Ewelme
Oxfordshire

Geophysical Surveys

for
The South Oxfordshire Project
Stephen Mileson
St. Edmund Hall
Oxford
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OX1 4AR

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Carried out by

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Ewelme, Oxfordshire
Report on Geophysical Surveys 2011

1 Summary

Magnetometry located a pit-like anomaly which was further investigated using resistivity. This appears to have dimensions consistent with those of Saxon sunken featured buildings. This may shed some context for metal detecting finds in this area.

2 Introduction

These surveys were carried out to ascertain if any traces of habitation could be located as part of the Victoria County History's researches in this area.
The site is on a south facing slope to the north west of Ewelme.
The geology, according to the British Geological Surveys Geology of Britain viewer, is:
Solid – West Melbury marly chalk formation
Drift – Part is covered by the Summertown Radley sand and gavel member (Flinty gravel) although our field observation indicates that the gravel may extend further than shown on their map.

The survey, centred on SU 640923 or 464045E 192324N was in a large arable field and mainly took place when it was covered with bean stubble. The survey area is on a shallow slope where the north east corner of grid 39 is at approx 81m OD and the south western corner of grid 9 is at approx 75mOD.
The area is not a Scheduled Monument.

This is part of a larger project which has carried out fieldwalking, metal detecting and will have done the historical researches. It is understood that metal detecting has located Saxon material whilst fieldwalking has found a small quantity of Roman and medieval pottery and a large quantity of probably post medieval roof tile. In 1903 Saxon burials were found in a gravel pit to the north east of the site.(1)

3 Methods

Both magnetometry and earth resistance were used although the area of resistivity was far smaller than that of magenetometry. These methods were chosen as the task of magnetometry was to locate the remains rather than understand them whilst the resistivity was designed to accurately locate the feature identified by the magnetometry.

For the magnetometery a Bartington Grad 601/2 fluxgate gradiometer was used which has a metre separation between its upper and lower sensors and collected data at a 1 metre line interval and 8 readings per metre along each line.
Magnetometry is unlikely to detect timber or chalk or flint buildings on this geology although the general location of buildings can be indicated by ditches, ceramic building materials and ferrous debris. It is also unlikely to detect graves as, even if they have iron grave goods, these give responses similar to those of other iron debris.

Resistivity was carried out on the same area as magnetometry grid no 25 with the same orientation of data collection. This earth resistance survey used a TR Systems resistance meter in twin probe array with 0.5metre separation of mobile probes. This collected data at a 0.5metre interval along lines 0.5 metres apart. A 0.5 metre mobile probe separation was used as it should be wide enough to get to below the ploughsoil whilst not being so wide as to give readings which could have missed a feature cut into gravel as often the primary silting of such features is gravely and is difficult to distinguish from the natural gravel.

Resistivity can be good at locating buildings and ditches once likely areas have been identified by magnetometry as it is a far slower technique. Again, it is unlikely to detect graves as these are usually quickly backfilled with the soil from which they were dug.

Please see appendix 10 for details of these methods.
The surveys took place between 25 January and 18 September 2011.

Grids were set out using a Trimble Pro XR differential gps which is normally accurate to some 40cms. The grid locations are shown in appendix 9.1. Each grid is 30metres square.

Both survey methods had the equipment hand carried by someone walking along lines with markings every metre.

All grids were surveyed with the start in the north western corner and the first line going eastwards and used a zig zag method of collection.

To process the data we use a specialist programme, ArcheoSurveyor.
The following principal processes were used:-
Magnetometry
Processes: 5

1 Base Layer
2 Clip from -100.00 to 100.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip at 1.00 SD
5 Clip from -2.00 to 2.00 nT

Resistivity
Processes: 3

1 Base Layer
2 Clip at 4.00 SD
3 Despike Threshold: 1 Window size: 3x3

The magnetpmetry survey plots are shown in greyscale, and as a trace plot. The printed reports have A3 printouts of the survey whilst the electronic copies have A4 versions on the assumption that not everyone has an A3 printer.

The resistivity is shown as a clipped plot of the data and then as a version with a high pass filter to seek to remove the effects of the slope which may have been damper at the bottom than at the top and may have had more topsoil further down the slope. It is also shown as a colour plot.

4 Results

Magnetometry.

See appendix 2C

This method detected very little bearing in mind the area surveyed. Here the main area of interest is the areas of high readings in the central part of the survey area. One of these was further investigated with resistivity. Once the anomalies probably caused by ceramic tile were filtered out the main anomalies detected appear to be:-

1 An alignment of high and low readings. Probably a ceramic pipe or a deep iron one.
2 Slight linear feature – possibly a pipe run or agricultural drainage.
3 Small areas of enhanced magnetic response. Possible pit-like archaeological features
4 Several low anomalies which are probably pieces of iron.
5 Several approximately parallel features. Probably agricultural drainage

Resistivity.

