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SULGRAVE BARROW GEOPHYSICAL SURVEY

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Summary

Magnetometry and earth resistance surveys failed to find a curved ditch around this Scheduled Ancient Monument. Whilst not all bowl barrows have ditches the lack of one may increase the possibility of it being something else such as a moot mound or tump. There is the possibility of it having been partially surrounded by rectininear ditches. Excavation may be needed to clarify this.

Introduction

Magnetometry and earth resistance surveys were carried out to investigate this barrow mound area to assist in the preparation of a scheme for its protection from animal burrows.

The work is funded by Natural England and is part of a project to exclude badgers from the barrow. Their setts represent a severe threat to the preservation of the site. On 9 March 2017 Historic England prepared a brief for works there which required work to establish the location of the ring ditch and to assist the understanding of the monument.

Brief description of the site

It is located south of Banbury Rd, Culworth, South Northamptonshire. Grid Ref SP559471. Nearest postcode OX17 2HT. Access is from the public road to the north of the site.

The barrow is some 2.5 metres high and covered with badger burrows and brambles, which have recently been cleared from the site, but can be expected to grow again. The badger setts are not all visible on the surface and an apparently good surface can collapse under a person's weight revealing a void underneath. The field to the west is wheat or similar and there is a wooded area to the south of the barrow.

Solid and drift geology

The geology is understood from the Geology of Britain viewer to be Northampton Sand Formation - sandstone, limestone and ironstone, although Whitby mudstone is also nearby. Augur holes in the cultivated area revealed grey clay still continuing at 0.5m depth. If this is the mudstone it indicates that the ironstone may be absent in this area.

The site is near the high point on a hill at approx 180m OD with expansive views particularly to the south and, from the top of the mound, to the north. We understand from the landowner that the soil in the wheat field is quite thin and we had difficulty in getting our earth resistance remote probes more than 15cms into the soil. The mound itself appears to be light coloured silty soil with small stones.

Summary of archaeological background

The site is reputed to be a Bronze Age Bowl barrow. We have not been able to find any record of previous excavation on this site.

It is a Scheduled Ancient Monument no 1010248.

The Historic England Pastscape system has this as Ancient Monument no 339264, Northamptonshire.

There it is referred to as a bowl barrow although their field investigator also considered a windmill mound to be a possibility. It also says that a slight ditch could be seen in the lusher vegetation on the northern side of the mound.
The Defra MAGIC website links to a page which has this as monument as no 13670 or Northamptonshire 174 and describes the barrow as:-
Sulgrave bowl barrow lies 1.5km to the north of Sulgrave village, on the south side of Banbury Lane. This Bronze Age bowl barrow consists of a mound up to 2m high and probably a surrounding ditch. The mound is oval in shape and measures approximately 25m x 40m. The peak of the clay mound lies at the northern end. Some large stones are exposed on the west side of the barrow mound suggesting the presence of internal burial cists or chambers used to inter the remains of the dead. Most of the barrow mound is intact but the site has been partly disturbed by badgers and it is not possible to trace a surrounding ditch, although one is likely to survive below ground.

There are air photos at the Historic England Archive in Swindon. It is understood that these show the site in various stages of badger erosion but were not taken in conditions suitable for detecting crop marks on this site.

Legal status of site.
The site is a Scheduled Ancient Monument no 13670, National Heritage List no 1010248. A Section 42 Licence to the survey work from Historic England has been obtained under the terms of the *Ancient Monuments and Archaeological Areas Act* 1979, ref AA/031797/5, case no SL00161899.

Survey objectives
To seek to establish whether remains can be located to assist in the positioning of a fence and other works to deter badgers from continuing to have setts on the barrow. As any fence will need to be deep enough to stop badgers from digging their way in underneath it, it would be desirable to establish whether there was a ditch around the barrow, as this could be damaged if the new fence intersects with its course. This fencing will obstruct future geophysics and its ferrous content will interfere with the results - hence the need to have these surveys before the works.

Survey methods used
Magnetometry
It had been intended to survey a larger area, but the agricultural regime meant that this could not be achieved. The whole of the barrow, an area 5m-10m wide around it, and a strip of 10m along the north edge of the cropped field were covered instead. We surveyed approx 0.2 hectares using this method.

A Bartington Grad 601/2 Gradiometer was used. Lines were 0.5 metre apart and readings taken at 8 per metre along the lines.
Trip hazards from sett entrances meant that the quality of positioning on the mound was not as good as we would have wished and the survey was much slower than usual.

Earth Resistance
A condition of Historic England's section 42 licence was that this should have readings at a 0.5 metre spacing. We used a 0.5m mobile probe spacing with a twin probe array.
Our original proposal had been to have readings at 3 different depths at a 1 metre spacing. This was based on the spatial resolution guidance in The EAC Guidelines for the use of Geophysics in Archaeology, 2015, p12, and had been designed to concentrate on locating any barrow ditch. Appendix 4 has our results from the part we surveyed at a 1m mobile probe spacing. We surveyed approx 0.1 hectares with the 0.5m mobile probe configuration.

Reasons for this choice
The main reason for the survey was to ascertain the position of any surrounding ditch to inform the location of any fencing and to record the mound as the fencing would make future surveys difficult or impossible. Thus the area at the base of the mound rather than the mound itself which was much badger damaged, was, we considered, of primary interest. As the soil from the mound could have eroded over the years and covered any ditch, a configuration to attempt to see a large ditch at depth was proposed.
A ground penetrating radar survey could be tried, but the unevenness of the ground would make this problematical. We did not propose to use this method.
A series of earth resistance profiles could be put over the barrow. We have had some success with this on level sites but it is very time consuming and the inversion modelling for the upstanding monument could require the expertise of others.

