STRATASCAN

Geophysical Survey Report

Hailes Abbey
Gloucestershire

for

English Heritage

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Hailes Abbey, Gloucestershire

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Techniques: **Detailed magnetic survey**
Resistance survey
Resistivity imaging survey

National Grid Ref: **SP 052 297**

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LIST OF FIGURES

1 SUMMARY OF RESULTS

A detailed magnetic survey and a resistance survey were carried out over approximately 8ha of land at Hailes Abbey, Gloucestershire. Six resistivity pseudosections were also produced to assess a leaking dam in the south east of the site and depth of sediments in a pond.

The geophysical survey has enabled the identification of a complex set of anomalies surrounding the abbey which indicate extensive structural remains are likely to exist. Within the abbey itself discrete linear anomalies suggest the presence of intact wall features, with possible outbuildings further out to the east.

The pseudosections have revealed anomalies that may represent weaknesses in the dam, while the transects over the pond have defined a lens shape anomaly likely to represent sediment deposits down to a depth of 1.6m in places that appear to get shallower to the south east.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by English Heritage to undertake a geophysical survey around Hailes Abbey. This survey forms part of an archaeological investigation being undertaken to inform future drainage plans for the site following a leak having developed from a pond on an adjoining property.

2.2 Site location

The site is located Hailes Abbey, Winchcombe, Gloucestershire at OS ref. SP 052 297.

2.3 Description of site

The survey area consists of approximately 8ha of land surrounding Hails Abbey. A pond on adjacent property to the south east of the site has developed a leak through its dam (Plate 1) making this area very wet with water erupting from the ground in various places (Plate 2).

Plate 1. Showing the dam separating the pond on the right and Abbey grounds on the left.

Plate 2. Water spring presumably being supplied from the leaking dam.

Hailes Abbey ruins are open to the public with the surrounding fields used as grazing. The underlying geology is Lower Lias (British Geological Survey South Sheet, Fourth Edition Solid, 2001). The overlying soils are of the Denchworth association. These consist of slowly permeable seasonally waterlogged clayey soils with similar fine loamy over clayey soils; some slowly permeable calcareous clayey soils also exist with localised landslips (Soil Survey of England and Wales, Sheet 5 South West England).

2.4 Site history and archaeological potential

http://cistercians.shef.ac.uk/abbeys/hailes.php
http://www.english-heritage.org.uk/server.php?show=conProperty.261

Richard Earl of Cornwall founded the Abbey in 1246 and it became populated by at most 25 Cistercian Monks. Although it wasn't until 1270, when the abbey was presented with a phial of Christs blood, that it became one of the main pilgrimage locations in England and an extension was built on the east end to house the relic. The abbey fell victim to the dissolution in 1539 and most of its buildings were dismantled except the west range, gatehouse and barn which were occupied by a private owner until 1687. After this date the site was allowed to ruin.

The remains of the abbey are now a Scheduled Ancient Monument and given the long history of the site the archaeological potential is considered high.

2.5 Survey objectives

The objectives of the survey are:

- to locate any anomalies that may be of archaeological origin.
- identify any underground breaches of the dam.
- estimate the amount of silt within a former fish pond.

2.6 Survey methods

Detailed magnetic survey, resistance survey and resistivity imaging surveys were carried out across the site in order to assess the area with complementary techniques. More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out over several visits initially commencing 11th April 2005 running up to the last visit on 17th March 2006.

3.2 Grid locations

The location of the survey grids and imaging transects have been plotted in Figure 2 together with the referencing information.

3.3 Description of techniques and equipment configurations

Magnetometer
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.

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 sensor has a 1m separation between the sensing elements giving a strong response to deep anomalies.

Resistance Meter
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 resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity 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.

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

Resistivity imaging
The technique employs a line of metal stakes (electrodes) temporarily inserted in the topsoil through which electrical current is made to flow. Four electrodes are used to make each measurement of the ground resistivity, two conducting current, two other electrodes measuring the electrical potential difference (voltage). By traversing the four electrodes along a line and repeating the process at larger electrode spacings (providing greater depths of investigation), it is possible to build-up a two-dimensional representation of the variation in ground resistivity (measured in Ohm metres, Ohm-m). Complex processing of the measured resistivity data produces the final resistivity image, which may then be used to interpret geological variations.

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

3.4.1 Sampling interval

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

Resistivity
Readings were taken at 1.0m centres along traverses 1.0m apart for both data sets. This equates to 900 sampling points in a full 30m x 30m grid. All traverses were surveyed in a "zigzag" mode.

Resistivity imaging
Probes were positioned at 1m intervals along survey transects over the pond, and at 2m intervals over the dam.

3.4.2 Depth of scan and resolution

Magnetometer
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 appropriate methodology balancing cost and time with resolution.

Resistivity
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 1m centres with a 0.5m probe spacing provides an appropriate methodology balancing cost and time with resolution.

The 1m probe spacing of a twin probe array has a typical depth of penetration of 1.0m. The collection of data with this probe separation allows data to be gathered with a greater depth range.

Resistivity imaging
Data has been recorded down to level n=10.

3.4.3 Data capture

Magnetometer
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.

Resistivity
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.

Resistivity imaging
Data is recorded on to a laptop on site which is later downloaded to a PC for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Magnetometer
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 all processed magnetometer data used in this report:

Zero mean traverse	*Last mean square fit = off*
Despike	*X radius = 1 Y radius = 1*
	Threshold = 3 std. dev.
	Spike replacement = mean

Resistivity
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 though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett 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.

