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BECKFOOT, Cumbria: Report on Geophysical Surveys, October 2005

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Summary

A geophysical survey was undertaken over the suspected site of a Roman milefortlet and cremation cemetery in a dune-system on the Cumbrian coast that is under serious threat of erosion. The magnetometer survey recorded evidence of burning, but no other significant features. The earth resistance survey revealed some areas of high resistance, but the patterning of these was not unambiguous enough for any causative features to be confidently identified.

Keywords

Geophysical Survey
Magnetometer
Fluxgate
Earth Resistance
Roman

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BECKFOOT, Cumbria.

Report on geophysical surveys, October 2005.

Introduction

Geophysical surveys of a total ground area of approximately 1.4 hectares were conducted over the predicted site of milefortlet 15 (MF15: Beckfoot beach), part of the Roman Cumbrian coastal defences, and a nearby cremation cemetery believed to be associated with either this, or the larger Beckfoot fort ~350m to the N (Caruana 2004, 153). The area under investigation lies within a dune grassland, with the W limit, a cliff face ~4.5m above the adjacent beach, being regularly eroded by the Solway Firth at a rate of ~0.3m per year (Collins 2005).

The milefortlets of the Cumbrian coast were an extension of the Roman defences from the W end of Hadrian's Wall at Bowness on Solway. As with the milecastles on the Turf Wall, these milefortlets were typically constructed of turf or clay ramparts and contained timber buildings; on average they covered an area of ~18x15m and were protected by a ditch (Breeze 2004, 74-6).

Cremation was the most common Roman burial rite until the 2nd century AD when a preference for inhumation began to increase (Caruana 2004, 154). Cremation cemeteries are found to include a range of pyre sites, pyre-debris disposal features and burial pits (Caruana 2004, 156). Unfortunately, however, due to a lack of structured analysis, little is known of Roman cemeteries in the N of England, particularly those associated with the military frontier (Breeze 2004, 84; Collins 2005).

Evidence for the location of MF15 was recorded by Richard Bellhouse: in the 1950s he recorded a line of 'fossilised' turf in the eroding cliff edge and through test-pits sited inland from this he determined the Roman ground level of cobbles and broken stone thinned out to the E and so presumed the fortlet to have largely been to the W of here (Bellhouse 1958, 21-22). In 1980 further investigation revealed gravel on the supposed position of the gate and the unusual lack of a surrounding ditch (Breeze 2004, 76 and 88). Both Bellhouse and Caruana have come to the conclusion that MF15 has already been lost to erosion (Bellhouse 1958, 22; Breeze 2004, 88; Caruana 2004, 168), however, an area of ~80x80m across the dune-system and beach currently remains scheduled (SAM No. CU258).

The extent and concentration of burial at the cemetery is unknown. The majority of finds recovered from the site have come from the eroding cliff face and it is thought that recovery has been biased towards pottery and artefacts (Caruana 2004, 156). There has been little exploration in-land, though Bellhouse did open a series of test-pits in an attempt to locate the position of MF15 (Bellhouse 1958, 22). Among the various funerary finds are whole and partial funerary pyres with a range of burnt bone and artefacts including a range of weapons (e.g. Caruana 2004, 137); a small pit of charcoal and burnt sand containing calcined bone and fragments of iron (Caruana 2004, 138); 'urn-burials' (e.g. Bellhouse and Moffat 1959, 57-61); and stone cists of dressed sandstone in clay (Bellhouse and Moffat 1959, 61-2; Hogg 1962).

The aim of this geophysical survey was to attempt to locate any features relating to MF15 and to the cemetery to inform a planned series of trial-trenches across the dune-system. Preservation by record has been chosen over preservation *in situ* due to the rate of erosion; stabilising of the cliff face is not considered economically viable and therefore an evaluation exercise is necessary in an attempt to record the archaeology before it is completely lost to the sea (Collins 2005).