See appendix 3D

6 High and low anomalies on ENE-WSW alignment. Whilst this alignment looks promising it also is on the same alignment of the crop and may well be where the tractor wheels have compacted the soil and this gives a linear effect as the soil has dried out differently depending on its compaction.
7 Two small pit-like low resistance features. There may also be more of these. They may be archaeological but tree-throw holes could also account for this type of anomaly.
8 A rectangular patch of low resistance. This could be a Saxon sunken featured building – although it may well turn out to be something else.

5 Conclusions

These techniques appear to have located little apart from a possible sunken featured building which may warrant further investigation.

This is however in an area where fieldwalking and metal detecting indicate that there are remains so this may provide some settlement basis for those finds. This type of feature is often associated with post-hole structures which are generally not detectable by geophysics.

Roger Ainslie 1 October 2011

6 Statement of Indemnity

Many features cannot be detected with magnetometry or resistivity. The fact that something has not been located should not be taken to imply that it is not there.

7 Acknowledgements

We would like to thank Dr Stephen Mileson for asking us to carry out these surveys. We would also wish to thank Philip Chamberlain for permitting access.

8 References

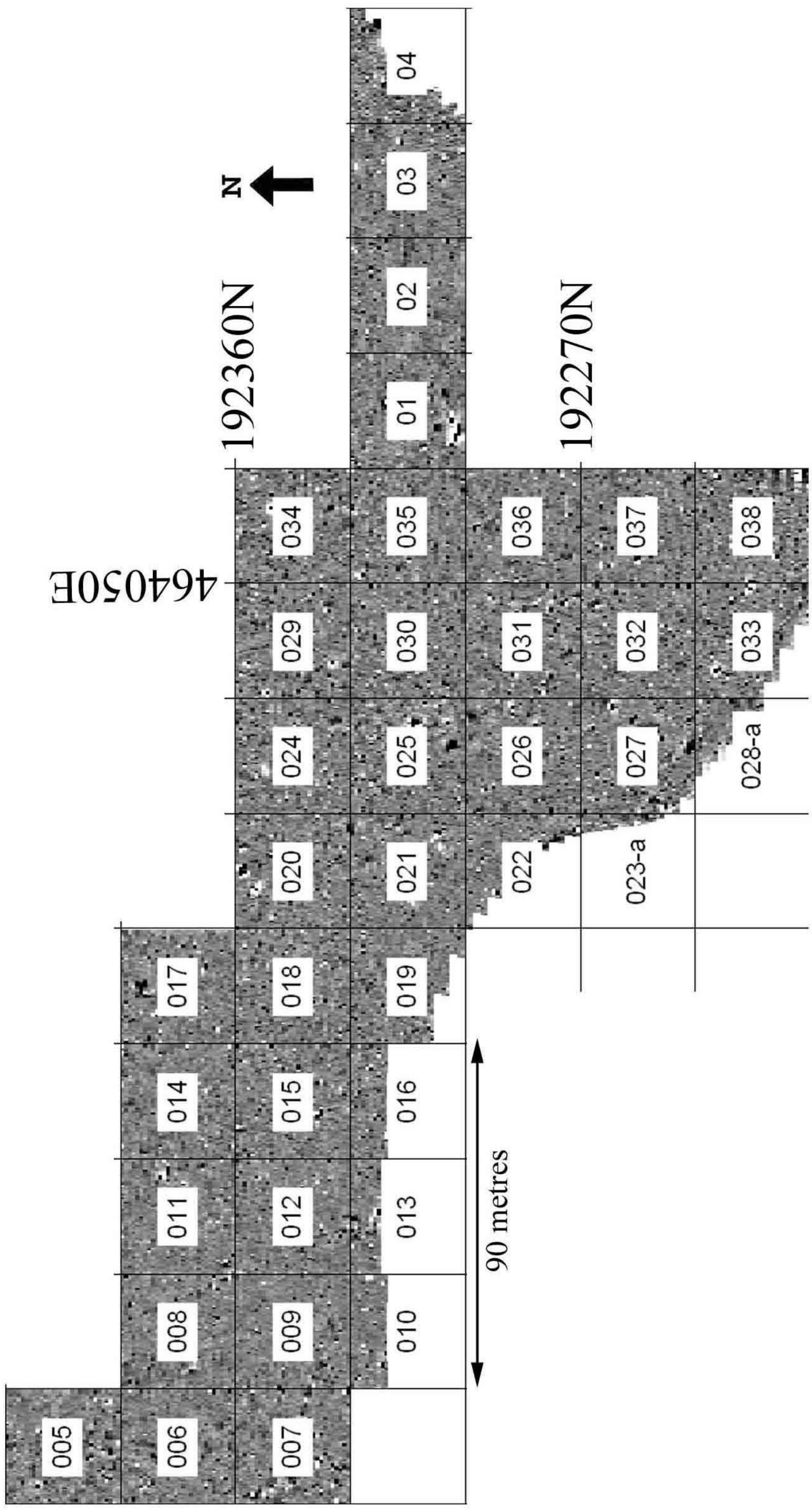
1 Victoria County History , Oxfordshire vol 1, University of London Institute of Historical Research, Oxford University Press, London1939, pp348-9

