STRATASCAN

Geophysical Survey Report

Shropham Quarry, Norfolk

for

Archaeological Solutions

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Stratascan Job Number: J2496

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LIST OF FIGURES

1 SUMMARY OF RESULTS

The geophysical survey carried out at Shropham Quarry totalling an area of 18ha has identified a quantity of positive linear anomalies which have been interpreted as cut features of probable archaeological origin Most notably of which is a complex of enclosures in the north of Area 1. The survey has also identified discrete positive anomalies, which have been interpreted as pits of possible archaeological interest and negative anomalies representing possible former earthworks or embankments.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Archaological Solutions Ltd to undertake a geophysical survey of an area outlined for development as an extension to Shopham Quarry.

2.2 Site location

The site is located to the north east of Shropham, Norfolk at OS ref. TL986 943. The site is split over two separate areas. Area 1 (Phase A) is to the north of Spong Lane and the east of Rocklands Road. Area 2 (Phase B) is located to the west of Rocklands Road and the south of Fish Farm.

2.3 Description of site

The survey area is 18ha is size and consisted of flat arable land. The crops over the site varied between potatoes, barley and beat.

2.4 Geology and soils

The underlying geology is Chalk, including Red Chalk (British Geological Survey South Sheet, Fourth Edition Solid, 2001) with a drift geology of Boulder Clay and Morainic Drift (Geological Survey Ten Mile Map, South Sheet, First Edition (Quaternary) 1977)

The overlying soils are understood to comprise of the Worlington Association, described as deep permeable sandy soils either over chalky drift or on glaciofluvial deposits. (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 Site history and archaeological potential

The site has a high potential for revealing archaeological remains dating to the Neolithic and Bronze Age periods, a low to moderate or moderate potential for Iron Age, Romano-British and Anglo-Saxon remains, and a low potential for finds or features dating to the Palaeolithic, Mesolithic, medieval and later periods.

Previous archaeological investigations to the immediate west and north-west of the site revealed extensive evidence of Neolithic and Bronze Age activity and occupation on the hilltop, which possibly served as a ceremonial focus-point. Phase B of the site is thought to have the highest potential for similarly-dated remains given its proximity to the known archaeological evidence. The eastern area of the site, Phase A, is known to have yielded finds of a single Neolithic pottery rim shard and a Neolithic or Bronze Age flint. Little is known of the site in later periods, other than it formed part of the Corporation of Norwich land located well-beyond the northern extent of Shropham village. (Shropham Quarry, Norfolk Proposed Extension. Archaeological Desk Based Assesment, Archaeological Solutions Ltd. Kate Doyle BA May 2008)

2.6 Survey objectives

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

2.7 Survey methods

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over 5 days from 30th June 2008 - 4thJuly 2008. Weather conditions during the survey were dry and sunny.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 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.

The location of the survey grids is based on the Ordnance Survey National Grid (see Figure 2). The referencing and alignment of grid baselines was achieved using a Leica DGPS System 500.

A DGPS (differential 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. Calculations to correct for these errors are performed at an accurately located base station. The base station then transmits the corrections which are received by DGPS consoles giving sub metre accuracy averaging around 0.5m error.

3.3 Survey equipment

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (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. Similarly, where a ploughed out embankment had originally been thrown up using less magnetic subsoil, a weak negative linear anomaly will be seen

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.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 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.

3.4.2 Depth of scan and resolution

The Grad 601 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an optimum methodology for the task balancing cost and time with resolution.

