GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services

SUMO Group Member

Project name:

Lower Brockhampton, Herefordshire

Client:

National Trust

June 2015

Job ref:

J8353

Report author:

Thomas Richardson MSc ACIfA

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Project name:
Lower Brockhampton, Herefordshire
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Techniques:
Ground Penetrating Radar
Gradiometry

Survey date:
20th-22nd May 2015

Site centred at:
SO 687 559

Post code:
WR6 5SH

Field team:
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TABLE OF CONTENTS

LIST OF FIGURES

1 SUMMARY OF RESULTS

Ground penetrating radar (GPR) and detailed gradiometer surveys were conducted over approximately 0.2 and 11 hectares of grassland respectively. The survey has identified a former pathway, and evidence of internal and external structural activity related to the chapel. A number of possible archaeological remains relating to the chapel and Lower Brockhampton have also been detected, however their origin cannot be determined with any degree of confidence. A number of natural and modern features have also been identified, relating to drains, a car park, a path way, and a road. The wider survey area has identified areas of ridge and furrow cultivation in the east of the site. The remaining anomalies are natural or modern in origin, relating to a small area of scattered magnetic debris, ferrous objects and fencing.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey to locate any archaeological remains at Lower Brockhampton. A gradiometer survey was employed over the entire survey area, with GPR targeted around Lower Brockhampton and the remains of a 12th century chapel. This survey forms part of an archaeological investigation being undertaken by the National Trust.

2.2 Site location

The site is located to the south of Limepits Wood, Brockhampton, Herefordshire at OS ref. SO 687 559.

2.3 Description of site

The survey area is approximately 11.3 hectares, however an area of steep slopes reduced the surveyable area to approximately 11 hectares of grassland and orchards. The site lies on a north facing slope, with Lower Brockhampton House and a chapel in the south-west of the area.

2.4 Geology and soils

The underlying geology is Raglan Mudstone Formation – Interbedded Siltstone and Mudstone across the majority of the site, with a small area of Raglan Mudstone – Sandstone seen in the centre of the area (British Geological Survey website). There is no recorded drift geology (British Geological Survey website).

The overlying soils are known as Bromyard, which are typical argillic brown earths. These consist of reddish fine silty soils over shale and siltstone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 *Site history and archaeological potential*

Lower Brockhampton is a timber framed manorial house built c.1400 within a moated site at the centre of Brockhampton Estate. A gatehouse was added in the middle of the 16th century. To the west of Lower Brockhampton is a remains of a 12th century chapel, thought to have been in use until 1790. The remains of the chapel comprise renovated walls and an octagonal font. There is no known surrounding churchyard (National Trust 2015).

The chapel (SMR number 938), house (SMR number 7157), and gatehouse (SMR number 939) are all recorded in the Herefordshire Sites and Monuments Record (SMR). A search of the SMR shows extensive medieval agricultural activity within and surrounding the survey area. The SMR contains numerous records of ridge and furrow earthworks, lynchet earthworks, and medieval banks and ditches. There are no records for any earlier activity on the site or in the surrounding area (Herefordshire Council 2015).

2.6 *Survey objectives*

The objective of the survey was to locate any features related to Lower Brockhampton or the chapel, as well as any other features of possible archaeological origin.

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.*

Combined GPR and detailed magnetic surveys (gradiometry) were used as an efficient and effective method of maximising the amount of archaeological information from the site. More information regarding these techniques is included in Appendix A.

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)

Radar
Processing is performed using specialist software (Mala Rslicer). There are a wide range of filters available, the application of which will vary depending on the project. The filters used were:

Gain	Amplification to correct for weakening of signal with depth.
DC-Shift	Re-establishes oscillation of the radar pulse around the zero point)
Dewow / Ringdown Removal	Removes low frequency, down-trace instrument noise
Bandpass Filtering	Suppresses frequencies outside of the antenna's peak bandwidth thus reducing noise
Background Removal	Can remove ringing, instrument noise and minimize the near-surface 'coupling' effect
Migration	Collapses hyperbolic tails back towards the reflection source
Amplitude Envelope	Simplifies pulses for production of time-slice maps by summing peak values, regardless of polarity, over a given time-window.

2.8.2 Presentation of results and interpretation

Gradiometer
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.

