

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Stoke Road, Bishop's Cleeve, Gloucestershire

Client:
CgMs Consulting

September 2015

Job ref:
J8780

Report author:
Rebecca Davies BSc (Hons)

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Job ref:

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**Detailed magnetic survey –
Gradiometry**

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Survey date:

**28th August & 3rd-4th September
2015**

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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.....	5
2.8.1 Processing	5
2.8.2 Presentation of results and interpretation.....	5
3 RESULTS.....	5
3.1 Probable Archaeology.....	6
3.2 Possible Archaeology	6
3.3 Medieval/Post-Medieval Agriculture.....	7
3.4 Other Anomalies	7
4 DATA APPRAISAL & CONFIDENCE ASSESSMENT.....	8
5 CONCLUSION.....	8
6 REFERENCES.....	9
APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT.....	10
APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY	11
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES.....	12

LIST OF FIGURES

Figure 01	1:1000	Site location, survey area & referencing
Figure 02	1:1000	Colour plot of gradiometer data showing extreme values
Figure 03	1:1000	Plot of minimally processed gradiometer data
Figure 04	1:1000	Abstraction and interpretation of gradiometer anomalies

1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 13.5 hectares of mixed arable land and pasture. A number of linear and curvilinear anomalies, along with a number of former pits provide evidence of an area of settlement activity, with an alignment of smaller pits possibly related to post-holes. Further linear anomalies and possible pits may be archaeological in origin, though the linear anomalies may be related to agricultural activity and the pits may be natural. Ridge and furrow cultivation and a former field boundary suggest the site has a more recent agricultural past. The remaining features are natural or modern in origin and include underground services, land drains, a footpath, magnetic debris, magnetic disturbance from nearby ferrous objects, and magnetic spikes which are likely to be modern rubbish.

2 INTRODUCTION

2.1 *Background synopsis*

Stratascan were commissioned to undertake a geophysical survey of an area outlined for residential development. This survey forms part of an archaeological investigation being undertaken by CgMs Consulting.

2.2 *Site location*

The site is located north of Stoke Road, Bishop's Cleeve at OS ref. SO 944 279. The site is bound by agricultural land to the north and west, with Malvern View Business Park to the south-east and residential housing to the east.

2.3 *Description of site*

The survey area is approximately 13.5 hectares of mostly flat farmland. The north-eastern and southern-most fields are recently harvested crop, while the two central fields are under pasture. The site is largely unobstructed, with electricity poles, trees and a small patch of overgrown vegetation providing the only obstructions.

2.4 *Geology and soils*

The underlying geology is mudstone of Charmouth Mudstone Formation (British Geological Survey website). No drift geology is recorded (British Geological Survey website).

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

2.5 **Site history and archaeological potential**

Extract from "Archaeological Desk-Based Assessment: Stoke Road, Bishop's Cleeve, Gloucestershire" (CgMs Consulting, 2014):

"A large number of archaeological studies and field investigations have been carried out in the vicinity of and adjacent to the study site, one of which (SMR34200) also partially extends into its eastern extent.

The previous work in the eastern most field of the study site comprised a desk-based assessment (CgMs 2009) and geophysical survey (SMR33903). Although the survey found extensive settlement activity, this was located to the north of the current study site boundary and no significant remains were found within the study site. The area subject to geophysical survey, to the north of the study site, was subject to archaeological evaluation (SMR35562). However, no trenches were excavated within the study site. Evidence of ridge and furrow was identified by the geophysical survey in the east of the study site and was observed by a site visit conducted as part of the earlier desk-based assessment (CgMs 2009).

The assessment has established that there is Roman settlement to the north and east of the study site. Such activity would appear to be characterised by the presence of small farmsteads and their associated field systems. Geophysical survey of the easternmost part of the study site indicates that these nearby sites do not continue into the study site.

