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ROTHERHOPE, ALSTON, CUMBRIA
REPORT ON GEOPHYSICAL SURVEY, NOVEMBER 2010

Andrew Payne

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SUMMARY

Earth resistance and magnetic surveys were conducted over a hengi-form enclosure with a double bank and ditch at Rotherhope near Alston, Cumbria in support of the Miner-Farmer Landscapes of the North Pennines Area of Outstanding Natural Beauty project. The site is situated on the lower reaches of the blanket peat covered moorland of Rotherhope Fell between two streams draining into the valley of the South Tyne. Despite waterlogged conditions at the site, the earth resistance data complemented both a topographic survey, undertaken simultaneously by the Archaeological Investigation team, and previous LiDAR imagery. The combined field work improved the interpretation of the site and the geophysical survey also clarified the previously uncertain course of the eastern perimeter of the enclosure.

CONTRIBUTORS

The field work was conducted by Neil Linford and Andrew Payne and the notes on the background to the Miner-Farmer project included in Annex 2 were supplied by Stewart Ainsworth.

ACKNOWLEDGEMENTS

The author wishes to thank Dave Went, Dave McOmish and Peter Topping for useful collaboration during the survey and coordinating the fieldwork and accommodation arrangements. The cover photograph shows the western part of the enclosure and the wider moorland setting looking north east towards the valley of the South Tyne and Alston Moor.

ARCHIVE LOCATION

Fort Cumberland.

DATE OF FIELDWORK AND REPORT

The fieldwork was conducted over a period of one week during the 15-19th November 2010. The report was completed on 12th April 2011.

CONTACT DETAILS

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CONTENTS

INTRODUCTION

Earth resistance and magnetic surveys were conducted over a hengi-form enclosure with a double bank and ditch (NMR NY 74 SW104) at Rotherhope near Alston, Cumbria in support of the Miner-Farmer Landscapes of the North Pennines Area of Outstanding Natural Beauty project (Ainsworth 2009). The purpose of the geophysical survey was to assist in defining the form, extent and character of the site, together with a topographic survey undertaken simultaneously by colleagues from the Archaeological Investigation team and previous LiDAR imagery. The enclosure has received little previous attention in terms of archaeological research to the extent that even a reliable period assignment is uncertain. A detailed survey was a pre-requisite for improving understanding of the function and purpose of this unusual moorland site which has been interpreted as either a Neolithic henge or segmented ditched enclosure or, perhaps, a settlement of later prehistoric origin.

The site is situated at NGR NY 722424 on the lower reaches of the blanket peat covered moorland of Rotherhope Fell between two streams (Dry Burn and Little Dry Burn) draining into the major valley of the South Tyne to the north. Prior to the detailed survey reported here, the site was thought to consist of two, roughly circular concentric ditches with diameters of approximately 80m and 50m respectively, each with an outer bank characteristic of a henge-type enclosure. However, due to the presence of later trackway routes and the narrow deeply incised valley of the Dry Burn stream the original extent of the eastern perimeter of the enclosure is unclear. It is possible that the earthwork always respected the natural scarp of the stream valley, or suffered extensive erosion in this area cut by the water course at a later date.

The soils of the area are predominantly of the Winter Hill association, consisting of perennially wet thick very acid raw peat soils, but on the lower reaches of Rotherhope Fell where the site is situated the local soils are of the Brickfield 3 association consisting of slowly permeable seasonally waterlogged fine loamy over clayey soils developed over drift from Paleozoic sandstone and shale (Soil Survey of England and Wales 1983). The underlying solid geology of the area consists of Scar Limestone of the Lower Carboniferous Middle Limestone group (Geological Survey of Great Britain (England and Wales) 1973). Persistent rain throughout the week during which the fieldwork was carried out resulted in very damp site conditions and standing water was present in the surface depressions defining the ditches of the enclosure.

METHOD

A grid consisting of 30m by 30m squares was set out using a Trimble 4800 series survey grade differential Global Positioning System (GPS) to cover the area of interest containing the enclosure earthworks and a margin around it (Figure 1). Much of the site is covered by tall clumps of reeds interspersed with more open areas of grass corresponding with the slightly raised dryer ground forming the banks and inner enclosure.

i) Magnetometer survey

Magnetometer survey was carried out using Bartington Grad601-2 dual sensor fluxgate gradiometers over an area of 1.1 hectare shown on Figure 1. Readings were recorded at intervals of 0.25m along successive north south traverses spaced 1.0m apart using the 100 nanotesla per metre (nT/m) instrument range setting. The fluxgate sensors had to be raised above normal instrument operating height to compensate for the tall reed growth across much of the site reducing the sensitivity of the response. The magnetic data is presented in linear greyscale and traceplot form in Figures 2 and 4 after post acquisition processing, that included the initial truncation of extreme values outside the range of ±25 nT/m caused by ferrous disturbance associated with modern landuse and agricultural activities, and the setting of each traverse to a zero mean, to remove any effects of directional sensitivity and instrument drift.

Due to the limited success of the magnetometer survey, coverage was limited to the main part of the enclosure, in favour of earth resistance survey.

ii) Earth resistance survey

Earth resistance readings were recorded at 1.0m intervals using a Geoscan RM15 resistance meter and a PA5 electrode frame in the Twin-Electrode configuration, with a mobile probe spacing of 0.5m, which proved the most appropriate methodology given the site terrain and vegetation. The earth resistance survey covered a reduced area west of the dry-stone wall boundary dividing the site, but was extended to capture the remainder of the enclosure to the east covering a total of 1.1 hectare (Figure 1).

The earth resistance data is presented in linear greyscale and traceplot form on Figures 3 and 4 with minimal processing applied except for the suppression of spurious high value readings caused by occasional poor probe contact through the application of a 2m by 2m thresholding median filter (Scollar *et al.* 1990, 492).

