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MARDEN HENGE, WILTSHIRE
REPORT ON GEOPHYSICAL SURVEY, APRIL 2008

Louise Martin

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SUMMARY
A pilot survey was conducted at Marden Henge to assess the geophysical response with a view to surveying the monument in its entirety as part of a wider research project. Earth resistance and magnetometer survey were shown to provide complementary results, recording anomalies relating to the bank and ditch of the henge enclosure and also the ditch of the Hatfield Barrow.

CONTRIBUTORS
The field work was conducted by Neil Linford, Paul Linford, Andy Payne and Louise Martin. Preliminary processing of the caesium magnetometer survey was conducted by Paul Linford.

ACKNOWLEDGEMENTS
Many thanks go to James Hues for permission to survey the land and to Sue Shepherd-Cross of Hatfield Farm for providing hot drinks on a cold day.

ARCHIVE LOCATION
Fort Cumberland.

DATE OF FIELDWORK AND REPORT
The fieldwork was conducted between 21st April and 25th April 2008 and the report was completed on 20th October 2008

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INTRODUCTION

Magnetometer and earth resistance surveys were conducted over an area of ~5.6 hectares of Marden Henge, Wiltshire (Monument Number 26707). The site is classified as a later Neolithic henge enclosure with a total area of ~14 Ha lying on a sloping terrace, bordered to the S by a tributary to the river Avon, 10 miles upstream from Durrington Henge (Field *et al.* 2008, 6-7). Within the enclosure are two known earthworks: to the E, Hatfield Barrow, a large earthen mound which was partially excavated by Cunnington in 1807 but by 1818 had collapsed (Wainwright 1971, 182-3); to the SW of the interior of the henge is a possible saucer barrow or smaller henge (NMR 1996; Field *et al.* 2008, 6). An excavation project led by Geoffrey Wainwright took place in 1969, mainly investigating the N entrance and subsequently revealing the trace of a timber circle within this entrance (Wainwright 1971). Other aspects of the site were investigated through geophysical survey conducted by A J Clark. Though scant physical records of the results survive, it was recorded that the E entrance was located and remains of a large ditch, 28m wide and 105m in diameter, were revealed (Wainwright 1971, 182). This latter anomaly was presumed to be the location for the Hatfield Barrow though it was centred some 70m E from the position recorded by the Ordnance Survey (OS). It was shown, through both excavation and survey of the two entrances that across which the ditch extends for a greater distance than the bank.

The aim of this survey was to test the geophysical response at the site as part of a larger research project into Marden Henge (Field *et al.* 2008,11). An area that included the site of the Hatfield Barrow and the E entrance in the enclosing bank and ditch was chosen for this preliminary work (Field *et al.* 2008).

The site (centred on SU092582) lies on deep well drained fine and coarse loamy glauconitic soils of the Ardington association (Soil Survey of England and Wales 1983) developed over Upper Greensand (British Geological Survey 1967). The field was under grass and not currently used for pasture.

METHOD

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

Magnetometer survey

The caesium magnetometer survey was conducted over the shaded area indicated in Figure 1 using an array of four specially modified high sensitivity Scintrex SM4 caesium vapour magnetometer sensors mounted on a non-magnetic cart system. Readings were collected at intervals of 0.5m x 0.125m along 100m traverses orientated ~NE-SW.

Corrections made to the measured values displayed in the plots were to zero-mean each instrument traverse to remove the directional sensitivity of the instruments and to edge-match adjacent grids to correct for discontinuities observed at grid edges close to strongly magnetised features. Such features are caused by diurnal variations in the Earth's magnetic field between the times the grids on either side of the common edge are surveyed. The response to individual vehicles passing along the road has also influenced the total field sensors to approximately 30m from the N field boundary. This detrimental effect is limited in spatial extent and generally demonstrates a low frequency negative response superimposed over the data in these areas. The low frequency response was estimated by applying a low-pass Gaussian convolution mask (radius 1m) and subtracted from the original data to improve the visual appearance of the survey results in these areas. This data is presented as both an X-Y traceplot and equal area greyscale plot, at a scale of 1:1250 in Figure 3. To improve the visual intelligibility of the traceplot presented in Figure 3A, the dataset has had the magnitudes of extreme values truncated to ±30nT.