9 Appendices

1 LOCATION PLANS

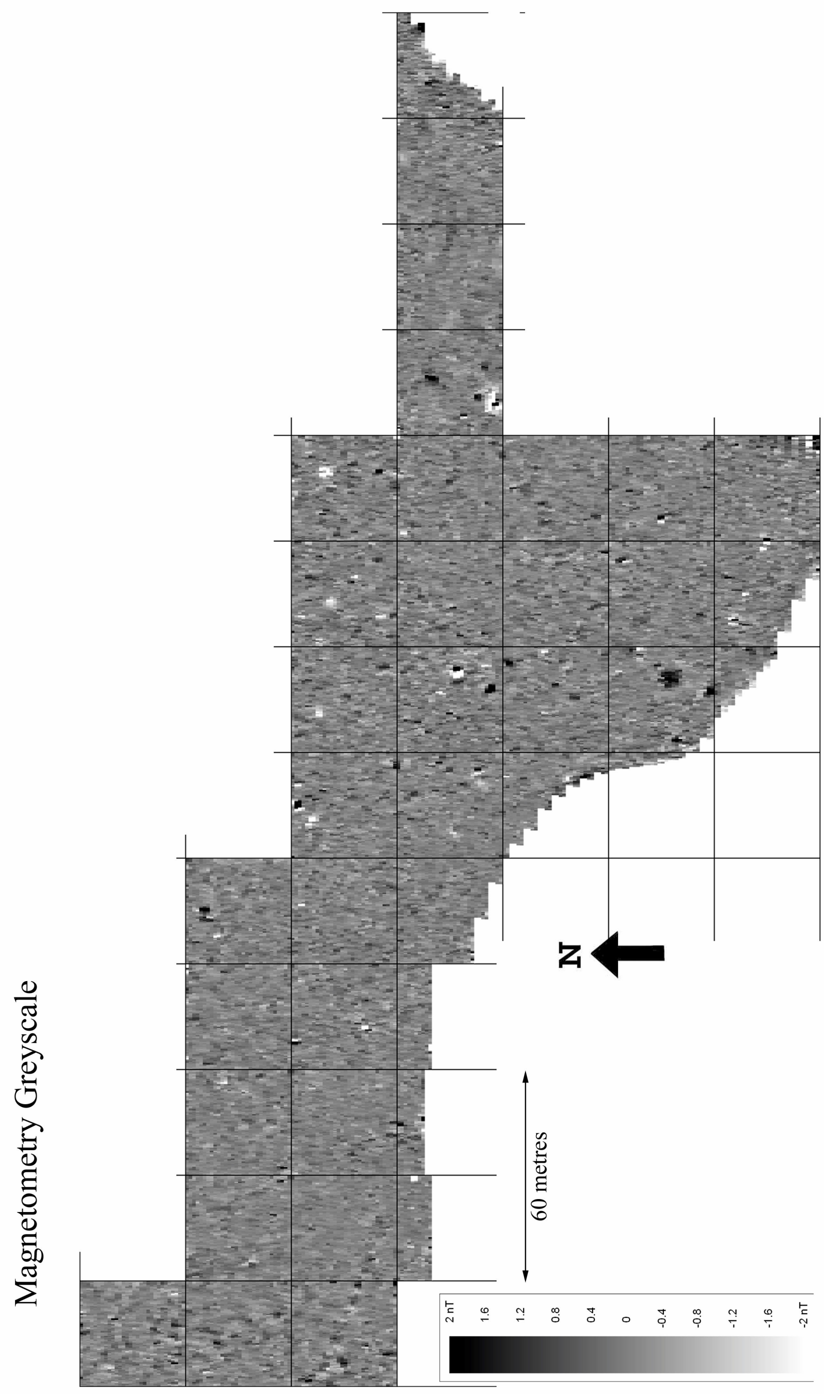
A Approximately located on Google Earth air photo