RESULTS

Graphical summaries of significant geophysical anomalies discussed in the text are identified by the prefixes [m] on Figure 5 and [r] on Figure 6, for the magnetic and earth resistance surveys respectively.

i) Magnetometer data

With the exception of very slight positive [m1-2] and negative [m3] responses to sections of the banks and enclosure ditch, little deviation from the almost uniform magnetic background across the survey area was recorded. Extremely tentative positive linear anomalies found at [m4-6] may relate to buried drainage features and further scattered areas of strong magnetic disturbance are reactions to metallic detritus of modern origin on the ground surface. An area of disturbed magnetic response is evident at [m7] in the centre of the enclosure, possibly indicative of burning or a concentration of ferrous material, perhaps associated with small scale industrial processes or more recent agricultural activity (cf [r16-18]).

ii) Earth resistance data

Despite the damp site conditions in the main survey area the ditches are well defined as low resistance anomalies, particularly around the western circumference of the enclosure where there are also slight indications of interruptions to the circuit [r1-4] and variations in the width of the ditch, possibly suggesting a segmented form to the earthworks or a number of causeways. A wider interruption occurs to the outer ditch on the north side of the monument where the low resistance ditch anomaly [r5] appears to terminate and then continue again in the eastern field after a gap of about 17m. Similar gaps may be present on the north and south sides of the inner enclosure ditch [r6 and 7] and a slight out-turn at [r6] suggests the presence of an entrance or opening on this side of the monument. However, the gap at [r7] may be associated with a drainage gully (see [r19 and 20] below). The inner and outer ditches on the western side of the enclosure clearly show a concentric arrangement and are spaced some 18-20m apart.

A series of weak high resistance anomalies to either side of the outer ditch [r8-13] may be indicative of bank features, but are highly intermittent contrary to the more continuous raised earthwork visible around much of the circuit. On the northern side of the enclosure the areas of higher resistance appear to correspond with weak linear positive magnetic anomalies [m1 and 2], suggesting some selective magnetic enhancement of the possible bank material. The ditch and bank of the outer enclosure also seem to be made up of distinct straight sections rather than a smoothly continuous arc. The earthworks of the outer enclosure appear to be a more flattened arc around the eastern side of the site [r14 and 15] in the area of rougher vegetation where it is less visible as the terrain drops sharply away towards the larger stream. However, the central linear portion at [r14] is highly tentative as it runs parallel to the grid edge and is a more intermittent response than the better defined anomalies to the south and north at [r13 and r15]. Analysis of the LiDAR imagery also suggests a correlation between [r14] and a pattern of north south drainage gullies running through the site across the moor.

The area of stony rubble features mapped in the centre of the inner enclosure seems to form a series of high resistance anomalies [r16-18], although it is difficult to determine a more precise structural form.

A narrow linear high resistance anomaly [r19] leading into the middle of the enclosure from the south west is probably related to a former drainage gully or natural water course running SSW to NNE through the central enclosure [r20] to exit on the north east where it runs down into the valley of the larger Dry Burn stream to the east. The high resistance response from the gully [r20] could indicate either partial in-filling with stony deposits or the erosion of the soil cover down to more resistive bedrock.

A weak high resistance anomaly [r21] corresponds to a linear bank visible as an earthwork 16m to the south of the main enclosure. A narrower linear boundary or drain running approximately east west has been mapped on the north side of enclosure at [r22] and a number of other low resistance linear anomalies [r23 and 24] are probably also related to drainage or features of natural origin.

CONCLUSION

Despite the waterlogged conditions at the site successful earth resistance results were obtained that complement the topographic survey undertaken simultaneously by the Archaeological Investigation team and the previous LiDAR imagery. Magnetometer survey was largely ineffective and added little additional detail except for a very partial response to sections of the enclosure earthwork and an area of intense disturbance in the centre. The geophysical results suggest that the outer enclosure does not appear to be entirely circular in form and also provides some tentative evidence for interruptions to the ditch circuit. This, together with a possible compartmentalised outer bank construction represented in the topographic data (D McOmish, pers. comm.), may indicate a segmented form to the outer enclosure earthwork. In addition, the geophysical results reveal the likely presence of stone structures within the inner enclosure although their function and date remain uncertain. The corresponding area of magnetic disturbance may, perhaps, suggest a more recent use of these structures, perhaps as sheep-folds or a small enclosed habitation.

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.

ANNEX 2: BACKGROUND TO THE MINER-FARMER PROJECT

In 2008, English Heritage's Research Department (now part of the Heritage Protection Department) initiated a five-year project called 'Miner-Farmer Landscapes of the North Pennines Area of Outstanding Natural Beauty' (Ainsworth 2008). This multidisciplinary landscape investigation is intended primarily to investigate the interwoven influences of historic industry and farming on the development of the landscape and settlement pattern of the AONB. The findings will inform the conservation, protection and management not just of the historic environment, but also of the so-called 'natural' environment, which has been widely, profoundly, and in many places obviously, shaped by past human activity. The project is being undertaken in partnership with the North Pennines AONB Staff Unit, the Environment Agency, Natural England and the North Pennines Heritage Trust and brings together, through a modular programme of research described below, contributions from all the partner organisations, from several specialist teams within English Heritage's Research Department, and from a number of contractors. Main funding has been provided by English Heritage's Historic Environment Enabling Programme (HEEP), now National Heritage Protection Commissions Programme (NHPCP).

At almost 2000 square kilometres, the AONB, which was designated as such in 1988, is the second largest in England and Wales, spanning parts of the counties of Cumbria, Northumberland and Durham. In 2003, the AONB was awarded European Geopark status, a UNESCO designation for areas with world-class geological heritage, making it Britain's first protected landscape with this status and also a founding member of the UNESCO Global Parks Network. The research concentrates on a core sample area in and around Alston Moor, a remote upland massif lying between the confluence of the Rivers Nent and North Tyne. In geological terms, the so-called 'Alston Block' is particularly complex, formed by alternating bands of limestone, sandstone and shales, within which are seams of coal, lead, iron and other minerals. As elsewhere in the AONB, all these resources have been intensively exploited for hundreds, if not thousands, of years, leaving a rich and diverse legacy of industrial remains.