I understand that the decision of Historic England to have the survey types they required in the Section 42 licence was that it was in accordance with their recommendations on page 8 of their 2008 guidance, Geophysical Survey in Field Evaluation. In view of the impediment the fencing would cause to future surveys, they considered it better to cover the whole area at magnetometry with a 0.5m line interval rather than a 1 metre interval which had been proposed. Similarly they required a 0.5m density earth resistance reading interval rather than at a 1m density but at 3 different depths which had been proposed.

Dates of fieldwork
Start 3 June and finish on12 June 2017.

Weather
The first days work was after a few light showers after a dry period of about a month. There had been good rain a few days before the second day and light showers in the days before the third days surveying.

Grid location
The earth resistance used a 20 metre grid and the magnetometry used a 30 metre grid. Each grid was surveyed in a zig zag fashion with the first line starting at the NE corner going towards the SE corner. Points were set out

using tapes and recorded using a Trimble Pro XR differentially corrected GPS, accurate to approx 0.5m or less.
The eastern hedge was the base line and 3 points were marked with pegs along it, 20 metres apart. The grid location and order plan (Appendix 2) shows the details.

Data processing
TerrraSurveyor was used for processing.

The principal processes for magnetometry were:-
Clip, to reduce the effect of very high or low readings,
De-stagger, to adjust for uneven walking speeds, the difficulty in keeping the sensors vertical and an apparent inherent lag in the Bartington data logger.

The principal processes for earth resistance were:-
Remove individual bad readings.
Clip to enable different ranges of readings to be seen in better detail.

The plans show magnetometry plots processed with different ranges to ensure that the highly responsive features do not obscure the weaker ones. The earth resistance is shown both as an overall plot and also as others clipped to maximise the variation in the low resistance area in case a ditch could be located.

Results - Magnetometry

1 Small area of low and high readings. It could be a pit and some ferrous material could be present.

2 High readings. These could be pits but are more likely to be badger setts.

3 Low anomalies. These are probably mainly caused by the ground surface being further from the sensor when it passed over a hollow in the ground. As these hollows appear to be caused by badgers, the anomalies relate to them rather than archaeology.

4 A pit–like anomaly. This indicates that the geology is suitable for such features to be detected. If there was a large ditch around the barrow, as is usual for Bronze Age barrows then I would have expected to see a larger and curved anomaly of this type of intensity, if not greater.

5 Probably a piece of iron.

6 An area of high and low readings. This appears to be where there has been a recent bonfire. The soil on the roots of trees which were burnt may have become magnetically enhanced in the fire.

Results - Earth resistance – 0.5m mobile probes

1 An area of low resistance in the corner of the field.

2 Small patch of low readings. This appears to be where the western side of 3 and the southern side of 4 would meet if they continued, so they could be related.

3 High readings near hedge. These could be caused by the hedge taking moisture from the soil but its western edge looks a bit too straight for that.
4 Area of higher readings between the monument and the road. A strip of grass had been cut in this area shortly before the survey and a path runs across the area. There could therefore be the possibility that anomalies could be caused by different surfaces having different absorption and evaporation rates. The anomaly does not however reflect the path line and the 2 grids were surveyed several days apart with rain in the intervening period, so the anomaly is probably genuine.
5 An area of low readings between 3 and the main mound. This is not as strong as I would expect from a Bronze Age barrow ditch and it appears not to be curved. It may therefore be something else.
6 Low readings – probably a badger sett.
7 The main mound. The anomalies on it are probably caused by badger diggings and the moss which they deposit on the surface, which when dry is a good electrical insulator.
8 Tail of barrow area where trees have fairly recently been felled.
9 Low readings in cultivated field. The ploughing affects the degree to which rainwater permeates the ground.
10 Possible ditch, similar to 5.
11 Location of a stone on the surface. Approximately 30cms x 30cms were visible. It could be one of the possible kerb stones referred to in the records of this monument.

Results - Earth resistance – 1.0m mobile probes

1 Area of low readings, similar to those in the 0.5m earth resistance results.
2 Low resistance areas shown in the high pass filtered results.
3 Possible small curved high resistance anomaly, although ditches can give high or low readings at different times of the year.
4 High resistance area, similar to the 0.5m results, although the western edge appears to be straighter.
5 Possible L shaped narrow high resistance anomaly. Uncertain.

Conclusions

1 The mound area has been too tunnelled by badgers to enable our geophysics to say anything meaningful about the mound.
2 We could not locate a large curved ditch of the type expected for Bronze Age barrows.
3 We may have located ditches to the north and east of the mound but this may or may not be associated with the mound. If they are straight and continue beyond the site it may imply that it was something later associated with a field system or other enclosure rather than being part of the barrow construction. It is possible that the barrow and a rectangular enclosure were part of the same monument and we have been unable to detect the southern and eastern sides.
4 If the geology here is mudstone then both magnetometry and earth resistance results may be less reliable than if they were on ironstone.

Statement of indemnity

Many features cannot be located by using magnetometry or resistivity. Features including flint scatters and burials may well exist which are not detectable by these survey methods. Geophysics alone cannot give a date to anomalies; this will have to be ascertained by other methods. The failure to locate remains by these methods should not be taken as evidence that they do not exist.

