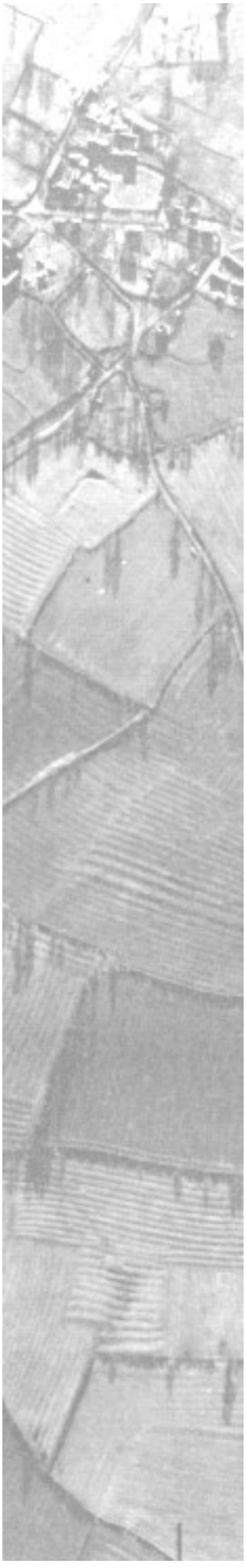

ARCHAEOLOGICAL SURVEYS

GEOPHYSICAL SURVEY REPORT

Keynsham Primary School

Magnetometer Survey

for

Kim Watkins

Archaeological Consultant and Contractor

David Sabin and Kerry Donaldson

July 2006

Ref no. 149

ARCHAEOLOGICAL SURVEYS

Keynsham Primary School

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Kim Watkins
Archaeological Consultant and Contractor

Report and fieldwork by David Sabin and Kerry Donaldson

Survey date – **5th July 2006**
Ordnance Survey Grid Reference – **ST 647 681**

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LIST OF FIGURES

SUMMARY

A magnetometry survey was undertaken across approximately 1ha of playing field at Keynsham Primary School. Magnetic anomalies located by the survey include areas of magnetic disturbance caused by steel fencing surrounding the site and magnetic debris associated with buried ferrous material. A series of positive linear anomalies have a pattern characteristic of land drains. A single positive linear anomaly of uncertain origin may represent a former cut feature although there is little to suggest significant archaeological features exist within the survey area.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys were commissioned by Kim Watkins, Archaeological Consultant and Contractor, to undertake a geophysical survey of an area of land at Keynsham Primary School. A design brief for archaeological works was prepared by Bath and North East Somerset Council Planning Services. This survey formed part of an assessment of any potential archaeology that may be affected by the construction of a new school on the site.

1.2 Survey objectives

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.

1.3 Site location

1.3.1 The site is located at Keynsham Primary School, Bath and North East Somerset - OS grid reference ST 647 681.

1.4 Site description

1.4.1 The geophysical survey covers an area of approximately 1ha of playing field immediately to the northwest of the current school. The surface slopes gently to the north and most of the area is enclosed by wire net fencing. There are a number of mature trees at the north western end of the survey area.

1.5 Site history and archaeological potential

1.5.1 The survey area lies close to where a prehistoric flint axe was discovered which may be an indication of prehistoric settlement.

1.6 Geology and soils

1.6.1 The underlying geology is Lias Limestone (BGS 2001), no overlying Quaternary deposits are mapped (BGS 1977).

1.6.2 The overlying soils across much of the site are from the Sherborne association and are brown rendzinas which are generally well-drained calcareous clayey soils (Soil Survey of England and Wales 1983).

1.6.3 The geology and soils of the area show much variation although generally appear favourable for magnetometry. Previous work carried out at Keynsham by Archaeological Surveys has revealed magnetic anomalies associated with archaeological features.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Detailed magnetometry records localised magnetic fields that can relate to former human activity. Alteration of iron minerals present within topsoil is related to activities such as burning and the break down of biological material. These minerals become weakly magnetic within the Earth's magnetic field and can accumulate in features such as ditches and pits that are cut into the underlying subsoil. Mapping this magnetic variation can provide evidence of former settlement and land use. Additional technical details can be found in Appendix A.

