GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:

Astley Mills, Worcestershire

Client:

NWAG - AMSAX Project

March 2016

Job ref:

J9239

Report author:

Rebecca Davies BSc (Hons)

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Field team:
Christian Adams BA (Hons), **Alexis Thouki** MA, **Stephen Weston** BA (Hons), **Sonia Kostrzewska** MA

Techniques:
Detailed magnetic survey – Gradiometry

Project manager:
Simon Haddrell BEng (Hons) AMBCS PCIfA

Survey date:
23rd - 24th November & 17th December 2015

Report written By:
Rebecca Davies BSc (Hons)

Site centred at:
SO 805 668

CAD illustrations by:
Rebecca Davies BSc (Hons)

Post code:
WR6 6TH

Checked by:
Peter Barker C.Eng MICE MCIWEM MCIfA FCInistCES

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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 6.1 hectares of grassland. Several anomalies related to former industrial activity on the site have been identified, including magnetic disturbance possibly associated with a former crane platform and two other similar features. A discrete anomaly and areas of debris are likely to be related to the industrial activity, as are a number of magnetic spikes. Former track-ways and areas of natural variation have also been identified, while the remaining features are modern in origin and include areas of magnetic disturbance from nearby ferrous metal objects, such as fencing.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area that is part of a research project investigating former industrial activity along Dick Brook and its confluence with the River Severn. This survey forms part of an archaeological research investigation being undertaken by North Worcestershire Archaeological Group.

2.2 Site location

The site is split into two areas, both are located north of Shrawley Wood, Worcestershire and to the west of the River Severn. The western area is centred at OS Ref. SO 799 668 and the eastern area is centred at OS ref. SO 809 667.

2.3 Description of site

The survey area is approximately 6.1 hectares of flat, unobstructed grassland. The site lies on flood meadows to the north of Dick Brook, the River Severn to the east and by woodland to the north and south.

2.4 Geology and soils

The underlying geology comprises sandstone of Bromsgrove Sandstone Formation (British Geological Survey website). The drift geology is Alluvium – clay, silt, sand and gravel (British Geological Survey website).

The overlying soils across the majority of the site are known as Bromsgrove which are typical brown earths. The soils across the eastern-most field of the site are known as Newport 4 which are typical brown sands. The Bromsgrove soils consist of well drained reddish coarse loamy soils mainly over soft sandstone while the Newport 4 soils consist of deep well drained sandy soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

Information from Mike Field (personal communication, October 2, 2015) provides evidence of substantial industrial activity in the area running along Dick Brook and its confluence with the River Severn. A former mill site and series of leats are recorded, along with a possible crane platform and potter's saggars. In addition to this, a former iron forge is recorded to the north of Dick Brook at OS Ref. SO 8058 6684 (Monument No. 116295). The forge is recorded to have been built in 1652 and was in use from 1713-1760 as a fulling mill, paper mill and flint grinding mill. A wheel pit, watermill and leat are also recorded in this location (PastScape, 2015).

This information suggests that the area has a largely industrial past, with a former mill, iron forge and evidence of pottery works recorded within close proximity of each other and it is likely that remains of this activity will be detected through geophysical survey.

2.6 *Survey objectives*

The objective of the survey was to locate any features of post-medieval industrial activity in order to determine the locations of further more detailed geophysics leading to strategic trenching as part of an excavation plan.

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 industrial remains to be identified, detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in Appendix A.

2.8 *Processing, presentation and interpretation of results*

2.8.1 *Processing*

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

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

1. *Destripe* (Removes striping effects caused by zero-point discrepancies between different sensors and walking directions)

2. *Destagger* (Removes zigzag effects caused by inconsistent walking speeds on sloping, uneven or overgrown terrain)

2.8.2 Presentation of results and interpretation

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

3 RESULTS

The detailed magnetic gradiometer survey conducted at Astley has identified a number of anomalies that have been characterised as being of a probable archaeological origin and features likely related to former industrial activity on the site.

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

*3.1 **Probable Archaeology***

1 A strong discrete feature some 24m square, broadly aligned with Dick Brook. Within the feature there appear to be a number of positive linear anomalies approximately 3m across and around 20m in length. At the south-west end is a strong discrete dipole with a further strong discrete feature on the south-eastern side at the edge of the brook. It is very likely that this is related to former industrial activity. The linear anomalies within this feature are likely related to former structural remains.