Additionally, processing was undertaken using a Wallis filter and the application of a 2m by 2m thresholding median filter (Scollar *et al.* 1990, 492). This latter operation reduces the distracting, localised, high-magnitude effects produced by surface iron objects. The results are presented as a linear greyscale plot overlain on the OS map in Figure 2. Also included on this figure are selected mapping details from the 1887 historic OS map.

Earth resistance survey

Subsequent to the magnetometer survey, earth resistance surveys were conducted in two different areas using two different techniques.

Square array

The survey was undertaken with an MSP40 wheeled resistance square array. Data was collected with a Geoscan RM15 in the square array configuration (with an electrode separation of 0.75m) along traverses separated by 1.0m.

With the square array, the two current injection and two potential measurement electrodes can be assigned to the four available electrode positions in a number of different ways each resulting in a different measurement. Only two such arrangements, know as the alpha and beta configurations, are truly independent (Aspinall and Saunders 2005) and from these, assuming a noise free system, measurements with any other configuration can be calculated. As the alpha and beta configurations are each slightly directionally sensitive, both are required to accurately map all subsurface anomalies in the general case. Hence the MSP40 system was configured to take measurements at 0.25m intervals along each traverse, alternating between alpha and beta measurements.

The two resulting datasets were minimally processed independently: all erroneous earth resistance measurements of less than 0 Ω were deleted and replaced with null values. As the data logger cannot log the alpha and beta readings simultaneously, one of the two measurements has to be taken slightly later than the other during which time the MSP40 cart has moved slightly beyond the measurement position. This has resulted in an offset in the direction of travel to measurement positions in the alpha dataset which has been corrected by shifting adjacent traverses longitudinally to maximise their correlation. A combined dataset was then produced by partitioning each of the alpha and beta datasets into high and low spatial frequency components. The two low frequency components were then overlaid and readings from each averaged to produce a combined regional component. The two high frequency components were also overlaid and a combined local component was produced by keeping the measurement with the greatest absolute magnitude at each position. These combined regional and local components were then added together to form the final combined dataset A high pass filtered version of the combined dataset was created using a high-pass Gaussian convolution mask (7m radius).

The filtered combined dataset is presented as a linear greyscale plot superimposed over the OS base map (1:2500) in Figure 4 along with selected mapping details from the 1887 historic OS map. Plots of both alpha and beta datasets are additionally presented as equal area greyscale plots, at a scale of 1:1250 in Figure 5 along with a traceplot and equal area greyscale plot of the raw combined dataset and a linear greyscale plot of the processed combined dataset.

Twin electrode

The survey was conducted over the hatched area indicated in Figure 1. Measurements were collected with a Geoscan RM15 resistance meter, MPX15 multiplexer and an adjustable PA20 electrode frame in the Twin-Electrode configuration. Readings were collected using the standard method outlined in note 1 of Annex 1 but with mobile electrode separations of 0.5m and 1.0m, taking readings at 1.0m along each traverse thereby producing two datasets preferentially sensitive to features at different depths. The sample densities for these were 0.5m x 1.0m for the 0.5m electrode separation and 1.0m x 1.0m for the 1.0m electrode separation.

All data has been 'despiked' through the application of a 2m by 2m thresholding median filter (Scollar *et al.* 1990, 492) to remove isolated high readings caused by poor contact. Additionally a high-pass Gaussian high-pass convolution mask (radius 5m) was applied to both datasets. A linear greyscale plot of the filtered 0.5m data is superimposed over the base OS map at a scale of 1:2500 in Figure 4. A plot of the raw 0.5m separation dataset is presented as both and X-Y trace plot and an equal area greyscale plot in Figure 6 along with a linear greyscale plot of the filtered data, all three plots are at 1:1250 scale. The equivalent plots for the 1.0 m separation data are depicted in Figure 7.

RESULTS

Magnetometer survey

A graphical summary of the anomalies discussed in the following text, superimposed on the base Ordnance Survey map data, is provided in Figure 8.