Edge matching	
Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

Resistivity imaging
The resistivity imaging data has been processed using the software RES2DINV V3.51.

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

Damping parameters	*Damping factor optimised*
	Model resistivity limited by 1 iteration
Inversion parameters	*Smoothing of model resistivity*
	Combined inversion method
	0.5 sized model cells

3.5.2 Presentation of results and interpretation

Magnetometer
The presentation of the data for the survey involves a print-out of the raw data both as grey scale (e.g. Figure 3) and trace plots (e.g. Figure 5), together with a grey scale plot of the processed data (e.g. Figure 9). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (e.g. Figure 11).

Resistivity
The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (e.g. Figure 13), together with a grey scale plot of the processed data (e.g. Figure 15). Anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing (e.g. Figure 19).

Resistivity imaging
The presentation of the data for the site involves a print out of the colour scaled data along with interpretations (Figures 21-26).

4 RESULTS

4.1 Detailed magnetic survey

The detailed magnetic survey has revealed large areas of magnetic noise across much of the site, particularly amongst the abbey ruins and to the west. This is probably related to the continued occupation and use of the site throughout its history. The area of magnetic debris to the west may be associated with the construction of the pipe line which is observed as a strong linear bipolar response running through this area. A second strong bipolar response is observed in the south of the area appearing to run from the dam. It is likely this represents the iron water pipe which feeds the local railway steam engines.

To the south of the abbey in the east of the site the general magnetic background is more uniform. Within this area several positive linear responses can be seen. It is likely these are caused by cut features of an archaeological origin. Positive anomalies with associated negative responses are also observed in this area. It is uncertain what may cause these although it is possible they may be related to garden features.

Positive anomalies with an associated negative response are observed which correlate in position with the area marked as 'fish ponds'. It is probable these returns relate to the fish ponds. A similar anomaly to this is observed approximately 15m to the west suggesting this too may be associated with a fish pond.

In the centre of the cloister area is a strong positive anomaly with associated negative response. While the position of this may be a coincidence and it may be caused by a modern ferrous object, it must be considered as a possible archaeological target which may relate to a structure within the cloisters contemporary with the abbey.

Several positive anomalies can be seen in the north west of the site. It is not apparent what causes these, although an archaeological origin can not be ruled out.

An area of magnetic debris in the southern corner of the survey area may relate to an area of made ground.

4.2 Resistance survey

The resistance survey has revealed numerous high resistance anomalies suggesting the presence of extensive structural remains across the site. In places these form precise linear responses indicative of intact wall features. This is particularly evident in the Nave, Quire and Presbytery areas of the abbey where rectilinear anomalies are likely to relate to internal walls. In other areas high resistance responses cover larger areas suggesting evidence for collapsing and rubble remains, for example on the northern side of the Nave in the corner with the Transept.

High resistance linear anomalies are observed to form a cross pattern in the cloisters. These anomalies become more subtle further from the centre of the cloisters, suggesting they are more likely to be associated with pathways rather than wall features.

High resistance anomalies are also seen to exist outside the abbey structure, particularly to the east and west. Those in the east appear to enclose large areas of open land which contain fainter high resistance anomalies. This corresponds with magnetic anomalies that suggest garden features in this area. Equally high resistance anomalies in the west may relate to outbuildings and field boundary walls.

The fish ponds appear to be identified by high resistance and low resistance anomalies marking the banks and cut areas respectively.

In the southern corner of the survey area the area of made ground can be seen marked by an area of high resistance. Local knowledge suggests that this material came from the clearing out of drains within the Abbey and placed on the dam face. The iron water pipe observed in the magnetic data is observed as a low resistance linear anomaly extending to the north from the dam. Equally the suspected service in the north east identified from the magnetic survey corresponds to a low resistance linear response.

4.3 Resistivity imaging

Pseudosection Transects 1 & 2 are positioned in the south east of the site to investigate the area of the leaking dam. Transect 1 shows two high resistivity areas occurring at around 4.5m depth which may be associated with voids caused by undergound leaks eroding and transporting material away. An area in the centre of the transect identifies a high resistivity anomaly which may be related to the structure of the dam, possibly related to water loss.

In the west of Transect 2 a high resistivity anomaly at 3.8m depth is observed which may represent a continuation of the high resistivity anomaly seen in Transect 1 possibly caused by water leakage. A surface response further to the west probably marks an area of made ground on top of the dam. A lower resistivity anomaly is seen in the east of the transect which is of uncertain origin that may be related to water leakage.

Pseudosection Transects 3-6 are located running across the pond in a northeast – southwest orientation aligned on the same line as the core samples. Transect 4 has returned the best quality data and allows a lens shape response to be defined in the centre of the Transect. This is roughly 45m long and extends down to 1.6m in the east and 1.25m in the west. This is likely to represent the sediment fill in the pond and suggests the depth of deposits in the east is greater than those in the west. Transects 5 & 6 also show a similar lens shaped anomaly in their centres, although the edges of these responses are less well defined perhaps suggesting a fluctuation in water levels or sedimentation rates along the ponds bank. The depths of similar anomalies in these transects are shallower than Transect 4 indicating less sedimentation in this region of the pond.

5 CONCLUSION

The geophysical survey has enabled the identification of a complex set of anomalies surrounding the abbey which indicate extensive structural remains are likely to exist. Within the abbey itself discrete linear anomalies suggest the presence of intact wall features, with possible outbuildings further out to the east.

The pseudosections have revealed anomalies that may represent weaknesses in the dam, while the transects over the pond have defined a lens shape anomaly likely to represent sediment deposits down to a depth of 1.6m in places that seem to get shallower to the south east.

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