3.4.3 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 job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Processing is performed using specialist software known as *Geoplot 3.* 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. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. 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 minimally processed gradiometer data used in this report:

1. *Zero mean traverse* (sets the background mean of each traverse within a grid to zero and is useful for removing striping effects)

   Geoplot parameters:
   Least mean square fit = off

The additional schedule shows the processing carried out on processed gradiometer data used in this report:

2. *Despike* (useful for display and allows further processing functions to be carried out more effectively by removing extreme data values)

   Geoplot parameters:
   X radius = 1, y radius = 1, threshold = 3 std. dev.
   Spike replacement = mean

3. Destagger (removes the 'stagger' caused by operators walking at an inconsistent pace. This usually occurs over uneven land)

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data both as greyscale (Figures 3 & 6) and trace plots (Figure 9), together with a greyscale plot of the processed data (Figures 4 & 7). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figures 5 showing Area 1 & 8 showing Area 2).

4 RESULTS

The magnetometer survey identified a number of geophysical anomalies across the site. These anomalies have been abstracted into the following categories:

- Positive linear anomalies of possible archaeological origin
- Negative linear anomalies representing possible banks or earthworks
- Positive area anomalies of possible archaeological origin
- Negative area anomalies
- Discrete positive anomalies
- Magnetic spikes / debris
- Agricultural marks
- Geological / Pedological responses

Positive Linear anomalies of possible archaeological origin.
The site as a whole has a significant number of positive linear features, representing cut features of possible archaeological origin. A series of linear features within Area 1 make up a complex enclosure (1). Some of the features traverse whole fields (2), these may be former field boundaries and are evident across the survey areas. The large number of short linear features are numerous and complex, suggesting these may be from several phases of activity within this area.

Negative linear anomalies representing possible banks or earthworks
A large linear negative anomaly, representing a possible former bank or earthwork (3) is evident traversing the eastern edge of the western field in Area 1. This feature is probably associated with the boundary itself. A linear feature which exhibits both positive and negative anomalies (4), which may be associated with a possible former field boundary, can be seen in the north of Area 2. Two separate linear features (5) can also be seen in the north of this area. Other negative linear anomalies can be seen in close proximity to positive features and are probably associated.

Positive area anomalies of possible archaeological origin
Several strong positive area anomalies can be seen across the area, with the two largest in Area 1 both having an associated negative response (6). These features may be large pits or cut features of an archaeological origin. The weaker anomalies in both areas may be of an archaeological origin but equally may also be of a geological / pedological origin. Further investigations of these anomalies are recommended to determine their true nature.

Negative area anomalies
A narrow negative area anomaly is evident in Area 2 (7), this anomaly seems to form the eastern edge of a large area of magnetic debris which it may be associated with. Other weak area anomalies can be seen in Area 1 which may be former earthworks or embankments but may also be geological / pedological in origin.

Discrete positive anomalies
Discrete positive anomalies representing possible pits of archaeological interest, can be seen across both areas of the survey, with the majority in Area 1.

Magnetic spikes / debris
Magnetic spikes caused by near surface ferrous objects can be seen across both area of the site. Area 1 contains a small area of magnetic disturbance in the north west and magnetic debris in the centre. The north west corner of the large field in Area 2 contains an area of magnetic debris of varying sizes and strengths. The smaller anomalies appear to be near surface ferrous objects, but some of the larger anomalies are of an amplitude of just ±30nT suggesting a different cause. It is recommended to investigate these further.

Agricultural Marks
Agricultural marks are evident in the data to the south of Area 2 which is consistent with the land use. The small field in the west of Area 2 contains a lot of background noise resulting from deep cultivations. Because of this small features may not show in the data.

Geological / Pedological responses
The survey area demonstrated a weak mottled background variation which is possibly caused by the local pedology / geology. As these responses cover the majority of the survey area they have not been identified within the interpretations.

5 CONCLUSION

The geophysical survey at Shropham Quarry has found evidence for archaeological activity across the survey area in the form of possible enclosures, former field boundaries, cut features, pits and banks / earthworks. One of the clearest features is an enclosure (see figure 1) with several possible pits and cut features within. A significant number of positive anomalies representing cut features of possible archaeological interest can be seen across the site suggesting several phases of human activity. The data also shows several former field boundaries in the form of long linear anomalies. The data over the potato crop has a high level a background noise caused by the deep cultivation (see Photograph 1) and this may be masking any subtle features within the area. Further investigation is therefore recommended to determine the true archaeological potential.