The Miner-Farmer project contributes to the 2004 *Statement of Joint Accord* between English Heritage and the National Association of AONBs, which pledged the organisations to work together to further the understanding, conservation, enhancement and public enjoyment of the historic environment within these 'protected landscapes' (see also English Heritage 2005a). With potential to deliver methodological models for holistic landscape research which will inform a range of national conservation, protection, management and research agenda for the wider environment, but especially for upland and industrial (particularly lead mining) landscapes, the project responds to key national themes and priorities identified for research (English Heritage 2005b). It also addresses gaps in knowledge identified in the *Regional Research Frameworks* for the North-East and the North-West (Brennand 2006; Petts and Gerrard 2006) and *The North Pennines Lead Industry: Key sites and proposals for action* (North Pennines Partnership 1998). It meshes well with the Peatscapes project, (in its final stages at the start of the Miner–Farmer Landscapes project), which is examining peat primarily as a natural resource (in other words, disregarding its historic use as a form of domestic and industrial fuel) and addressing issues such as the damaging artificial drainage of blanket bogs (North Pennines AONB Partnership 2008). Both projects contribute to the objectives of the AONB's own management plan for the period 2004-9 (North Pennines AONB 2004), many of which correspond closely to English Heritage's (2005b) *Research Agenda*.

The extent to which industrial activity has contributed to both the creation and destruction of the wider historic environment through time has been poorly understood. Previous recording of these landscapes has been too often restricted to individual buildings and/or archaeological sites with little regard to the overall development of the landscape and the historical, archaeological and architectural context within which the different elements reside. Nor has there been any systematic evaluation of threats that are pertinent to these landscapes to inform long-term conservation and management.

The Miner-Farmer project consists of the following modules

Module 1: Desk-based aerial survey of 234 square km as part of the National Mapping Programme being undertaken by the English Heritage Aerial Survey and Investigation team (Heritage Protection Department).

Module 2.1: Supply of aerial imagery, including LiDAR, RGB full spectrum and infrared orthophotography, and hyperspectral data. Contract awarded to Infoterra Ltd. Funded by Historic Environment Enabling Programme (NHPCP 5330), Peatscapes Project (AONB), and Living North Pennines Project (AONB).

Module 2.2: Archaeological ground survey of 32 square km of the core sample area by the English Heritage Archaeological Survey and Investigation team (Heritage Protection Department).

Module 2.3: Capacity-building: archaeological ground survey of 18 square km of the core sample area to be surveyed under contract by North Pennines Archaeology Limited. Funded by the Historic Environment Enabling Programme (NHPCP 6072).

Module 2.4: Applications of remote-sensing: research, in collaboration with VISTA Spatial and Technology Unit at Birmingham University, into the identification of moorland industrial activity and the relationship with the natural environment and erosion, including gathering of environmental data. Funded by the Historic Environment Enabling Programme (NHPCP 5761).

Module 2.5: Landscape characterisation study of farmstead types by the English Heritage Historic Landscape Characterisation team (Heritage Protection Department).

Module 2.6: Study of the built environment within the project area by the English Heritage Architectural Survey and Investigation team (Heritage Protection Department).

Module 2.7: Study of the consequences of mineral procurement, environmental impact and pollution by the English Heritage Archaeological Science team (Heritage Protection Department).

Module 3: Targeted ground survey by the English Heritage Archaeological Survey and Investigation team (Heritage Protection Department).

Module 4: Targeted geophysical survey by the English Heritage Geophysics team (Heritage Protection Department).

Module 5: Publication of results.

This report results from work undertaken in Module 4 and forms part of Module 5.

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Figure 1

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Location of geophysical surveys, November 2010

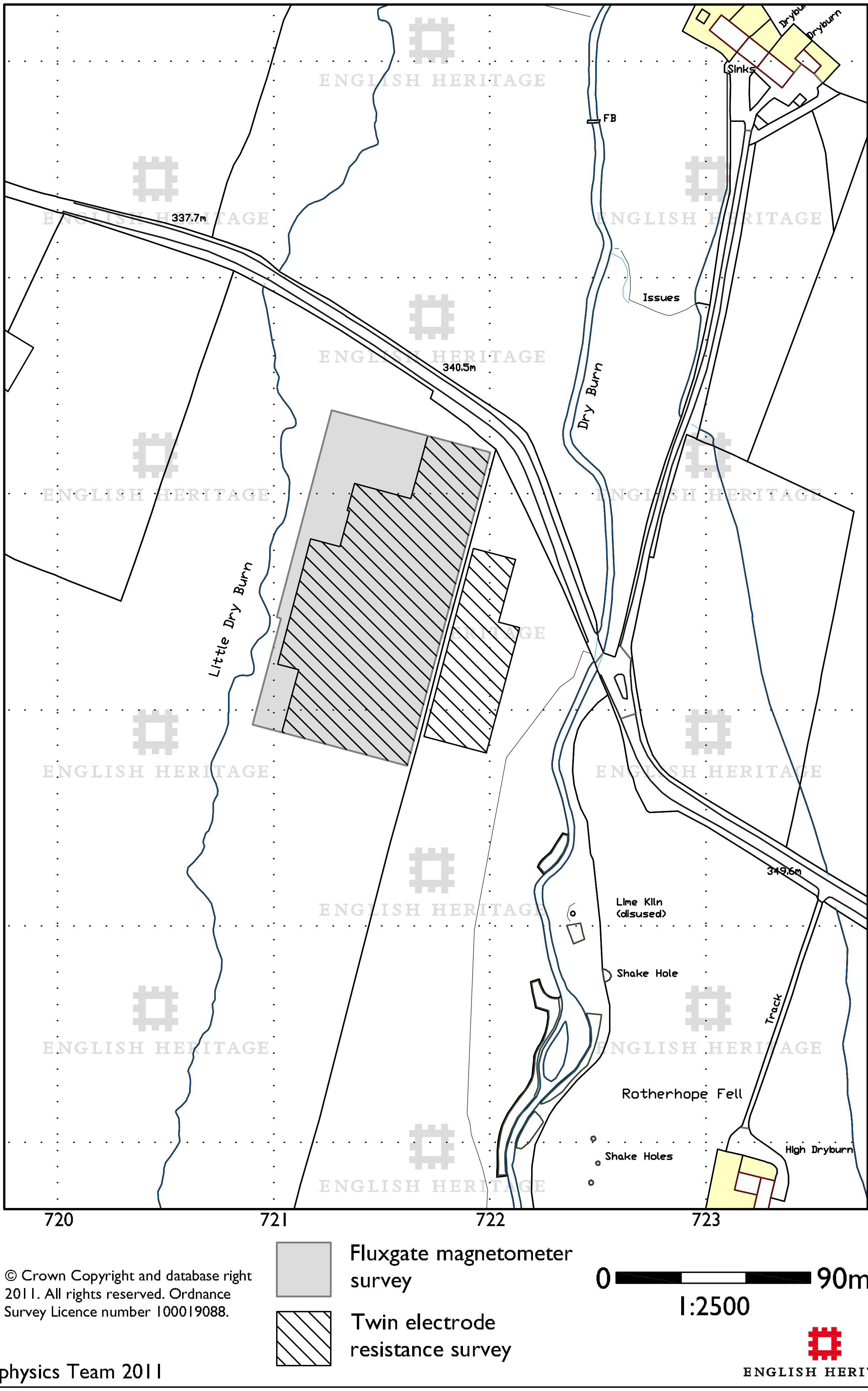

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Figure 2

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Location of fluxgate magnetometer survey, November 2010