The general magnetic response in this area was low with background readings $<\pm 1$nT/m. Modern disturbance is in evidence across the site, with extreme readings recorded adjacent to metal fences enclosing the field. Two linear anomalies formed of extreme readings [M1-2] are typical of responses to ferrous pipes. The location of water troughs at the intersections of these pipe anomalies with the fence between the two surveyed fields indicates the pipes have been laid to service the troughs. A discontinuous linear arrangement of extreme responses [M3] following the approximate line of the extant enclosure bank is most likely a previous fence line, as noted on the 1887 OS map. Further responses to the S are also likely to be of the same origin. Numerous scatters of dipolar responses across the site probably relate to ferrous litter of modern origin.

Parallel linear anomalies have been recorded in both fields, though at different spacing and alignments. Portions of these responses are illustrated at [M4-5]. Those in the northern field at [M4] are typical of ridge and furrow ploughing but those to the S at [M5] are too broadly spaced and may relate to drainage activity rather than ploughing.

Both positive and negative linear anomalies [M6-7] are probably of relatively recent origin. The twinned parallel linear anomalies at [M6] appear most likely to be the result of "tramlines" made vehicles but the branching pattern at [M7] is more suggestive of tracks caused by the passage of sheep or people.

Broad linear negative magnetic anomalies at [M8-9] correlate with the position of the henge ditch. To the S, [M9] is bordered by a positive magnetic response that may derive from the banks. This is a somewhat atypical response for a ditch feature: ditches are normally recorded as positive magnetic responses due to the silting of more magnetic top soil into a feature cut into less magnetic subsoil or bedrock. In this instance it is possible that the depth of the original ditch, recorded as between 2-3.5m during the excavations at the N entrance (Wainwright 1971, 185-7), has led to the enhanced magnetic fill from the time of occupation initially silting the ditch then subsequently being buried beneath less enhanced greensand colluvium from the bank. It is also possible that the magnetic minerals have been leached out of the soil in the ditch due to some level of waterlogging: it was noted during the 1969 excavations, to the N and on higher ground, that the water table was reached at a depth of 2.9m, causing waterlogging to 1-1.9m of deposits (Wainwright 1971, 187). Furthermore, during an initial site visit by the author in January 2008 it was observed that the ground across the ditch was wetter than elsewhere and that there were significantly fewer mole-hills in this vicinity: they were quite prolific elsewhere across the site.

Two strong dipolar responses, [M10-11] have been recorded along the length of [M9]. These are likely to be from ferrous material and could be coincidental in location; however, they could be from material that has been deliberately deposited in the ditch. One possible theory is they are short lengths of pipe positioned to assist drainage in this area, which would be more likely if the ditch were indeed occasionally waterlogged.

Two isolated pit-type anomalies at [M12] and an amorphous area of raised magnetic response [M13] are the only indicators of further anthropogenic activity across the interior of the henge. There is little other obvious evidence for occupation of the site: numerous dipolar responses are suggestive of modern ferrous litter, but no other indicators of magnetic enhancement that might represent pits, hearths or even timber structures have been recorded.

Earth resistance survey

The survey to the N has revealed a large area of low resistance [R1]. It is assumed the response would continue beyond the surveyed area, but what has been recorded appears approximately circular in shape with a protrusion to the NE of the anomaly. The location and dimensions of [R1] compare favourably with the previous geophysical results for the ditch surrounding the Hatfield Barrow. However, as the survey only covered the SE third of the ditch it is not possible to provide information about the remnants of the barrow mound, or an explanation for the extension of the ditch on the eastern side of the barrow.

S of [R1] is an area of much higher resistance [R2]. This amorphous area is likely to be geomorphological in origin, however, a dissecting low resistance linear [R3] correlates with the pipe recorded in the magnetometer survey at [M1].

The high resistance anomaly [R4] corresponds with the N terminal of the bank of the henge enclosure at its E entrance. Further areas of high resistance just S of here [R5] are not easily interpretable and they may be merely geomorphological in origin or related to differential soil drainage. There are no anomalies that correlate with the position of the henge ditch as recorded by the magnetometer survey.

