GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Group Member

Project name:

Ashton Under Hill, COSMIC

Client:

Worcestershire County Council

March 2014

Job ref:

J6429

Report author:

Thomas Richardson MSc AIFA

GEOPHYSICAL SURVEY REPORT

Project name:
Ashton Under Hill, COSMIC
Client:
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Job ref:
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Techniques:
Detailed magnetic survey – Gradiometry

Survey date:
11th February

Site centred at:
SO 998 376

Post code:
WR11 7SX

Field team:
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over twenty five 30mx30m grids of agricultural land. The grids targeted known crop marks for further investigation. The survey has shown a good correlation between the geophysical data and the known crop marks. A number of anomalies that are likely to be associated with the crop marks have been identified. A probable former enclosure, not shown by any crop marks has also been identified.

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 Worcestershire County Council.

2.2 *Site location*

The site is located in Ashton Under Hill, Worcestershire at OS ref. SO 998 376.

2.3 *Description of site*

The survey covered twenty five 30x30m grids spread over an area of agricultural land in the south of Ashton Under Hill. The survey area is generally flat with no obstructions.

2.4 *Geology and soils*

The underlying geology is Charmouth Mudstone Formation - Mudstone (British Geological Survey website). The drift geology is Head – Clay, Silt, Sand and Gravel (British Geological Survey website).

The overlying soils for the majority of the site are known as Denchworth which are typical pelo-stagnogley soils. These consist of clayey soils with similar fine loamy over clayey soils. Grids 20-22 are covered by Evesham 2, which are typical calcareous pelosols. These consist of calcareous clayey soils, some non-calcareous clayey and fine loamy or silty over clayey soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

The survey is targeted over a number of known crop marks.

2.6 *Survey objectives*

The objective of the survey was to locate any features of possible archaeological origin.

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 in Appendix A.

2.8 *Processing, presentation and interpretation of results*

2.8.1 Processing

Processing is performed using specialist 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 greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Ashton Under Hill has identified a number of anomalies that have been characterised as being of a *probable* 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.

Grids 1-3
A number of positive linear anomalies indicative of former cut features have been identified in this area. All but one of these anomalies correlate with the known crop marks. The single anomaly that does correlate with a known crop mark is likely to be part of the same feature as it shares a similar orientation.

Grids 4-5
A number of curvi-linear positive anomalies have been identified, a number of which relate to known crop marks. These anomalies are indicative of former cut features. Six anomalies have been identified that do not correlate with any crop marks. These are likely to be of archaeological origin.

Grids 6-8
A number of positive linear anomalies have been identified. These are indicative of former cut features and are likely to be related to a former enclosure or field boundaries. A small discrete positive anomaly has also been identified. This is indicative of a small former cut feature, such as a backfilled pit, and is likely to be of archaeological origin.

Grids 9-11
Positive linear anomalies relating to the known crop marks have been identified. Five additional positive linear anomalies have been identified. These are indicative of former cut features and are likely to be of archaeological origin. A small discrete positive anomaly has also been identified. This is indicative of a small former cut feature, such as a backfilled pit, and is likely to be of archaeological origin. Two negative linear anomalies are indicative of former bank or earthwork features and are likely to be of archaeological origin.

Grids 12-14
Positive and negative linear anomalies as well as a small discrete positive anomaly have been identified as relating directly to the crop marks. A further three positive anomalies and two small discrete positive anomalies not correlating with any known crop marks have also been identified. These are indicative of cut features, such as ditches or backfilled pits, and are likely to be of archaeological origin. A single dipolar 'magnetic spike' can be seen, this is likely to be related to modern ferrous debris.

Grids 15-16
Five positive linear anomalies and four discrete positive anomalies relating to known crop marks have been identified. A single negative linear anomaly has also been identified. This is indicative of a former bank or earthwork feature and is likely to be of archaeological origin.

Grids 17-18
A single positive anomaly relating to crop marks has been identified. Five positive linear anomalies, indicative of former cut features, have also been identified and are likely to be of archaeological origin. A small discrete positive anomaly has also been identified. This is indicative of a small former cut feature, such as a backfilled pit, and is likely to be of archaeological origin.

Grids 19-21

A number of positive linear anomalies relating to crop marks have been identified. A single positive linear anomaly, indicative of a former cut feature, has also been identified and is likely to be of archaeological origin. Widely spaced curving parallel linear anomalies, indicative of ridge and furrow cultivation, can also be seen.