2 A strong discrete feature similar in character to Anomaly 1 but smaller in size at approximately 11m by 14m. Again the anomaly appears to be made up of four positive linear features around 14m in length and is thought to relate to industrial activity.

3 A further strong discrete feature 28m long by 22m wide with similar characteristics to Anomaly 1, including a strong discrete feature on the south-west side. In the adjacent plot to the south there is a suspected crane platform which may be associated with this feature.

4 Localised areas of strong magnetic debris at five locations across the site. These are likely to be related to former industrial activity. The strength of these responses suggests that they comprise of highly magnetic material such as ferrous metal.

5 Linear anomalies made up of strong magnetic debris, approximately 3m wide, seen in the west, centre and east of the site. They run roughly parallel with Dick Brook. The strength of the response suggests that they are somehow related to the industrial activity of the site and represent ditches infilled with magnetic debris. In the east of the site these features seem to connect areas of discrete magnetic disturbance (Anomalies 2 & 3).

6 Areas of strong magnetic debris in the centre of the site, immediately south of a former cottage. These lie in close proximity to the former forge and are likely made up of an assortment of magnetic debris including building rubble and rubbish from the nearby cottage along with possible slag.

7 A small area of scattered magnetic debris in the centre of the site. These are likely to be related to the possible industrial activity seen in Anomaly 6. The debris is likely to comprise of small metallic objects, bricks and other rubble.

8 A number of magnetic spikes in the east of the site. Given the proximity of these features to evidence of industrial activity, it is likely that the magnetic spikes are related to this.

3.2 ***Possible Archaeology***

9 A series of magnetic spikes forming linear anomalies in the south-east of the site. These are possibly related to a former fence-line, however their proximity to the former mill suggests that may be related to this.

10 A positive linear anomaly in the centre of the site, east of the 'Stepping Stones'. This is indicative of a former cut feature, such as a ditch. Given the proximity to a cottage to the north, it is possible that this is related to a service trench associated with the building.

11 A discrete positive anomaly in the south-east of the site, to the west of the modern footbridge crossing Dick Brook. In a recent investigation in this area, brick and stonework remains have been uncovered and it is likely that the response is related to this.

12 A number of small discrete positive anomalies across the east of the site. These are indicative of former cut features, such as backfilled pits. In this instance, they may be related to the former industrial activity

3.3 Other Anomalies

13 Areas of magnetic debris in the west and east of the site. These are related to modern track-ways present at the time of survey. In the west of the site, a possible leat is thought to run along the course of the modern trackway, and it is plausible that the disturbance is associated with this.

14 A weak linear anomaly, with both positive and negative elements, running northeast-southwest in the east of the site. The feature is likely to be a ploughed out ditch, possibly associated with a former watercourse/drainage channel or field boundary. The feature corresponds with a former trackway that is visible on aerial photographs of the site dating back to 1945 (Google Earth, 2016).

15a **15b** Sections of weak linear anomalies running parallel with the brook. Anomalies 15a are negative and 15b are positive. These may be man-made and relate to possible leats, however a natural origin should not be discounted.

16 A small area of scattered magnetic debris in the west of the site. This is likely to be modern in origin.

17 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and a foot bridge. These effects can mask weaker archaeological anomalies, but on this site have not affected a significant proportion of the area.

18 A number of magnetic 'spikes' indicate ferrous metal objects. These are likely to be modern rubbish.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Sandstone geologies, such as those across the site, generally provide an average response for gradiometer survey, however, alluvial deposits have the potential to mask weaker archaeological anomalies. The features of industrial activity which have been detected are all of sufficient amplitude to be seen through the alluvial deposits, though weaker anomalies may not have been discovered as a result. Given the number of features of industrial activity that have been identified, it can be determined that the survey has been effective.

5 CONCLUSION

The survey at Astley Mills, Worcestershire has identified a number of features that are likely to be related to the former industrial activity of the site.

Three areas of strong magnetic features (Anomalies 1, 2 and 3) have a high probability of being sites of industrial activity. Anomaly 3 lies to the north of a possible crane platform and may be associated with this, though it could equally be related to other industrial activity. Further areas of magnetic disturbance (Anomalies 4) are further evidence of industrial activity on the site.