Archaeological and cartographic evidence, as well as the presence of ridge and furrow suggests that the study site was part of a wider field system of Bishop's Cleeve from the medieval period, if not earlier, and remained in agricultural use to the present. Beyond these agricultural remains a low potential for as yet undiscovered heritage assets of significance within the study site is identified. Ploughing will have truncated any archaeological deposits within the east of the study site, if any are present."

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

Due to the good response of Charmouth Mudstone for gradiometer survey, and the close proximity of Roman settlement to the site, detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in Appendix A.

2.8 **Processing, presentation and interpretation of results**

2.8.1 *Processing*

Processing is performed using specialist software. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all minimally processed gradiometer data used in this report:

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)
2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

2.8.2 *Presentation of results and interpretation*

The presentation of the data for each site involves a print-out of the minimally processed data both as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

3 **RESULTS**

The detailed magnetic gradiometer survey conducted at Bishop's Cleeve 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*

- 1-2** A number of positive linear and curvilinear anomalies in the centre and north-west of the site. These are indicative of former cut features, such as ditches and are likely to represent areas of settlement activity. Given the close proximity of Roman settlement to the north and east of the site, it could be assumed that the features are contemporary with this activity.
- 3** A positive sub-circular anomaly to the east of the concentration of Anomaly 2. This is indicative of a former cut feature, such as a ditch, and may be related to a former ring-ditch.
- 4** Positive area anomalies in the centre of the site. These are indicative of former cut features and are likely to be related to the settlement activity seen in Anomaly 2.
- 5-6** A number of small, discrete positive anomalies in the north-west and centre of the site. These are indicative of small former cut features of archaeological origin, such as backfilled pits, and are likely to be related to the settlement activity visible in Anomalies 2 and 4. A linear alignment of very small pits (Anomaly 6a) may be related to former post-holes.
- 7** A negative linear anomaly in the centre of the site. This is indicative of a former bank or earthwork and is likely to be related to the former settlement activity evidenced by Anomalies 2, 4 and 6.

3.2 *Possible Archaeology*

- 8** Weak positive linear anomalies in the north-west of the site. These are indicative of former cut features and may be archaeological or agricultural in origin.
- 9** A number of areas of positive responses in the centre of the site. These are of possible archaeological origin, though they may also be related to natural variations in geology or pedology.
- 10** A number of small, discrete positive anomalies in the north and west of the site. These are indicative of small cut features, such as backfilled pits, and may be archaeological or natural in origin.

3.3 *Medieval/Post-Medieval Agriculture*

- 11** Widely spaced parallel linear anomalies across the north, north-west and south of the site. These are related to ridge and furrow cultivation.
- 12** A linear anomaly in the west of the site. This is related to a former field boundary present on available mapping from 1841 to 1923.
- 13** An area of weak scattered magnetic debris in the west of the site. This is related to a former field boundary (Anomaly 12) that is present on available mapping from 1841 to 1923.

3.4 *Other Anomalies*

- 14** A weak positive linear anomaly in the north of the site. This is possibly related to a footpath.
- 15** A number of weak bipolar linear anomalies in the north-east of the site. These are related to land drains.
- 16** Strong bipolar linear anomalies in the south and east of the site. These are related to modern underground services, such as pipes or cables.
- 17** A number of areas of amorphous magnetic variation across the site. These are likely to be natural in origin.
- 18** Areas of scattered magnetic debris in the south and north of the site. These are likely to be modern in origin.
- 19** 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.
- 20** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Charmouth Mudstone geology generally provides a good response for gradiometer survey. A high contrast between responses and the background level is visible, and a large number of archaeological and agricultural features have been identified. This indicates that the survey has been effective. The background magnetic level is uniform in appearance suggesting that there is little activity outside of the anomalies identified.