2.1.2 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 nanoteslas (nT) which are equivalent to 10^{-9} tesla (T).

2.2 Equipment details and configuration

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally. The instrument is extremely sensitive and is able to measure magnetic variation to 0.1 nanoTesla (nT). All readings are saved to an integral data logger for analysis and presentation.

2.2.2 Data was collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 1995).

2.2.3 The survey grids were set out using a Topcon APL1 robotic total station and orientated in order to give coverage of target areas whilst minimising partial grids. This was achieved by setting out parallel to the south western boundary fence. A CSI Wireless differential GPS was used to map the boundary of the survey area in order to create a simple georeferenced plan.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger is analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix B contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor.

2.3.2 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data is always analysed and displayed in the report as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

Processing schedule

- Clipping of the raw data at ±10nT to improve greyscale resolution
- Clipping of processed data at ±10nT to enhance low magnitude anomalies
- Clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses
- Destagger is also used to enhance linear anomalies
- Zero median traverse is applied to processed data in order to balance readings along each traverse.

Clipping

Clipping replaces the values outside the specified minimum and maximum with those values. The process is useful for displaying detail as extreme values are removed allowing greyscale shades to be allocated to a narrower range of values which improves the definition of anomalies.

Zero Median Traverse

The median of each traverse is calculated ignoring data outside a threshold value, the median is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and is used to remove striping.

2.3.3 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. 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 assessment of features within each survey area. Where further interpretation is possible or where a number of possible origins should be considered, more detailed discussion is set out in Section 4.

2.3.4 The main form of data display used in this report is the greyscale plot. Magnetic data is also displayed as a traceplot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot. Graphic raster images in Windows bitmap format are initially prepared in ArcheoSurveyor. These images are combined with base mapping using AutoCAD LT 2007 creating DWG file formats. All images are fully embedded within the file and not externally referenced. Although AutoCAD DWG files are a universally excepted format, the programme does not handle fully embedded graphics well and there is inevitable compromise of quality. Quality is also compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive including raster images is produced with this report allowing separate analysis if necessary, see 2.4 below.

2.4 Archive

2.4.1 Survey results are produced in hardcopy using A4 for text and A3 for plots (all plots are scaled for A3). In addition digital data created during the survey is supplied on CD. Further information on the production of the report and the digital formats involved in its creation are set out below.

2.4.2 This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.0.4.3 (geophysical data analysis)
- AutoCAD LT 2007 (report figures)
- JASC Paint Shop Pro 8 (image rotation)
- Microsoft Word 2000 (document text)
- PDF Creator version 0.9 (PDF archive).

2.4.3 Digital data is supplied on CD ROM and includes the following files:

- ArcheoSurveyor grid and composite files for all geophysical data
- CSV files for raw and processed composites
- Composite graphics as windows bitmaps
- AutoCAD DWG file in 2000 version
- Microsoft Word 2000 doc file
- PDFs of all figures

2.4.4 The CD ROM structure is formed from a tree of directories under the title J149 Keynsham – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data – each directory holds grid, composite and graphic files with CSV composite data held in export.

2.4.5 The CAD file contains embedded graphics as bitmaps, see 2.3.4, with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen.

3 RESULTS

3.1.1 The detailed magnetic survey was carried out over approximately 1ha. Geophysical anomalies located can be generally classified as follows: a positive linear anomaly of uncertain origin, positive linear anomalies associated with land drains, an area of magnetic debris associated with magnetically thermoremnant or ferrous material, magnetic disturbance from ferrous material and strong dipolar anomalies relating to ferrous objects and material in the topsoil. Anomalies located within each survey area have been numbered and will be outlined below (3.1.3) with subsequent discussion in Section 4.