The site (centred on NY087485) lies on mainly deep well drained calcareous and non-calcareous sandy soils of the Sandwich association (Soil Survey of England and Wales 1983), developed over wind blown sand (British Geological Survey 1980), underlain by Stanwix Shales (British Geological Survey 1963). At the time of the survey the uneven dune system was largely overgrown with tall grasses and occasional gorse bushes. It has been predicted the buried archaeology lies at a depth of ~1m (Collins 2005) although remains have been found at ~1.8m (Hogg 1962, 323).

Method

All areas for survey were gridded using a real-time kinematic Global Positioning System (GPS).

Magnetometer survey

The location of MF23 to the N of Maryport fort has been confirmed by a magnetic survey (Biggins and Taylor 2004, 117) and surveys on the wind blown coastal sands of St Martin's, Isles of Scilly, have located possible burnt features such as hearths, stones and a probable kelp burning pit (Bartlett 1978). Therefore magnetometry was chosen in an attempt to locate burnt features and possibly ditches likely to be associated with both the milefortlet and the cemetery. 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 plot of the data-sets is superimposed over the Ordnance Survey (OS) base map at a scale of 1:2500 on Figure 2. Additionally an X-Y traceplot and linear greyscale plot of the data are presented at a scale of 1:1500 on Figure 3.

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). This latter operation reduces the distracting, localised, high-magnitude effects produced by surface iron objects. Data from one of the instruments exhibited high-spatial frequency noise due to a sensor alignment fault. A 0.5m low-pass Gaussian filter was used to suppress the effects of this. A similar filter was then applied to the combined data-set to create a more unified appearance. To improve the visual intelligibility of the traceplot presented in Figure 3a, the data-set has had the magnitudes of extreme values truncated to ±5nT/m.

Earth resistance survey

Subsequent to the magnetometer survey, an earth resistance survey was conducted over the scheduled area, suggested as a possible location of MF15. This technique successfully assisted in further defining features identified in a magnetic survey of MF23 (see Biggins and Taylor 2004, 117). 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. A median filter was applied to the data-set in an attempt to show overall trends and remove slight speckling caused by contact resistance. A greyscale plot of the filtered data is superimposed over the base OS map at a scale of 1:2500 in Figure 4. Plots of the raw data-set are additionally presented as both an X-Y traceplot and equal area greyscale plot and the filtered data as a false-colour plot, all at a scale of 1:1000 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 very low with background readings <±1nT/m. Modern disturbance is in evidence with extreme readings [M1] recorded adjacent to the road running along the E of the survey grids. The road has obviously been re-cut over the years as there were pot-holes and traces of tarmac within the grassed area. However, the strength of the response here may be due to a service pipe running adjacent to the road. Elsewhere more discrete zones of magnetic noise are likely to be caused by modern ferrous detritus, which was frequently witnessed during the survey.

A linear area of raised magnetic response [M2] in the N of the survey grid may relate to the coastal path which cuts further in land here, or to the car-park which used to exist in this area. The raised response [M3] probably also relates to the car-park and the arrangement of wooden posts demarcating it.

In the area bounded by [M1-3] a few discrete positive magnetic anomalies [M4] have been recorded. These may be of archaeological origin, perhaps caused by small pits or burnt features, however, their location within the car-park area and the vicinity of magnetic disturbance reduces the certainty of such an interpretation. S of [M3] are an assortment of slightly larger and generally stronger positive magnetic anomalies [M5] and [M6]. Though there is no obvious patterning to the distribution of these, it is quite possible that they relate to significant archaeological features.

To the S, a weakly positive linear magnetic anomaly [M7] has been recorded. On a similar alignment further S are additional positive magnetic anomalies, though that at [M8] appears to curve to the NW and is bordered to the E by a negative magnetic response. Aside from their common alignment, there is no evidence to suggest these anomalies are associated with one another and their isolation from other magnetic activity makes interpretation difficult.

To the E of [M8] a negative magnetic anomaly [M9] has been recorded. Again it is not clear to what this might relate, though possibly it has been caused by water run-off from the road.

Earth resistance

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

Despite the sandy nature of the site, the earth resistance survey has generally worked well, with only a low level of measurement noise due to poor electrical contact and few of the extreme values caused by high contact resistance that might be expected on a well drained site. In general the background response is low to the N, increasing to the S.

