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WHITBY CLIFF, NORTH YORKSHIRE

REPORT ON GEOPHYSICAL SURVEY, JUNE 2007

Louise Martin

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Whitby Cliff, North Yorkshire
Report on Geophysical Survey, June 2007

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Research Department Report Series 70/2007

Whitby Cliff, North Yorkshire
Report on Geophysical Survey, June 2007

Louise Martin

Summary

Magnetometer and earth resistance surveys were conducted in a field on headland of Whitby's eroding East Cliff where excavations in 2001 had demonstrated the presence of a complex archaeological sequence. The results of the magnetometer survey indicated areas of enhancement and some strong pit type anomalies that might be evidence for settlement. However, neither technique recorded a response to either the known Iron Age round house or any further similar structures.

Keywords

Fluxgate
Gradiometer
Iron Age
Early Medieval
Geophysical Survey
Earth Resistance
Magnetometer

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WHITBY CLIFF, North Yorkshire.

Report on geophysical survey, June 2007.

Introduction

Geophysical surveys covering an area of approximately 5.1 hectares were conducted over part of the headland NE and E of Whitby Abbey. The field in which the surveys took place abuts the cliff edge along which the Cleveland Way footpath runs. This section of cliff is unstable and a major collapse occurred to the NW in 2001 with further significant erosion anticipated over the next 20-25 years. In anticipation of the footpath being moved further inland, mitigation excavations of a section of the field were undertaken in 2002 to assess the potential for archaeological remains in this area (Jennings and Wilmott 2007, 5). These revealed part of an Iron Age round house, measuring approx 11m in diameter, buried beneath medieval ridge and furrow. Anglian archaeological remains were discovered to the W and included ditches with very burnt fills and evidence for lead and glass working. A return excavation season in September 2007 has been planned to further investigate the complex archaeology and the potential for an Iron Age settlement on the headland. One goal of the additional archaeological assessment is to explore the possibility that remains of a settlement boundary might exist to the E and S running along the line of a visible scarp (S. Jennings *pers comm.*).

The aim of this geophysical survey was to investigate the immediate area proposed for excavation and as much of the surrounding land as possible in an attempt to identify the nature and extent of any archaeological remains, in particular any further evidence for an Iron Age settlement and its boundary. In support of the project an assessment of the topographical features was conducted by the Archaeological Survey and Investigations (ASaI) team and the results are summarised within this report.

The site (centred on NZ905113) lies on slowly permeable seasonally waterlogged reddish fine loamy soils of the Salop association (Soil Survey of England and Wales 1983), developed over Boulder Clay and the Lower Oolite Esturine series and Upper Lias Dogger (British Geological Survey 1950). The field is used for cattle pasture though cleared of stock at the time of the survey. The weather conditions deteriorated to heavy rain and wind as the week progressed.

Method

All areas for survey were divided into grids of 30m squares, located using a real-time kinematic Global Positioning System (GPS).

Magnetometer survey

Magnetometer survey was chosen in an attempt to map any settlement activity that maybe associated with an Iron Age village, including the ditches of round houses, field boundaries, pits or hearths.

The survey was conducted over the shaded area in Figure 1 with two Bartington *Grad601* fluxgate gradiometers following the standard method outlined in note 2 of Annex 1. A linear greyscale plot of the data-set is superimposed over the base OS map at a scale of 1:2500 in Figure 2 together with the results of the ASal team's survey. Additionally an X-Y traceplot and linear greyscale plot of the data are presented at a scale of 1:2000 in Figure 3.

Corrections made to the measured values displayed in the plots were to zero the median of each instrument traverse to correct for instrument heading errors and to 'despike' the data through the application of a 2m by 2m thresholding median filter (Scollar, Tabbagh *et al.* 1990, 492). This latter operation reduces the distracting, localised, high-magnitude effects produced by surface iron objects. To improve the visual intelligibility of the traceplot presented in Figure 3A, the data-set has had the magnitudes of extreme values truncated to ±40nT/m.

Earth resistance survey

Subsequent to the magnetometer survey, an earth resistance survey was conducted over the location of the known round house.

Measurements were collected with a Geoscan RM15 resistance meter and a PA5 electrode frame in the Twin-Electrode configuration. Readings were collected using the standard method outlined in note 1 of Annex 1, with readings taken at 0.5m along traverses separated by 0.5m. A high-pass Gaussian filter with a radius of 7m was applied to the raw data in an attempt to remove large scale regional trends.