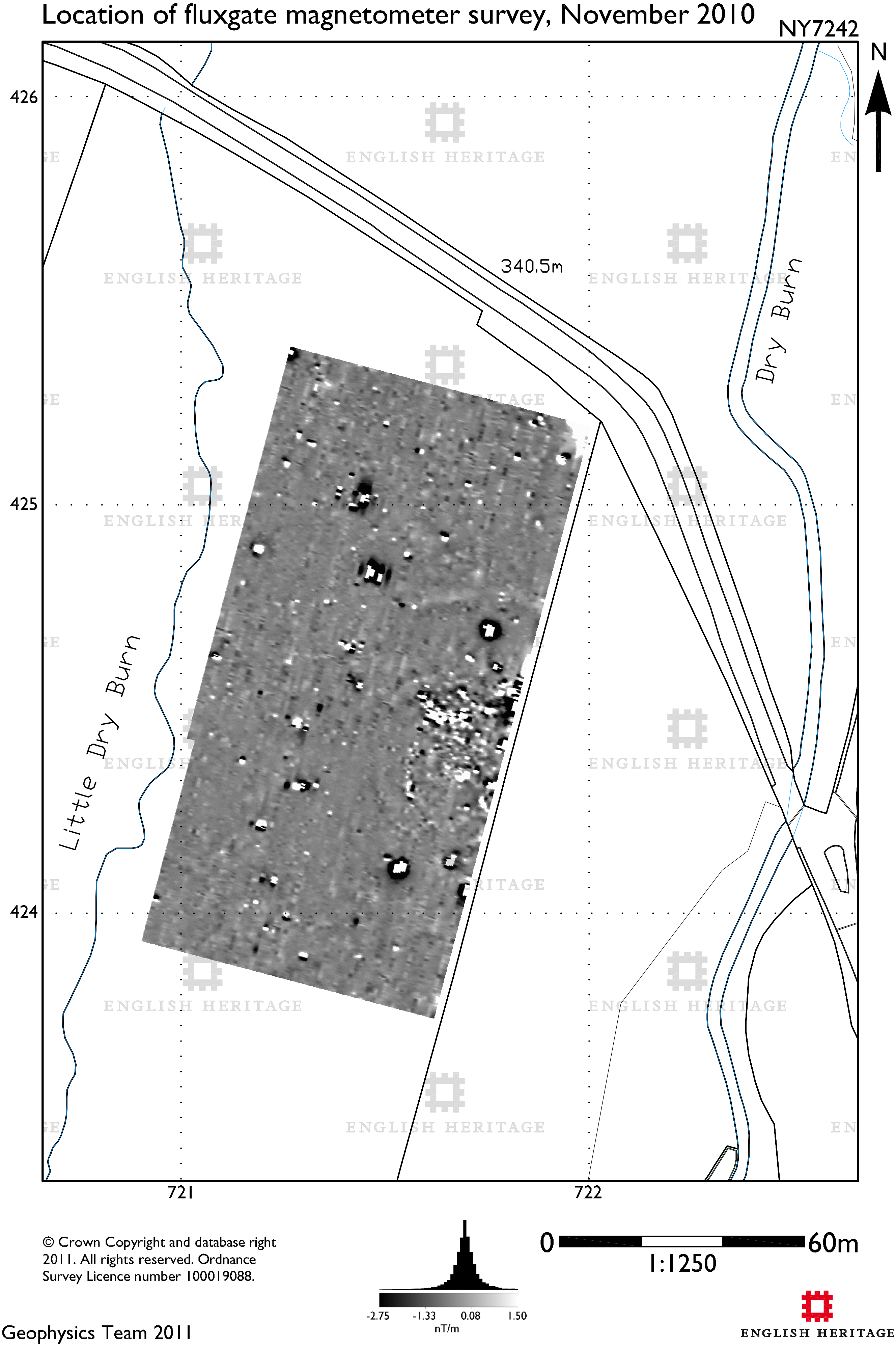

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Figure 3

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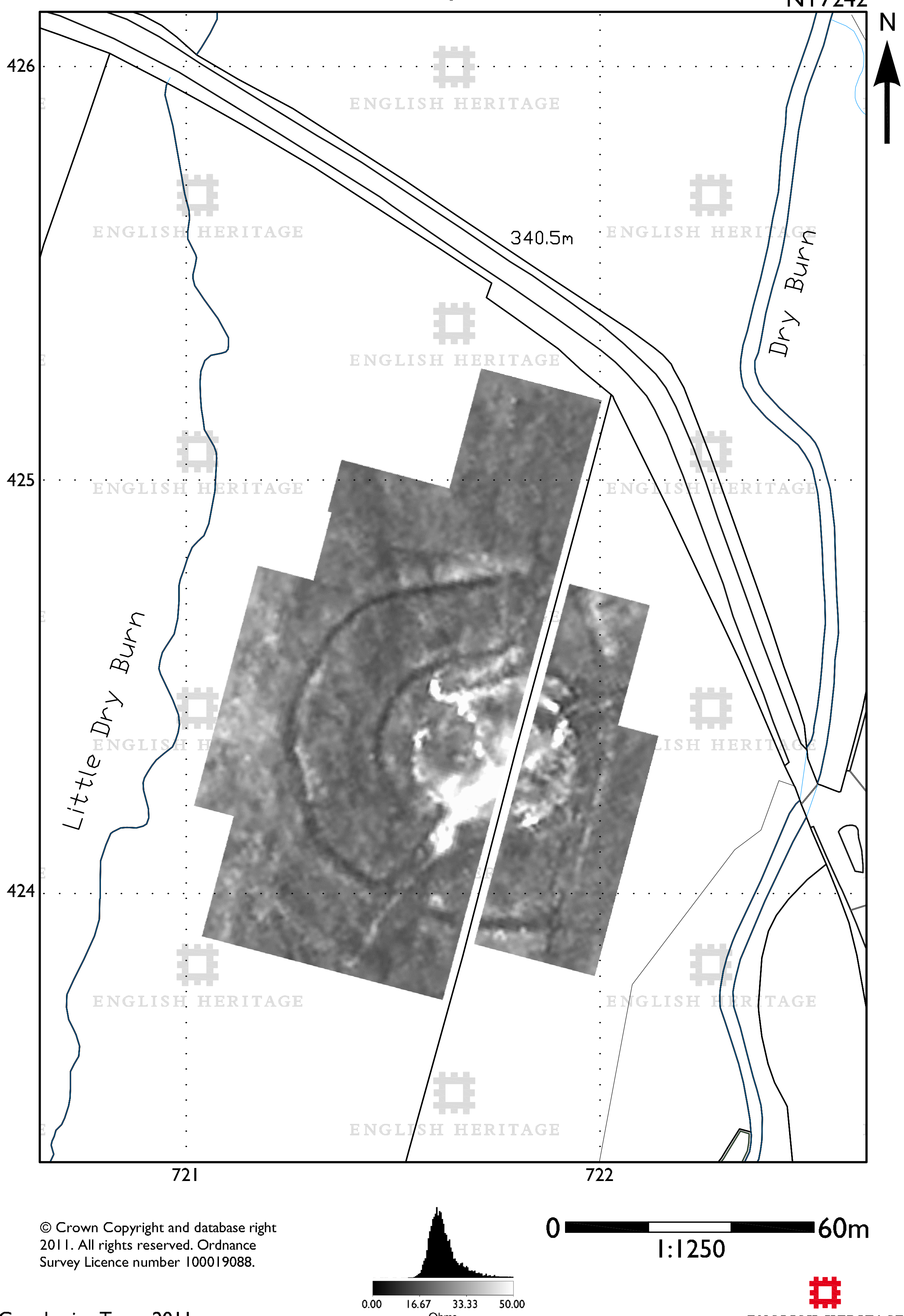