Extremely low readings [R1] have been recorded to the very N of the survey grid and this may well relate to modern activity associated with the former car-park. Other occasional areas of low resistance, e.g. [R2], could relate to modern activity, though there is no correspondence with disturbed magnetic responses. Another interpretation is that these areas have been previously excavated, though this is entirely conjectural.

Several areas of high resistance [R3-4] have been recorded to the S. These could relate to building foundations but may be due to variations in drainage caused by the local geomorphology. To the W of [R3] are a series of at least six small high resistance responses [R5]. Their regular spacing is highly suggestive of a feature of archaeological significance. The anomalies [R3-5] all lie within a roughly rectangular area of raised electrical resistance and it would be tempting to see this as the footprint of an encompassing structure. However, at ~42x32m it is approximately twice the standard size of most known milefortlets.

A linear area of raised readings [R6] runs to the E of the above mentioned anomalies and may correlate with a topographical depression in the dunes (though this needs to be clarified on site). It may be evidence for a route or track-way here, however, the nature of a dune system would suggest that an ancient feature would be unlikely to remain visible topographically for very long.

Conclusion

The magnetic enhancement of the site was very low; however a few discrete positive anomalies have been recorded. These could well relate to burnt features, as might be expected on a cremation site e.g. pyres or pits into which material was buried. No response was recorded to delimit the cemetery. Also no anomalies could be specifically related to MF15. Some of the burnt features could be hearths rather than pyres as might be expected within a milefortlet (Breeze 2004, 76), but it is not possible to discern the difference in use, particularly with no other anomalies recorded with which to relate them. However, this negative evidence does not definitely signify a lack of archaeology. It could be that there was no activity that would have created magnetic contrasts: timber and turf constructions lacking an encompassing ditch are generally not ideal targets.

Also there could be too great an over-burden of sand on top of any archaeology. Unless a feature was highly magnetised it is unlikely to be recorded below ~1m.

The earth resistance survey has also recorded little that can be confidently interpreted. The arrangement of high resistance anomalies cover a roughly rectangular area, and could be traces of clay, e.g. ramparts, though the area they cover is far greater than the standard size for a milefortlet. However, the largest recorded milefortlet, at Cardurnock (MF5), is of similar dimensions, though this was probably only of such a size because it guarded the entrance to Moricambe Estuary (Breeze 2004, 76). There was no similar feature to guard here, but even if so, the vicinity of Beckfoot fort would have probably made this unnecessary, unless there was a clear distinction in period of use between the fort and the milefortlet, but this is not yet known (Breeze 2004, 79).

Surveyed by: L Martin
A Payne

Date of survey: 10-14/10/2005

Reported by: L Martin

Date of report: 11/1/2006

Geophysics Team,
English Heritage.

List of enclosed figures.

Figure 1 Location plan of survey area over base OS map (1:2500).

Figure 2 Linear greyscale plot of magnetometer data over base OS map (1:2500).

Figure 3 Traceplot and linear greyscale plot of magnetometer data (1:1500).

Figure 4 Greyscale plot of earth resistance data over base OS map (1:2500).

Figure 5 Traceplot, greyscale and false colour plots of earth resistance data (1:1000).

Figure 6 Graphical summary of significant magnetometer anomalies over base OS map (1:2500).

Figure 7 Graphical summary of significant earth resistance anomalies over base OS map (1:2500).

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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Figure 1

BECKFOOT, CUMBRIA
Location of geophysical survey, October 2005.

Magnetometer survey

Earth resistance survey

Scheduled area

0 90m
1:2500

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Figure 2

BECKFOOT, CUMBRIA
Magnetometer survey, October 2005.