B Magnetometry (resistivity was over the same grid as magnetometry grid 25)

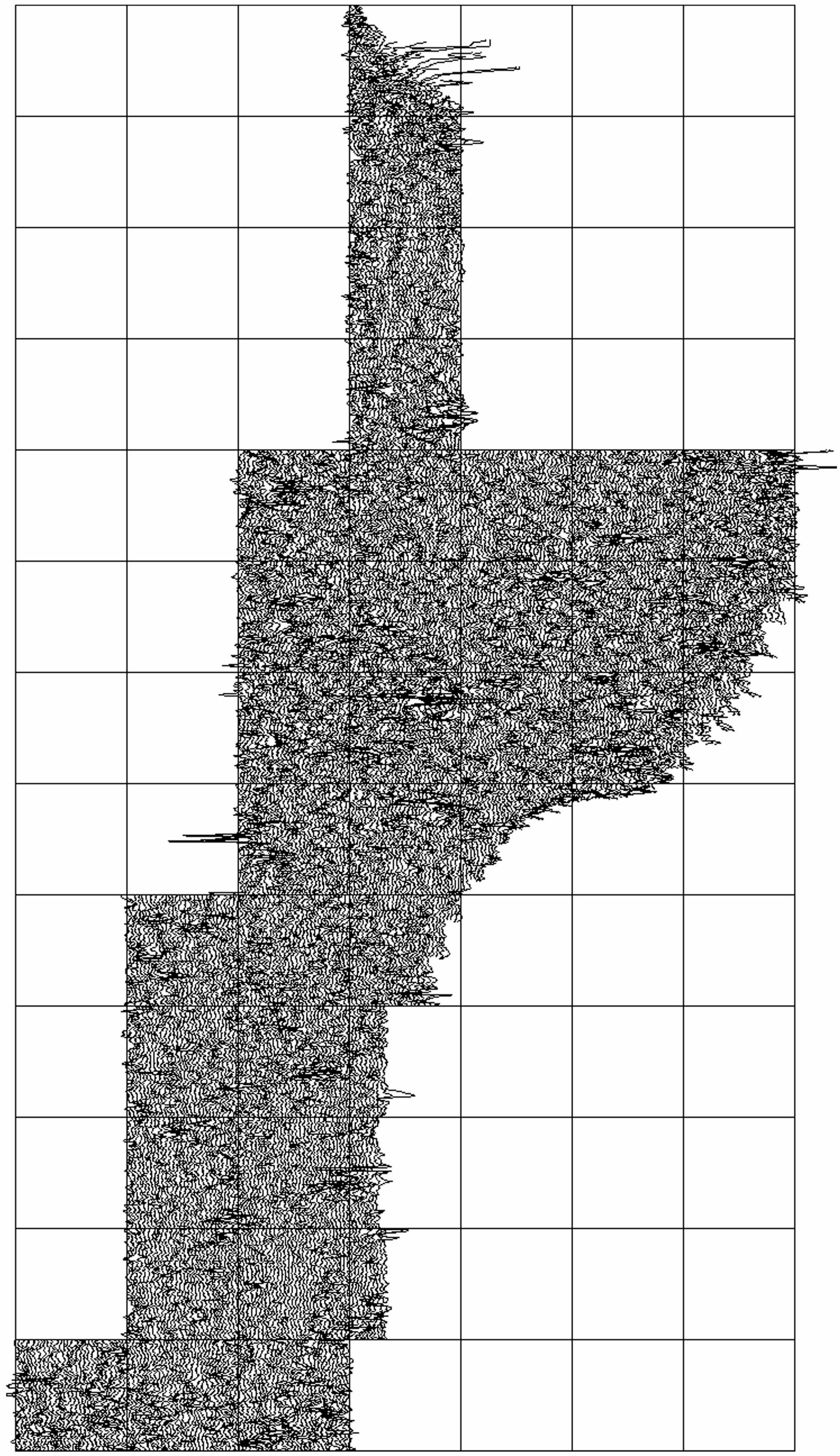


2 MAGNETOMETRY PLANS

A Greyscale

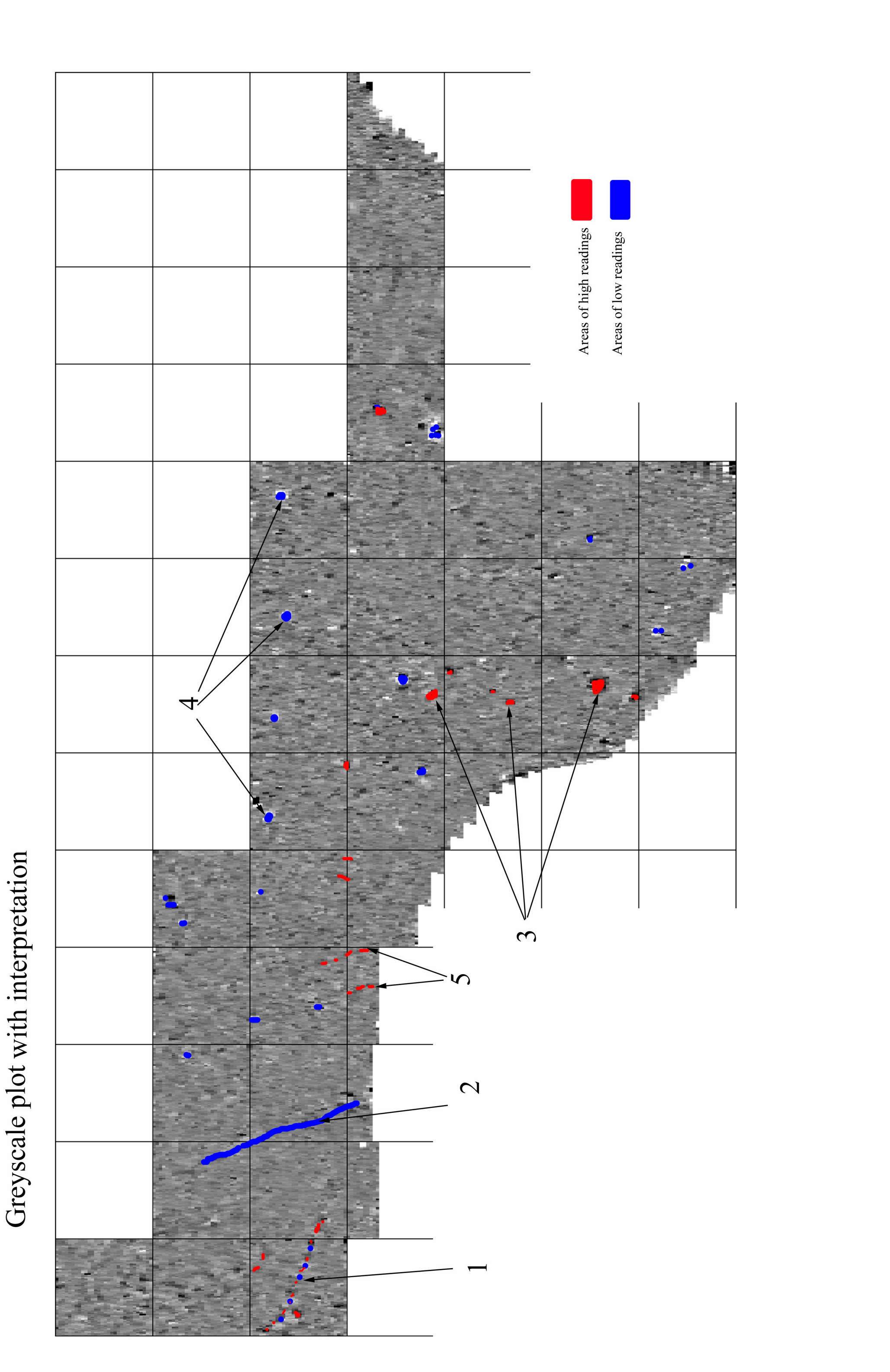


B Trace



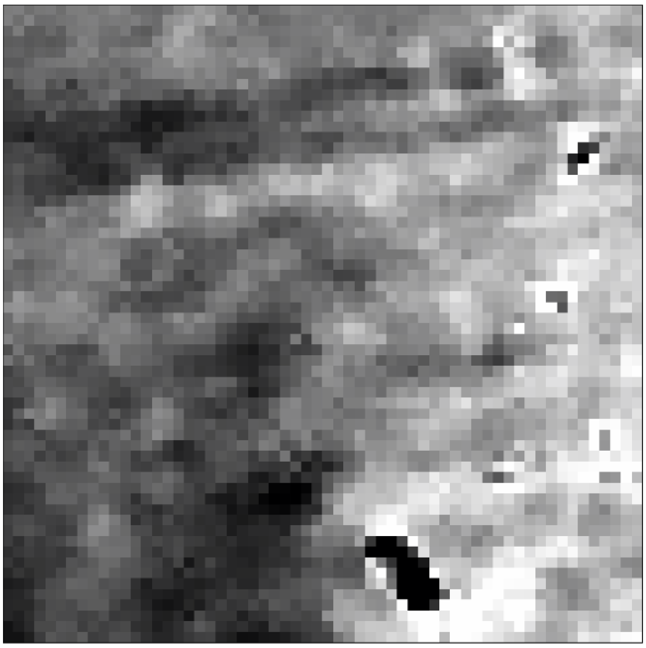
Trace plot

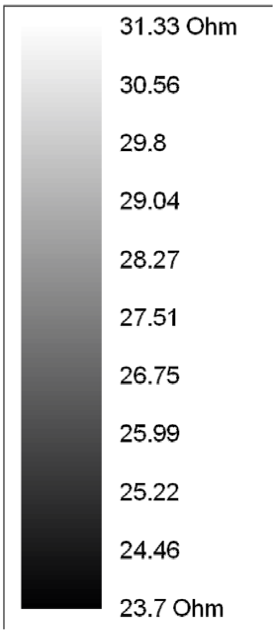
C Interpretation



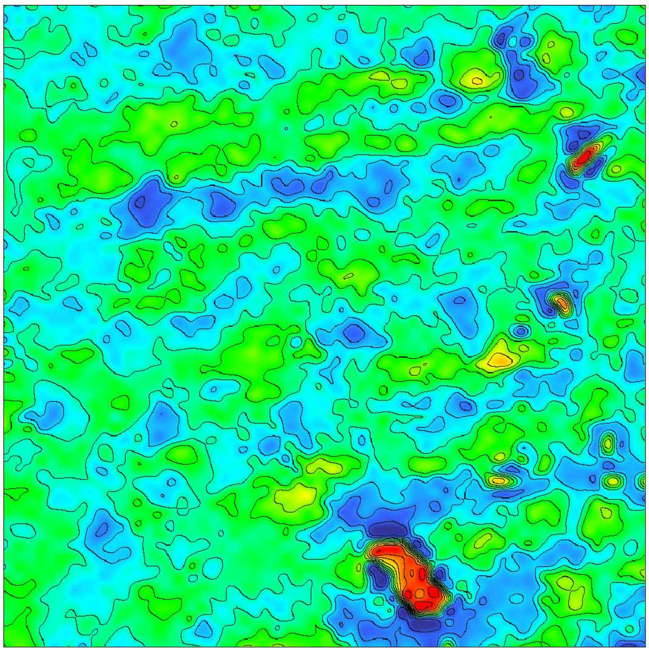
3 RESISTIVITY PLANS

A Greyscale

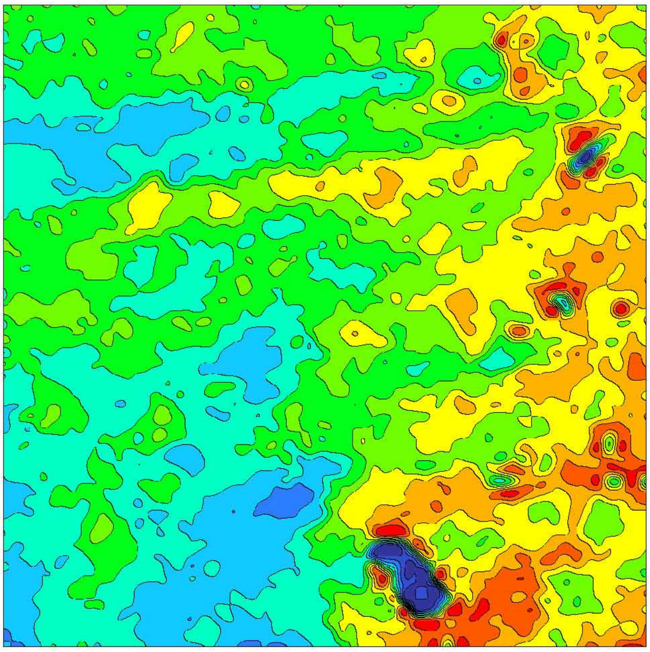




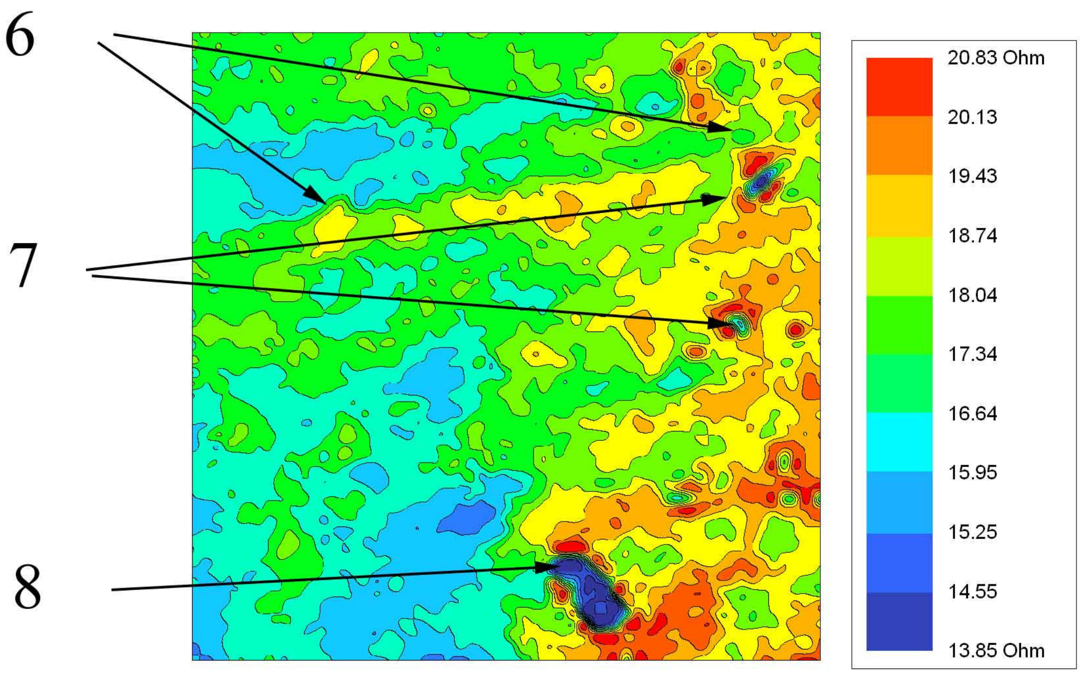
B High pass filtered



C Colour



D Interpretation



10 Technical details of methods and equipment

Magnetometry

A magnetometer is designed to detect variations in the Earths magnetic field. These variations occur where the field has been changed by factors such as iron pipes and features of archaeological interest. To be detected these features have to have certain properties. They have to contain iron and this has