

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:

Alverdiscott

Client:

Devon County Council

February 2015

Job ref:

J7928

Report author:

Rebecca Davies BSc (Hons)

GEOPHYSICAL SURVEY REPORT

Project name:

Alverdiscott

Client:

Devon County Council



Job ref:

J7928

Techniques:

Detailed magnetic survey –

Gradiometry

Earth resistance survey –

Resistivity

Survey date:

26th January - 12th February 2015

Site centred at:

SS 491 253

Post code:

EX39 4QQ

Field team:

James Slater BSc (Hons), **Richard Collins** BA (Hons),

Tim Coombs MSc PCIfA

Project manager:

Simon Haddrell BEng(Hons) AMBCS PCIfA

Report written By:

Rebecca Davies BSc (Hons)

CAD illustrations by:

Rebecca Davies BSc (Hons)

Checked by:

David Elks MSc ACIfA

TABLE OF CONTENTS

LIST OF FIGURES.....	2
1 SUMMARY OF RESULTS	3
2 INTRODUCTION	3
2.1 Background synopsis.....	3
2.2 Site location	3
2.3 Description of site	3
2.4 Geology and soils	3
2.5 Site history and archaeological potential	4
2.6 Survey objectives	4
2.7 Survey methods	4
2.8 Processing, presentation and interpretation of results.....	4
2.8.1 Processing	4
2.8.2 Presentation of results and interpretation.....	5
3 RESULTS.....	5
3.1 Probable Archaeology (Gradiometer).....	6
3.2 Possible Archaeology (Gradiometer)	7
3.3 Other Anomalies (Gradiometer)	7
3.4 Probable Archaeology (Earth Resistance).....	8
3.5 Possible Archaeology (Earth Resistance)	8
3.6 Other Anomalies (Earth Resistance)	8
4 CONCLUSION.....	8
5 REFERENCES	10
APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT	11
APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY	12
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES.....	13

LIST OF FIGURES

Figure 01	1:25 000	Location plan of survey area
Figure 02	1:1250	Location of survey grids and referencing
Figure 03	1:1250	Colour plot of gradiometer data showing extreme values
Figure 04	1:1250	Plot of minimally processed gradiometer data
Figure 05	1:1250	Abstraction and interpretation of gradiometer anomalies
Figure 06	1:1250	Plot of minimally processed resistance data
Figure 07	1:1250	Plot of processed resistance data
Figure 08	1:1250	Abstraction and interpretation of resistance anomalies
Figure 09	1:1250	Combined abstraction and interpretation of gradiometer and resistance anomalies

1 SUMMARY OF RESULTS

A combined gradiometry and resistance survey was conducted over approximately 4.9 hectares of pasture. A triple-ditched enclosure, associated backfilled pits and rectilinear enclosure have been identified, and relate to the Scheduled Monument of an Iron Age enclosure and Roman marching camp. Additional linear anomalies and former pits provide further evidence of settlement activity on the site. Former field boundaries, ridge and furrow and evidence of modern ploughing suggest a more recent agricultural past. The remaining features are natural or modern in origin and include areas of natural magnetic variation, disturbance from nearby ferrous objects and magnetic spikes that are likely to be modern rubbish.

The majority of the archaeology is likely to be well preserved with some minimal damage in isolated locations.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey of an area in order to establish the exact location and extent of the buried remains of the Scheduled Monument to inform management proposals and address any areas of damage to buried features. This survey forms part of an archaeological investigation being undertaken by Devon County Council under a S17 English Heritage Grant

2.2 *Site location*

The site is located at OS ref. SS 491 253 and the site is bound by agricultural land on all sides.

2.3 *Description of site*

The survey area is approximately 4.9 hectares of grassland pasture. The area is slightly undulating, with a small number of water troughs providing the only obstructions. These do not significantly affect the total survey area.

2.4 *Geology and soils*

The underlying geology is Bude Formation – mudstone and siltstone (British Geological Survey website). No drift geology is recorded (British Geological Survey website).

The overlying soils are known as Denbigh 2 which are typical brown earths. These consist of well drained fine loamy soils (Soil Survey of England and Wales, Sheet 5 South West England).

2.5 **Site history and archaeological potential**

The Scheduled Monument of a multivallate Iron Age enclosure and Roman marching camp (SM No .1004558) are present within the survey area while a number of further enclosures and a ring ditch are present within the surrounding area. It was considered likely that further archaeological features of Iron Age and Roman date, associated with the monuments, would be identified within the area.

A Section 42 licence has been granted by English Heritage to carry out the survey.

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 to determine potential survival, the extent of any damage, and risk factors, to inform future management.

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*.