Acknowledgements

We would like to thank Graham Keevill and Mrs Magnay for asking us to carry out the surveys and also for cutting the grass and clearing the site. We would also like to thank Dr Helen Woodhouse of Historic England for correcting the draft report.

Archive

As this is part of a larger scheme of surveys and other investigations, the archive for this aspect will be combined with the rest and dealt with by Keevill Heritage Ltd.

General Sources

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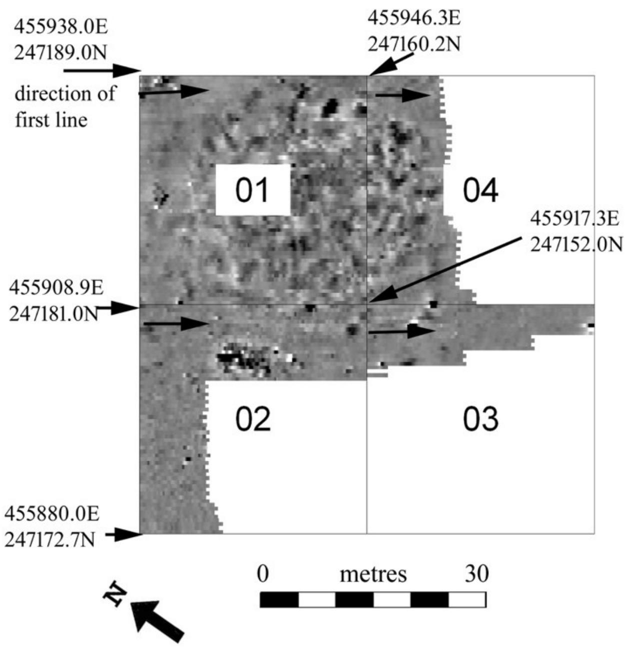
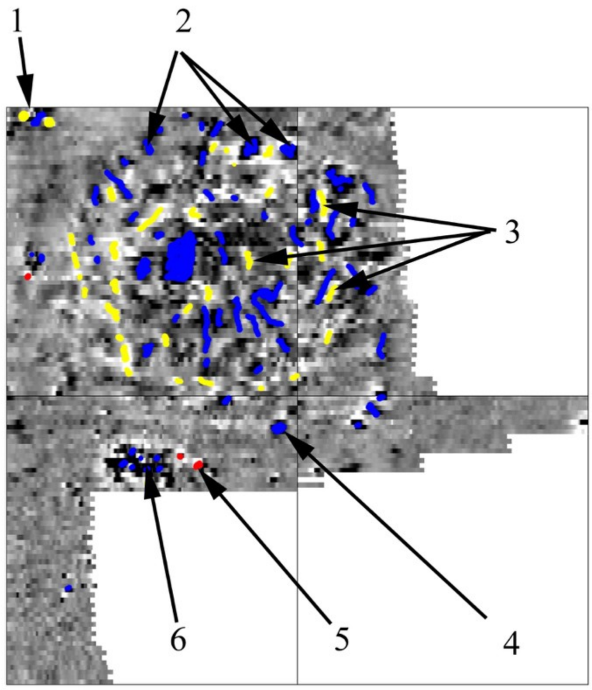
APPENDIX 1 - General Location