A discrete positive anomaly and areas of magnetic disturbance across the site are likely to be related to the industrial activity, as are the number of magnetic spikes and the linear features that have been identified in the east of the site.

Small discrete anomalies, possibly indicative of backfilled pits, have been detected across the site. Weak linear anomalies in several locations may be related to former leats, however a natural origin cannot be ruled out.

Areas of strong debris situated immediately south of a cottage have been detected and are thought to be related to industrial activity in this area. A linear anomaly to the east of these features is also possibly related to the cottage, and may represent a service or service trench. The remaining features are modern in origin and include former track-ways, magnetic disturbance from nearby ferrous objects and magnetic spikes which are likely to be modern rubbish.

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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.

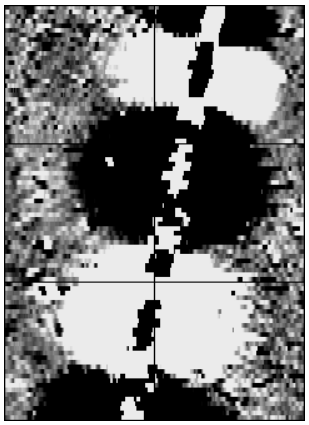
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

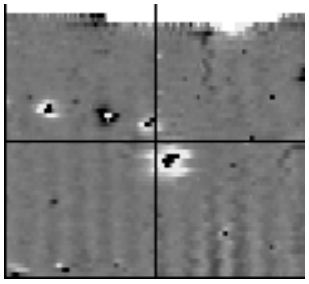
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

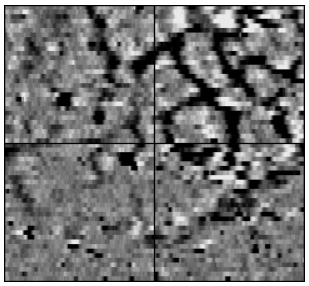


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

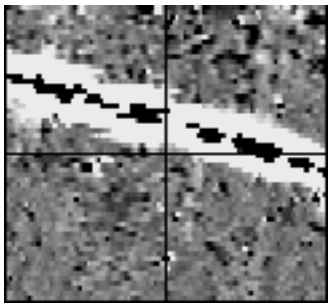
See bipolar and dipolar.

Positive linear



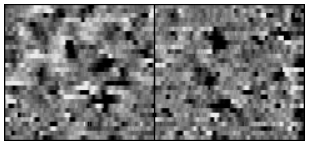
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



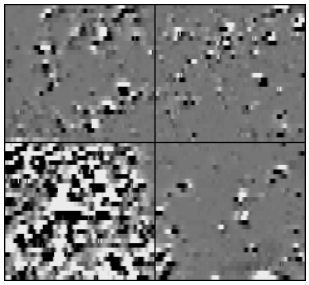
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



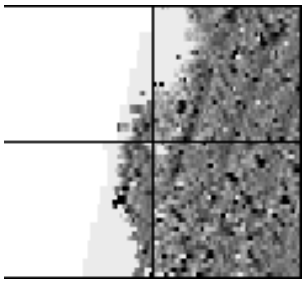
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



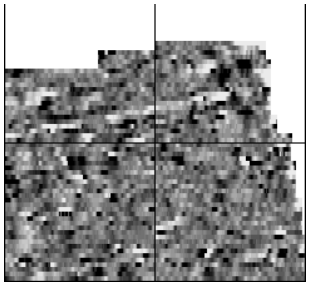
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

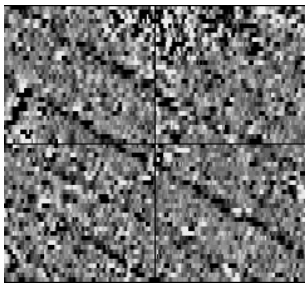


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

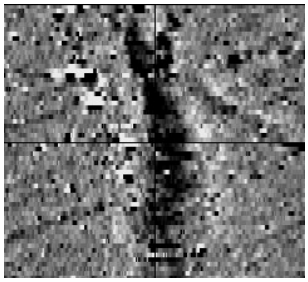
Strength of response

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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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

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SUMO Group Member