As the site contains the Scheduled Monument of an Iron Age enclosure and Roman marching camp, a multi-technique approach has been adopted to gain an increased amount of information. Both detailed magnetic survey (gradiometry) and earth resistance survey were used as an efficient and effective method of locating archaeological anomalies. More information regarding these techniques 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.

Detailed magnetic survey

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 and the passing of the data through a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The net effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

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

Despike	X radius = 1 Y radius = 1 Spike replacement
High Pass Filter	X radius = 10 Y radius = 10

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, together with a greyscale plot of the processed data. 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 raw data as a grey scale plot (Figure 4), together with a grey scale plot of the processed data. Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing.

3 RESULTS

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.

Gradiometer

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

3.1 Probable Archaeology

- 1** Positive linear anomalies in the southwest of the survey area related to the triple-ditched Iron Age enclosure.
- 2** A number of small, discrete positive anomalies in the southwest of the survey area. These are indicative of former cut features such as backfilled pits and are associated with Anomaly 1.
- 3** Negative linear anomalies in the southwest of the site, associated with Anomaly 1, are related to the triple-ditched Iron Age enclosure. These are indicative of former banks or earthworks.
- 4** A positive rectilinear anomaly in the centre of the site, indicative of a former cut feature of archaeological origin, is related to the Roman marching camp.
- 5** Negative linear anomalies, indicative of former banks or earthworks of archaeological origin. These are related to the Roman marching camp.
- 6** Positive linear anomalies across the site that are indicative of former cut features, such as ditches.
- 7** A number of small, discrete positive anomalies across the site. These are indicative of former cut features such as backfilled ditches and are related to the settlement activity of the site.
- 8** Negative linear anomaly, associated with Anomaly 6, is indicative of former bank or earthwork and is related to the settlement activity of the site.

- 9 Positive linear anomalies running east-west across the centre of the site. These are related to a former field boundary present on available historic mapping from 1887 to 1958.
- 10 A positive linear anomaly in the east of the site. This is related to a former field boundary visible on available historic mapping from 1887 to 1906.
- 11 Positive linear anomalies in the north and east of the site. These are likely to be related to former field boundaries but are not visible on available historic mapping.

3.2 Possible Archaeology

No features of possible archaeological origin have been identified.

3.3 Other Anomalies

- 12 Areas of amorphous magnetic variation across the site. These are likely to be natural, i.e. geological, in origin.
- 13 Large areas of amorphous magnetic variation within the Roman camp. These may be related to ephemeral archaeological features within the camp, however they are more likely to be of natural origin.
- 14 Closely spaced, parallel linear anomalies across the site. These are likely to be related to modern agricultural activity such as ploughing.
- 15 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, but on this site have not affected a significant proportion of the area.
- 16 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

Earth Resistance

The earth resistance survey conducted at Alverdiscott has identified a number of anomalies that have been characterised as being either of a *probable* or *possible* archaeological origin.

3.4 *Probable Archaeology*

- A Moderate resistance linear anomalies in the southwest of the site. These are related to the Iron Age enclosure and can be associated with Anomaly 1. They suggest that in places the ditches contain stone remains.
- B Moderate resistance linear anomalies across the site. These are probably related to former field boundaries. They may be of stone construction or highly compacted hard ground.
- C Moderate resistance linear anomalies in the east of the site that are related to former field boundaries present on available historic mapping from 1887 to 1958.
- D Parallel linear anomalies in the south of the site. These are related to ridge and furrow cultivation.
- E Moderate resistance linear anomalies in the north and northeast of the site. These are likely to be related to former field boundaries that are not present on available historic mapping.

3.5 *Possible Archaeology*

- F A small number of moderate resistance linear anomalies that may be of archaeological or natural origin.
- G Low resistance linear anomalies in the centre of the site. These may be possible cut features of archaeological or natural origin.

3.6 *Other Anomalies*

- H Large amorphous anomalies across the site. These are likely to be natural, i.e. geological, in origin.
- I Closely spaced, parallel linear anomalies across the site. These are related to modern ploughing activity.

4 CONCLUSION

The surveys at Alverdiscott have identified a large number of features of archaeological origin. The scheduled monument of an Iron Age enclosure has been identified, along with the Roman

marching camp. A number of former pits, likely related to the triple-ditched enclosure, have been identified and provide further evidence of settlement activity on the site. A number of linear anomalies across the site are probably related to a former field system and may be associated with the Iron Age settlement activity of the site. Further, more recent, former field boundaries, present on available historic mapping, have been identified along with evidence of ridge and furrow cultivation suggesting an agricultural history.

The remaining features are natural or modern in origin and include large areas of amorphous magnetic variation, evidence for modern agricultural activity, such as ploughing, magnetic disturbance from nearby ferrous metal objects, such as fences, and magnetic spikes that are likely to be modern rubbish.