A linear greyscale plot of the filtered data is superimposed over the base OS map at a scale of 1:500 in Figure 4. Plots of the data-set are additionally presented as both an X-Y traceplot and equal area greyscale plot of the raw data and a linear greyscale plot of the Gaussian filtered data, all at a scale of 1:500, in Figure 5.

Results

Magnetometer survey

A graphical summary of the significant anomalies discussed below is provided on Figure 6. Numbers in [ ] refer to annotations in this figure.

The general magnetic response in this area was quite varied, with background levels >±1nT/m. The direction of ploughing is clearly visible across the whole data-set as noted at [M1]. Investigation by the ASal team has determined two phases of ploughing, only a sample of which is recorded on Figure 2. The first phase is of a traditional broad-rig ridge and furrow, the second, the intersecting of ridges to a shallower depth to create double the number of furrows (Al Oswald *pers comm.*). A broad band of raised magnetic response [M2] to the E edge of the survey area is indicative of a ploughing headland.

Evidence for modern disturbance has been recorded across the site notably in areas adjacent to field boundaries where ferrous fencing is the cause. A large dipolar anomaly [M3] in the NW corner of the survey has resulted from a large service cover set in concrete. E of here are four similar anomalies [M4-7], the latter three of which appear to be in a line. These could relate to drainage features or some other modern service. Increased magnetic response, especially between [M5-6], including two positive linear anomalies heading N from the former gives further weight to the suggestion that they might be connected. Further E again are two sections of a disturbed linear magnetic anomaly [M8] indicative of a buried pipe, again of modern origin.

Various discrete positive magnetic anomalies have been recorded across the site that may be pits of unknown date or origin. The largest of these [M9] has a maximum reading of ~39nT/m which demonstrates a considerable level of enhancement. Several other pit-type anomalies, mainly along the N edge of the survey area within 35m of the cliff edge, exhibit maximum signal strengths of between 5-18nT/m and are likely to be archaeologically significant. Attention is also drawn to clusters of pit-type anomalies and increased background response around [M10] and [M11]. These areas of greater enhancement might be of archaeological origin but could also be the result of more modern activity.

To the E, various positive and negative magnetic anomalies [M12] appear to align in a roughly inverted Y shape. This arrangement may be coincidental, but their proximity to potential modern drainage features, in particular [M5], running from higher to lower ground is suggestive of further water management systems.

A negative rectilinear anomaly [M13] coincides with part of the 2001 excavation trench. Just E of this is a partial circulinear anomaly [M14]. Though this falls within the boundary of the previous trench, only the topsoil was stripped in this area (Sarah Jennings *pers comm.*). Therefore there is the possibility that this relates to an unexcavated feature rather than an effect of the backfilling process.

Earth resistance

A graphical summary of the significant anomalies discussed below is provided on Figure 7. Numbers in [ ] refer to annotations in this figure.

The earth resistance survey has also recorded the direction of ploughing, mainly as bands of high resistance as illustrated at [R1]. A broader band of high resistance has been recorded at [R2]. Due to its alignment it is also likely to be the result of ploughing up against the edge of the field.

A roughly circular area of high resistance [R3] approximately corresponds with the magnetic anomaly [M14]. This could possibly be the inner floor surface to a small (~5m across) structure. This interpretation is very tentative given the weak nature of both anomalies.

Conclusion

Soils at the site exhibited significant variations in magnetic susceptibility allowing the ridge and furrow ploughing to be clearly detected. A wide distribution of pits, with some exhibiting significant degrees of magnetic enhancement, is suggestive of human activity. Unfortunately, the magnetometer did not detect any evidence for the hut circle remains discovered during the 2002 excavations nor for any other directly associated activity. However, the lack of geophysical response to known archaeology means that the presence of other features cannot be ruled out. It is possible that the enhancement of the soil that is demonstrated so well by the ploughing activity occurred after the Iron Age and is effectively blanketing out the signal from deeper or less well enhanced archaeology.

The earth resistance survey was only conducted on a small scale, but it was hoped the narrow sample interval of 0.5x0.5m would reveal more information about the previously recorded hut circle. But, as with the magnetometer survey, no trace was detected. However, there was some correlation with the magnetic results potentially suggesting another circular anomaly to the E.

Neither survey revealed any boundary to the putative settlement. This is supported by the ASaI topographical assessment which concluded that the identified scarp was in fact the more pronounced northern side of the head of a dry shallow natural valley (Al Oswald *pers comm.*). A pipe drain was also recorded as running along the floor of the valley and then following a deep furrow W across the field. There was no corresponding anomaly to this feature in the magnetometer survey which is unusual as both ferrous and ceramic pipes would be expected to exhibit a strong or dipolar magnetic response. Plastic piping is less frequently recorded but on a well enhanced site would be ordinarily appear as a negative anomaly. However, the pipe trench may be so closely aligned with the direction of ploughing that such a weak magnetic anomaly could not be distinguished.