Radar
If a number of radargrams are collected over a grid, or in conjunction with GPS data, it is possible to reconstruct the entire dataset into a 3D volume. This can then be resampled to compile 'plan' maps (time slices) of response strength at increasing time offsets (typically converted to show approximate depth), thus simplifying the visualisation of how anomalies vary beneath the surface across a survey area. The close centred traverses of the Mala MIRA make for effective time slices, which are included at a number of depths.

3 RESULTS

3.1 Gradiometer

The detailed magnetic gradiometer survey conducted at Lower Brockhampton has not identified any anomalies that can be characterised as being of a *probable* or *possible* archaeological origin. The following list of numbered anomalies refers to numerical labels on the interpretation plots.

3.1.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

3.1.2 Possible Archaeology

No possible archaeology has been identified within the survey area.

3.1.3 Medieval/Post-Medieval Agriculture

1 Widely spaced, curving, parallel linear anomalies in the east of the site. This is indicative of ridge and furrow cultivation.

2 A weak linear anomaly in the east of the site. This is related to a former field boundary present on available mapping 1886-1993.

3.1.4 Other Anomalies

3 A high amplitude positive linear anomaly in the south-west of the site. This is related to a modern path way.

4 Areas of magnetic variation across the site. These anomalies are likely to be geological or pedological in origin.

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

6 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.

7 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

3.2 *Radar*

The GPR survey conducted at Lower Brockhampton 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.

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

3.2.1 *Probable Archaeology*

A A linear feature made up of point diffraction anomalies, within the confines of the chapel. This is indicative of a wall feature, and is likely related to structural remains of the chapel.

B A linear feature made up of discrete responses. This is indicative of a buried surface, likely relating to a former path way leading to the door of the chapel.

C An area of complex responses along the northern wall of the chapel. This is indicative of disturbed ground, likely related to the construction of the chapel.

3.2.2 *Possible Archaeology*

D An area of small linear features made up of broad crested responses to the north-east of the chapel.

E Two small discrete anomalies, one to the west of Lower Brockhampton House, and the other in the west of the chapel. These are indicative of small buried features, and may be of archaeological origin.

F A weak area anomaly, to the west of Lower Brockhampton House, seen in timeslices of the data. This may be caused by a buried obstruction, or relate to an area of compacted ground beneath a swing.

G A weak linear area anomaly, to the east of Lower Brockhampton House, seen in timeslices of the data. This is indicative of a buried surface, and may relate to a former path way.

3.2.3 Medieval/Post-Medieval Agriculture

No medieval or post-medieval agriculture has been identified within the survey area.

3.2.4 Other Anomalies

H Linear features made up of point diffraction responses around Lower Brockhampton House. These are indicative of buried services, and are likely to relate to drainage from the house.

I A complex area anomaly to the west and north-west of the chapel. This is indicative of an area of disturbed ground, and is likely to be natural or modern in origin.

J A number of small discrete anomalies to the north of the chapel. These are likely to relate to former tree boles.

K A linear anomaly to the south of the chapel. This is related to the boundary of the hard-core car park and grass lawn.

L Linear areas of conductive surfaces to the south and west of Lower Brockhampton House. These are related to a modern path way and road.

4 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Gradiometer
Sedimentary geologies can generally be recommended for magnetic survey, however mudstone can give variable results. The survey has identified areas of ridge and furrow cultivation, in keeping with the known history of the area, suggesting the survey has been effective. However, the data does have a homogeneous appearance in places, meaning it is not possible to completely discount weak archaeological anomalies being masked by geological responses.

Radar
The radar data generally has a 'quiet' background response with a number of clearly defined features. This suggests that the survey has been effective and successful in identifying archaeological features to a depth of approximately 2m. The survey has not identified any

graves around the chapel, however this does not mean they do not exist. Graves can be hard to detect with radar as the response they give relies on a number of factors including the ground conditions, condition of burial (i.e. wooden coffin, lead coffin, no coffin etc.), and activity in the area since burial.

5 CONCLUSION

The survey at Lower Brockhampton has identified a number of probable archaeological anomalies relating to the chapel. A former pathway leading to the entrance of the chapel can be seen, as well as evidence of internal and external structural activity. This suggests that there may have been a wall or other structure within the eastern end of the chapel. A number of possible archaeological remains relating to the chapel and Lower Brockhampton have also been detected. These may relate to structural remains, a former path way and buried archaeological features, however their origin cannot be determined with any degree of confidence. A number of modern and natural features have also been identified in the area. The modern anomalies relate to drains, a car park, a path way, and a road.

