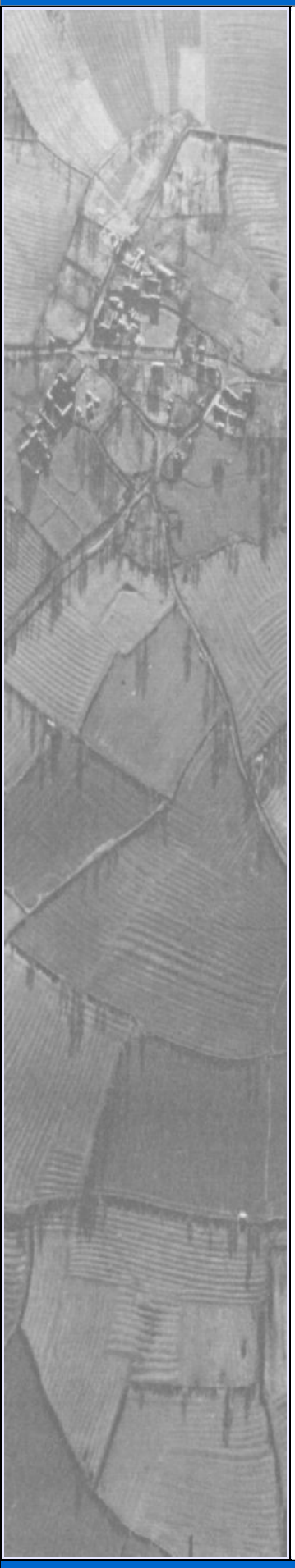

Land to the south of Oakridge
Highnam
Gloucestershire

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

Kerry Donaldson & David Sabin

September 2015

Ref. no. 631

ARCHAEOLOGICAL SURVEYS LTD

Land to the south of Oakridge
Highnam
Gloucestershire

Magnetometer Survey Report

for

Cotswold Archaeology

Fieldwork by David Sabin (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey date – 28th September 2015
Ordnance Survey Grid Reference – **SO 79985 19800**

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SUMMARY

A detailed magnetometer survey was carried out by Archaeological Surveys Ltd, at the request of Cotswold Archaeology Ltd, on land to the south of Oakridge, Highnam in Gloucestershire. The results demonstrate the presence of a number of very weakly positive linear responses that lack a coherent pattern or morphology, preventing confident interpretation. A small number of discrete anomalies appear to relate to pit-like features, but their origin is uncertain. Evidence for a number of former land boundaries and agricultural activity has also been located.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology to undertake a magnetometer survey of an area of land at Highnam in Gloucestershire. The site has been outlined for a proposed residential development and the survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2015) and approved by Charles Parry, Archaeologist for Gloucestershire County Council, prior to commencing the fieldwork.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* and Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located to the south of Oakridge, at Over Farm on the south eastern edge of Highnam in Gloucestershire. It is centred on Ordnance Survey National Grid Reference (OS NGR) SO 7998519800, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 4ha within the northern half of a single arable field which had been recently cultivated prior to the survey. The land slopes down gently towards the south and south west.

Plate 1: Survey area looking north west

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were variable fine and sunny.

1.4 Site history and archaeological potential

1.4.1 An Archaeological Desk-Based Assessment has been carried out for the site (CgMs, 2015). It outlines that there are no designated or undesignated heritage assets within the site, although there are a number within the wider vicinity. These include the line of a Roman road 450m to the south with another to the south east and Roman sites and findspots to the south. A possible medieval moated site is recorded 250m to the east with other medieval remains to the north east and north west. There is widespread evidence for Civil War activities in the area, including a Civil War siege at Highnam Court 700m south west, a possible Civil War battle site 600m to the north east and defences at the Vineyard 1.2km east, which is associated with the Siege of Gloucester.

1.4.2 Despite the lack of recorded archaeological sites and findspots within the site, there is always potential for the geophysical survey to locate anomalies that relate to archaeological features should they be present within the site.

1.4.3 The surface conditions within the site were suitable for the observation of cultural material during the course of the survey. No significant scatters were noted.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is from the undifferentiated Blue Lias Formation and Charmouth Mudstone Formation (BGS, 2015). Frequent quartzite pebbles were visible on the field surface and indicate the possibility of a thin layer of superficial deposits overlying the solid geology.

1.5.2 The overlying soil across the survey area is from the Wickham 3 association and is a typical stagnogley. It consists of a slowly permeable, seasonally waterlogged, fine, loamy over clayey soil (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced good results. The underlying geology and soils are, therefore, considered acceptable for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged computer.

2.2.2 Data are collected along a series of parallel survey tracks wherever possible. The length of each track is variable and relates to the size of the survey area and other factors including ground conditions. A visual display aids accurate placing of tracks and their separation.

2.2.3 Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display using TerraSurveyor.

2.3.2 The data are collected between limits of ±10000nT and clipped for display at ±3nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.17m along each survey track. A zero median traverse function is required in order to remove fixed offset values present within the sensors which do not undergo a zeroing procedure in the field. The approach ensures that the gradiometer sensors are very accurately aligned and fixed to the vertical magnetic field and are not influenced by localised magnetic fields or disturbed by vibration. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on any processes, such as clipping, carried out on the data.

2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot.

2.3.5 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG (2010) file formats. All images are

externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.6 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within the survey area.

2.3.8 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over 4ha within the northern half of a single arable field.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, anomalies associated with land management, linear anomalies of an agricultural origin and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within the survey area have been numbered and are described in 3.4 below.

