GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services

SUMO Group Member

Project name:

Devil's Dyke Hillfort, West Sussex

Client:

John Moore Heritage Services

February 2016

Job ref:

J9470

Report author:

Thomas Richardson MSc ACIfA

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Devil's Dyke Hillfort, West Sussex
Client:
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Earth Resistance

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1 SUMMARY OF RESULTS

Detailed gradiometry and earth resistance surveys were conducted over approximately 0.5 hectares of grassland. The surveys have identified a small number of ditches in the east of the area, including a possible ring ditch, as well as two areas of possible compacted ground that may relate to former ground surfaces. Other linear and discrete anomalies, possibly relating to archaeological features, have been identified across the site however they could equally be modern or natural in origin. The remaining anomalies relate to areas of waterlogging and modern features. The modern features include ferrous objects and magnetic disturbance from buildings and fencing.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey as part of an archaeological investigation being undertaken by John Moore Heritage Services.

2.2 Site location

The site is located to the west of Devil's Dyke Road, Brighton, West Sussex at OS ref. TQ 257 108.

2.3 Description of site

The survey area is approximately 0.5 hectares of grassland, with a small area of woodland at the eastern end which is unsurveyable. The site is a 20m wide strip inside of the ramparts forming part of Devil's Dyke Hillfort. The hillfort is a Scheduled Ancient Monument and a Section 42 licence was obtained prior to carrying out the survey.

2.4 Geology and soils

The underlying geology is Lewes Nodular Chalk Formation – chalk, whilst the east is covered by Seaford Chalk Formation – chalk (British Geological Survey website). There is no recorded drift geology (British Geological Survey website).

The overlying soils are known as Andover 1, which are typical brown rendzinas. These consist of calcareous silty soils over chalk (Soil Survey of England and Wales, Sheet 6 South East England).

2.5 *Site history and archaeological potential*

The site runs along the internal side of a bank which forms part of the southern side of the Scheduled Monument of Devil's Dyke Hillfort (Monument Number 1014953). The monument includes a univallate Iron Age hillfort enclosing approximately 14 hectares. The fort is roughly rectangular on north-east to south-west alignment defended by a large bank and external ditch. Excavations within the fort have uncovered a round house, refuse pits, and human burials (Historic England 1996).

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 Chartered Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey.*

A combined magnetic and earth resistance survey (gradiometry) was used as an effective method of maximising the archaeological information that can be found across the site. More information regarding this technique is included in Appendix A.

2.8 *Processing, presentation and interpretation of results*

2.8.1 *Processing*

Gradiometer

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)

Earth Resistance

The processing was carried out using specialist software known as Geoplot 3 and involved the 'despiking' of high contact resistance readings.

The following schedule shows the processing carried out on the processed resistance plots.

Despike	X radius = 1
	Y radius = 1
	Spike replacement

2.8.2 *Presentation of results and interpretation*

Gradiometer

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.

Earth Resistance

The presentation of the data for the site involves a print-out of the processed data as a grey scale plot. Anomalies have been identified and plotted onto the ‘Abstraction and Interpretation of Anomalies’ drawing.

3 RESULTS

The survey at Devil’s Dyke Hillfort has identified a number of anomalies that have been characterised as being of a *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 labels on the interpretation plots.

3.1 **Gradiometer**

3.1.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.1.2 Possible Archaeology

1 Two curved parallel linear anomalies in the east of the site. These may form one continuous anomaly, however magnetic disturbance is obscuring the area. These are indicative of former cut features, and may relate to a former ring ditch. Magnetic disturbance and constraints of the survey area make a more confident interpretation difficult.

2 Two positive linear anomalies, one in the east of the area and one in the west. These are likely former cut features, and may be of archaeological or agricultural origin.

3 Three small discrete positive anomalies. These are likely small cut features, such as back filled pits, and may be of archaeological or relate to natural pitting in the chalk bedrock.

4 Areas of positive responses across the site. These could relate to former cut features and be of archaeological origin. However, they could equally relate to modern magnetic disturbance or geological variation.

3.1.3 Medieval/Post-Medieval Agriculture

No medieval or post-medieval agriculture has been identified within the survey area.

3.1.4 Other Anomalies

5 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can mask weaker archaeological anomalies.

6 A number of magnetic ‘spikes’ (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

3.2 ***Earth Resistance***

3.2.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.2.2 Possible Archaeology

A Low resistance linear anomalies in the centre of the site. These are likely to be areas of looser soil or retaining more water, such as ditches. These may relate to archaeological ditch features.

B A sub-circular high resistance anomaly with a low resistance anomaly at the centre. The exact origin of this anomaly is unknown, however it may relate to an area of compacted ground or stone with a pit at the centre. This may be of archaeological origin.

C Two discrete low resistance anomalies in the east of the site. These are likely areas of increased moisture or looser soil, indicative of former pit features. These may be archaeological or natural in origin.

D An area of high resistance in the west of the site. This may relate to an area of compacted earth or stone, such as a former floor surface, however it could equally be natural in origin.

E A discrete high resistance anomaly in the west of the site. This is likely related an area of drier ground due to faster draining soil. This may relate to an archaeological pit feature or be natural in origin.

F Areas of high resistance across the centre and east of the site. These are indicative of areas of drier or more compact ground. The may be of archaeological or natural origin.

3.2.3 Other Anomalies

G Areas of low resistance responses. These are caused by waterlogging in the area and may mask archaeological responses.

