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Wharram le Street, North Yorkshire
Report on Geophysical Surveys, February-March 2006

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Summary

Geophysical surveys were conducted at Wharram le Street, North Yorkshire to attempt to relocate a crop-mark feature suggestive of a hengiform monument. The area had been surveyed 28 years previously and successfully located considerable Roman settlement, but it was hoped that modern, more sensitive equipment would elucidate earlier activity at the site.

Both magnetometry and earth resistance survey recorded a large circular ditch and internal oval anomaly to the W of the head to the Gypsey Race. Part of the Roman activity was re-surveyed and showed good correlation with the existing data, though a newly surveyed area to the E indicated less intense occupation.

Keywords

Geophysical Survey
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WHARRAM LE STREET, North Yorkshire: February-March 2006.

Geophysical survey report.

Introduction

Geophysical surveys of a total ground area of approximately 2.8 hectares were conducted over a Roman ladder settlement and the suspected site of a henge at Wharram-le-Street, North Yorkshire. The ladder settlement had been previously investigated and recorded by a magnetometer survey in 1978 (David 1980) and through a series of 1m^2 test-pits and one 5x1m trench the following year (Rahtz, Hayfield *et al.* 1986). Some of these test-holes are now thought to have also partly sectioned the henge ditch (Gibson 2005, 11). However, the form and significance of the double ring ditch was only noted when recorded in its entirety as a cropmark on an aerial photograph in 1999 (Gibson 2006, 3).

The aim of this survey was to attempt to digitally record the hengiform ditch and surrounding features as part of a wider project, to date and reassess the Neolithic occupation of the Upper Wold Valley, being conducted by the University of Bradford with funding from English Heritage. The surrounding area is considered to be of national importance to Neolithic and Bronze Age studies, with the wealth of archaeology being second only to the SW chalklands of Wessex (Gibson 2005, 1). There are six other henges/hengiform monuments known of in the study area (Gibson 2005, 11), but the example at Wharram le Street lies at the springhead of the Gypsey Race and so is of particular interest to the wider project due to the potential for waterlogged deposits (Gibson 2005, 21).

The site (centred on SE868662) lies on deep calcareous and non-calcareous fine silty soils of the Andover 1 association (Soil Survey of England and Wales 1983) developed over Welton and Burnham Chalk formations (British Geological Survey 1993). At the time of the survey the field was mainly fallow, but with cultivation underway in the southern half restricting the area available for survey.

Method

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

Magnetometer survey

Despite the previous magnetometer survey not recording the henge ditches, it was hoped that the advantages of modern equipment, which include much greater sensitivity and the ability to digitally record the data allowing for post-processing, would provide the evidence required.

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 false-colour plot of the processed data-set is superimposed over the Ordnance Survey (OS) base map at a scale of 1:2500 on Figure 2. A section of the linear greyscale plot of the raw data-set is superimposed over the Ordnance Survey (OS) base map at a scale of 1:1000 on Figure 3, together with the approximate location of the 1979 excavation test-holes. Additionally an X-Y traceplot and linear greyscale plot of the raw data are presented at a scale of 1:1500 on Figure 4.

Corrections made to the measured values displayed in the plots were to zero-mean 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. The previous season's extant potato ridged ploughing and frozen/defrosting soil conditions made traversing the site at a regular pace difficult, and resulted in striping in the data. Therefore, to remove periodic artefacts caused by operator gait and produce a more comprehensible plot, periodic artefacts at a frequency of 1 cycle/m were suppressed using a Butterworth band-reject filter in the fourier domain and then the data was 'destaggered' to maximise the correlation of adjacent traverses. The data-set presented in Figure 2 had an additional low pass Gaussian filter with a radius of 1m applied. To improve the visual intelligibility of the traceplot presented in Figure 3a, the data-set has had the magnitudes of extreme values truncated to ±50nT/m.

Earth resistance survey
Subsequent to the magnetometer survey, an earth resistance survey was conducted over the location of the henge. 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 1.0m along traverses separated by 1.0m. The raw data was despiked to remove individual high magnitude readings caused by poor contact resistance, again attributable to the frozen state of the soil. A low-pass median filter was applied to the data-set in an attempt to show overall trends and remove some of the speckling caused by contact resistance. A high-pass Gaussian filter was then applied to the median filtered data in an attempt to remove large scale regional trends.

A greyscale plot of the raw data is superimposed over the base OS map at a scale of 1:2500 in Figure 5. Plots of the data-set are additionally presented as both an X-Y traceplot of the raw data and equal area greyscale plots of the raw and median filtered data as well as a linear greyscale plot of the Gaussian filtered data, all at a scale of 1:1500, in Figure 6.

Results

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

The general magnetic response in this area was ≤ ±1nT/m, with greatest anthropogenic enhancement to the SW and least to the NE. Modern disturbance has been recorded along the fenceline to the N and just W of the pond. This latter ferrous linear anomaly [M1] is indicative of a pipe – possibly assisting the drainage of water from the current spring-line to the pond.

The strongest anomalies of archaeological origin recorded at the site are two sides of a rectilinear arrangement at [M2]. The northern extent of this has a maximum strength of ~99nT and the eastern a maximum of ~30nT. These correspond to the NE corner of the main enclosure recorded by the previous survey. However, the eastern section appears to show an additional break near the NE corner that had not been previously identified. Additionally the area of enhancement interpreted as a possible building has been recorded as a series of discrete anomalies, but not forming a significant pattern susceptible more specific analysis. A small trench (100) was excavated in this area in 1979 and recorded post holes and burnt foundations (Rahtz, Hayfield et al. 1986, fig 8 and 13) – which would all contribute to the increased magnetic response recorded here. The nearby test-hole 26 was sited close to the originally interpreted entrance to the main enclosure and revealed at least three successive road surfaces (Rahtz, Hayfield et al. 1986, fig11). There is no evidence for these in the magnetometer survey, but the chalk construction material of the roads is unlikely to provide a significant magnetic contrast to the surrounding soil.