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics within the survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeological features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies.
Anomalies relating to land management AS-ABST MAG BOUNDARY	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
Anomalies associated with magnetic debris AS-ABST MAG STRONG DIPOLAR	Strong discrete dipolar anomalies are responses to ferrous and other magnetically thermoremnant objects within the topsoil.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 379985 219800, see Figures 03 & 04.

Anomalies with an uncertain origin

(1) - A weakly positive linear anomaly, with an associated stronger discrete response, is located in the north eastern part of the survey area. The linear anomaly is around 1.2nT, the discrete 10-12nT peaking at over 30nT. The discrete anomaly is 5m by 1.5m. It is possible that they are associated with cut features, although they do not have a coherent form or pattern.

(2) - Located 106m to the south west of anomaly (1) is a discrete positive response. It is possible that it forms an elongated pit-like feature, or it relates to two conjoined pit-like responses. It has dimensions of 4.5m by 1.1m, a response of 8-10nT and has a similar orientation and form as the discrete anomaly (1).

(3) - A small number of weak, discrete, positive anomalies can be seen elsewhere within the site. They have a response of less than 10nT, and although they appear to relate to pit-like responses, they are generally isolated.

(4) - A very weakly positive linear anomaly extends north north eastwards from the southern edge of the survey area for approximately 20m. It is very indistinct and

appears to have been truncated by agricultural activity.

(5) - A number of weakly positive linear anomalies are evident in the south western corner of the survey area. They have a response of <1nT and are very indistinct.

(6) - Several weakly positive linear anomalies are located in the northern part of the survey area. They are short, weak and lack a coherent morphology.

Anomalies associated with land management

(7-9) - Linear anomalies that relate to former mapped field boundaries. Anomaly (8) is associated with a large number of strong, dipolar anomalies.

(10) - A positive linear anomaly is broader and stronger than most of the agricultural responses (11) and although an agricultural origin is possible, a former unmapped field boundary should be considered.

Anomalies with an agricultural origin

(11) - A series of parallel linear anomalies, spaced approximately 3m apart, can be seen extending throughout the survey area. A response to ridge and furrow is possible; however, they are very straight and narrow which may indicate a more recent formation.

Anomalies associated with magnetic debris

(12) - Strong, discrete, dipolar anomalies are a response to ferrous and other magnetically thermoremnant objects within the topsoil.

4 CONCLUSION

4.1.1 The results of the geophysical survey indicate that there are a small number of very weakly positive linear anomalies that lack a coherent morphology preventing confident interpretation. A small number of pit-like responses has also been located, some with a moderate response. Evidence of former land boundaries and agricultural activity have also been abstracted from the magnetic data.

5 REFERENCES

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±5nT and ±3nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (destripe) Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

Magnetometer data

COMPOSITE
Filename: J631-mag-proc.xcp
Description: Imported as Composite from: J631-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 379883.01661524, 219927.079568098 m
Southeast corner: 380087.86661524, 219674.459568098 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 1321400

Dimensions
Composite Size (readings): 1204 x 1485
Survey Size (meters): 205 m x 252 m
Grid Size: 205 m x 252 m
X Interval: 0.17 m
Y Interval: 0.17 m

Stats
Max: 3.00
Min: -3.00
Std Dev: 0.83
Mean: 0.04
Median: 0.00
Composite Area: 5.1671 ha
Surveyed Area: 3.9213 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2
1 Base Layer
2 Clip from -3.00 to 3.00 nT

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A copy of the report in PDF/A format will be supplied to the Gloucestershire Historic Environment Record, together with a DXF of the survey boundary. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data Area 1 - path: J631 Highnam\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
highn1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	28/09/15	D.J.Sabin
highn1\MX\J631-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	29/09/15	K.T. Donaldson
Mag\comps\J631-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	29/09/15	K.T. Donaldson
Mag\comps\J631-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±3nT).	29/09/15	K.T. Donaldson
Graphic data - path: J631 Highnam\Data				
Mag\graphics\ J631-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±3nT.	29/09/15	K.T.Donaldson
Mag\graphics\ J631-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	29/09/15	K.T.Donaldson
CAD data - path: J631 Highnam\CAD				
J631 version 1.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	27/09/15	K.T.Donaldson
Text data - path: J631 Highnam\Documentation				
J631 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	29/09/15	K.T.Donaldson

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Archaeological Surveys Ltd

Geophysical Survey
Land to the south of Oakridge
Highnam
Gloucestershire

Map of survey area

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N

Survey location

● Survey location

Site centred on OS NGR
SO 79985 19800

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophysical Survey
Land to the south of Oakridge
Highnam
Gloucestershire

Referencing information

Referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

379900 219700

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

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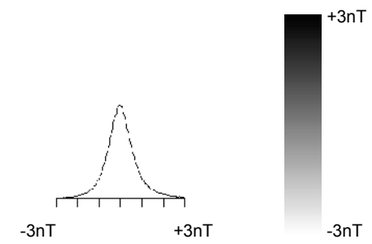
FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Land to the south of Oakridge
Highnam
Gloucestershire

Greyscale plot of minimally processed magnetometer data



SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

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FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Land to the south of Oakridge
Highnam
Gloucestershire

Abstraction and interpretation of magnetometer anomalies

PARK BRAKE

IDGE

N

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Positive linear anomaly - possible former field boundary
- Discrete positive response - possible pit-like feature
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

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FIG 04