

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Etonbury Middle School, Stotfold, Bedfordshire

Client:
Albion Archaeology

April 2014

Job ref:
J6648

Report author:
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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:

3rd April 2014

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TL 205 371

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 2 hectares of agricultural land. A number of archaeological and possible archaeological features have been identified. The south of the site contains a high number of features indicative of possible former settlement features and a small, concentrated area of complex positive features is interpreted as archaeological pitting. These may relate to Prehistoric or Roman-British settlement recorded in the vicinity.

Other anomalies observed are likely modern in origin including agricultural activity, magnetic disturbance (relating to field boundaries and fences) and isolated magnetic spikes in the topsoil.

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 Albion Archaeology.

2.2 *Site location*

The site is located near Stotfold, Bedfordshire at OS ref. TL 205 371. The survey area sits to the west of Stotfold itself and directly east of the Etonbury Middle School site. Stotfold Road runs to the north of the site and the Arlesey – Stotfold Bypass (A507) runs to the west.

2.3 *Description of site*

The survey area is approximately 2 hectares of arable land, currently under grass. The topography is flat overall.

2.4 *Geology and soils*

The underlying geology is West Melbury Marly Chalk Formation - Chalk (British Geological Survey website). The drift geology is Glaciofluvial Deposits, Mid Pleistocene - Sand And Gravel (British Geological Survey website).

The overlying soils are known as Wantage 2 which are typical shallow well drained calcareous silty soils over argillaceous chalk associated with similar soils affected by groundwater (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 *Site history and archaeological potential*

The following has been taken from the WSI provided by Albion Archaeology (Starke 2014):

“Information from Central Bedfordshire Council’s Historic Environment Record demonstrates that the PDA is located within a rich archaeological landscape of Iron Age, Roman and Saxo-Norman remains. Archaeological investigations in the recent decades, especially in conjunction with the Arlesey – Stotfold Bypass and residential developments in the area, have revealed a number of sites within the vicinity of the site.

Field survey and archaeological evaluations on the bypass corridor (EBD188, EBD599) revealed evidence for prehistoric activity within the area in form of residual flint scatters in areas to the north-west and south of the PDA. A D-shaped enclosure recorded through aerial photography on the field adjacent to the east of the PDA is thought to be of prehistoric date.

Late Bronze Age to Roman occupation was identified at Etonbury Farm immediately to the north of the bypass (Heritage Network 2003), c. 1.3km to the north-west of the PDA. Bronze Age settlement evidence was also recorded during excavations to the south of Stotfold (Albion Archaeology 2011) and at a site on Arlesey Road, Stotfold, c. 400m to the east of the PDA (Albion Archaeology forthcoming (a)). This site revealed evidence of human occupation from the late Bronze Age right through to the late Romano-British period, comprising field systems, trackways and settlement features. The medieval period was represented here by field systems of ridge and furrow cultivation. Excavations at Fairfield Park (formerly Fairfield Hospital), c. 1.8km to the south of the PDA, also revealed early to late Iron Age settlement structures as well as evidence for Roman occupation (BCAS 1997; Webley et al 2007; Albion Archaeology forthcoming (b)).

The investigations along the bypass also produced evidence for the Iron Age in the form of enclosures and earthworks including a possible hill fort at Etonbury (HER16095/6, HER16083). A geophysical survey undertaken in 2012 on the premises of Etonbury Academy itself (EBD969) revealed a series of rectilinear and curvilinear enclosures in the western half of the current playing field. In the same year, ten 1m² test pits were excavated by school students and teachers of the Best Archaeological Society (BEST) along the outer northern and western perimeter of the site. One pit was excavated between the two larger pitches. These pits produced probable Neolithic flints, Iron Age and Roman pottery and a coin (no written report on the excavation results was available at the time of writing this document).

Stotfold Road, which borders onto the northern boundary of the PDA, is thought to be in alignment with a possible Roman road (HER296). This is not one of the routes postulated by the Viatores (1964). Traces of this road were reportedly recorded during roadworks in the 1970s.

The area investigated to the south of Etonbury Academy during the bypass evaluation produced evidence for Saxon occupation. However, the settlement focus was thought to lie north of the bypass corridor, where a geophysical survey suggested the possible existence of sub-surface features characteristic of sunken-featured buildings (SFBs). However, as they were located outside the road corridor, these features were not further investigated (GSoB 1993; BCAS 1995).

In the wider context, the PDA lies between Arlesey and Stotfold. Both towns are mentioned in Domesday Book. Both settlements appear to have been very large at the time. Stotfold is recorded with 41 households and 4 mills, Arlesey with four entries totalling 38 households and 3 mills. Also close by is the medium-sized settlement of Astwick and the settlement at Henlow, which is also classed as large. Recent excavations in Stotfold (Albion Archaeology 2011) have revealed evidence of extensive late Saxon/Saxo-Norman settlement at the southern margins of the present-day settlement, c. 1.4km south-east of the PDA.

A number of heritage assets dating to the post-medieval and modern period are located within close proximity of the PDA. These encompass two former gravel pits (HER 2932, HER5198) the Fox and Duck Public House (HER16307) and the site of a former gas works built in 1903 (HER6798). The Fox and Duck is a 19th-century building that was first licensed as a public house in 1858. It is located on the adjoining property to the east of the PDA (thus in Stotfold parish).

