GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:

Land at Raunds, Northamptonshire

Client:

CgMs Consulting

May 2015

Job ref:
J8210

Report author:
Rebecca Davies BSc (Hons)

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Techniques:

Detailed magnetic survey – Gradiometry

Survey date:

30th March - 2nd April, 7th - 14th & 27th - 29th April 2015

Site centred at:

SP 985 726

Post code:

NN9 6EH

Field team:

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 52 hectares of arable farmland. Cotton Henge, visible as crop-marks in aerial photography, has been identified, along with a small sub-circular feature which may be associated with a prehistoric barrow cemetery. A number of linear anomalies are likely to be related to prehistoric settlement activity, while further linear anomalies are of possible archaeological or agricultural origin. A number of former field boundaries and ridge and furrow suggest a more recent agricultural history. The remaining features are natural or modern in origin and include underground services, magnetic disturbance from nearby ferrous objects and fencing, scattered magnetic debris, a track-way and magnetic spikes that 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 mixed residential and commercial development. This survey forms part of an archaeological investigation being undertaken by CgMs Consulting.

2.2 *Site location*

The site is located to the east of Raunds, Northamptonshire at OS ref. SP 985 726. Meadow Lane forms the northern boundary of the site while Hog Dyke forms the southern boundary of the site.

2.3 *Description of site*

The survey area is approximately 52 hectares of mostly flat, arable farmland and the site is unobstructed.

2.4 *Geology and soils*

The underlying geology across the west and south of the site is mudstone of Whitby Mudstone Formation. The geology across the central part of the site comprises ironstone of Northampton Sand Formation. Across the east of the site the geology comprises limestone of Blisworth Limestone Formation and a small area of Rutland Formation mudstone. (British Geological Survey website). Drift geology of Ecton Member sand and gravel is recorded across the western edge of the site, with no further drift geology recorded (British Geological Survey website).

The overlying soils are known as Moreton which are typical brown calcareous earths. These consist of well drained calcareous clayey and fine loamy soils over limestone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

"The study site occupies an area of c.51ha situated on the western edge of Raunds. The area has been subject to previous field investigations conducted as part of the Raunds Project, this comprising field walking (surface finds collection) and targeted geophysical survey and trial trenching on the site of a recorded cropmark henge monument (Cotton Henge). These works have confirmed the presence of the henge alongside later Prehistoric and Romano-British occupation activity, the later evidence for which is known from identified buried remains, suggested cropmarks and concentrations of surface finds material. The noted evidence for the study site to date suggests that it could therefore contain further below ground archaeological remains than are currently understood to be present. In addition, the western extent of the study site lies in close proximity to the scheduled remains of West Cotton and the recorded site of a Prehistoric barrow cemetery." (Steven Weaver, personal communication, March 19, 2015).

Cotton Henge (NMR No. SP 97 SE 56) is described as "*A henge monument located some 500 metres to the east of the monument complex at West Cotton, and excavated as part of the Raunds area project. The site had initially been identified as a cropmark on air photographs. The monument comprises two concentric sub-circular ditches, the outer measuring between 70 and 75 metres across, with the long axis orientated northwest-southeast. The inner circuit is circa 21 metres in diameter. Geophysical survey and excavation was undertaken in 1993 by the Central Excavation Unit. Previously the area had been fieldwalked as part of the Raunds Area Survey and had produced the most extensive surface flint scatter from within the Raunds area. The outer ditch circuit is continuous and may have been accompanied by an internal bank. The area inside the inner ditch may have been mounded. Few artefacts were found, and no samples suitable for radiocarbon dating were recovered. Flint artefacts from the ditch fills are broadly Neolithic, but otherwise not particularly diagnostic, and it has not proved possible to establish a relative sequence for the various phases of the monument. However, both ditches appear to have been deliberately backfilled, possibly as a single episode. Several post holes were examined, but generally proved undatable with the exception of an Iron Age four-post structure just outside the outer ditch, dating evidence being some potsherds. Despite its distance from the West Cotton monuments, the henge is clearly related to them - when projected eastwards, the axis of the long mound (SP 97 SE 85) passes through the henge."* (English Heritage PastScape, 2015)

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 high potential for prehistoric and Romano-British remains, 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*

Handheld Collection:

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.