5 CONCLUSION

The survey at Bishop's Cleeve has identified a number of features of archaeological origin. Areas of former settlement activity have been identified, with a number of ditches, pits and an alignment of smaller pits possibly related to post-holes. A sub-circular anomaly to the east of the main concentration of settlement activity may be related to a ring ditch, though its exact origin is unknown. Given the close proximity of Roman settlements to the north and east of the site, it could be assumed that the features identified are contemporary with those mentioned in the desk-based assessment. Further linear anomalies and pit-like features may be archaeological in origin, but may also be related to natural or agricultural activity. A former field boundary and large areas of ridge and furrow cultivation indicate that the site has been used for agricultural purposes since the medieval period, supporting the fact that the study site was part of a wider field system of Bishop's Cleeve from the medieval period or earlier.

The remaining features are natural or modern in origin and include a possible footpath, land drains, underground services, areas of scattered magnetic debris, and magnetic disturbance from nearby ferrous metal objects such as fencing.

6 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.

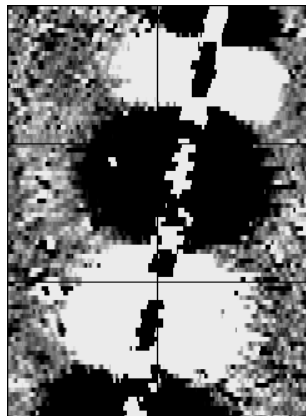
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

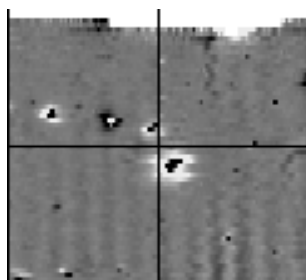
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

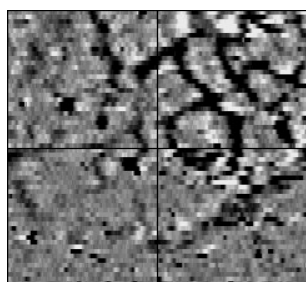


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

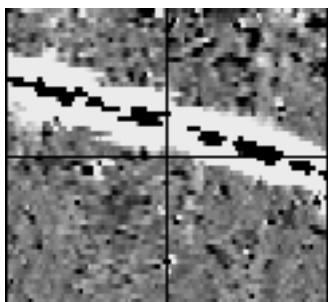
See bipolar and dipolar.

Positive linear



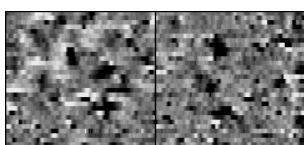
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



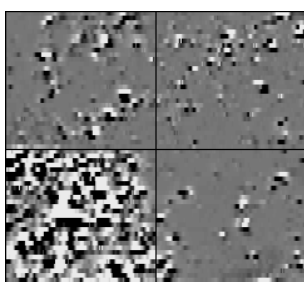
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



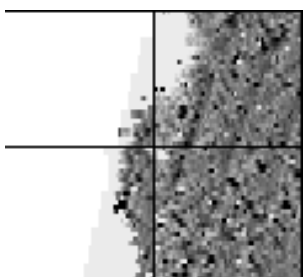
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



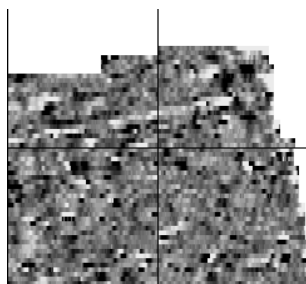
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

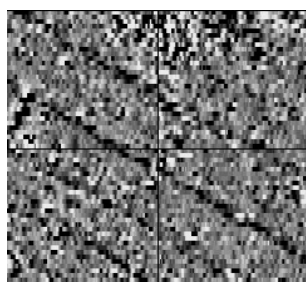


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

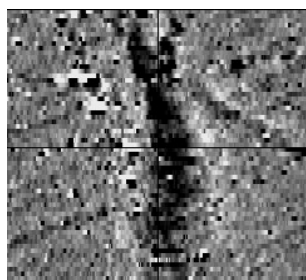
Strength of response

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.

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