

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Dacorum Area, Hertfordshire

Client:
Archaeological Services & Consultancy Ltd - Milton Keynes

June 2013

Job ref:
J3349

Report author:
Bryony P Marsh BA

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Field team:

Richard Fleming

Adam Cooper MSc

Steve Hamflett MSc

Thomas Desalle MSc

Alex Portch BSc (Hons)

Paul Stevens

Stephen Weston

Adam Green

Techniques:

**Detailed magnetic survey –
Gradiometry**

Project manager:

Simon Haddrell BEng(Hons) AMBCS PIFA

Survey date:

May 2013

Report written By:

Bryony P Marsh BA

Site centred at:

LA1 - TL 059 090

LA2 - TL 055 081

LA4 - SP 981 069

LA5 - SP 908 112

CAD illustrations by:

Bryony P Marsh BA

Post code:

LA1 – HP2 6DX

LA2 – HP2 5SD

LA4 – HP4 3NG

LA5 – HP23 4LB

Checked by:

David Elks MSc AIFA

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 33.6 hectares of mixed use land divided across four survey areas in the Dacorum area of Hertfordshire. The survey has identified a single response of probable archaeological origin; a linear anomaly in area LA5 which correlates with the documented route of a footpath from 1924. Additional positive responses are noted across much of the site and may indicate former cut features of possible archaeological origin, however these anomalies are not in a form typically associated with archaeological activity and other origins should not be discounted.

Modern activity is evident across these sites and includes magnetic disturbance and 'spikes' caused by ferrous materials and high amplitude responses associated with modern services. Amorphous variations are also observed and are likely to be of natural origin.

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 Archaeological Services and Consultancy Ltd.

2.2 *Site location*

The survey area consists of four separate parcels of land situated around Hemel Hemstead, Berkhamstead and Tring in Hertfordshire.

2.3 *Description of site*

The survey area consists of a total area of approximately 33.6ha divided across four sites as described below:

LA1: This is the largest of the four survey areas and is divided across six fields. The north western field was unsurveyable due to a mature wheat crop, and several additional fields were unavailable for survey due to the presence of livestock.

LA2: This area is a small parcel of grassland surrounded by modern housing to the east and south and bordered by a carriageway to the east.

LA4: This area is surrounded by heavily wooded boundaries to all sides which has restricted the available survey area. Obstructions such as ponds and trees were also present across the site.

LA5: This area is divided across six fields, one of which was unsurveyable due to livestock present at the time of survey. The area is bordered by a modern housing estate to the east, a cemetery to the south west and a Roman Road in the south.

2.4 **Geology and soils**

LA1, LA2 & LA4: The underlying geology is Lewes Nodular Chalk Formation and Seaford Chalk Formation (British Geological Survey website). There is no drift geology recorded in areas LA1 or LA2, however Clay-With-Flints Formation is evident in area LA4 (British Geological Survey website).

LA5: The underlying geology is Holywell Nodular Chalk Formation and New Pit Chalk Formation (British Geological Survey website). There is no drift geology recorded in the area.

LA1: The overlying soils are known as Batcombe which are stagnogleyic palaeo-argillic brown earth soils. These consist of fine silty over clayey and fine loamy over clayey soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

LA2 & LA4: The soils are unlisted due to the urban environment (Soil Survey of England and Wales, Sheet 4 Eastern England).

LA5: The overlying soils are known as Andover 1, which are typical brown rendzina soils. These consist of shallow well drained calcareous silty soils over chalk (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 **Site history and archaeological potential**

The following extracts are taken from the 'Design Brief for Archaeological Desk Based Assessment, Geophysical Survey and Targeted Field Evaluation – DBC Housing Allocation Sites'. Produced by Hertfordshire County Council, Historic Environment Unit:

LA1 - MARCHMONT FARM

The site is within the Gade valley which is one of the most archaeological important river valleys in the county and which has a very high known density of heritage assets with archaeological and historical interest. Many known heritage assets occupy similar topographic positions to that of the Marchmont Farm site, for example, later Bronze-Age settlement at Gadebridge (HER7981), and have shown such positions to be preferred locations for later prehistoric/Roman settlement.

A number of Scheduled Monuments of Roman date are known from Hemel Hempstead. A villa at Boxmoor (SM27916), temple complex at Wood Lane End (SM27921), large barrow at High Street Green (SM27901), and villa at Gadebridge (SM27881), which is sited on the opposing slope of the river valley, approximately 730 west of the Marchmont Farm site. This, and evidence for several important Roman roads apparently converging, and a number of relatively recent archaeological discoveries, notably, Roman occupation (probably another villa site) at Spencer's Park (HER15191), suggest that this area was an important high status 'hinterland' to Verulamium.

LA2 – OLD TOWN, HEMEL HEMPSTEAD

The site is within the Gade valley which is one of the most archaeological important river valleys in the county and which has a very high known density of heritage assets with archaeological and historical interest.