Cart Collected Data:

2.8.3 Processing

Data has been processed using an in house software package (CartEasy^{N}) and a colour plot has been produced using Surfer 8 software.

Zero Median Traverse	This process sets the background median of each traverse to zero. Limits are applied to reduce the effect of extreme readings which can skew the statistics. The operation minimises the differences between adjacent sensors.
Projection	Greyscale images require data to be sampled at regular intervals on each traverse. Due to the high precision of the RTK GNSS on the CartEasy^{N} magnetometer cart small velocity & traverse separation

	variations result in an irregular sampling interval. Projection involves converting WGS84 coordinates to OSGB36 and re-sampling the collected data at regular intervals during the post processing stage.
Colouring extreme values	Surfer 8 software is used to colour extreme values within the dataset. A colour scale is used with plotting parameters set at +100nT and -100nT.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Raunds 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 Two concentric, sub-circular anomalies in the centre of the site. These are related to the known monument of Cotton Henge (NMR No. SP 97 SE 56).

2-9 A number of positive linear and curvilinear anomalies across the site. These are indicative of former cut features of archaeological origin and are likely to be associated with prehistoric and Romano-British activity.

10 A small, sub-circular feature and associated pit in the north-west of the site is likely to be related to the prehistoric activity visible across the site and may be related to the prehistoric barrow cemetery.

3.2 Possible Archaeology

11-16 A number of positive linear anomalies across the site. These are indicative of former cut features and may be of possible archaeological or agricultural origin.

17 A number of small, discrete positive anomalies across the site. These are indicative of former cut features, such as backfilled pits, and may be of archaeological or natural origin.

18-19 Negative linear anomalies in the centre and south of the site. These are indicative of former banks or earthworks and may be of archaeological or agricultural origin.

3.3 Medieval/Post-Medieval Agriculture

20 Widely spaced, slightly curved, parallel linear anomalies across the site. These are related to ridge and furrow cultivation.

21-22 Linear anomalies in the west and centre of the site are related to former field boundaries that are visible on available historic mapping. Anomaly 21 is present from 1885 to 1958, and Anomaly 22 is present from 1885 to 1974.

23-27 A number of linear anomalies across the site. These are likely to be related to former field boundaries that are not present on available historic mapping.

28 Linear anomaly running southwest-northeast in the centre of the site. This is related to a track-way visible on aerial photographs.

3.4 Other Anomalies

29 Large areas of amorphous magnetic variation across the site. These are likely to be natural, i.e. geological, in origin. They are especially prominent in the north of the site corresponding with the ironstone geology in these parts.

30 Areas of weak scattered magnetic debris in the north and south-east of the site. These are likely to be modern in origin.

31 Strong, bipolar linear anomalies across the site. These are related to modern underground services, such as pipes.

32 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.

33 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

Mudstone geologies can provide variable results for gradiometer survey, however ooidal ironstone and Jurassic limestones generally provide a good response to magnetometer survey. The area in the south-west of the site, on mudstone geology, gives a weaker response to the survey however ridge and furrow and field boundaries have still been discovered. Given the large number of archaeological anomalies that have been identified, it is likely that the survey has been effective, and that the differing geologies across the site has not affected the survey.

5 CONCLUSION

The survey at Raunds has identified a large number of anomalies of probable and possible archaeological origin. The two concentric ring ditches of Cotton Henge have been identified, along with the later prehistoric or Romano-British settlement activity surrounding it. A number of possible pit-like features may relate to post holes, such as those identified by excavations of the area, however they could equally be of natural origin. There is possible evidence of the prehistoric barrow cemetery in the north-west of the site, however interpretation of this is limited by the extents of the survey area. Further linear anomalies may be of archaeological or agricultural origin, however their origin cannot be determined with any degree of confidence. Former field boundaries, evidence of ridge and furrow cultivation across the site, a track-way and evidence of modern ploughing suggest that the site has been used for largely agricultural purposes since the medieval period.

