

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Cirencester Solar Park

Client:
Cotswold Archaeology

September 2014

Job ref:
J7115

Report author:
Rebecca Davies BSc (Hons)

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Job ref:

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Field team:

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Techniques:

**Detailed magnetic survey –
Gradiometry**

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Survey date:

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 38 hectares of arable land. A large area of probable settlement or agricultural activity has been identified, along with evidence of ridge and furrow cultivation. A former field boundary, possible former field boundary, a former track and a former pond have been identified along with a number of cut features of possible archaeological origin. A large area of natural pitting and associated linear anomalies has been identified, as well as further areas of amorphous magnetic variation that is natural in origin. The remaining features are modern in origin and relate to services, land drains and nearby ferrous metal objects.

2 INTRODUCTION

2.1 *Background synopsis*

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

2.2 *Site location*

The site is located at OS ref. SP 050 013, to the east of the A417 and south of London Road. Witpit Lane forms the western boundary of the site.

2.3 *Description of site*

The survey area is approximately 38 hectares of flat arable land, with the only obstructions coming in the form of small areas of overgrown vegetation along the perimeters of the fields.

2.4 *Geology and soils*

The underlying geology is Forest Marble Formation – Mudstone across the west of the site and Forest Marble Formation – Limestone across the east. There is no recorded drift geology (British Geological Survey website).

The overlying soils are known as Sherborne which are typical brown redzinas. These consist of shallow well drained brashey calcareous clayey soils over limestone (Soil Survey of England and Wales, Sheet 5 South West England).

2.5 *Site history and archaeological potential*

Extract from “Witpit Solar Farm, Cirencester, Gloucestershire – Heritage Desk-Based Assessment” (Cotswold Archaeology 2014):

“There is clear evidence of Iron Age and/or Roman settlement and farming activity to the south and north of the site, and crop-marks in its southern extremity suggest that this evidence continues into the site. In addition, crop-marks recorded by the National Mapping Programme

strongly suggest that the whole study area was organised and farmed in the later prehistoric to Roman period. The study area also contains scattered indications of earlier prehistoric activity, in the form of flint artefact scatters and rare pottery.

Medieval activity is indicated on the western edge of the site. Ridge and furrow earthworks are or were widespread within the study area and on the site itself, and their relationship to present field boundaries suggests that these are the result of early enclosure by agreement, a view confirmed by the 1770 Enclosure Map. Some present day fields are the result of amalgamation of these older fields, and such merging of fields has occurred within the site, where recently mapped boundaries are no longer extant."

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*.

Due to the high potential of identifying Prehistoric, Roman and Medieval features 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. <i>Destripe</i> | (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions) |
| 2. <i>Destagger</i> | (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 Cirencester Solar Park 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.

3.1 Probable Archaeology

- 1-4** Positive linear anomalies in the east of the site. These are indicative of former cut features and likely to be of archaeological origin. They are likely to be related to agricultural or settlement activity in the area.
- 5-6** Linear anomalies likely to be related to former field boundaries that are not present on available mapping.
- 7** Linear anomaly in the southern of the central fields that is likely to be a former track-way that is not present on available mapping.
- 8** An area of widely spaced curving parallel linear anomalies in the centre of the site. This is indicative of ridge and furrow cultivation.

3.2 *Possible Archaeology*

- 9 A number of positive linear anomalies across the site. These are indicative of former cut features, and may be of archaeological or agricultural origin.
- 10 A number of small discrete positive anomalies across the east of the site. These are indicative of small former cut features, such as backfilled pits, and may be of archaeological origin. However they could also be related to the widespread natural pitting seen in the area.
- 11 Positive linear anomaly, running north-south in the western field is possibly a former field boundary that is not visible on available mapping.
- 12 A negative linear anomaly in the north western field. This is indicative of a former bank or earthwork feature, and may be of archaeological or agricultural origin.

3.3 *Other Anomalies*

- 13 Closely spaced parallel linear anomalies across much of the site are related to agricultural activity such as ploughing.
- 14 Bipolar linear anomalies on the western edge of the site and in the central fields that is related to a pipe, cable or other modern service.
- 15 Large area of pitting in the east of the site that is probably of natural origin.
- 16 Linear anomalies that relate to the large area of pitting (anomaly 15) are probably of natural origin.
- 17 Small area of strong magnetic debris in the west of the site that is related to a former pond visible on available historic mapping.
- 18 A large area of weak scattered magnetic debris in the centre of the western fields is probably related to modern agricultural activity.
- 19 A number of linear anomalies in the south-west of the site that are likely to be related to land drains.
- 20 Area of amorphous magnetic variation in the south-east of the site of natural/geological origin.
- 21 Small areas of scattered magnetic debris likely to be modern in origin.
- 22 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.

