

GEOPHYSICAL SURVEY REPORT

STRATASCAN™



Project name:
Wickham Market, Suffolk

Client:
Amec Environment and Infrastructure UK Ltd.

November 2013

Job ref:
J5892

Report author:
Joshua T. Jones Bsc (Hons)

Orlando J. Prestidge BA(Hons) MA PIfA

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Techniques:

**Detailed magnetic survey –
Gradiometry**

Survey date:

October 2013

Site centred at:

TM 312 569

Post code:

IP13 0AB

Field team:

Sean Parker

Steve Hamflett

Andy Bateman

Project manager:

Simon Haddrell BEng(Hons) AMBCS PIFA

Report written By:

Joshua T. Jones BSc (Hons)

Orlando J. Prestidge BA(Hons) MA PifA

CAD illustrations by:

Orlando J. Prestidge BA(Hons) MA PifA

Joshua T. Jones BSc (Hons)

Checked by:

David Elks MSc AIFA

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over 25 hectares of agricultural land. A wide ranging variety of both archaeological and other features were identified within the data. These include cut features of archaeological origin, including possible enclosures, ring ditches and field boundaries. There were also a number of cut features of possible archaeological origin, indicative of enclosures, pits and possible ring ditches. Large areas of modern agriculture (ploughing) cover the majority of the survey area, and modern services, areas of magnetic disturbance and areas of natural, geological variation were also present.

A 2 hectare targeted earth resistance survey was also carried out over areas where archaeology was identified in the magnetic survey results. These surveys only indicated modern ploughing and the presence of amorphous areas of high resistance which are difficult to interpret.

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 Amec Environment and Infrastructure UK Ltd.

2.2 *Site location*

The site is located at the junction between the A12 and the B1078/B11 to the North-East of Wickham Market at OS ref. TM 312 569

2.3 *Description of site*

The survey area is made up of two areas; the largest one to the North of the A12 merge slip road approximately 22 hectares. The smaller site is between the slip road and the A12 and is approximately 2.5 hectares. The combined site is approximately 25 hectares. The larger area to the North is arable farmland. Hedgerows and woodland belts mark some field boundaries.

2.4 *Geology and soils*

The underlying geology is Crag Group - Sand. Sedimentary bedrock. (British Geological Survey website). The drift geology is Lowestoft Formation - Sand And Gravel (British Geological Survey website).

The overlying soils are known as Burlingham 3 which are typical stagnogleyic argillic brown earths. (Soil Survey of England and Wales, Sheet 4 Eastern England). These consist of Deep fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging.

2.5 **Site history and archaeological potential**

A Romano-British settlement (Hacheston) was partially excavated in the 1970s along the line of the A12, the Wickham Market Bypass, which forms the southern boundary of the site. Hacheston has been interpreted as a large Romano-British settlement (Blagg et al 2004). The nature and full extent of the settlement remains unknown

2.6 **Survey objectives**

The objective of the survey was to locate any features of possible archaeological origin in order that they may be assessed prior to development.

2.7 **Survey methods**

This report and all fieldwork have been conducted in accordance with both the English Heritage guidelines outlined in the document: *Geophysical Survey in Archaeological Field Evaluation, 2008* and with the Institute for Archaeologists document *Standard and Guidance for Archaeological Geophysical Survey*.

Detailed magnetic survey (gradiometry) and detailed earth resistance survey (resistivity) were used as an efficient and effective method of locating archaeological anomalies. A trial gradiometer and earth resistance (resistivity) survey on the south western section of the site was carried out at first, and acting on the results, a more widespread gradiometer survey was chosen as the preferred survey method. A targeted earth resistance survey was then used over two of the areas with the highest concentration of anomalies. More information regarding this technique is included in the Methodology section below and in Appendix A and D.

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

2.8.1 *Processing*

Gradiometer

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)

Earth resistance

The processing was carried out using specialist software known as Geoplot 3 and involved the 'despiking' of high contact resistance readings and the passing of the data through a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The net effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

1. *Despike* $X \text{ radius} = 1$
 $Y \text{ radius} = 1$
Spike replacement

2.8.2 Presentation of results and interpretation

Gradiometry

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, together with a greyscale plot of the processed data. Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site.

Earth resistance

The presentation of the data for the site involves a print-out of the raw data as a grey scale plot, together with a grey scale plot of the processed data. Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing.