Location of earth resistance survey, November 2010



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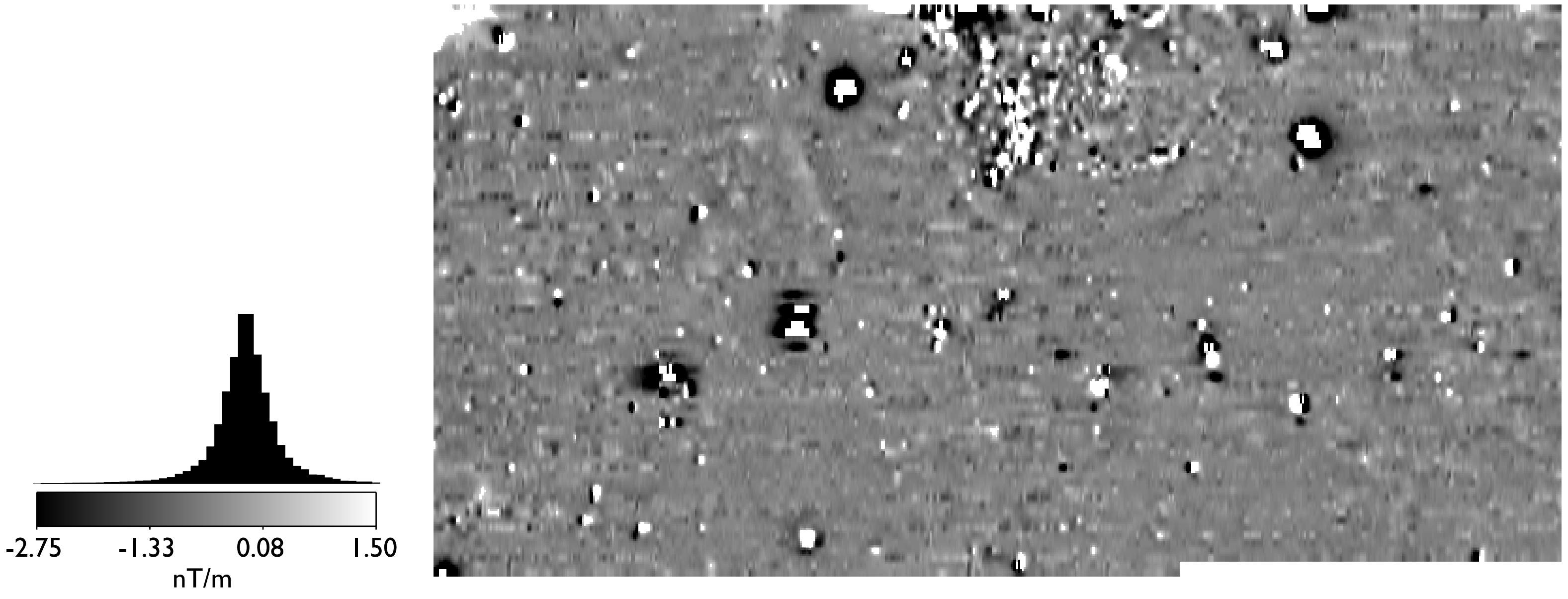
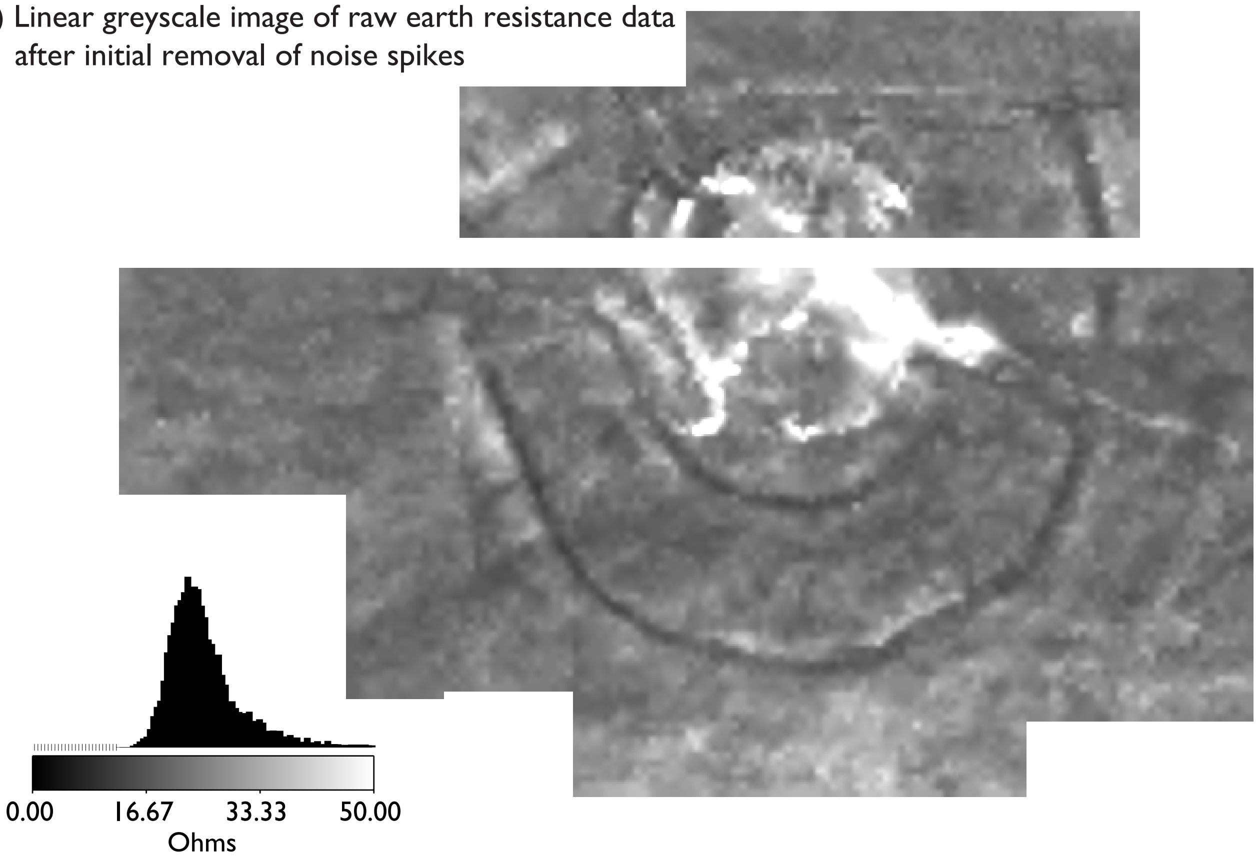
ROTHERHOPE, ALSTON, CUMBRIA Geophysical surveys, November 2010