to be of a type which can be magnetically enhanced by human settlement. The larger the difference the better it can be detected. This enhancement can be by being burnt or it can be caused by microbes which by some process tend to concentrate magnetic material. The two factors necessary are therefore to have iron in the soil and for this to have been changed where human activity (or bacteria) has altered it.

It is therefore very unlikely that features will be detected which are made exclusively of oolitic limestone or chalk as these deposits contain very little iron. Even if there has been a lot of human activity there has just not been the iron there for that activity to enhance. Fortunately the topsoils on chalk soils often have quite strong magnetic characteristics so they can reveal ditches and other features which are cut into the underlying chalk. It is this difference in one area having magnetically enhanced soil and others not having it which is detected. A road surfaced with limestone cut into an iron rich topsoil would similarly show as that area would have less magnetic enhancement than the surrounding soils.

The theory is all very well but the practicalities are a bit more difficult. The main problem is that the earth has a magnetic field of approximately 40,000 nanoTesla whilst the features which we are seeking to detect have a difference above the background level of 0.5 to 10 nanoTesla. Things are complicated further by the magnetic field then changing during the day and by magnetic fields caused by railway trains, electricity pylons and other factors changing as well. In order to seek to overcome these problems the sensors which are used are put in gradiometer mode which means that they are mounted as pairs with one above the other. Our equipment has the sensors separated by 1 metre but other manufacturers make equipment where the separation is 0.5 metres. What happens then is that the earth's magnetic field is detected by both sensors but only the bottom one also detects most of the reading caused by archaeological features. The readings from the top sensor are automatically deducted from those of the bottom sensor and this gives the reading which should approximate to the reading of the archaeological features.

A magnetometer will detect ditch - like features better than it can detect shallow spreads even of the same volume. The orientation of the survey traverses can be of importance as the processing used to remove striping caused by minor balancing errors in the sensors can also remove some of the data from the archaeological features. It is therefore best to have a grid at an angle to the expected remains rather than being on the same alignment.