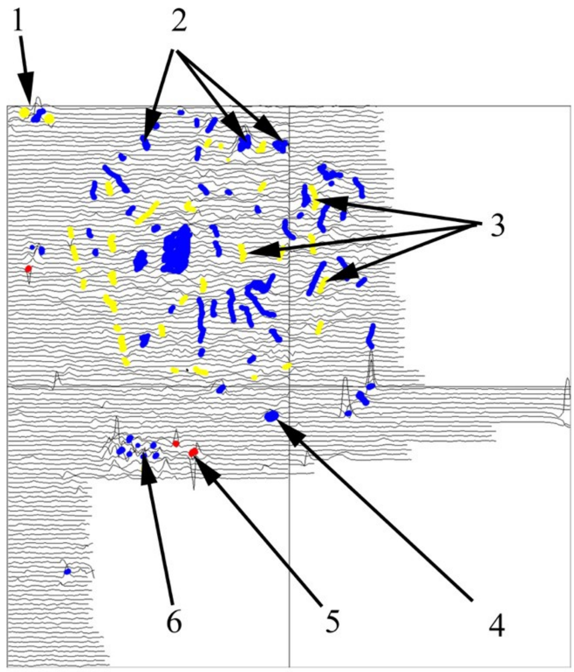
Approx Location on Google Earth photo

Appendix 2 MAGNETOMETRY

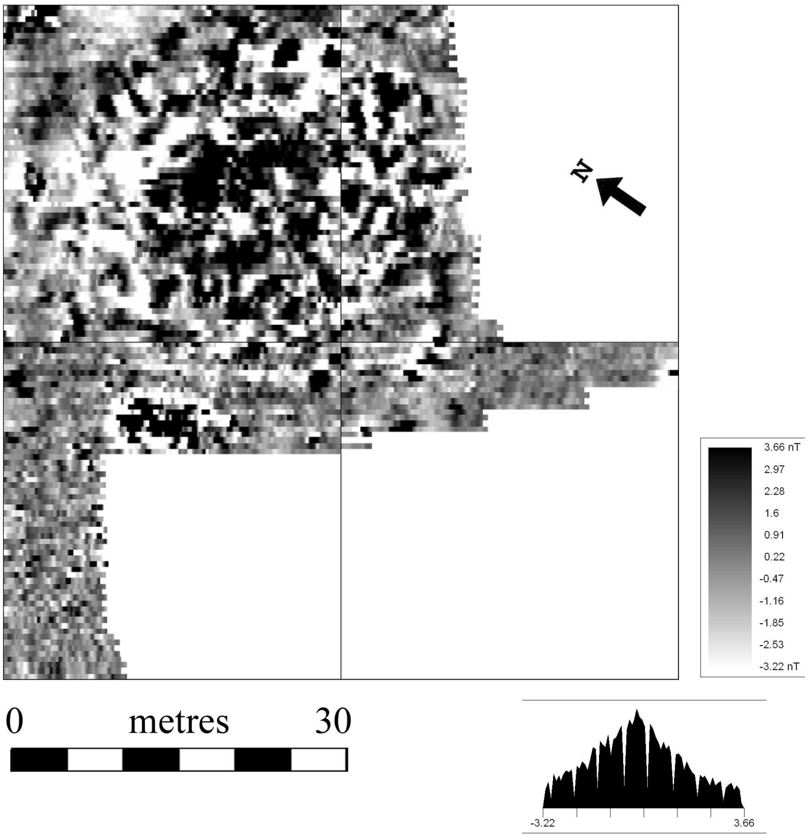


Magnetometry Detailed location and grid order

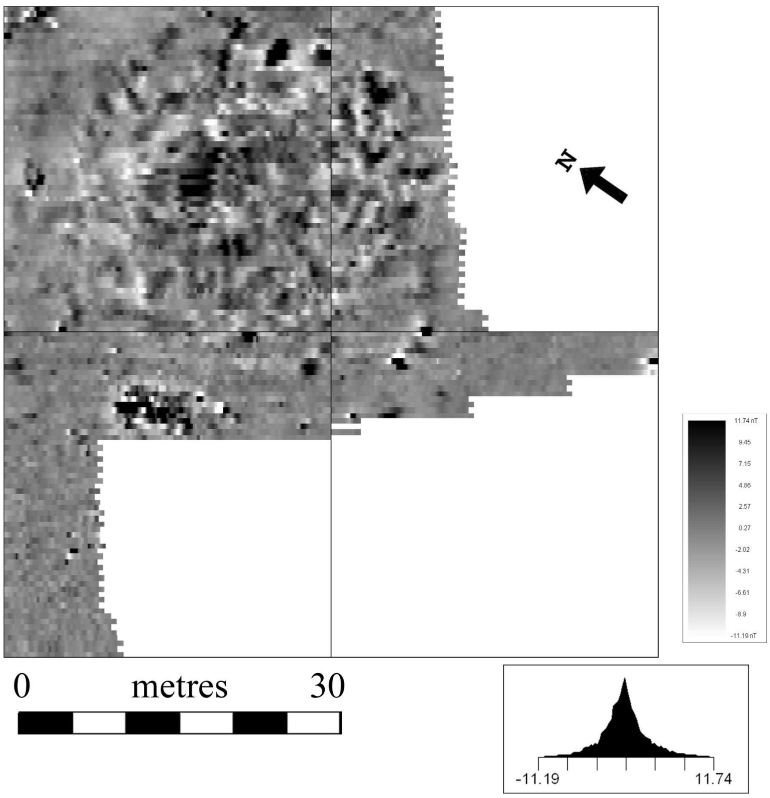




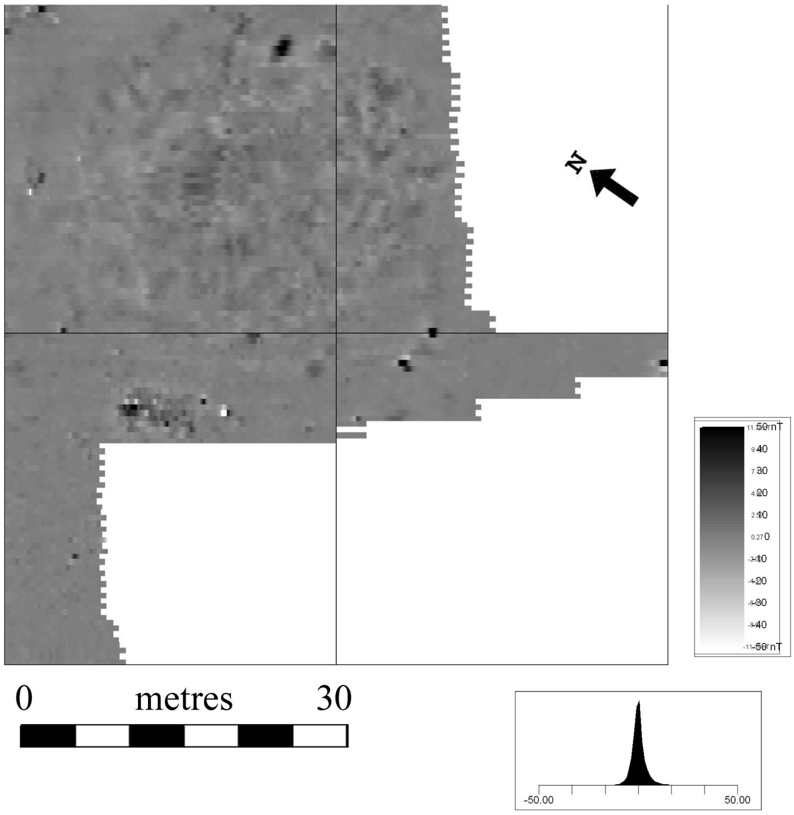
Magnetometry interpretation on greyscale and trace plots