The site immediately abuts the northern edge of Area of Archaeological Significance (AAS) number 36. This notes that Hemel Hempstead is a medieval settlement recorded in Domesday Book as 'Hamelamstede'. The medieval core of the settlement (Hemel Hempstead EUS) is believed to extend to within a few tens of metres of the 'Old Town site' boundary. Also, a number of earthworks are visible on 2010 Hertfordshire vertical aerial photomaps. One linear bank is clearly modern, running parallel to Fletcher Way, however, the form and alignment of the remainder suggest a medieval or earlier origin (HER18267).

In addition, a number of Scheduled Monuments of Roman date are known from Hemel Hempstead. A villa at Boxmoor (SM27916), temple complex at Wood Lane End (SM27921), large barrow at High Street Green (SM27901), and notably a villa at Gadebridge (SM27881), which is sited on the opposing slope of the river valley, approximately 500m north-west of the 'Old Town site'. This, and evidence for several important Roman roads apparently converging, and a number of relatively recent archaeological discoveries, notably, Roman occupation (probably another villa site) at Spencer's Park (HER15191), suggest that this area was an important high status 'hinterland' to Verulamium.

LA4 - REAR OF HANBURYS, SHOOTERSWAY, BERKHAMSTED

The proposed housing allocation site is situated on an area of high land at the head of a dry valley on the southern edge of Berkhamsted. Berkhamsted was an important centre during the medieval period, as is demonstrated by the presence of a substantial motte and bailey castle (SM20626). The area around the town is known to contain a number of important prehistoric, Roman and medieval sites. Several significant prehistoric sites were identified during the construction of the A41 Berkhamsted bypass.

LA5 – WEST TRING

The site is within the Bulbourne valley which has a very high known density of heritage assets with archaeological and historical interest.

The site lies on the western edge of Tring, a settlement of medieval origin. The site is bounded along its southern edge by Akeman Street, a major Roman road.

Evidence for prehistoric, Roman and medieval occupation has been identified from the wider vicinity, including two late Iron Age shaft furnaces (HER6069), identified during the construction of the A41 Tring bypass.

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 in the Methodology section below and 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 the four Dacorum Area sites 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.

Area LA1

3.1 Probable Archaeology

No probable archaeology has been identified within survey area LA1.

3.2 Possible Archaeology

- 1-7** Within area LA1, several positive linear anomalies are observed. These responses are seen in a complex rectilinear arrangement in the north of the site (Anomaly 1) and as fragmented curvilinear anomalies in the south (Anomalies 2-4). This type of response is indicative of a former cut feature such as a ditch and may be of archaeological origin. Several additional weak positive anomalies are also noted in the west and south of the site (Anomalies 5 & 6).
- 8** Further positive anomalies are noted across the area and are seen in either large area responses or smaller discrete anomalies. These responses are again associated with former cut features and may indicate in-filled pits of possible archaeological origin.
- 9** A negative linear anomaly is identified in the south of the area and is indicative of a former banked feature of possible archaeological origin.

3.3 Other Anomalies

- 10** 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.
- 11** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.
- 12** In the south of the area, an area of magnetic variation is observed which is typically associated with former cut features of natural origin such as former ponds or sandpits.
- 13** In the north of the site, several areas of scattered magnetic debris are observed. These are likely to be caused by modern ferrous material.

Area LA2

3.4 Probable Archaeology

No probable archaeology has been identified within survey area LA2.

3.5 Possible Archaeology

- 14** In the south of LA2, a series of positive linear responses are noted and are indicative of former cut features of possible archaeological origin. These anomalies are fragmented and of a similar orientation, possibly suggesting an association with agricultural activity. However these anomalies are seen within an area of magnetic debris which makes interpretation problematic.
- 15** Two discrete positive anomalies are also observed and may be associated with in-filled pits of possible archaeological origin.

3.6 Other Anomalies

- 16** 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, and in this instance much of the eastern extent of the area is obscured.
- 17** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern debris.
- 18** A high amplitude linear response is noted in the east of the site and is associated with a modern pipe or service.
- 19** In the south of the site, a large area of scattered magnetic debris is observed. These are likely to be caused by modern ferrous material.

Area LA4

3.7 Probable Archaeology

No probable archaeology has been identified within survey area LA4.

3.8 Possible Archaeology

No possible archaeology has been identified within survey area LA.

3.9 Other Anomalies

- 20** 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.
- 21** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern debris.
- 22** A high amplitude linear response is noted in the east of the site and is associated with a modern pipe or service.
- 23** Several small areas of scattered magnetic debris are observed. These are likely to be caused by modern ferrous material.
- 24** Amorphous magnetic variations are observed across much of this area and are indicative of variations within the natural geology or pedology of the area.

Area LA5

3.10 Probable Archaeology

- 25** In the eastern extent of area LA5, a positive linear response is observed. This anomaly is seen to correlate with the location of a former footpath documented on historic site mapping from 1924 to 1996.