The wider survey area has identified areas of ridge and furrow cultivation in the east of the site. This suggests that the area has been used for agricultural purposes since the medieval period, which correlates with the known history of Brockhampton Estate. The remaining anomalies are natural or modern in origin. The modern anomalies relate to a small area of scattered magnetic debris, ferrous objects and fencing.

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APPENDIX A – METHODOLOGY & SURVEY EQUIPMENT

Gradiometer

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.

Radar

Sampling interval

Readings were taken at 0.08m intervals with traverse intervals of 0.08m. All survey traverse positioning was carried out using a Trimble S6 Robotic Total Station.

Depth of scan and resolution

The average velocity of the radar pulse is calculated to be 0.13m/nsec which is typical for the type of sub-soils on the site. With a range setting of 60nsec this equates to a maximum depth of scan of 2m but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

Data capture

Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

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.

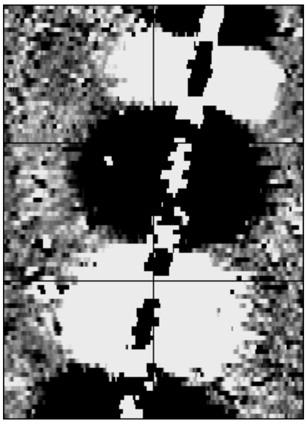
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement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

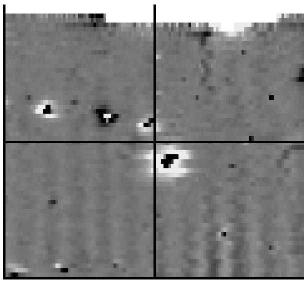
APPENDIX C – GLOSSARY OF MAGNETIC ANOMALIES

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

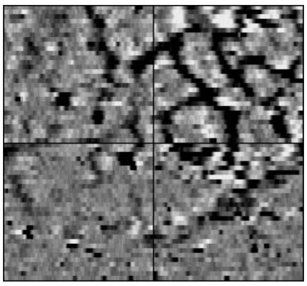


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

Positive anomaly with associated negative response

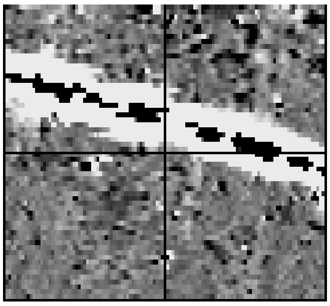
See bipolar and dipolar.

Positive linear



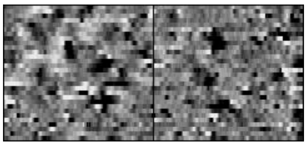
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

Positive linear anomaly with associated negative response



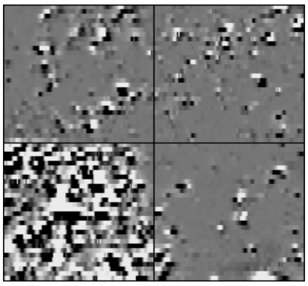
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

Positive point/area



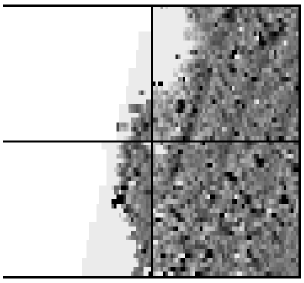
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

Magnetic debris



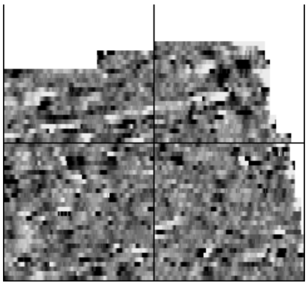
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

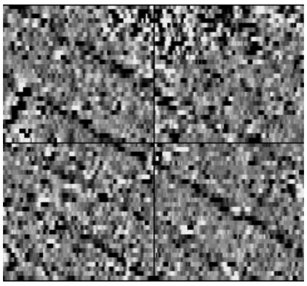


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

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).

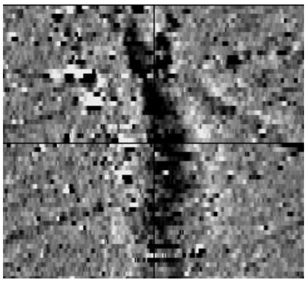
Strength of response

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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