3.1.2 The brief listing of anomalies below attempts to set out a number of separate categories that reflect the range and type of likely causative features:

Anomalies with an uncertain origin
(Positive anomalies abstracted are plotted in orange)

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 archaeologically significant features but equally relatively modern features, geological/ pedological anomalies and agricultural features should be considered.

Anomalies associated with land drains
(Anomalies abstracted are plotted in cyan)

Land drains often form a series of parallel positive linear responses that link together or ‘feed’ a collector drain. Often an acute angle occurs between the collector and its feeding drains. Positive response is likely to be related to ceramic or terracotta drains.

Anomalies associated with modern ferrous objects
(Anomalies abstracted are plotted in magenta)

The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables etc. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance – such disturbance can effectively obscure low magnitude anomalies if they are present.

Anomalies associated with magnetic debris
(Anomalies abstracted are plotted in magenta)

The response often appears as areas containing many small dipolar anomalies that may range from weak to strong in magnitude. Magnetic debris often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures or hearths and may therefore be archaeologically significant.

3.1.3 Anomalies with an uncertain origin

(1) A low magnitude positive linear anomaly was located in the survey area with an orientation not reflected in nearby land boundaries or other anomalies.

Anomalies associated with land drains

(2) A series of moderately strong (<20nT) linear anomalies form a distinctive pattern associated with land drainage.

Anomalies associated with modern ferrous objects

(3) An area of magnetic disturbance surrounds most of the survey area. It has been caused by steel wire net fencing surrounding the site possibly enhanced by underground services in places.

(4) Strong discrete dipolar anomalies have been caused by shallow ferrous objects.

Anomalies associated with magnetic debris

(5) An area of magnetic debris has probably been caused by dumped ferrous material.

4 DISCUSSION

4.1.1 The magnetometry has revealed little evidence for archaeological features within the survey area. However, it is possible that minor anomalies are hidden by areas of magnetic disturbance around the perimeter of the site and a region of magnetic debris.

4.1.2 A single positive linear anomaly of uncertain origin was abstracted from the magnetic data. It is not possible to comment further on the anomaly although it may be a response to a former cut feature.

5 CONCLUSION

5.1.1 The results of the magnetometry survey do not indicate the presence of significant archaeological features on the site, most anomalies located by the survey could be confidently attributed to modern features and former land drainage. It should be considered, however, that low magnitude anomalies may effectively be obscured around the perimeter of the site due to the strong magnetic flux created by metal fencing.

6 REFERENCES

British Geological Survey, 1977, *Geological Survey Ten Mile Map, South Sheet, First Edition (Quaternary),* Scale 1:625 000.

British Geological Survey, 2001, *Solid Geology Map, UK South Sheet, 1:625 000 scale, 4th edition.*

English Heritage, 1995, *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No 1*.

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

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 on 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 the 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 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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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 of magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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 – survey and data information

Raw magnetometer data

Filename: J149-raw.xcp
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Surveyed by: on 05/07/2006
Assembled by: on 05/07/2006
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: One

Dimensions
Composite Size (readings): 600 x 90
Survey Size (meters): 150 m x 90 m
Grid Size: 30 m x 30 m
X Interval: 0.25m
Y Interval: 1m

Stats
Max: 10.00
Min: -10.00
Std Dev: 5.49
Mean: 0.51

Processes: 3
1 Base Layer
2 Clip from -10 to 10
3 De Stagger: Grids: Mode: Both By: -1 intervals

Source Grids: 11
1 Col:0 Row:0 grids\J149-01.asg
2 Col:0 Row:1 grids\J149-02.asg
3 Col:1 Row:0 grids\J149-03.asg
4 Col:1 Row:1 grids\J149-04.asg
5 Col:1 Row:2 grids\J149-05.asg
6 Col:2 Row:0 grids\J149-06.asg
7 Col:2 Row:1 grids\J149-07.asg
8 Col:2 Row:2 grids\J149-08.asg
9 Col:3 Row:0 grids\J149-09.asg
10 Col:3 Row:1 grids\J149-10.asg
11 Col:4 Row:0 grids\J149-11.asg