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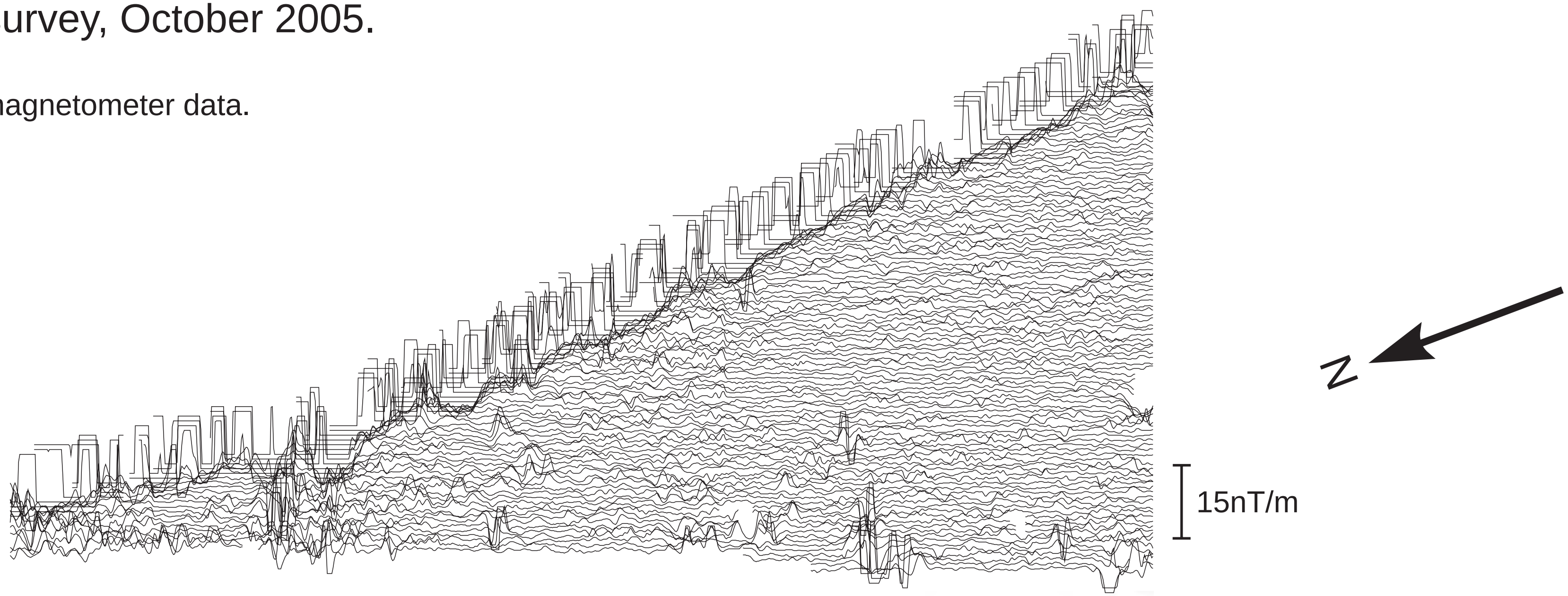
BECKFOOT, CUMBRIA
Magnetometer survey, October 2005.

Figure 3

A) Traceplot of magnetometer data.



B) Greyscale plot of magnetometer data.