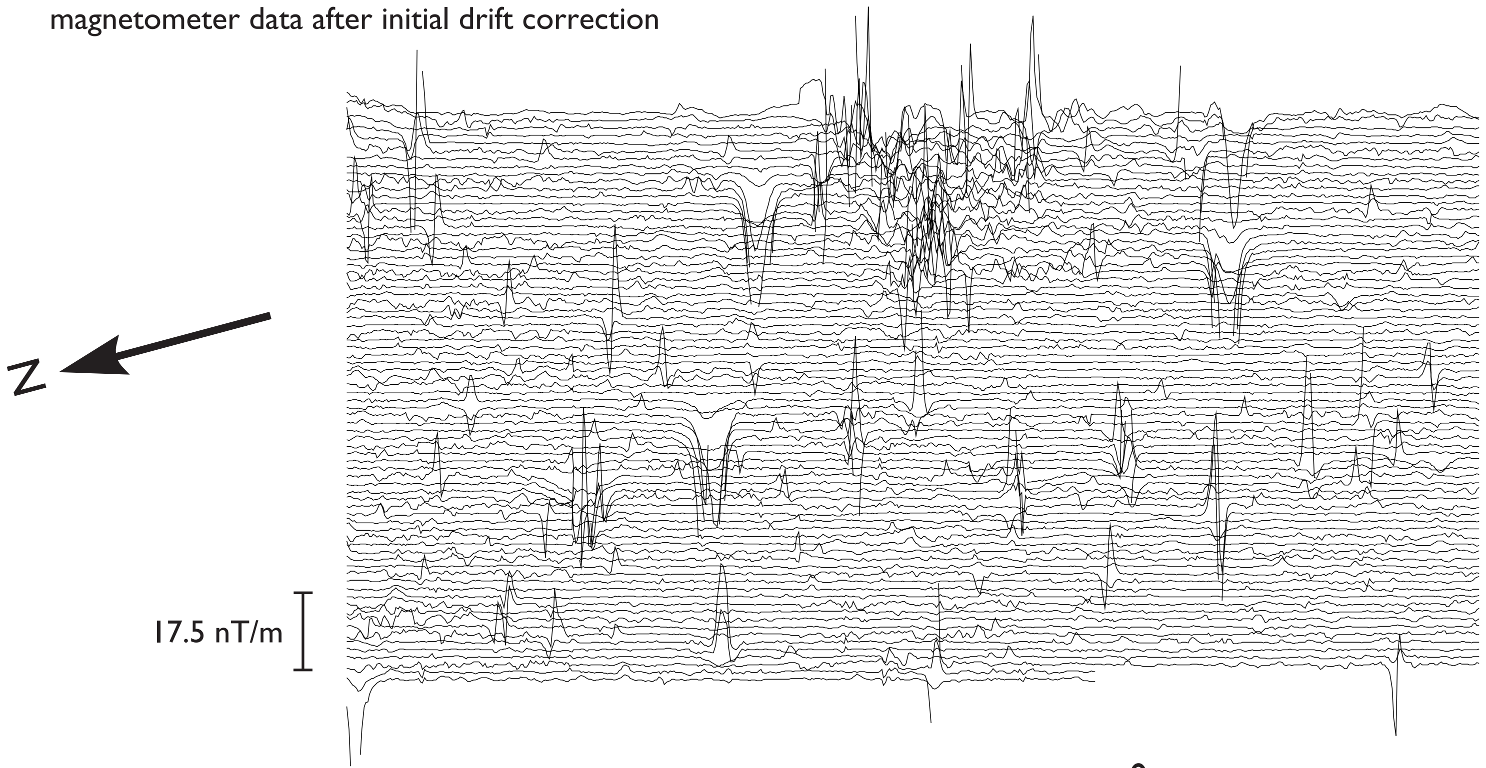
(A) Linear greyscale image of range truncated (-25 to 25 nT/m) magnetometer data after initial drift correction