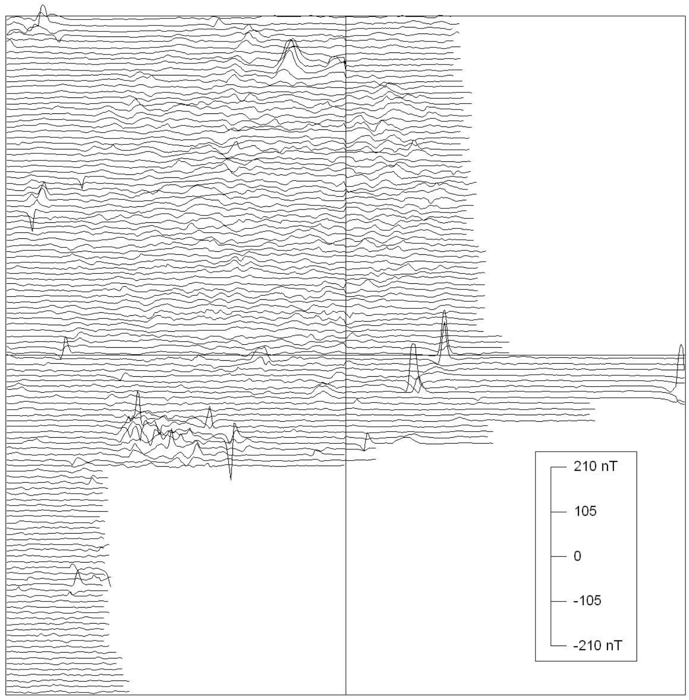
Magnetometry clipped at 3.5nT



Magnetometry clipped at 11nT



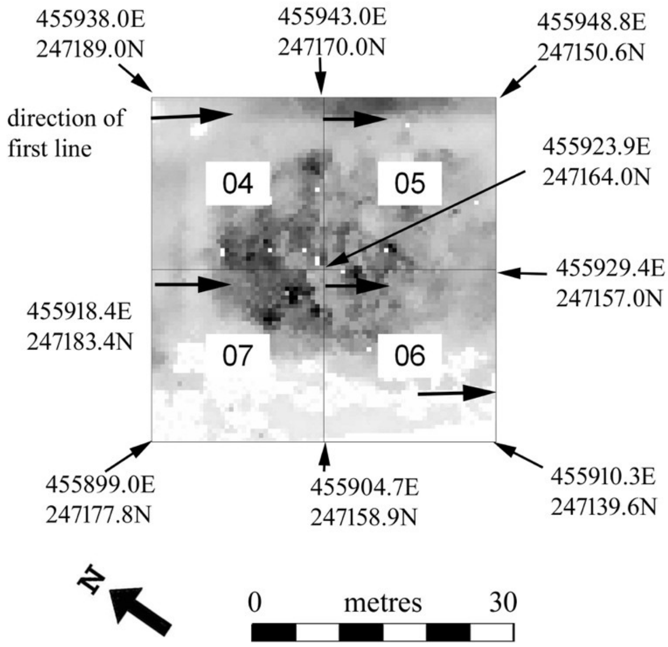
Magnetometry clipped at 50nT



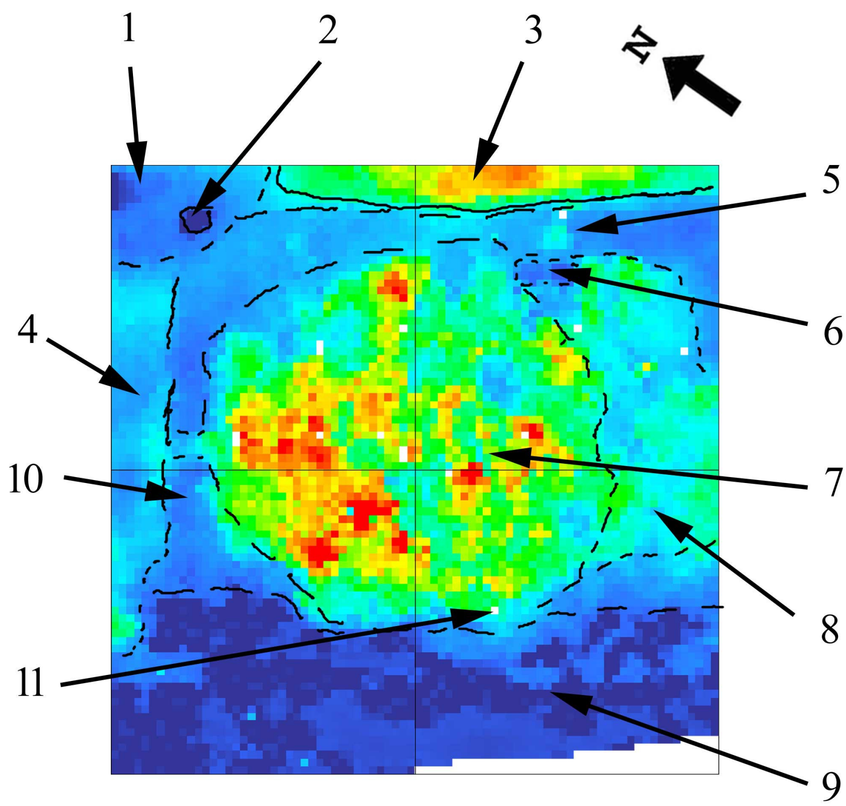