Processed magnetometer data

Filename: J149-proc.xcp
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Surveyed by: on 05/07/2006
Assembled by: on 05/07/2006
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: One

Dimensions
Composite Size (readings): 600 x 90
Survey Size (meters): 150 m x 90 m
Grid Size: 30 m x 30 m
X Interval: 0.25m
Y Interval: 1m

Stats
Max: 10.00
Min: -11.10
Std Dev: 5.48
Mean: 0.36

Processes: 4
1 Base Layer
2 Clip from -10 to 10
3 De Stagger: Grids: Mode: Both By: -1 intervals
4 DeStripe Median Grid: Grids:

Source Grids: 11
1 Col:0 Row:0 grids\J149-01.asg
2 Col:0 Row:1 grids\J149-02.asg
3 Col:1 Row:0 grids\J149-03.asg
4 Col:1 Row:1 grids\J149-04.asg
5 Col:1 Row:2 grids\J149-05.asg
6 Col:2 Row:0 grids\J149-06.asg
7 Col:2 Row:1 grids\J149-07.asg
8 Col:2 Row:2 grids\J149-08.asg
9 Col:3 Row:0 grids\J149-09.asg
10 Col:3 Row:1 grids\J149-10.asg
11 Col:4 Row:0 grids\J149-11.asg