The magnetic response to the ridge and furrow is greatest in two bands, one along the N coastal edge of the survey and the second across the centre of the area. Both areas could represent enhancement caused by concentrations of archaeological activity although, given the evidence for medieval and later agricultural regimes at the site, a relatively recent origin cannot be totally dismissed.

Surveyed by:	A Payne L Martin	Date of survey:	11-15/6/2007
Reported by:	L Martin	Date of report:	28/08/2007

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List of enclosed figures.

Annex 1: Notes on standard procedures

1) **Earth Resistance Survey:** Each 30 metre grid square is surveyed by making repeated parallel traverses across it, all aligned parallel to one pair of the grid square's edges, and each separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metres from the nearest parallel grid square edge. Readings are taken along each traverse at 1 metre intervals, the first and last readings being 0.5 metres from the nearest grid square edge.

   Unless otherwise stated the measurements are made with a Geoscan RM15 earth resistance meter incorporating a built-in data logger, using the twin electrode configuration with a 0.5 metre mobile electrode separation. As it is usually only relative changes in earth resistance that are of interest in archaeological prospecting, no attempt is made to correct these measurements for the geometry of the twin electrode array to produce an estimate of the true apparent resistivity. Thus, the readings presented in plots will be the actual values of earth resistance recorded by the meter, measured in Ohms (Ω). Where correction to apparent resistivity has been made, for comparison with other electrical prospecting techniques, the results are quoted in the units of apparent resistivity, Ohm-m (Ωm).

   Measurements are recorded digitally by the RM15 meter and subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to Fort Cumberland using desktop workstations.

2) **Magnetometer Survey:** Each 30 metre grid square is surveyed by making repeated parallel traverses across it, all parallel to that pair of grid square edges most closely aligned with the direction of magnetic N. Each traverse is separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metre from the nearest parallel grid square edge. Readings are taken along each traverse at 0.25 metre intervals, the first and last readings being 0.125 metre from the nearest grid square edge.

   These traverses are walked in so called 'zig-zag' fashion, in which the direction of travel alternates between adjacent traverses to maximise survey speed. Where possible, the magnetometer is always kept facing in the same direction, regardless of the direction of travel, to minimise heading error. However, this may be dependent on the instrument design in use.

   Unless otherwise stated the measurements are made with either a Bartington *Grad601* or a Geoscan FM36 fluxgate gradiometer which incorporate two vertically aligned fluxgates, one situated either 1.0m or 0.5 metres above the other; the bottom fluxgate is carried at a height of approximately 0.2 metres above the ground surface. Both instruments incorporate a built-in data logger that records measurements digitally; these are subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to Fort Cumberland using desktop workstations.

It is the opinion of the manufacturer of the Geoscan instrument that two sensors placed 0.5 metres apart cannot produce a true estimate of vertical magnetic gradient unless the bottom sensor is far removed from the ground surface. Hence, when results are presented, the difference between the field intensity measured by the top and bottom sensors is quoted in units of nano-Tesla (nT) rather than in the units of magnetic gradient, nano-Tesla per metre (nT/m).

3) **Resistivity Profiling:** This technique measures the electrical resistivity of the subsurface in a similar manner to the standard resistivity mapping method outlined in note 1. However, instead of mapping changes in the near surface resistivity over an area, it produces a vertical section, illustrating how resistivity varies with increasing depth. This is possible because the resistivity meter becomes sensitive to more deeply buried anomalies as the separation between the measurement electrodes is increased. Hence, instead of using a single, fixed electrode separation as in resistivity mapping, readings are repeated over the same point with increasing separations to investigate the resistivity at greater depths. It should be noted that the relationship between electrode separation and depth sensitivity is complex so the vertical scale quoted for the section is only approximate. Furthermore, as depth of investigation increases the size of the smallest anomaly that can be resolved also increases.

Typically a line of 25 electrodes is laid out separated by 1 or 0.5 metre intervals. The resistivity of a vertical section is measured by selecting successive four electrode subsets at increasing separations and making a resistivity measurement with each. Several different schemes may be employed to determine which electrode subsets to use, of which the Wenner and Dipole-Dipole are typical examples. A Campus Geopulse earth resistance meter, with built in multiplexer, is used to make the measurements and the Campus Imager software is used to automate reading collection and construct a resistivity section from the results.

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