Magnetometry Trace plot

Appendix 3 EARTH RESISTANCE

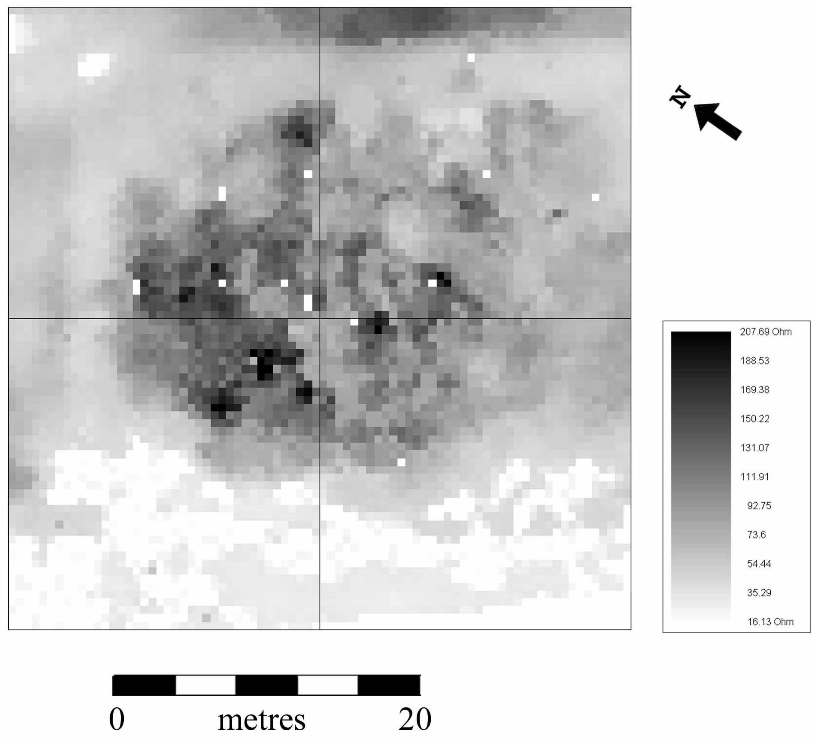
Earth Resistance with 0.5m mobile probe separation



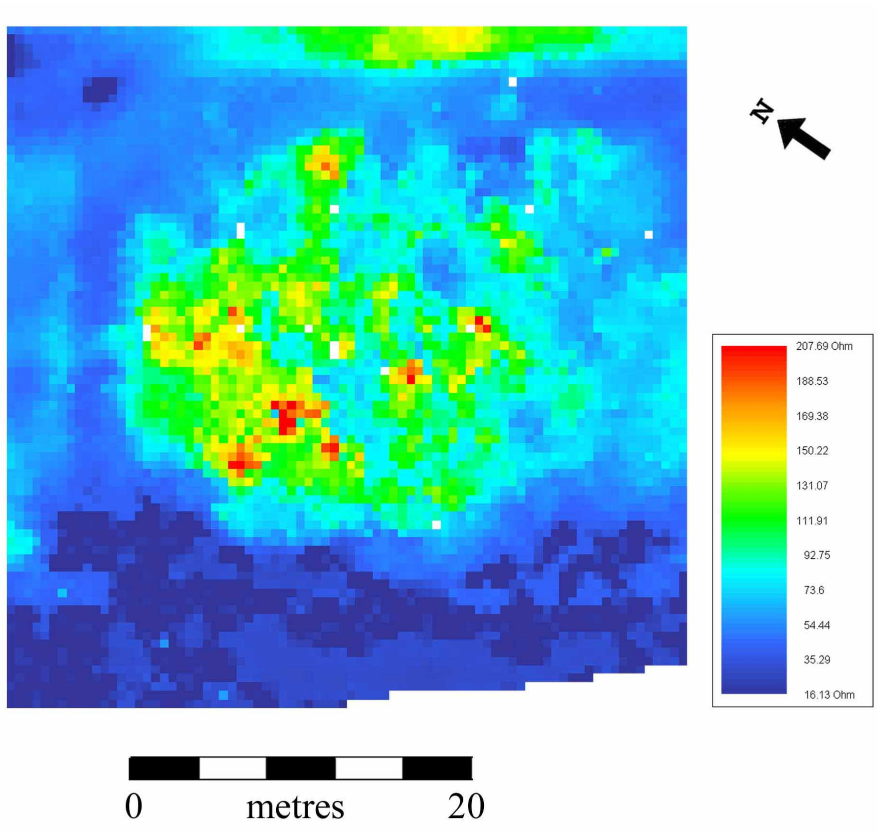
Earth resistance detailed location and grid order.