Archaeological Surveys

Geophysical Survey
Keynsham Primary School

Map of survey area

● Survey location

Site centred on OS NGR
ST 646 681

SCALE 1:25 000

0km 1km

FIG 01

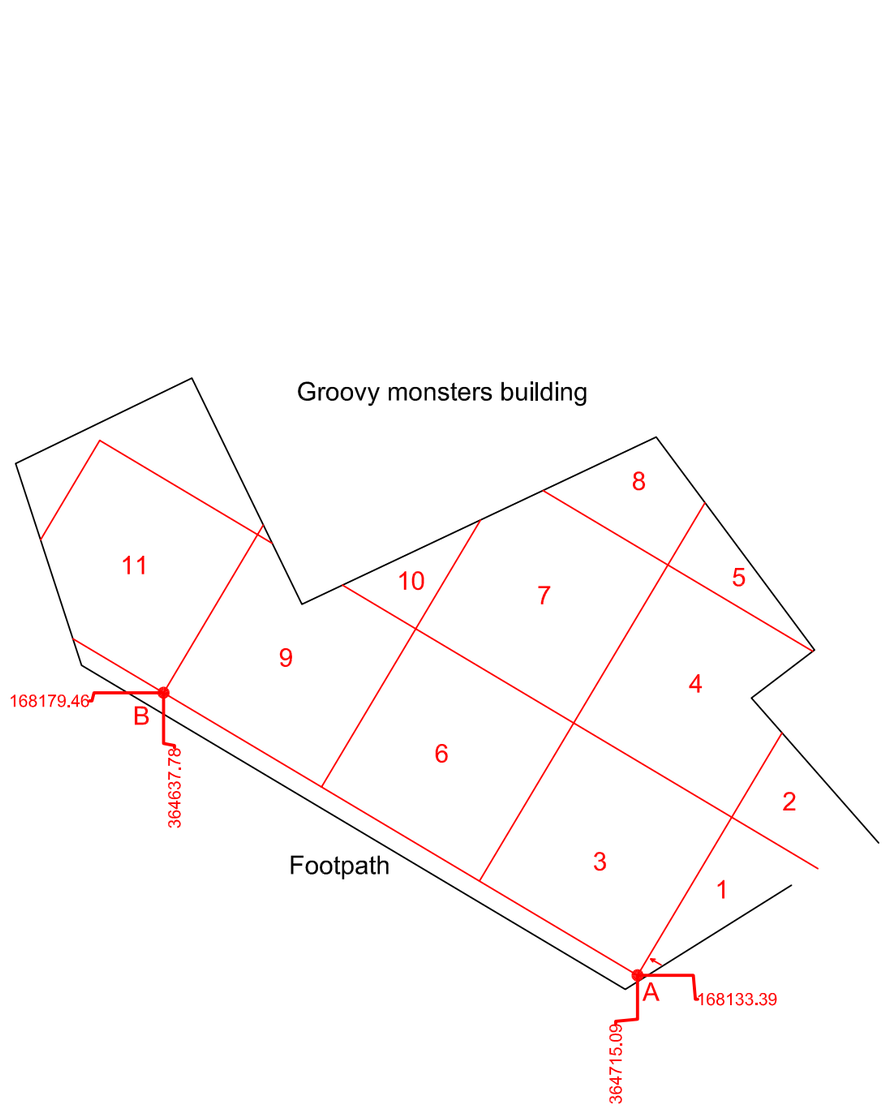
Archaeological Surveys

Geophysical Survey
Keynsham Primary School

Referencing information

Based on OS coordinates (OSGB36)

Baseline A-B is parallel and 3m away from fenceline to the southwest. Point A is 1m away from fenceline to the southeast.