3.11 Possible Archaeology

- 26a** A positive linear response is observed in LA5 and is indicative of former cut feature of possible archaeological origin.
- 26b** Several positive linear responses are observed in LA5 and are indicative of former cut features of possible archaeological origin. However, a more modern origin possibly related to agricultural activity is more likely.

3.12 Other Anomalies

- 27** 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.
- 28** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern debris.
- 29** A linear response is observed crossing the site in the north eastern corner and is associated with a modern footpath.
- 30** Two areas of scattered magnetic debris are observed. These are likely to be caused by modern ferrous material.
- 31** A series of high amplitude linear anomalies are noted in the east of the area and are likely to be associated with modern pipes or services.
- 32** Parallel linear responses are evident across much of this area and are indicative of modern agricultural activity such as ploughing.

4 CONCLUSION

The detailed gradiometer survey carried out across four parcels of land around Dacorum in Hertfordshire, has identified little evidence of anomalies typically associated with archaeological activity. One linear response has been noted in area LA5 which appears to correlate with the location of a footpath recorded on historic mapping dating to 1924.

Positive anomalies which may indicate former cut features of possible archaeological origin have been identified across many of the areas, however a more modern origin cannot be ruled out. Discrete anomalies are also observed which may indicate former archaeological pits.

Modern activity on the site is evident through areas of magnetic disturbance, debris, 'spikes' and high amplitude anomalies associated with modern pipes or services. Also noted are areas of magnetic variation of probable natural origin; associated with variations within the geology or pedology of the site.

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.

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<http://www.archaeologists.net/sites/default/files/nodefiles/Geophysics2010.pdf>

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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.

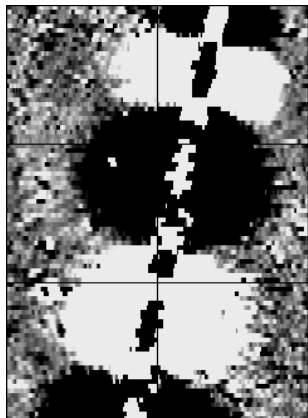
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

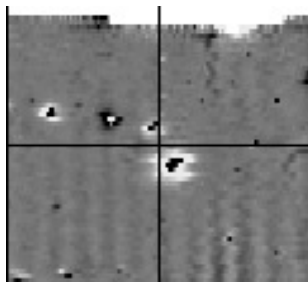
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

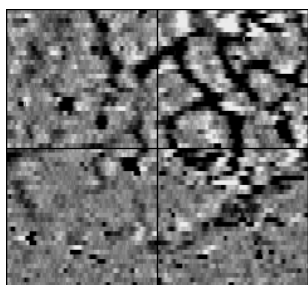


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

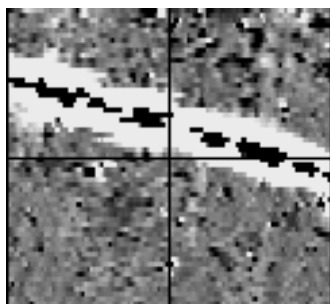
See bipolar and dipolar.

Positive linear



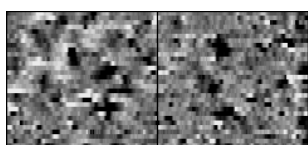
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

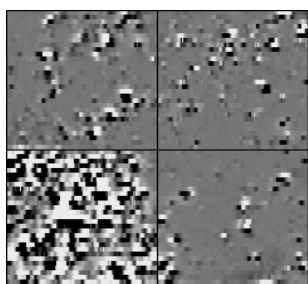
Positive point/area



depressions in the ground.

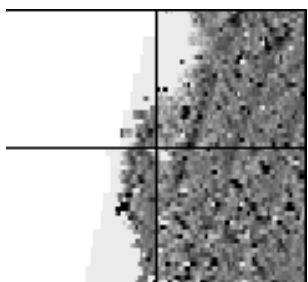
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



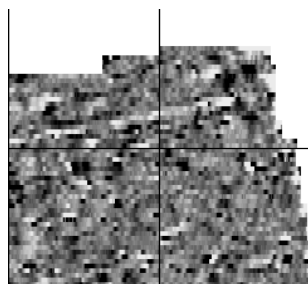
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

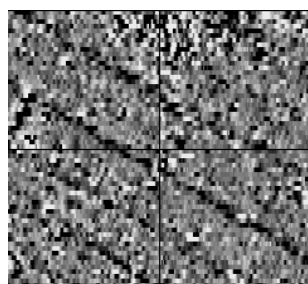


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

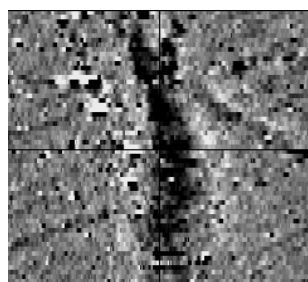
Strength of response

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