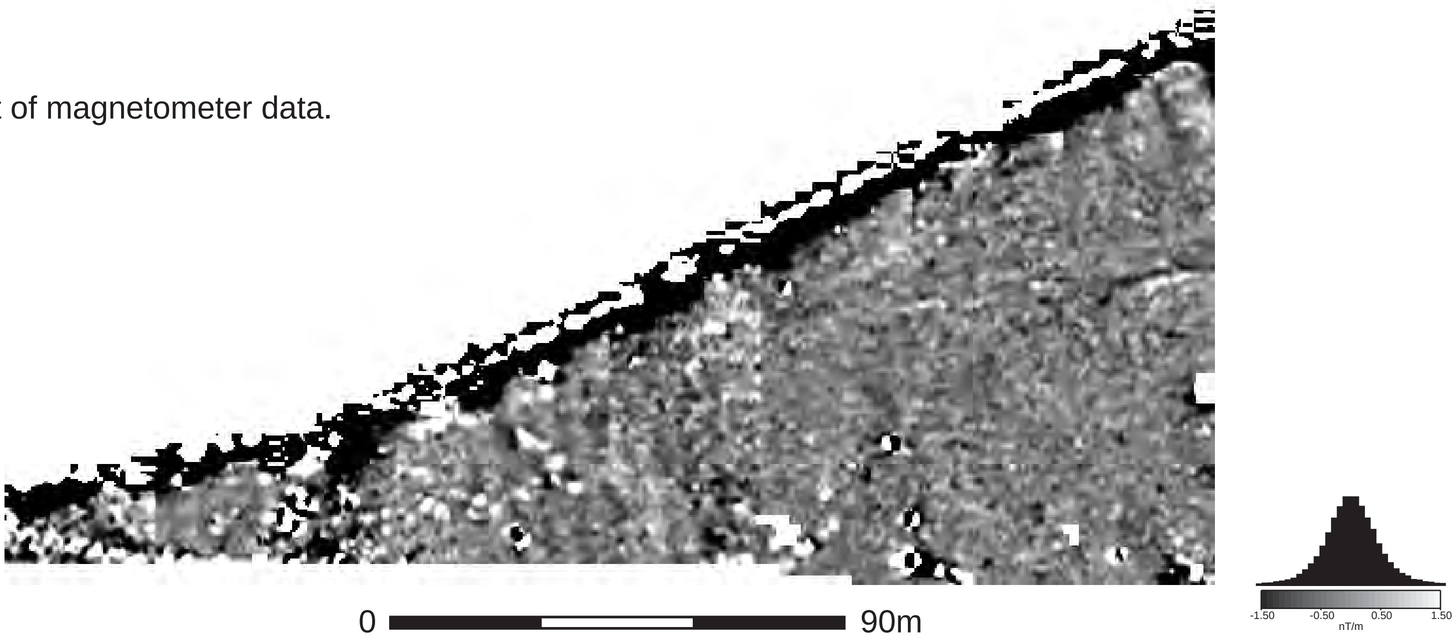


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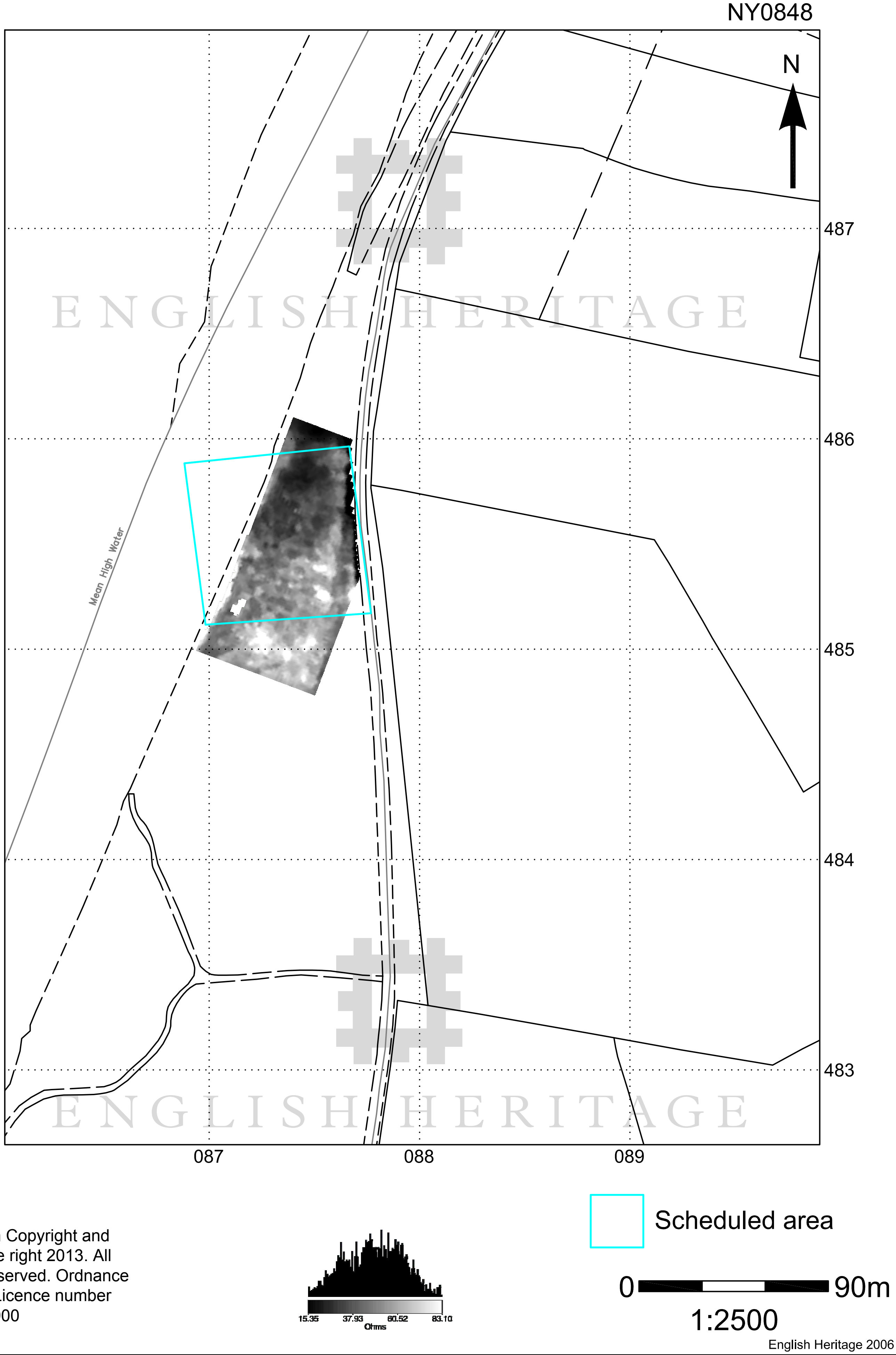
Figure 4