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

4 CONCLUSION

The survey at Cirencester Solar Park has identified a number of features of probable and possible archaeological origin. A large number of positive anomalies in the east of the site are likely to be related to settlement or farming activity on the site and supports the evidence provided in the heritage desk-based assessment. An area of ridge and furrow cultivation has been identified along with one former field boundary and a former track that are not visible on available mapping. A possible former field boundary and negative linear feature associated with a former bank or earthwork have also been identified. Cut features of possible archaeological origin may related to agricultural activity, however they may be natural in origin and relate to the substantial pitting that is evident in the east of the site. A former pond, visible on available historic mapping, has been identified. A number of services, such as pipes or cables, have been identified with the remaining features all likely to be modern in origin. They include evidence of ploughing, land drains, an area of weak scattered magnetic debris associated with modern agricultural activity, magnetic disturbance associated with nearby substantial ferrous metal objects and a number of magnetic spikes that are likely to be modern rubbish.

The change between the mudstone geology across the west of the site and limestone in the east is clearly evident within the survey data. Large areas of pitting can be seen in the limestone, whilst the mudstone produces very quiet data. There is also a difference in the amount of archaeological anomalies being seen over each geology. The limestone produces very clear anomalies and a number of archaeological anomalies, whilst there are very few anomalies in the west of the site. It is possible that the archaeology extends into the west of the site but it is not evidence due to the mudstone geology, which can give very variable responses to magnetic survey.

5 REFERENCES

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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.

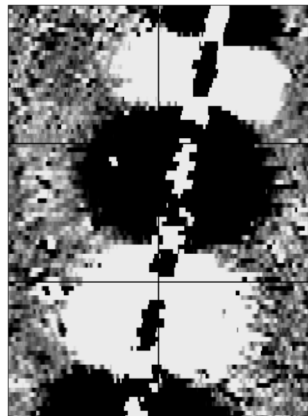
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

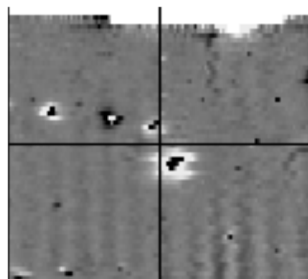
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

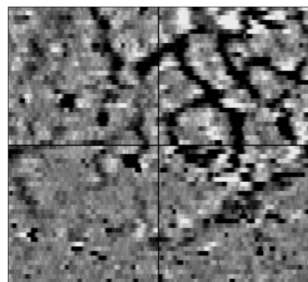


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

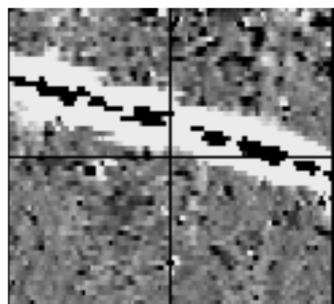
See bipolar and dipolar.

Positive linear



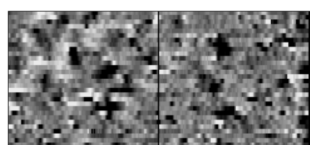
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



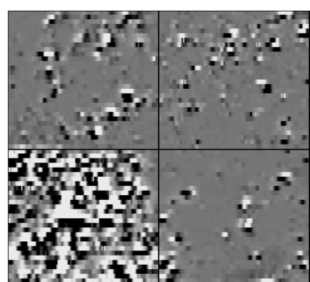
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



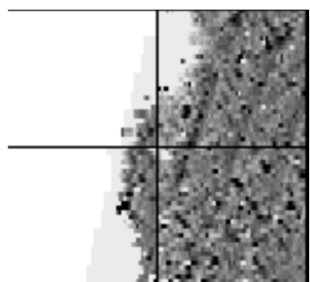
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



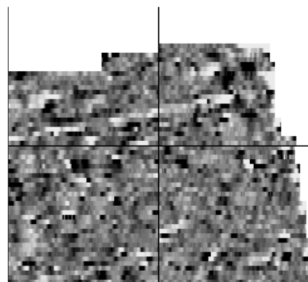
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3\text{nT}$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger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

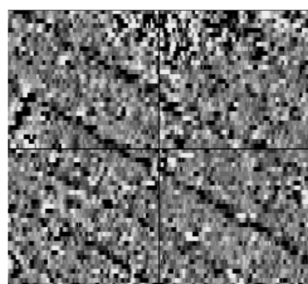


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

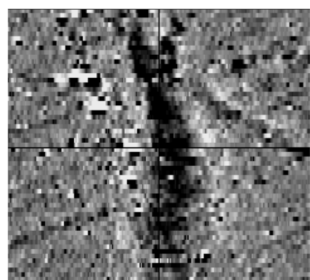
Strength of response

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.

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