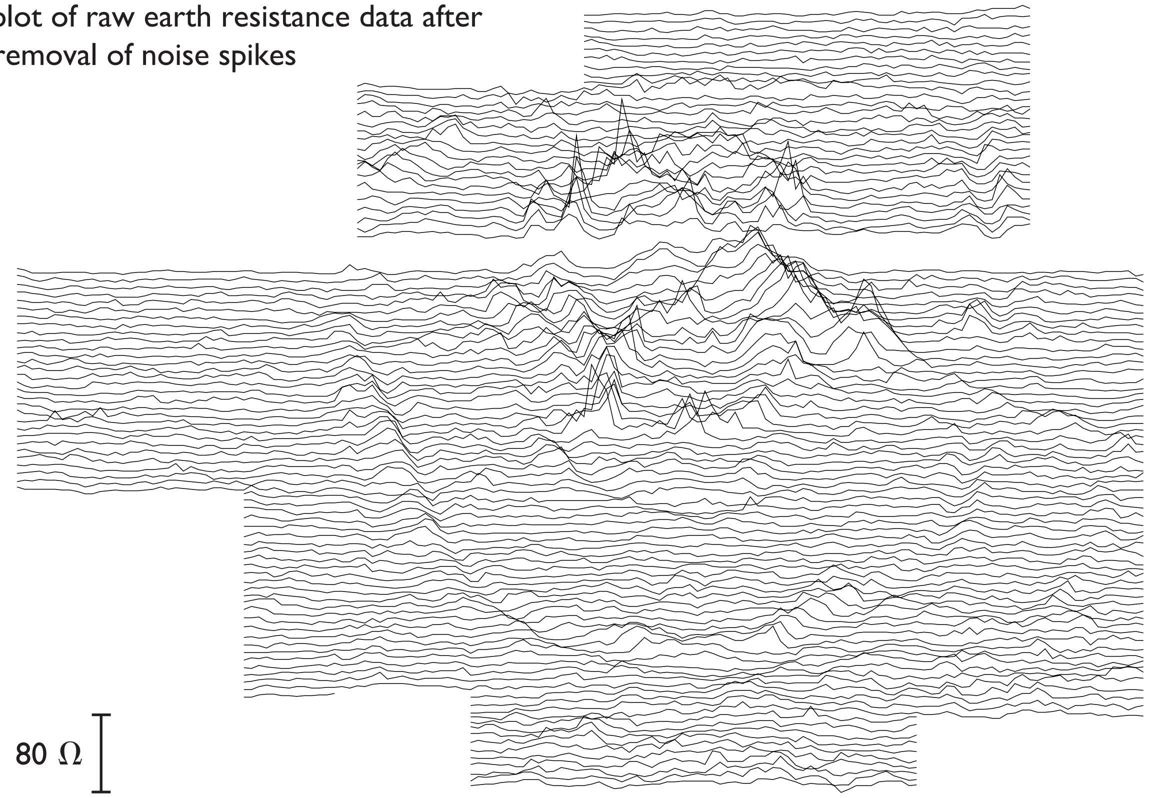
(C) Linear greyscale image of raw earth resistance data after initial removal of noise spikes



(B) Traceplot of range truncated (-25 to 25 nT/m) magnetometer data after initial drift correction



(D) Traceplot of raw earth resistance data after initial removal of noise spikes



0 60m
1:1000

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Figure 5

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Graphical summary of significant magnetic anomalies