In the area surveyed to the S, a low resistance linear anomaly [R6] correlates with the magnetic anomaly [M9] and the position of the henge ditch. Bordering this to the W and S is a narrow high resistance anomaly [R7]. A faint parallel, weaker high resistance linear anomaly [?R7] runs through the centre of [R6] connecting to the main [R7] anomaly at its southern end and forming an extension or return to it. This superimposition of anomalies may suggest more than one phase of construction. It is also possible that [R7] represents some sort of capping to stabilise the sides of the ditch: it was noted during the 1969 excavation that the greensand was very unstable (Wainwright 1971, 185) and in some areas blocks of sandstone or greensand were used to revet the bank (Wainwright 1971, 190). The presence of [R7] across the width of [R6] is suggestive of a terminal to the ditch, though none has been recorded here before. The installation of the adjacent fence may have affected the response in this area. Further low resistance anomalies [R8] appear to relate to the top of the bank.

Inside the enclosure is an area of raised resistance containing some discrete high resistance anomalies [R9]. These are stronger in magnitude that the general background variations in earth resistance over the site and may indicate anthropogenic activity. However, they do not exhibit any discernable pattern making a definitive interpretation impossible.

CONCLUSION

The magnetometer survey covered a large area of the henge enclosure including the E entrance and the site of the Hatfield Barrow. Though the survey has responded to some of the known archaeological features, still expressed as variations in local topography such as the henge ditch, little other evidence of past human activity has been recorded.

There was no response of the Hatfield Barrow and the E entrance has not been clearly defined. Though a break in magnetic response of the ditch exists, the effect of the nearby ferrous pipe precludes accurate definition of the terminals. However, the unusual nature of the magnetic signal over the ditch may be an indicator of post depositional processes.

The magnetometer results do not exhibit any clear evidence for human activity within the henge and it is possible that this is because the magnetisation of the local soil, derived from the parent greensand geology, is not significantly enhanced by anthropogenic processes. However, it should be noted that at Durrington, to which this site is frequently compared (especially after the excavation of the timber circle to the N), the majority of geophysical anomalies were not evenly distributed across the site and appeared to be clustered in certain areas. Therefore, while there is little magnetic evidence for activity in the area so far surveyed at Marden, this does not necessarily mean that such magnetic anomalies do not exist elsewhere within the henge enclosure.

The earth resistance survey has been more successful at locating the Hatfield Barrow, and also part of the bank, but not the ditch of the E entrance. Further S the ditch, rather than the bank, has been more clearly defined. A possible new terminal or phase of construction has been revealed and though there are a few anomalies within the enclosure close to the ditch, it is not clear what they represent.

Therefore, despite some uncertainties, the multi-technique approach adopted for the pilot survey has successfully produced two complementary datasets both containing significant anomalies. Out of the two techniques, the magnetometer survey has provided a more complete definition of the henge ditch but has not detected any internal features whilst the earth resistance survey has detected an anomaly likely to be associated with the Hatfield Barrow and provided potential new detail on the henge ditch and bank in the southern part of the survey area.

LIST OF ENCLOSED FIGURES

Figure 1 Survey location plan (1:2500).

Figure 2 Linear greyscale plot of processed magnetic data superimposed over base OS map annotated with selected features from the 1887 OS map (1:2500).

Figure 3 Trace plot and linear greyscale plot of the magnetic data (1:1250)

Figure 4 Linear greyscale plot of processed earth resistance data superimposed over base OS map annotated with selected features from the 1887 OS map (1:2500).

Figure 5 Traceplot and greyscale plots of raw and filtered square array earth resistance data (1:1250).

Figure 6 Traceplot and greyscale plots of raw and filtered 0.5m mobile probe separation twin probe earth resistance data (1:1250).

Figure 7 Traceplot and greyscale plots of raw and filtered 1.0m mobile probe separation twin probe earth resistance data (1:1250).

Figure 8 Graphical summary of significant magnetometer anomalies superimposed over base OS map (1:2500).

Figure 9 Graphical summary of significant earth resistance anomalies superimposed over base OS map (1:2500).

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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.

Figure 1

MARDEN HENGE, WILTSHIRE
Location of geophysical surveys, April 2008.