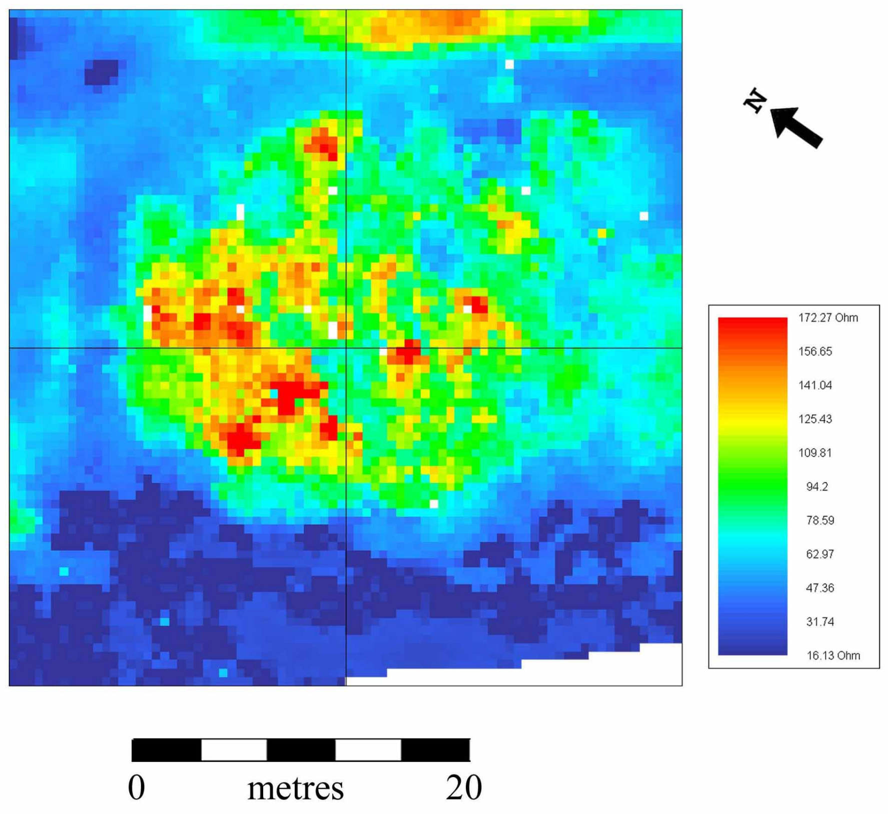
Earth Resistance Interpretation



Greyscale Clipped to 16-207ohms



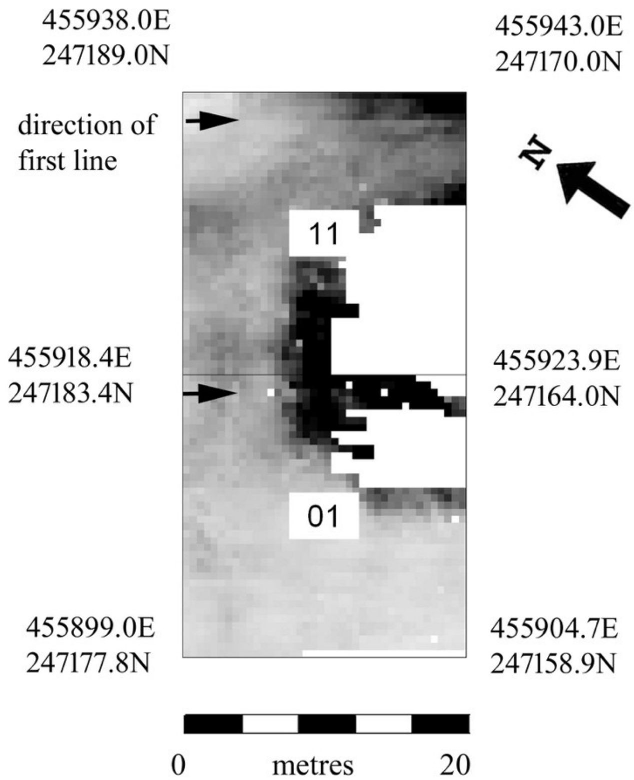
Colour plot clipped to 16-207 ohms



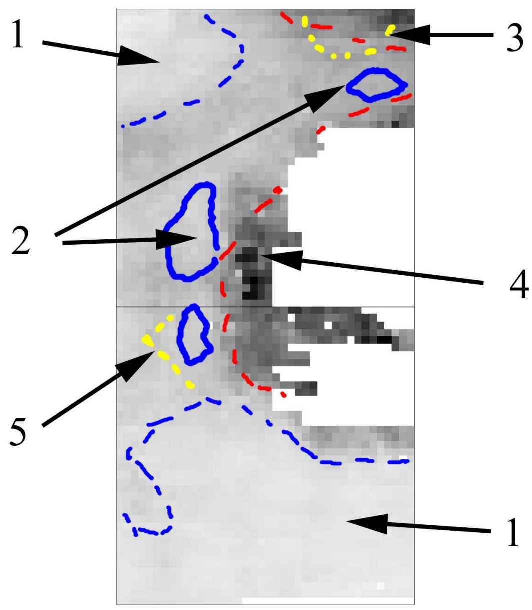
Colour plot clipped to 16-172 ohms

Appendix 4 **EARTH RESISTANCE**

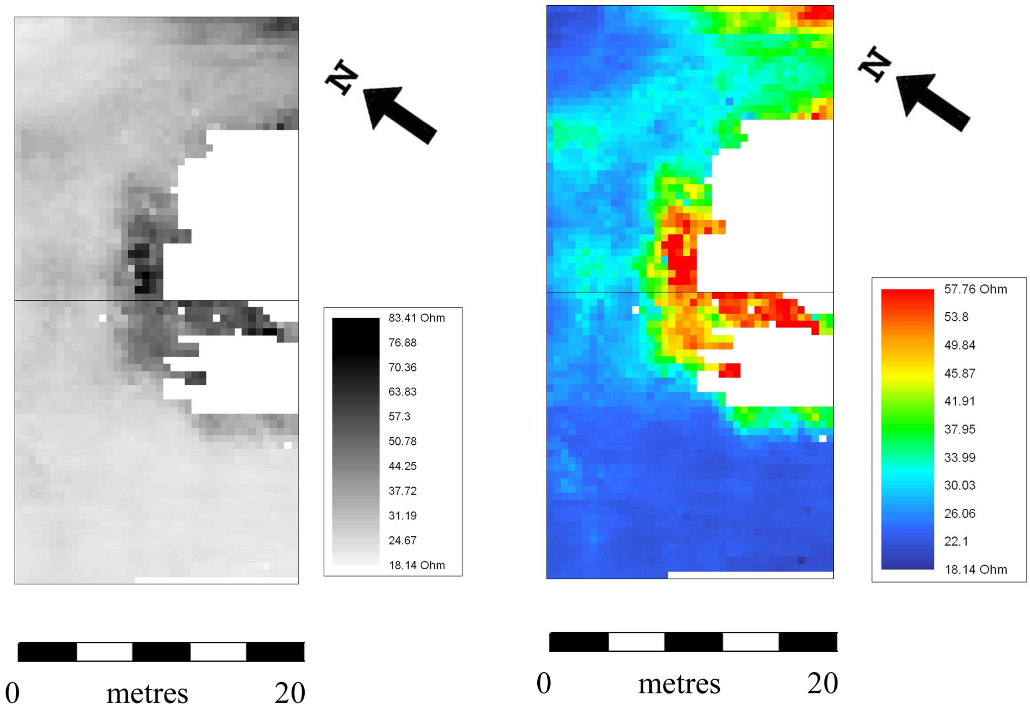
Earth Resistance with 1m mobile probe separation.



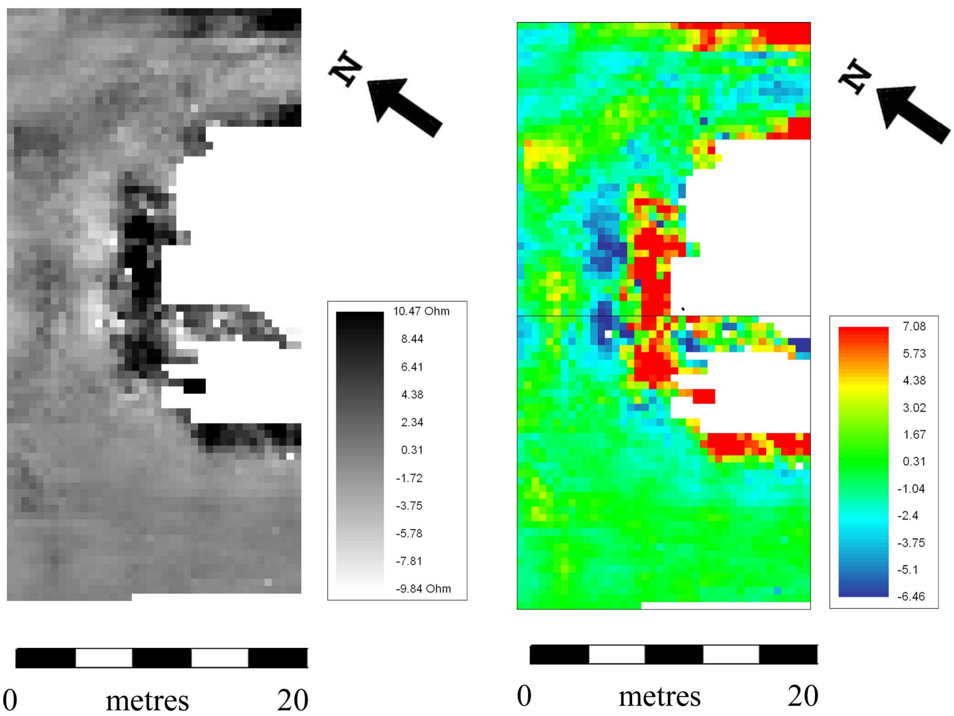
Location and grid order



Interpretation plot



Greyscale , clipped to 18-83ohms, and colour plot clipped to 18-57 ohms



Greyscale and Colour plots, high pass filtered

Appendix 5 – Technical details of methods and equipment

Magnetometry

A magnetometer is designed to detect variations in the Earth's 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 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 more difficult. The main problem is that the earth has a magnetic field of approximately 47,000 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.

Like most UK archaeological geophysicists we use fluxgate sensors in gradiometer mode. Other types, such as caesium sensors are also used by some and claim a greater degree of sensitivity than fluxgate sensors. The English Heritage 2008 guidance, p21, is that 0.3nT is adequate for most UK soils, so our equipment's 0.1nT is well within that. As caesium sensors are even more expensive than fluxgate ones they tend not to be used in gradiometer mode with any drift being sorted out by the data processing. The one site where we were able to compare our results with caesium survey found that the caesium had found ridge and furrow, also visible on Google Earth, better than the fluxgates. The fluxgates however had located a Bronze Age enclosure and presumed Iron Age houses which were not identified in the caesium report. This may be because the fluxgates may be better at identifying narrow cut features rather than spreads of material.

Our single axis fluxgate 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 rapidly as the distance between the anomaly and the sensor increases. 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 .

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 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 mobile 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. 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 magnetometery-about one third of the speed at best. The data often needs less processing than magnetometery 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 during dry periods. Paved surfaces can resemble broad walls but sometimes the paving ponds groundwater creating a low resistance area.

Processing

Magnetometry

We use the programme TerraSurveyor (formerly 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 can be 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, our Bartington 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 logger 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 can be used to remove interference from iron nails and similar debris.

Resistivity

This generally needs less processing. Clipping and replacing individual readings 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. A high pass filter can partially remove the effect of ground moisture naturally varying in a sloping field.

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.