Magnetic anomalies are difficult to detect at the best of times and the amount which can be detected declines with the distance between the anomaly and the sensor. Therefore it is important to have the sensors low enough to maximise data from archaeological features whilst avoiding confusion caused by minor ferrous material on the ground and also avoiding the sensors being caught in vegetation. We tend to carry ours with the bottom sensor approx 20cms from the ground surface. The equipment can therefore detect small shallow anomalies or deep ones provided that they are large. Alluvium covering weak archaeological anomalies can therefore make them undetectable

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Earth Resistance (also known as Resistivity)

This is, in theory, the simplest method as it relies on detecting the electrical resistance of the soil. In practice this is a bit more complex as it has been found that if you just place two probes into the ground then the current between them will change as the ground around the terminals becomes polarised. Then if you then stick the probes into the same area again you get a different reading. This is caused by the contact between the soil and the probes changing each time as different surface areas of grains touch the surface of the probes. To overcome this various arrays of probes have been developed but these rely on the current being sent via one set of probes and read by another set. There are various arrays such as Wenner, Schlumberger, pole- pole and Twin. The most commonly used are twin and pole- pole both of which involve having a pair of remote probes at least 15 metres away from the area being surveyed (assuming 0.5 metres between the probes in the survey area). For twin the remote probes are spaced approx 0.5metres apart and this is increased to over 15metres for pole-pole.

Earth resistance is largely dependent upon the moisture content of the soil as a ditch will often have silts which retain moisture whilst the natural soil around may be more freely draining. Of course the opposite can happen, as rubble filled ditches can be more freely drained than the surrounding soils. Similarly walls tend to be drier and give higher resistance values than the soil around them.

Various pieces of equipment are used which can give between one and four readings at a time. Our equipment unfortunately only takes one reading at a time. Usually these have probes which are separated by 0.5 metres which can give a depth of reading of almost 1 metre-depending upon soil conditions and probe array. A 1 metre separation between the probes in the survey area, (the mobile probes), can go even deeper.

This method is good for finding walls but has the drawback of being far slower than magnetometry-about one third of the speed at best. The data often needs less processing than magnetometry data although high pass filtering can be useful to remove the effects of geology on a site, and de-spike used to remove the effect of the occasional poor reading caused by the probes hitting stones on the soil surface. The other main drawback of this method is that as it is greatly influenced by the amount of moisture in the soil. In the summer soil conditions can be too dry to get good results and in the winter the opposite can be the case. Often, however, something shows at most times of the year, it is just that at optimum times the clarity of the features is far better. In some areas, particularly urban areas, there are electrical currents which have leaked into the earth or are there as part of the electricity transmission system. These can badly affect the readings and filtering them out lengthens the time taken to carry out the survey.
Interpreting resistivity results can have its problems which include:-
Walls usually have high resistance but robbed out walls can have low resistance.

Ditches usually have low resistance but if they are filled with rubble or gravel they can have high resistance.
Paved surfaces can resemble broad walls but sometimes the paving ponds groundwater creating a low resistance area.

Processing

Magnetometry

We use the programme ArcheoSurveyor to process the data. In general one should avoid over processing as it can create spurious features. However the presence of large anomalies caused by iron pipes means that the data has to be clipped as otherwise the plots would show little more than the largest anomalies.
After clipping a zero mean traverse is used which removes striping in the plot caused by the magnetometers not being balanced with each other and going out of balance during a survey. Magnetometers are balanced at the start of work and at lunchtime to reduce the drift and in hot weather even more frequently. That being said, these magnetometers are far more stable than their predecessors.
The next process is destagger. This removes the zig zag effect of delays at the start of walking lines and sensor lags. As we use a marked string to ensure the location of each reading these are fairly constant although sloping and bumpy ground can cause variations. Despike is used to remove interference from iron nails and similar debris. Compression filters are used to amplify the responses as otherwise some sites with low responses appear to be very flat.

Resistivity

This generally needs less processing. Clipping and de-spiking can stop occasional high readings caused by poor contact from distorting the survey plot. Edge matching can also reduce distortions caused when grids have been surveyed in different days with different amounts of soil moisture.

General

The relatively recent availability of automatic data logging, reasonably priced computer memory and processing software has made it possible to survey far larger areas than were previously practicable.

Further Reading

The best reference book on this is *Seeing Beneath the Soil* by A. J. Clark, 1990. Other books by I Scollar *Archaeological Prospecting and Remote Sensing* Cambridge University Press 1990 and by Gaffney and Gater *Revealing the Buried Past* Tempus, 2003 are also useful. Andrew David's guide *Geophysical survey in archaeological field evaluation* English Heritage, 2008 gives a very good overview of techniques and what to expect in reports. More recently *Magnetometry for Archaeologists* by Aspinall et al (2008) has given more information on that technique. Our website www.archaeologicalgeophysics.co.uk gives examples of sites and other details.