3 RESULTS

The detailed magnetic gradiometer survey conducted at Wickham Market 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.

A trial gradiometer and earth resistance (resistivity) survey on the south western section of the site was carried out at first, and acting on the results, a more widespread gradiometer survey was chosen as the preferred survey method as it was more successful in locating archaeological features. A targeted earth resistance survey was then used over two of the areas with the highest concentration of anomalies. These have been included within the overall listing of results below.

The following list of numbered anomalies refers to numerical labels on the interpretation plots.

3.1 *Probable Archaeology*

- 1 Circular positive anomalies, probably cut features of archaeological origin.
- 2 Closed quadratic features showing a positive anomaly. Probably cut features of archaeological origin such as enclosure ditches.
- 3 Linear features with a positive anomaly probably cut features of archaeological origin. Possible large enclosures or boundaries.
- 4 Small point features with a positive anomaly. Probable cut features of archaeology origin such as pits.
- 5 Negative anomaly, probably bank or earthwork of archaeological origin.
- 6 Linear anomaly associated with former field boundaries.

3.2 *Possible Archaeology*

- 7 Linear, positive anomalies. Possibly cut features of archaeological origin. Possible enclosures or boundary lines.
- 8 Positive, point features. Possible small, cut feature.
- 9 Linear, negative anomaly. Possible bank or earthwork of archaeological origin
- 10 Area of weak positive anomalies. Possible cut features of archaeological origin.

3.3 *Other Anomalies*

- 11** 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.
- 12** Area of amorphous magnetic variation probable natural e.g. geological or pedological origin
- 13** A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.
- 14** Linear anomaly possible related to pipe, cable or other modern service.
- 15** Closely spaced parallel, linear anomalies probably related to agricultural activity such as ploughing.

4 CONCLUSION

The site had a moderate archaeological potential due to its location within a potential Romano-British landscape.

There is a large concentration of anomalies that are of an archaeological origin across the western and central section of the survey area. This area includes numerous linear and curvilinear anomalies indicative of ditches, field boundaries and enclosures, as well as some smaller, roughly-circular anomalies that suggest ring ditches.

The anomalies are very closely concentrated, and this suggests an area of settlement, and some features also appear to cut each other, suggesting multiple periods of occupation.

A targeted earth resistance survey was also carried out over two areas of concentrated archaeological activity in the west and centre of the survey area. In the western area, the gradiometer survey had indicated a roughly circular feature with two possible pits in its centre. However, the earth resistance survey only indicated the presence of modern ploughing, with an amorphous area of high resistance on the edge of the targeted area. In the centre of the survey area, an area of small enclosures and circular features had been indicated. The earth resistance survey indicated further amorphous areas of high resistance, but further interpretation is difficult.

There are also a number of weaker linear anomalies located towards the south of the survey area, indicating cut features of a possible archaeological origin. These may be historic field boundaries or ditches but could also be of a modern agricultural origin. A number of small, roughly circular features are also present across the south of the survey area. These indicate pits of possible archaeological origin, although their size and scattered nature make further interpretation difficult. A small number of weak, negative linear anomalies are also present in the survey data, and these could be related to banks or earthworks of an archaeological origin. Their linear and isolated nature within the survey area could also indicate them to be of a modern agricultural origin.

Modern agricultural activity is visible across the centre of the survey area, in the form of closely spaced parallel linear anomalies, probably related to ploughing. The survey data has also shown

a number of other anomalies probably relating to modern pipes, services or cables, and nearby metallic objects such as services or field boundaries. Areas of natural geology or pedology can also be observed in the north and south west corners of the survey area and magnetic spikes, which are associated with modern rubbish, are also present.

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APPENDIX A – GRADIOMETRY: METHODOLOGY & SURVEY EQUIPMENT

Grid locations

The location of the survey grids has been plotted together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site or a Leica Smart Rover RTK GPS.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. A SmartNet RTK GPS uses Ordnance Survey's network of over 100 fixed base stations to give an accuracy of around 0.01m.

Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Depth of scan and resolution

The Grad 601-2 has a typical depth of penetration of 0.5m to 1.0m, though strongly magnetic objects may be visible at greater depths. The collection of data at 0.25m centres provides an optimum methodology for the task balancing cost and time with resolution.