BECKFOOT, CUMBRIA
Earth resistance survey, October 2005.

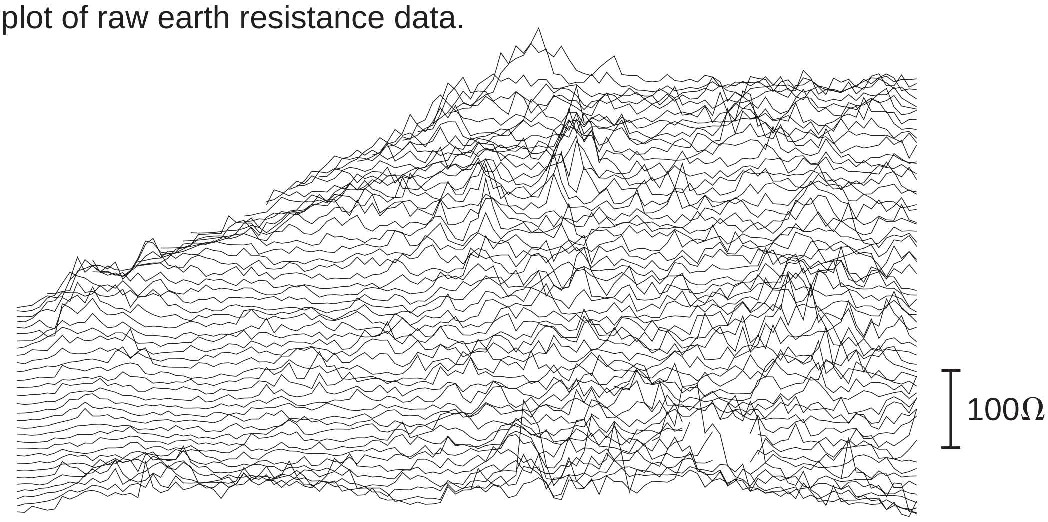


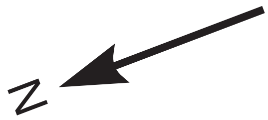
BECKFOOT, CUMBRIA

Earth resistance survey, October 2005.