Across the rest of the W and S extents of the current survey a series of linear positive magnetic anomalies characterising the ladder settlement have been recorded and correlate well with the major elements recorded on the 1978 survey. The main components are a second rectilinear enclosure at [M3] and a series of probable trackways and smaller enclosures at [M4]. There are only a few minor discrepancies between the two surveys in these areas, mainly where the response is weakest. Test-hole 28, excavated in 1979 was sited on a strong linear anomaly parallel to the E of the main enclosure [M2] and recorded the edge of a ditch next to a chalk ridge (Rahtz, Hayfield et al. 1986, fig11).

To the SW of the pond a broad curvilinear response [M5] has been recorded. This narrows to the N and W and appears discontinuous. Due E of here and ~25m S of the pond, there is a possible break in the course of the response. Towards the centre of the space enclosed by [M5], is a second smaller curvilinear anomaly [M6]. The northern part of its circuit appears straightened giving an overall irregular ovoid shape, similar to a capital letter 'D'. These two concentric anomalies are likely to be responses to infilled ditches, and their size and form would suggest a henge ditch and an internal feature. They correlate well with the key 1999 aerial photograph of the henge, however, there is also trace evidence for these features on an earlier photograph taken in 1978 by Tony Pacitto, published and described in 1986 (Rahtz, Hayfield *et al.* 1986, Section 8, Pl1, fig3). The survey also indicates that several of the enclosure anomalies abut or overlie the ditch anomaly [M5], particularly to the W. Also, between [M6] and [M5] to the S, a discrete anomaly [M7], ~24nT in strength has been recorded. It is not possible to ascertain which phase of occupation this response relates to. The 1979 excavations are likely to have intersected approximately with anomaly [M5] at test-hole 32 and 40 and with [M6] at test-hole 36. Test-hole 32 contained an uneven chalk slope about 0.45m wide and descending 0.35m to the W down to an area of flattish chalk (Rahtz, Hayfield et al. 1986, fig 12) and most likely correlates with one of the overlapping enclosure ditches. There were no discernible features in test-hole 40, however, test-hole 36 contained the edge of a ditch interpreted as a possible watercourse (Rahtz, Hayfield et al. 1986, fig 12), which would in fact appear to be the inside northern edge of anomaly [M6].

To the E of the pond the survey extends beyond the coverage of the 1978 data-set and 1979 excavations. Here the level of enhancement appears much less than elsewhere. Several linear anomalies [M8] have been recorded and, though many share a common alignment, there is no clear patterning to the activity here. It is most likely that they represent peripheral field boundaries; however, it should be noted that the weaker response recorded could be due to a greater overburden of silted material, laid down before the spring and stream were managed as they are today.

Earth resistance

A graphical summary of the significant anomalies discussed below is provided on Figure 8. Numbers in [ ] refer to annotations in this figure.

The collection of earth resistance data was affected by the ground conditions at the time. Namely frozen ground with additional ice collected between the previous season's plough ridges. This led to problems with contact resistance and caused the striping of anomalously high readings seen in the raw data.

A low resistance linear anomaly [R1] has been recorded to the W of the pond. This corresponds with the disturbed magnetic response [M1] and is again suggestive of a pipe or similar cut feature.

Several large areas of both high and low readings have been recorded – the general amorphous shape of which, and lack of corresponding magnetic anomalies, would suggest a geological origin such as pockets of clay or former spring-lines. However, the area of high resistance [R2] coincides almost exactly with the interior of the SE corner of the rectilinear enclosure [M3]. This may therefore represent a floor surface or collapse of rubble. To the E a faint linear response [R3] has been recorded. This lies between two linear magnetic anomalies: the grouping of response here is suggestive of a solid road surface with ditches to either side.

Within an area of high resistance to the SW of the survey area are four less distinct low resistance linear anomalies [R4]. These also coincide with linear positive magnetic features, indicating the fill of the ditches is more porous and magnetic than the surrounding soil.

A curvilinear low resistance anomaly [R5] correlates with the location of the SW circumference of the henge ditch. However, the recorded response is not distinct enough to accurately indicate continuations to the N and E. To the NE of [R5] is partial curvilinear low resistance anomaly [R6]. Again this is only an incomplete manifestation of the magnetic response recorded here ([M6]), obscured by a much bigger band of low resistance readings to the N. However, both [M6] and [R6] seem to indicate a possible entrance to the NE.

Conclusion

The magnetometer survey has successfully relocated elements of the Roman ladder settlement first recorded in 1978. In addition a large part of the suspected henge ditch has been recorded and accurately positioned on the ground. The internal concentric ditch appears irregular in form and both features appear to have been transversed by later linear enclosures. The difference in strength of anomaly response from W to E across the site may indicate the focus of occupation, but could also be due to a greater overburden of soil on lower lying areas relating to the spring.

The earth resistance response has been influenced by both underlying geology and the prevailing surface conditions at the time of the survey. However, the henge ditch and internal ditch have been partially located and several linear track/roadways and enclosure ditches have been tentatively interpreted.

Both surveys have increased the understanding of the site. Digital recording has allowed for greater manipulation of the data than was possible with the technology available in 1978, and this has improved its presentation, allowing more subtle anomalies to be discerned.

Surveyed by: L Martin
A Payne

Date of survey: 27/2/2006 - 3/3/2006

Reported by: L Martin

Date of report: 1/12/2006

Geophysics Team,
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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 the Centre for Archaeology 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 the Centre for Archaeology 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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