Photograph 1 – View over potato crop hiding deep ploughing beneath

Figure 17 – Eenclosure Identified in Area 1

6 REFERENCES

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid)*. British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern England*.

Shropham Quarry, Norfolk Proposed Extension, Archaeological Desk Based Assesment Archaeological Solutions Ltd, Kate Doyle BA, May 2008.

APPENDIX A – 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 *thermoremnant* 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.

Thermoremnance 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. Thermoremnant archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

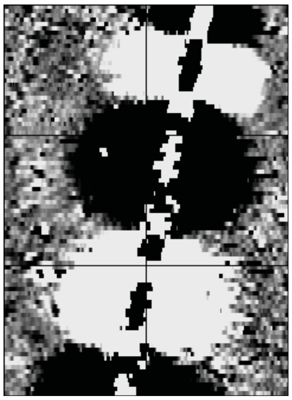
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 either 0.5 or 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.

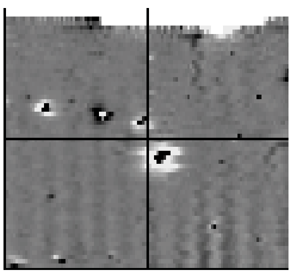
APPENDIX B – Glossary of magnetic anomalies

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

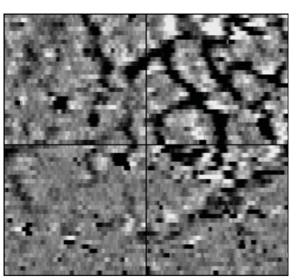


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

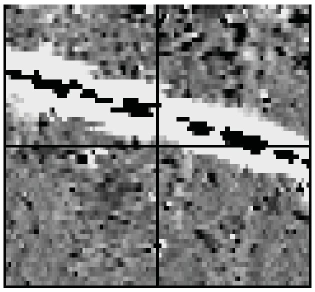
See bipolar and dipolar.

Positive linear



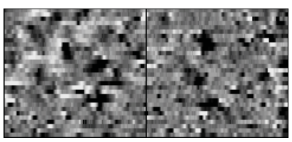
A linear response which is entirely positive in polarity. These are usually related to infilled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



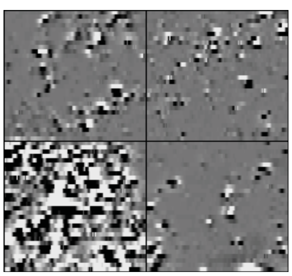
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



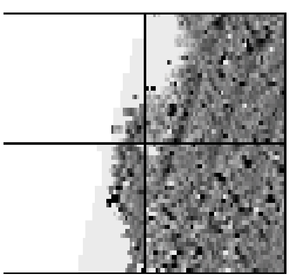
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by infilled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



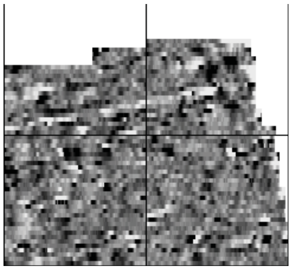
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

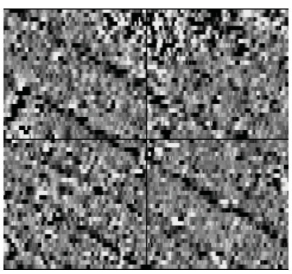


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

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).

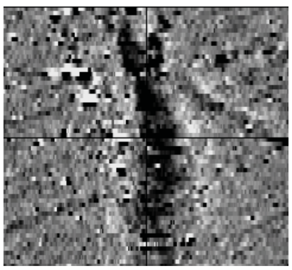
Strength of response

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 $10m^2$ 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. Trace plots are used to show the amplitude of response.

Thermoremnant 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 insitu (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.