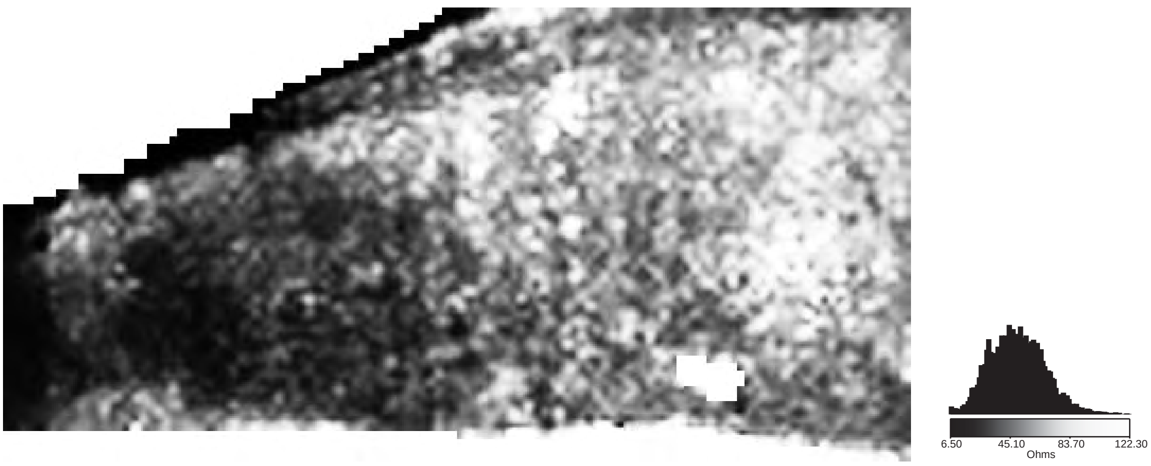
Figure 5

A) Traceplot of raw earth resistance data.





B) Greyscale plot of raw earth resistance data.



C) False colour plot of median filtered earth resitance data.

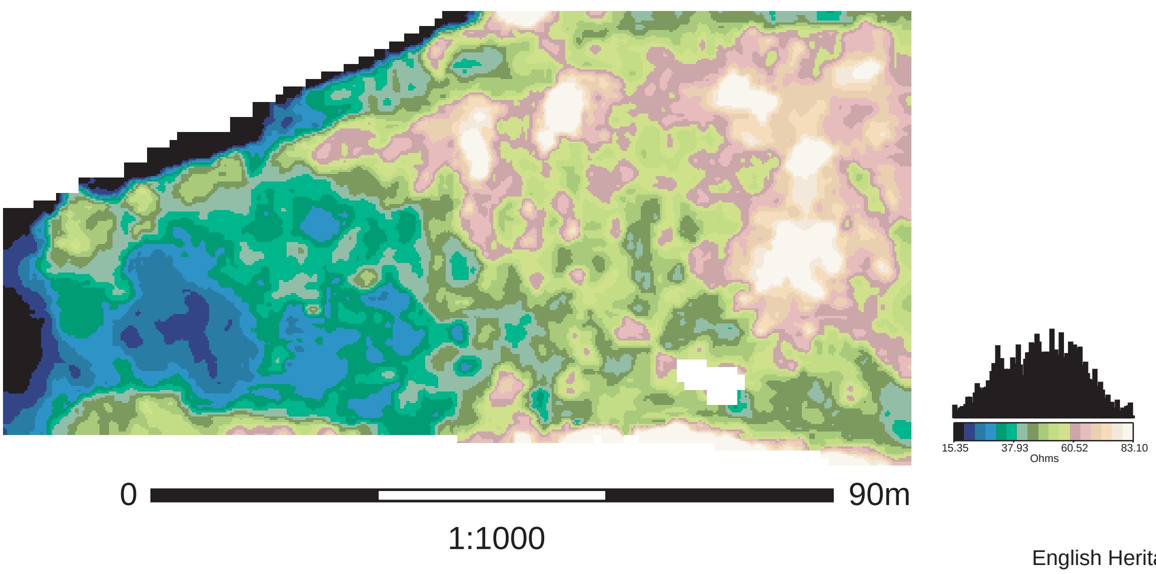


Figure 6

BECKFOOT, CUMBRIA
Graphical summary of significant magnetometer anomalies, October 2005.

