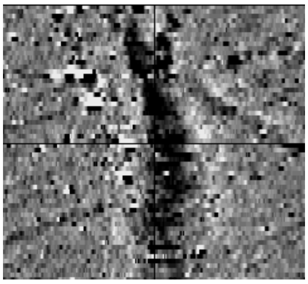
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a $10m^2$ area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.

STRATASCAN LTD
Vineyard House Upper Hook Road Upton upon Severn
Worcestershire WR8 0SA United Kingdom

T:0 1684 592266 F: 01684 594142
info@stratascan.co.uk www.stratascan.co.uk