Survey start and traverse direction

SCALE 1:1000

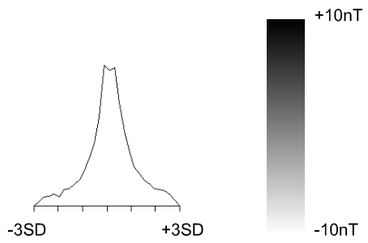
0m 10 20 30 40 50m

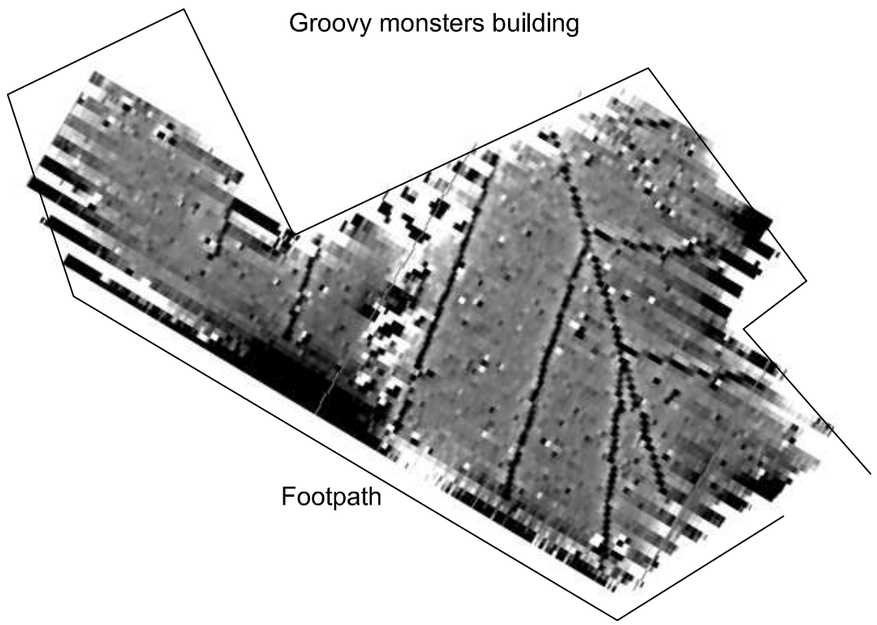
FIG 02

Archaeological Surveys

Geophysical Survey
Keynsham Primary School

Greyscale plot of raw magnetometer data





N

SCALE 1:1000

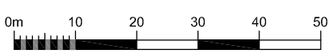


FIG 03

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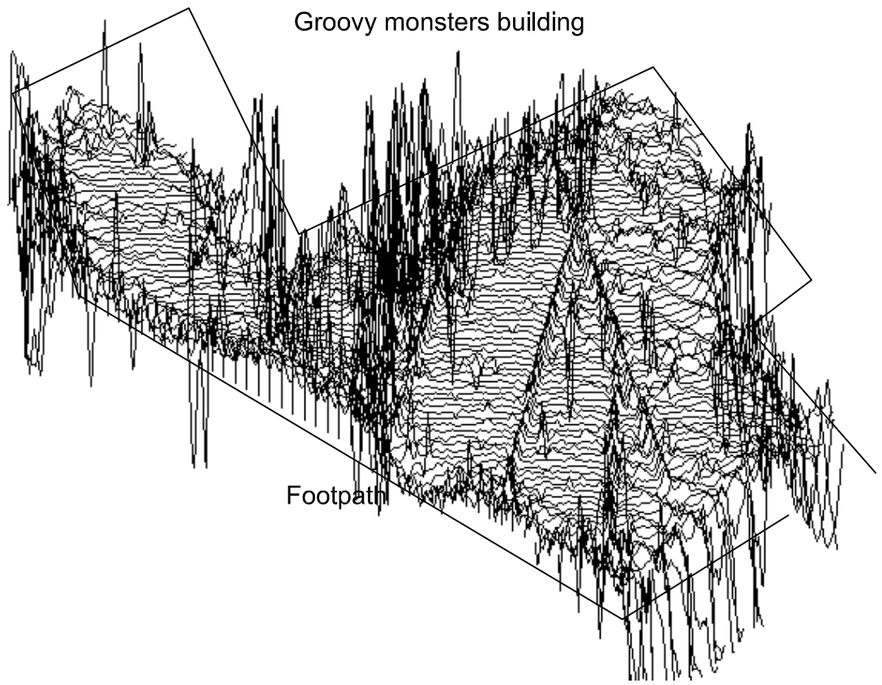
Geophysical Survey
Keynsham Primary School