Both former gravel pits are located south of Stotfold Road. Pit (HER2932) is located on the Academy premises c. 80m north of the current buildings close to the northern boundary. Gravel pit HER5198 is located c. 90m to the west of the PDA adjacent to the Stotfold Road/A507 roundabout. The site of the former gas works (HER6798) is now a gas distribution station on the southern side of Stotfold Road, east of the roundabout with the A507. The majority of the original gas works have now been demolished leaving only boundary walls, gate piers and a dwelling house.”

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*.

Previous magnetometer surveys have been carried out in the immediate vicinity of this site. These surveys successfully identified a wide variety of features so the same technique was deemed most appropriate for this survey. 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 Stotfold 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 A concentrated area of positive anomalies indicative of cut features of archaeological origin. These include a number of linear and curvi-linear anomalies and a clear quadrilateral anomaly. These could relate to settlement features of the Prehistoric or Romano-British periods
- 2 A number of positive point anomalies. These are indicative of cut features of

an archaeological origin, and could indicate the presence of an area of pitting.

3.2 *Possible Archaeology*

- 3 A small number of weaker linear anomalies, possibly indicative of cut features of archaeological origin.

3.3 *Other Anomalies*

- 4 Closely spaced parallel linear anomalies, probably related to agricultural activity such as ploughing.
- 5 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.
- 6 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**

A detailed magnetic survey was conducted over approximately 2 hectares at Stotfold. A number of archaeological and possible archaeological features have been identified. The southern area of the field contains a high number of features indicative of former settlement features and a small, concentrated area of complex positive features is interpreted as archaeological pitting. These positive features include a large quadrilateral enclosure and a number of fragmented linear and curvilinear features surrounding and within the enclosure. These may relate to Prehistoric or Roman-British settlement recorded in the vicinity and are likely to extend beyond the limit of the survey area.

A small number of positive linear features, located in the south east and north west corners of the survey area, could represent possible archaeological features however further interpretation is difficult due to their weaker responses.

Other anomalies observed are likely modern in origin including agricultural activity, magnetic disturbance (relating to field boundaries and fences) and isolated magnetic spikes in the topsoil.

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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.

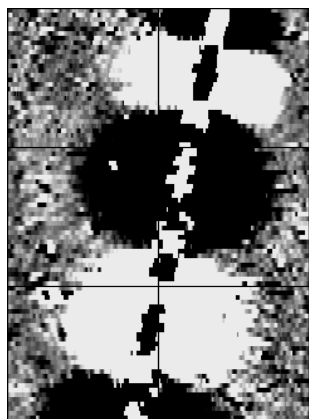
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

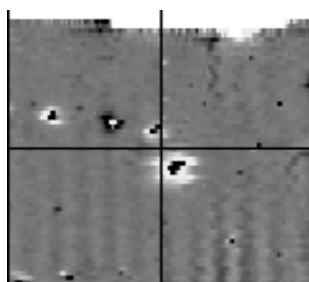
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

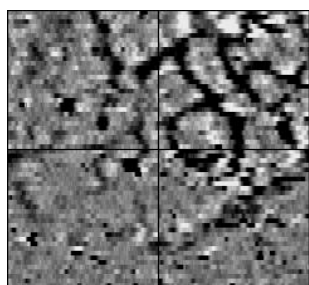


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

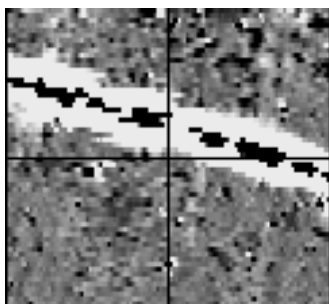
See bipolar and dipolar.

Positive linear



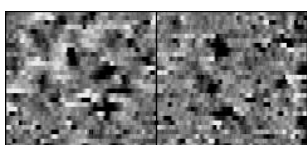
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



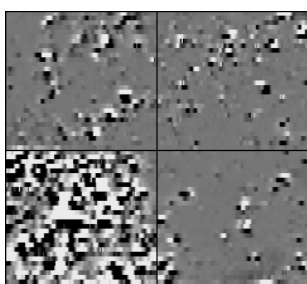
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



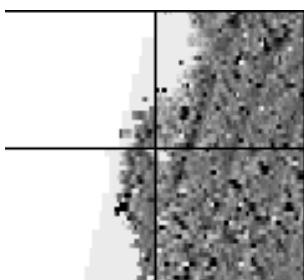
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



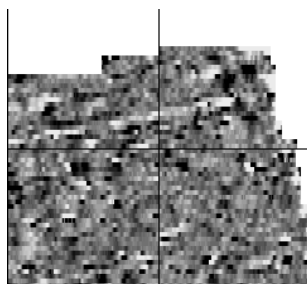
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

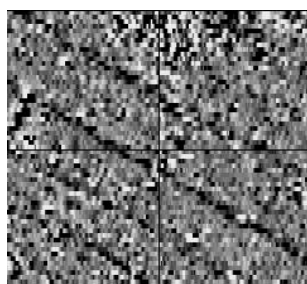


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

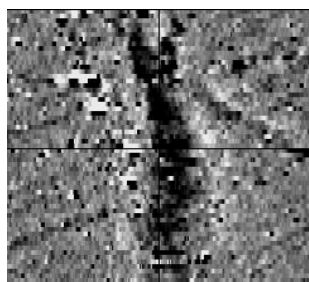
Strength of response

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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