The remaining features are natural or modern in origin and include underground services, scattered magnetic debris, areas of magnetic disturbance from nearby ferrous metal objects and fencing, and magnetic spikes that are likely to be modern rubbish.

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APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Hand-held Collection

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.

Cart-Collected Data

All survey data points had their position recorded using Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS equipment. The geophysical survey area is georeferenced relative to the Ordnance Survey National Grid.

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.

Technique	**Instrument**	**Traverse Interval**	**Sample Interval**
Magnetometer	CARTEASY^N cart system (Bartington 1000L Sensors)	0.75m	10Hz (approximating 0.125m)

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 and a CartEasyN magnetometer cart system utilizing Bartington 1000L Gradiometer sensors manufactured by Bartington Instruments Ltd. The instruments consist 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.

For cart collected data readings were taken at intervals of 0.125m along traverses 0.75m apart.

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 CartEasyN magnetometer cart system collects data at 10Hz which approximates 0.125m.

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.

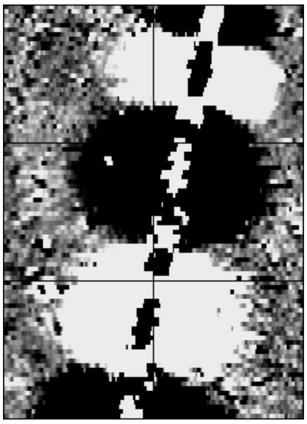
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

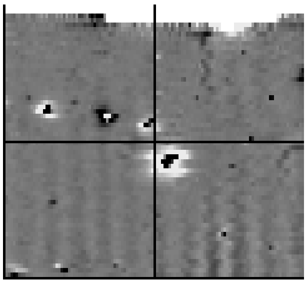
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

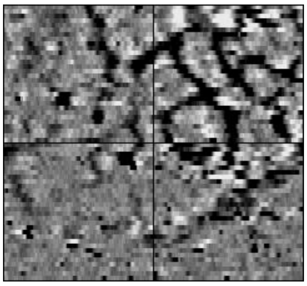


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

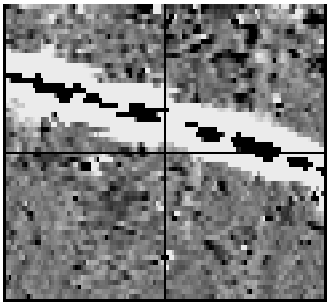
See bipolar and dipolar.

Positive linear



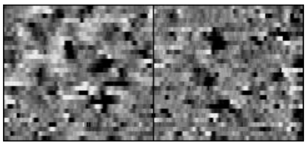
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



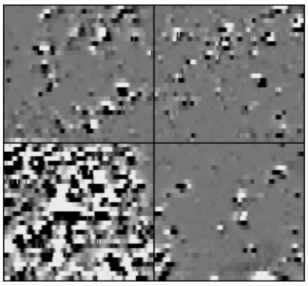
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



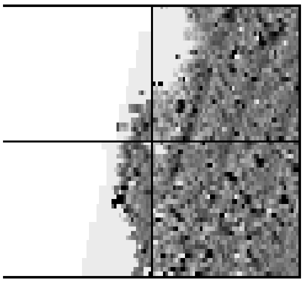
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



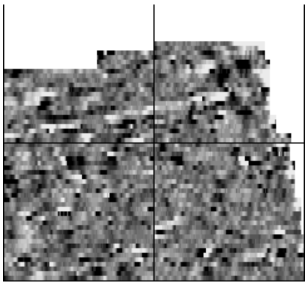
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

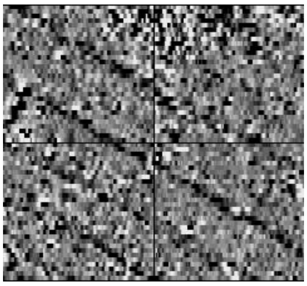


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing. Clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

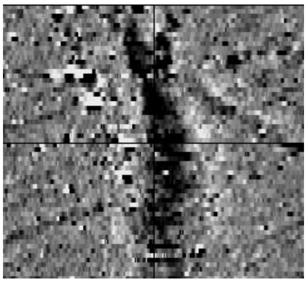
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m^2 area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.

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