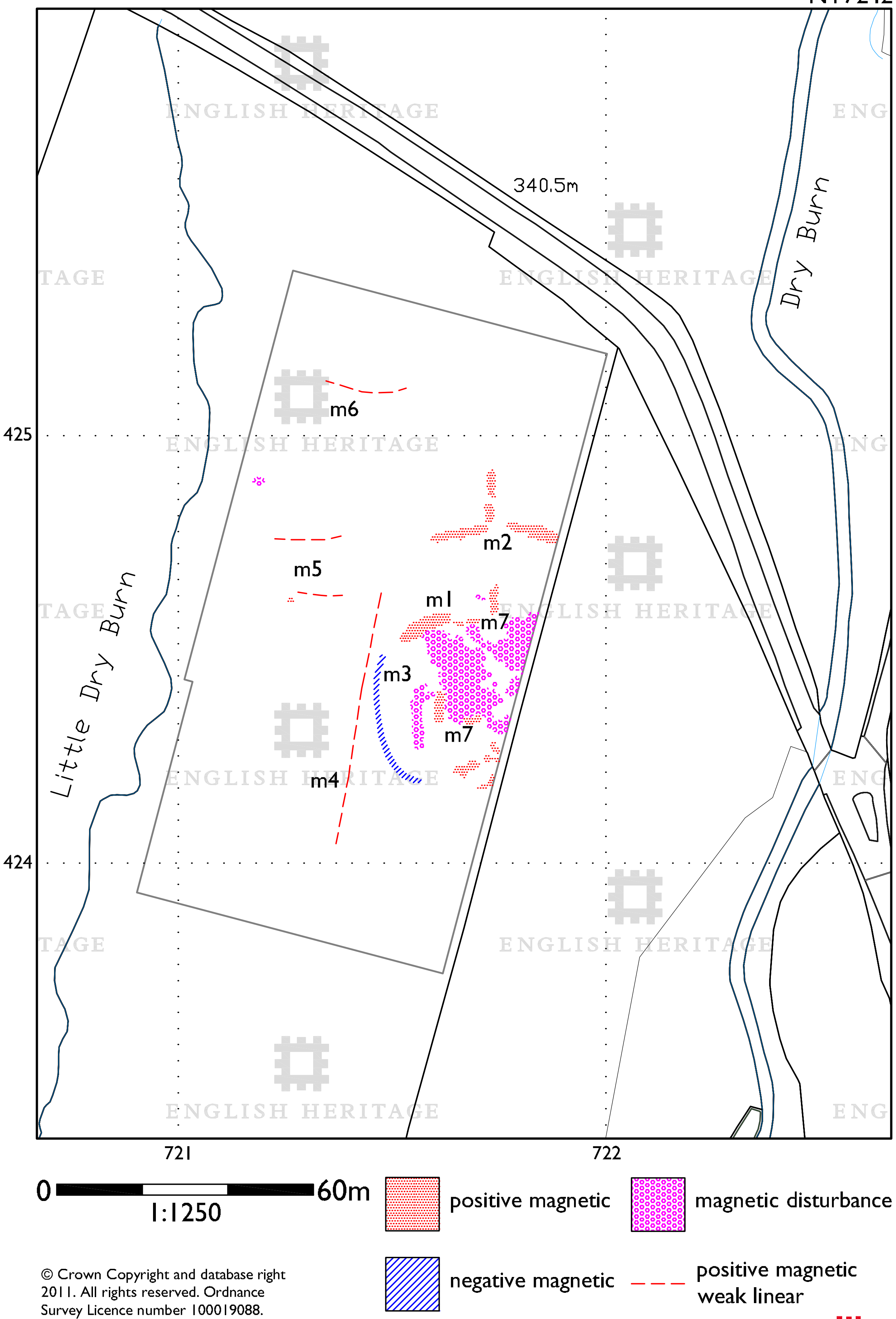

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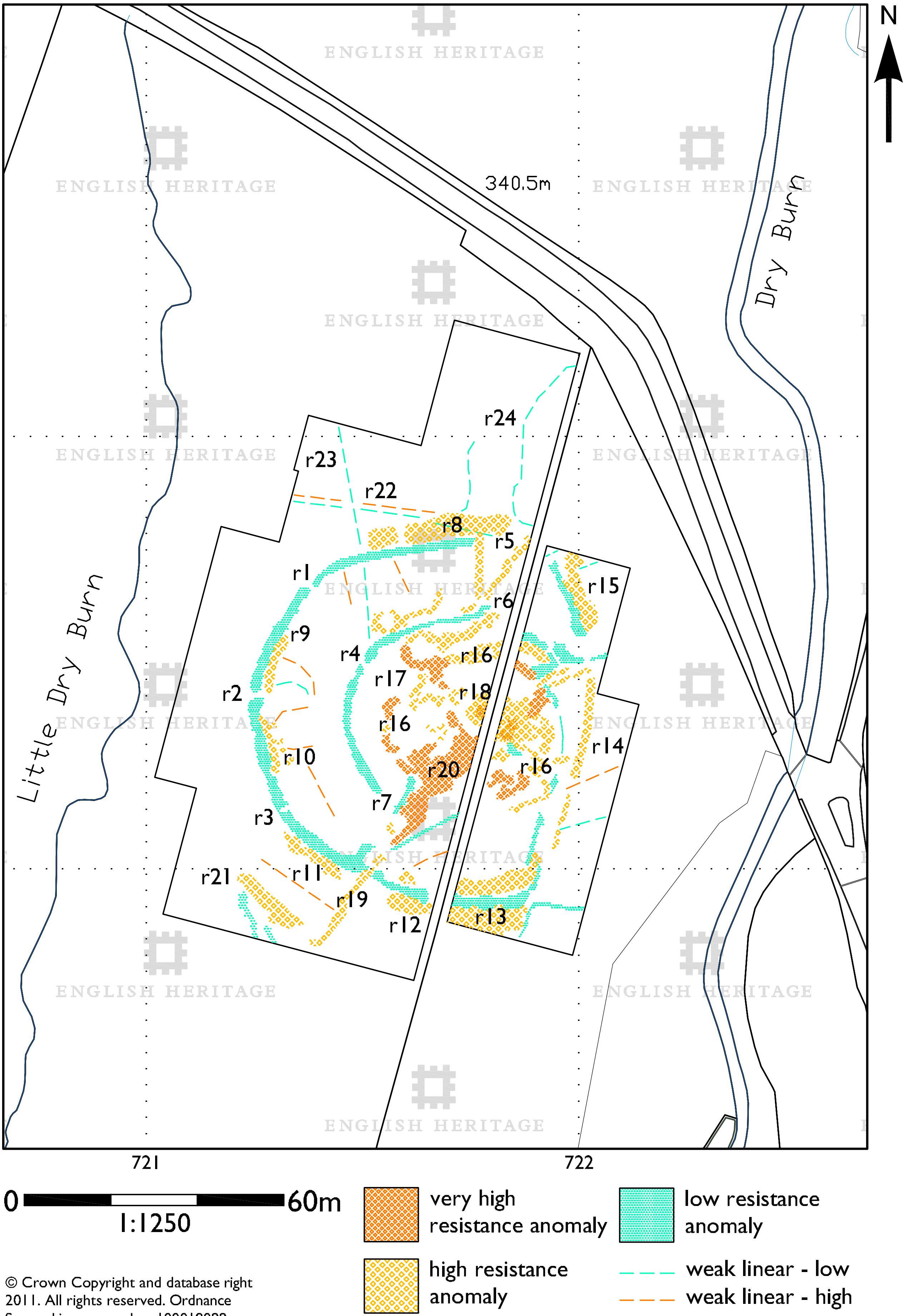
Figure 6

ROTHERHOPE, ALSTON, CUMBRIA

Graphical summary of significant earth resistance anomalies



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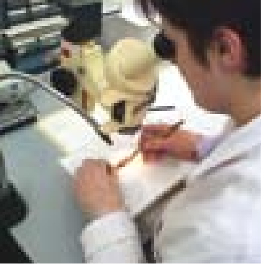
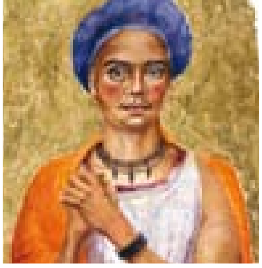



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* *Archaeological Projects (excavation)*
* *Archaeological Science*
* *Archaeological Survey and Investigation (landscape analysis)*
* *Architectural Investigation*
* *Imaging, Graphics and Survey (including measured and metric survey, and photography)*
* *Survey of London*

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