Grid 22

Three positive linear anomalies related to crop marks have been identified. An addition positive linear anomaly with the same orientation has also been identified. These anomalies are all indicative of former cut features and are likely to be of archaeological origin.

Grids 23-25

Positive and negative linear anomalies relating to crop marks have been identified. An additional five positive linear anomalies have been identified. These anomalies are indicative of former cut features and a re likely to be of archaeological origin.

4 CONCLUSION

The survey at Ashton Under Hill has shown a good correlation between the geophysical data and the known crop marks across the site. A number of anomalies that do not directly correlate with any crop marks but are likely to be associated have been identified. This is particularly evident in Grids 9-11. There are also a number of anomalies identified that have no relation to the crop marks. This is evident in Grids 6-8, where a probable former enclosure with associated pit feature has been identified.

5 REFERENCES

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

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

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

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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.

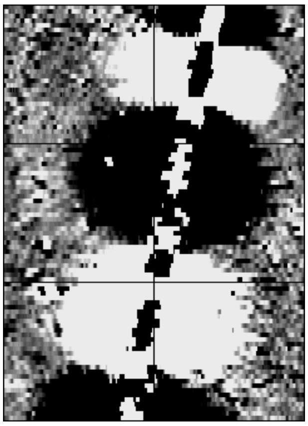
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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.

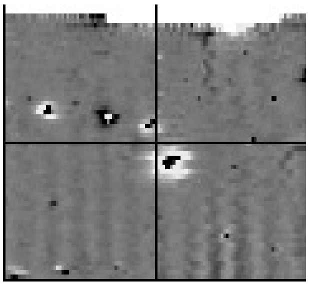
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

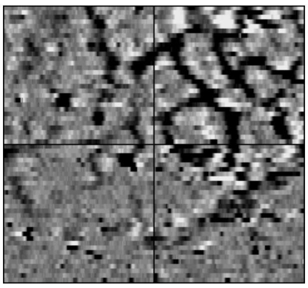


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

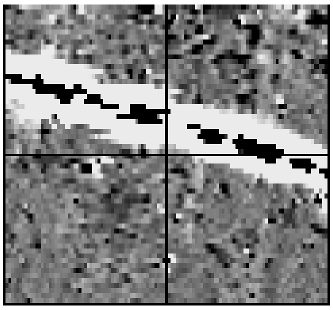
See bipolar and dipolar.

Positive linear



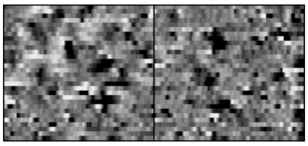
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



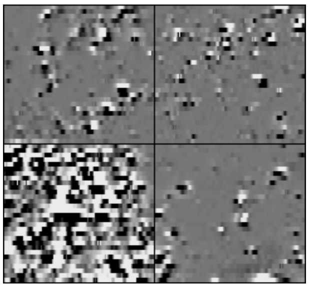
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



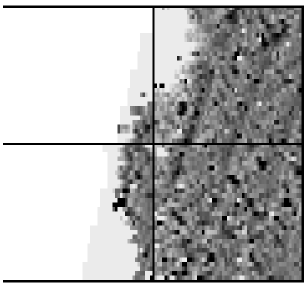
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



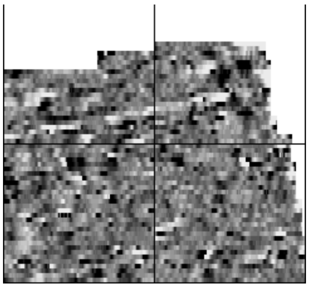
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-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

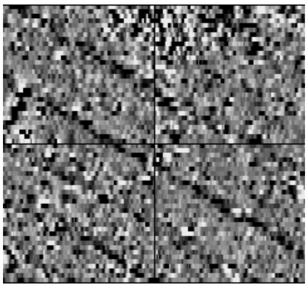


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

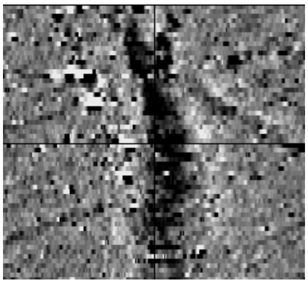
Strength of response

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.

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