The Roman marching camp is not visible in the earth resistance data, and only a small portion of the Iron Age enclosure has been identified with this survey method. Field boundaries and evidence of modern ploughing have been identified and correspond with features identified in the gradiometer data. It is possible that the difference in the results of the resistivity and gradiometry is due to the depths of the features. The gradiometry will detect features up to a depth of approximately 1 metre, whereas the resistivity will detect down to approximately 0.5 metres. Given the post-medieval agricultural activity across the site, it is possible that the archaeology is at a depth greater than 0.5 metres. However it may also indicate that the Iron Age and Roman archaeology contain little stone remains and are composed of mainly of earthen features.

Most of the archaeological responses have well defined edges in the gradiometer data and do not appear to have been 'spread' by historic, as opposed to more recent, ploughing. This suggests that the below ground remains are likely to be well preserved. A small number of exceptions to this are in the south of the site. Anomalies 6a, 11a and A1 appear to be slightly weakened or 'spread' in the orientation of the later plough lines. This may be a result of the fact that these anomalies correspond to areas of higher ground where it is likely that the depth of the topsoil is less and have therefore been affected by ploughing activity. Anomaly 4a appears to change in nature from a magnetically strong response to a weaker one and may possibly have been damaged with the creation of adjacent field boundaries or as a result of differential cultivation.

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.

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>

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet5 South West 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 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.

Earth Resistance

Readings were taken at 0.5m centres along traverses 0.5m apart. This equates to 3600 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.

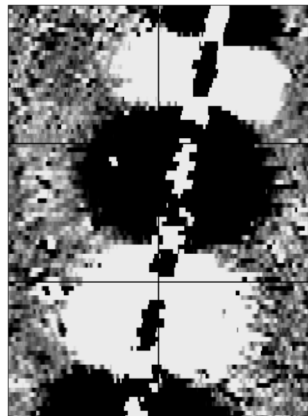
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

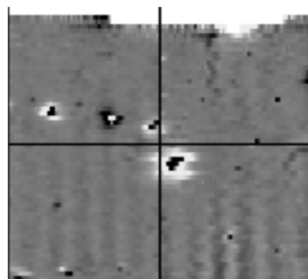
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

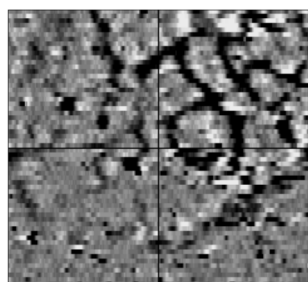


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

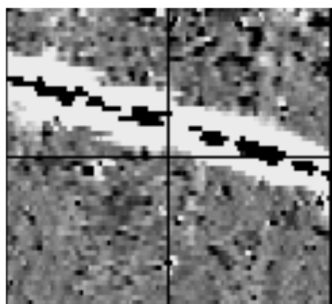
See bipolar and dipolar.

Positive linear



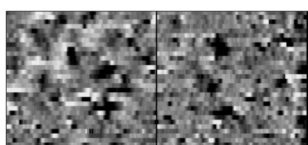
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



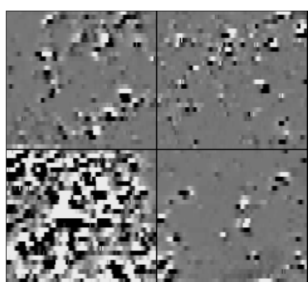
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



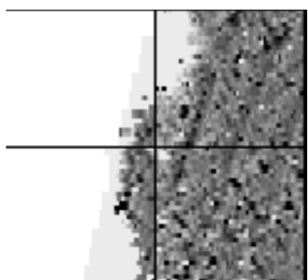
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



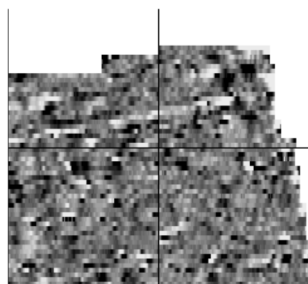
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250nT$) 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

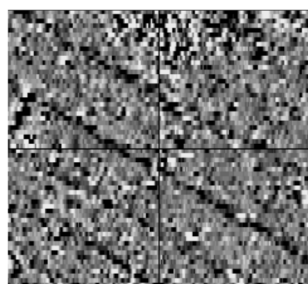


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

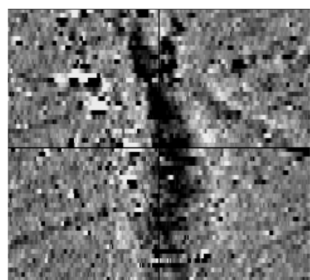
Strength of response

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 10m² 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™



SUMO
Group
Member

STRATASCAN LTD

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

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