Traceplot of raw magnetometer data



N

School playground and buildings

Playing fields

+80nT
+40nT
0nT
-40nT
-80nT

Approximately 40nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

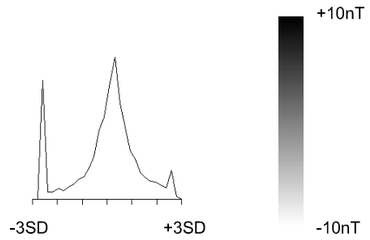
0m 10 20 30 40 50m

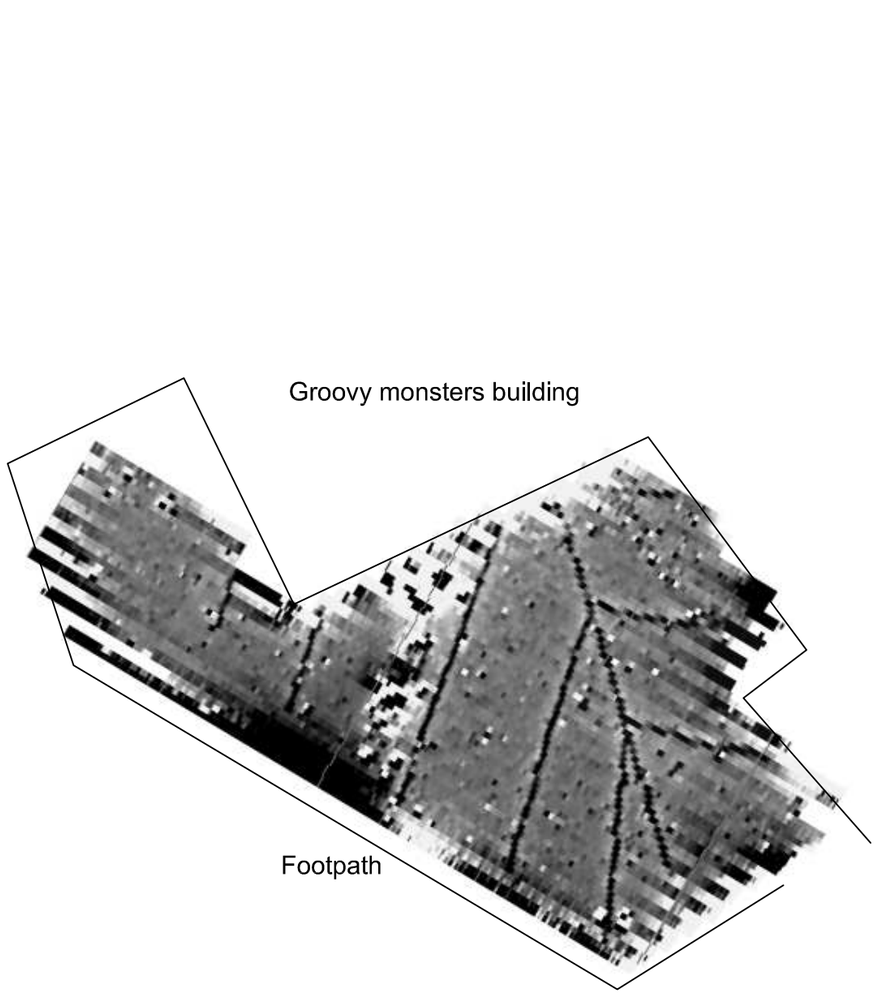
FIG 04

Archaeological Surveys

Geophysical Survey
Keynsham Primary School

Greyscale plot of processed magnetometer data





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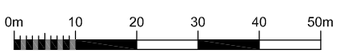
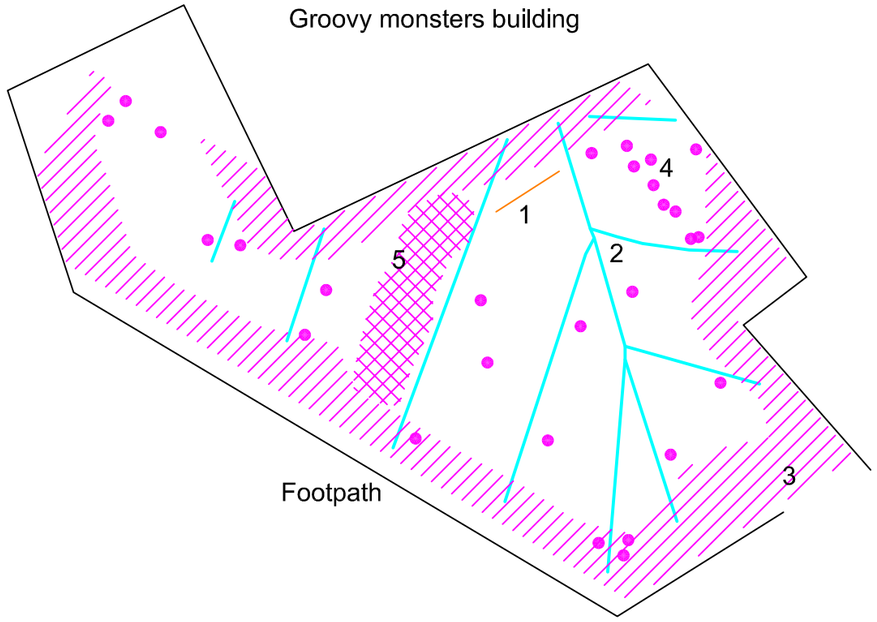


FIG 05

Archaeological Surveys

Geophysical Survey
Keynsham Primary School

Abstraction and interpretation of magnetometer anomalies



N

- Positive linear anomaly - possible cut feature of uncertain origin
- Positive linear anomaly - land drain
- Magnetic debris - spread of thermoremnant/ ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1000

0m 10 20 30 40 50m

FIG 06