3.3 *Correlation of Results*

There is generally little correlation between the gradiometer and earth resistance survey results. A pit in the west of the site is the only feature to give responses in both surveys (Anomalies 3a and E). There are other areas where anomalies are seen in both surveys (Anomalies 2a and D), however it is thought to be unlikely that these responses are caused by the same feature.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Cretacious chalk geologies, such as those at Devil's Dyke Hillfort, generally give good responses to magnetic survey. The detection of a number of possible archaeological anomalies suggests that the survey has been effective. However there are areas of magnetic disturbance, particularly across the east of the site that hinder confident interpretation of some anomalies and may be masking weaker archaeological anomalies.

The earth resistance survey is hampered by the area of waterlogged ground along the base of the bank, as evidenced by the large low resistance anomalies seen in the centre and east of the site. This makes identification and interpretation of subtle features difficult as there is likely to be less contrast with the background response of the site. However, high contrast anomalies are seen in the areas not affected by waterlogging, suggesting that the survey has been effective in these areas.

5 CONCLUSION

The surveys at Devil's Dyke Hillfort have identified several possible archaeological features. A small number of ditches are seen in the east of the area, including a possible ring ditch, however areas of magnetic disturbance and waterlogging makes differentiation between archaeological and modern or natural features difficult. Two areas of possible compacted ground or stone may relate to former ground surfaces, but could equally be natural in origin. Other linear and discrete anomalies, possibly relating to archaeological features, have been identified across the site however they could equally be modern or natural in origin. The remaining anomalies relate to areas of waterlogging and modern features. The modern features include ferrous objects and magnetic disturbance from buildings and fencing.

6 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.

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

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

Historic England, 1996. *National Heritage List for England – Devil's Dyke Hillfort.* Available from: https://historicengland.org.uk/listing/the-list/list-entry/1014953 [Accessed on 28/01/16]

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 6 South East England*.

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.

Gradiometer

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 1600 sampling points in a full 20m x 20m 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.

Earth Resistance

Readings were taken at 1m centres along traverses 1m apart. This equates to 900 sampling points in a full 30m x 30 grid. All traverses were surveyed in a "zigzag" mode.

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.

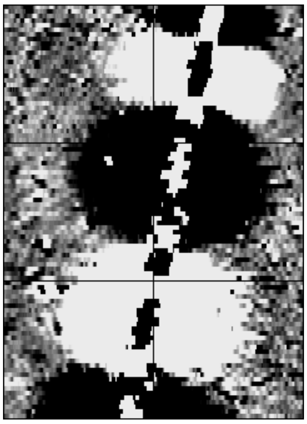
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

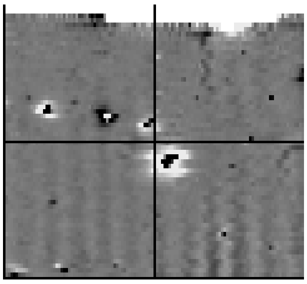
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

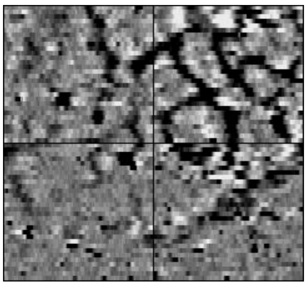


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

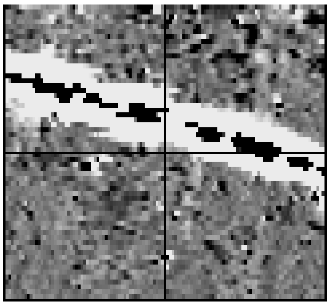
See bipolar and dipolar.

Positive linear



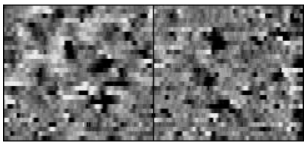
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



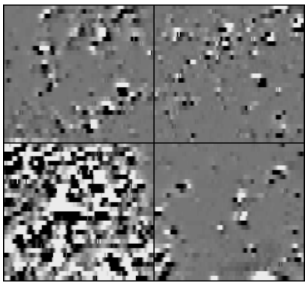
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



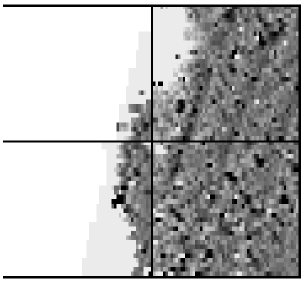
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



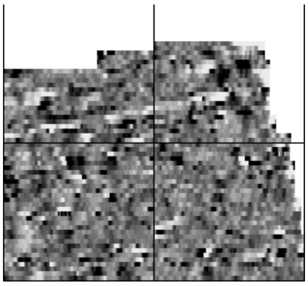
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

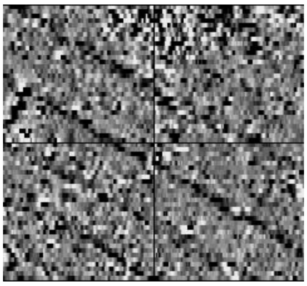


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

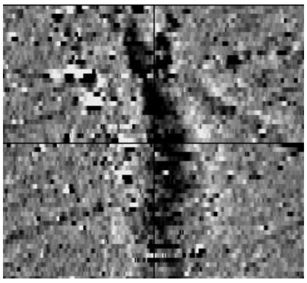
Strength of response

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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