Data capture

The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

APPENDIX B – BASIC PRINCIPLES OF MAGNETIC SURVEY

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

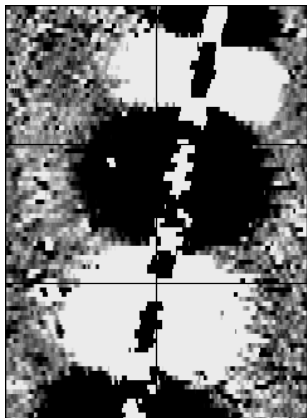
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

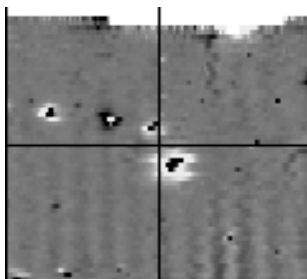
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

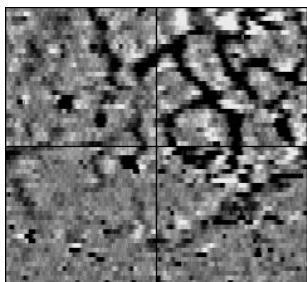


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

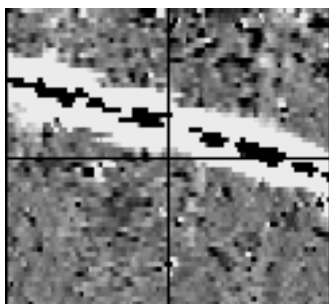
See bipolar and dipolar.

Positive linear



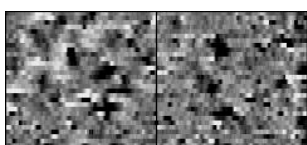
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



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

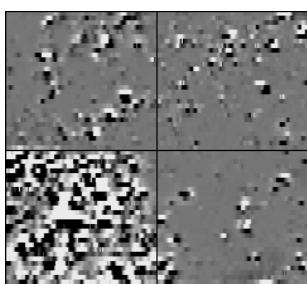
Positive point/area



depressions in the ground.

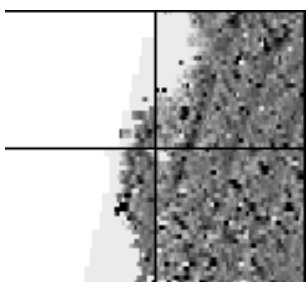
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



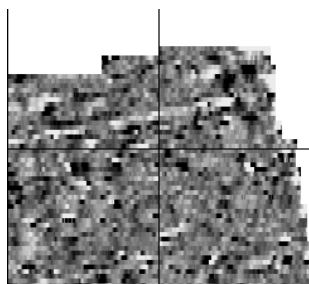
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

Magnetic disturbance



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

Negative linear

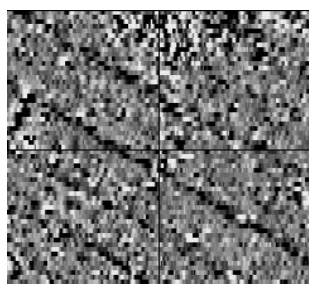


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

Negative point/area

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

Ploughing activity



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

Polarity

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

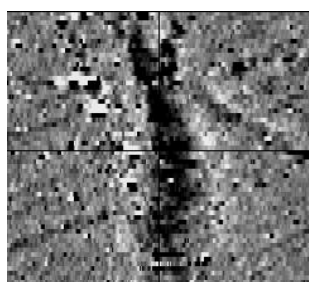
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m² area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

Thermoremanent response

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

Weak background variations



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

APPENDIX D – RESISTIVITY: METHODOLOGY & SURVEY EQUIPMENT

Survey equipment and principle of methodology

This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As earth resistance is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high earth resistance response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

The resistance meter was used in conjunction with an MPX15 multiplexer to allow two adjacent readings to be taken at each instrument position.

Though the values being logged are actually resistances in ohms they are directly proportional to earth resistance (ohm-metres) as the same probe configuration was used through-out.

Sampling interval

Readings were taken at 1m centres along traverses 1m apart. This equates to 900 sampling points in a full 30m x 30m grid.

Depth of scan and resolution

The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m. The collection of data at 0.5m centres with a 0.5m probe spacing provides an optimum resolution for the task.

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.



STRATASCAN™



STRATASCAN LTD

Vineyard House Upper Hook Road Upton upon Severn
Worcestershire WR8 0SA United Kingdom

T: 01684 592266 F: 01684 594142
info@stratascan.co.uk www.stratascan.co.uk