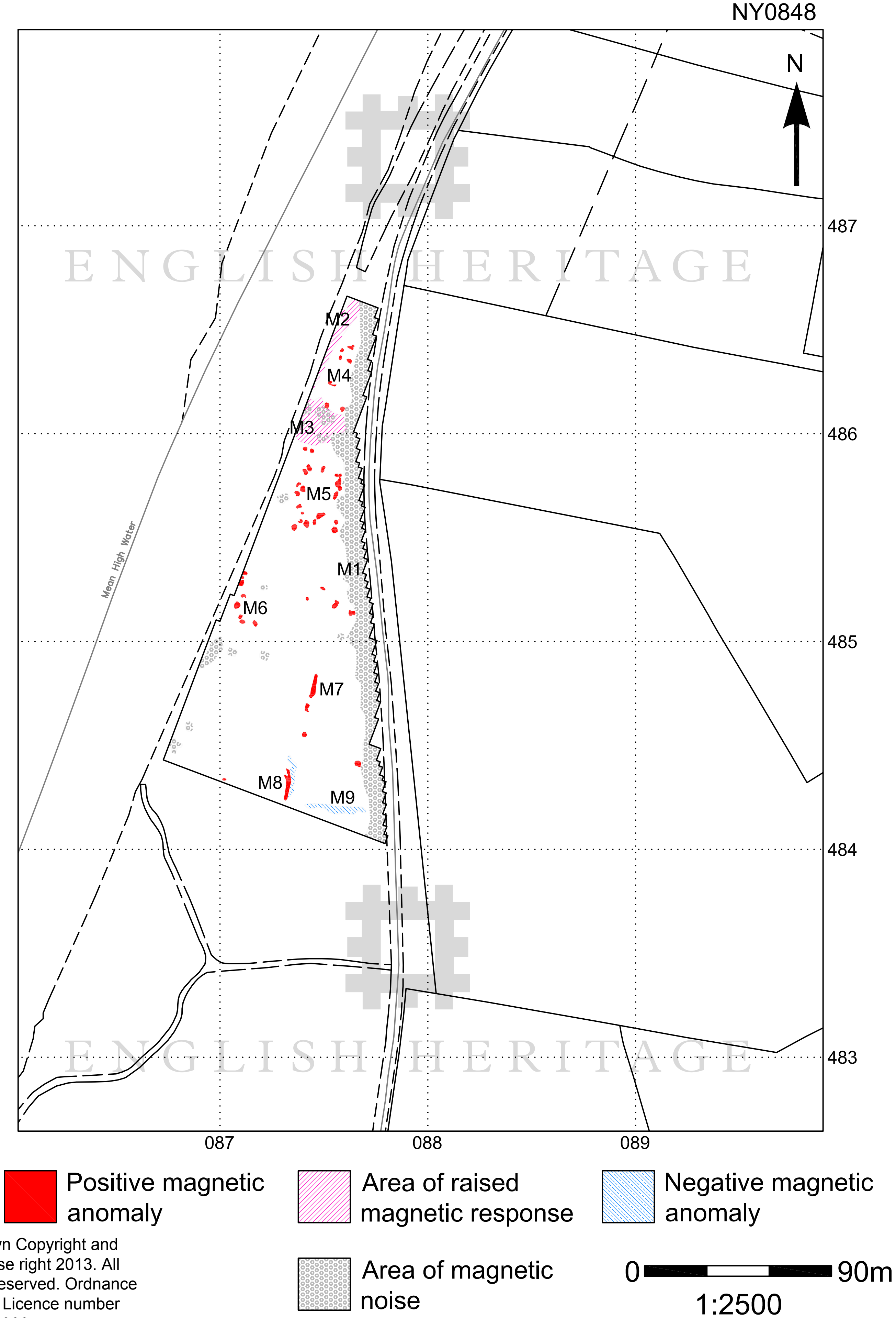


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Figure 7

BECKFOOT, CUMBRIA

Graphical summary of significant earth resistance anomalies, October 2005.

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