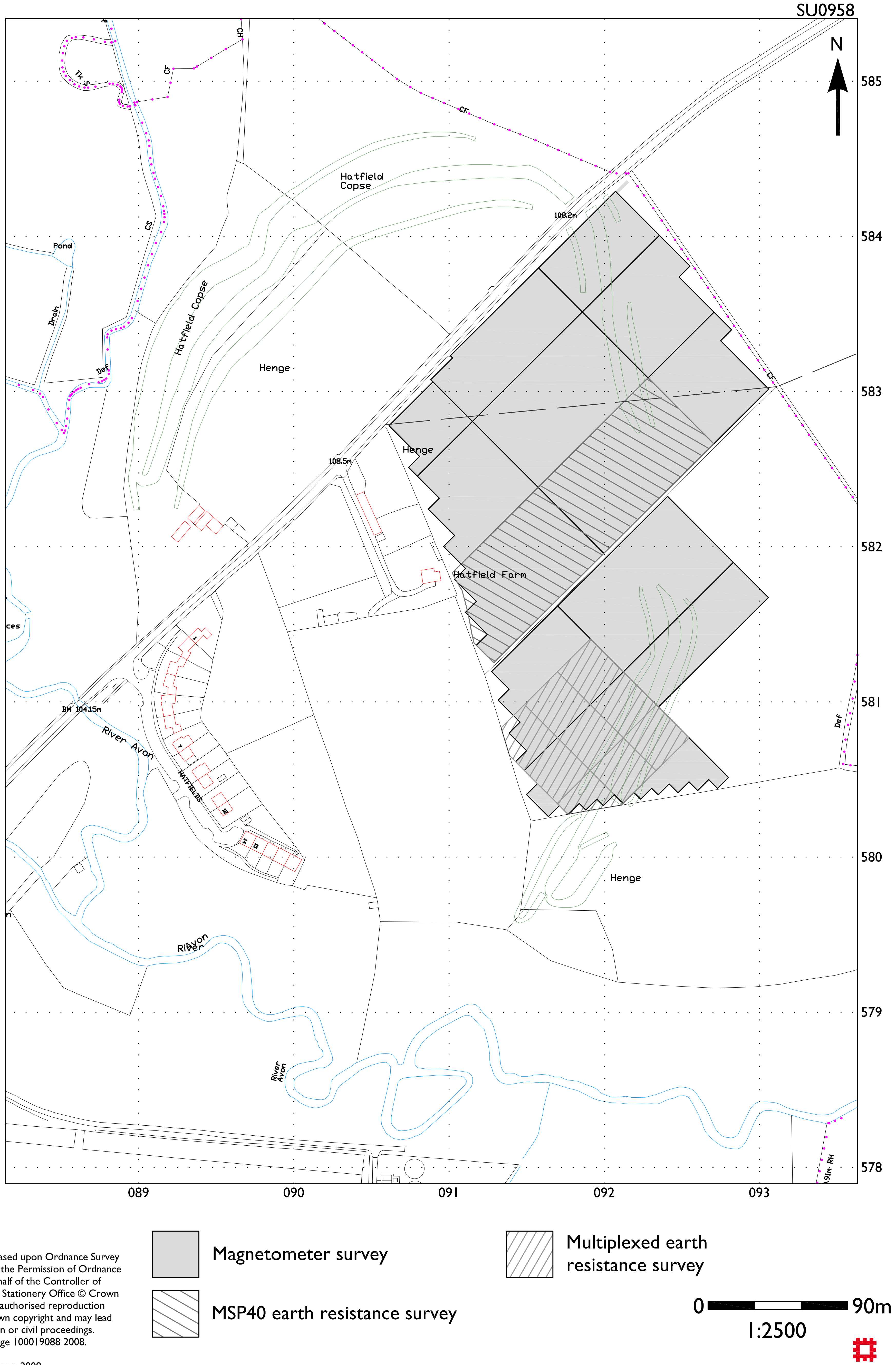

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Figure 2

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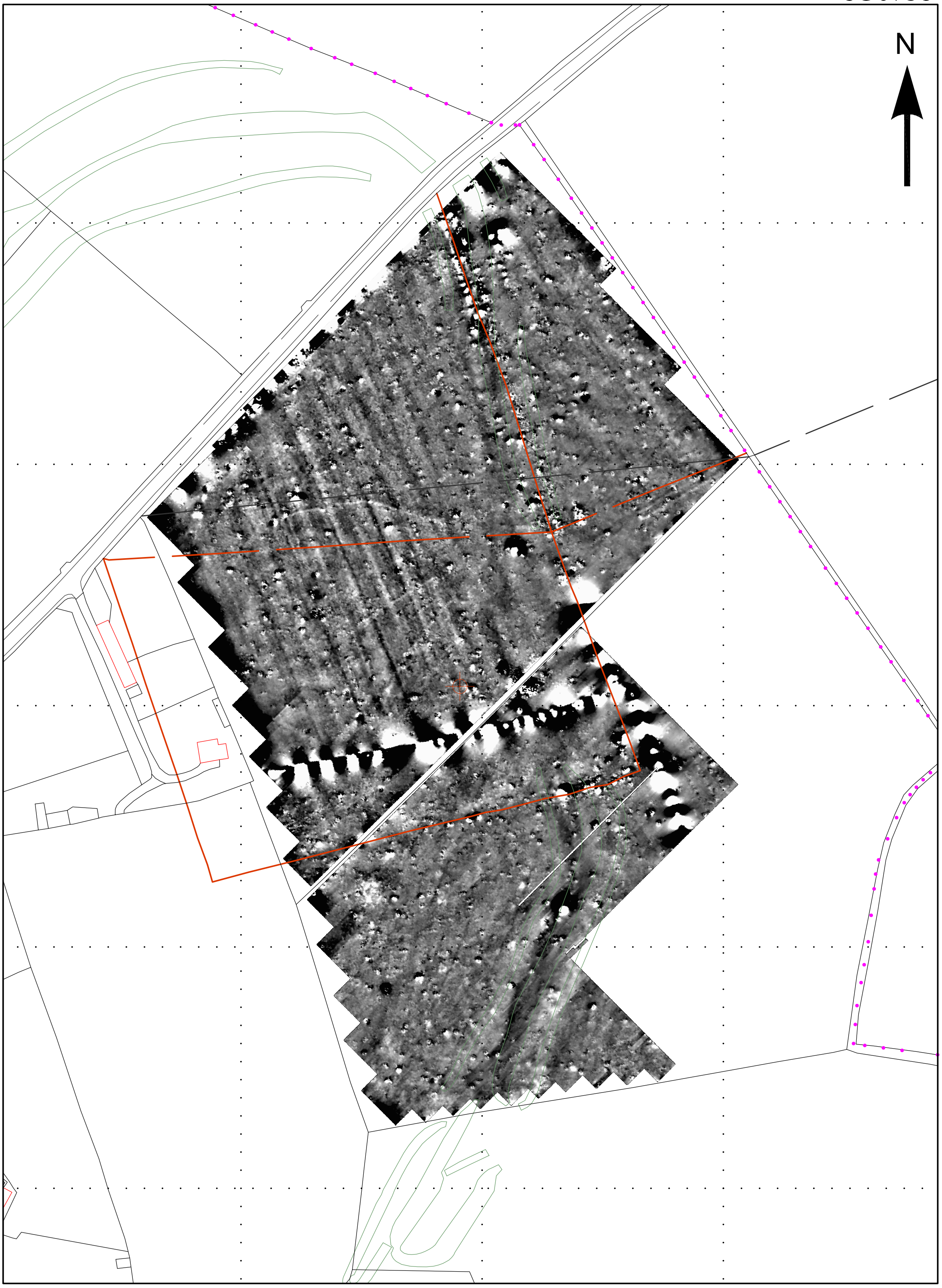
Magnetometer survey, April 2008.



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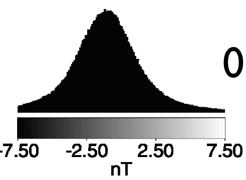
Historic OS map key:

Field boundary

Footpath

Hatfield Barrow



0 90m

1:2500

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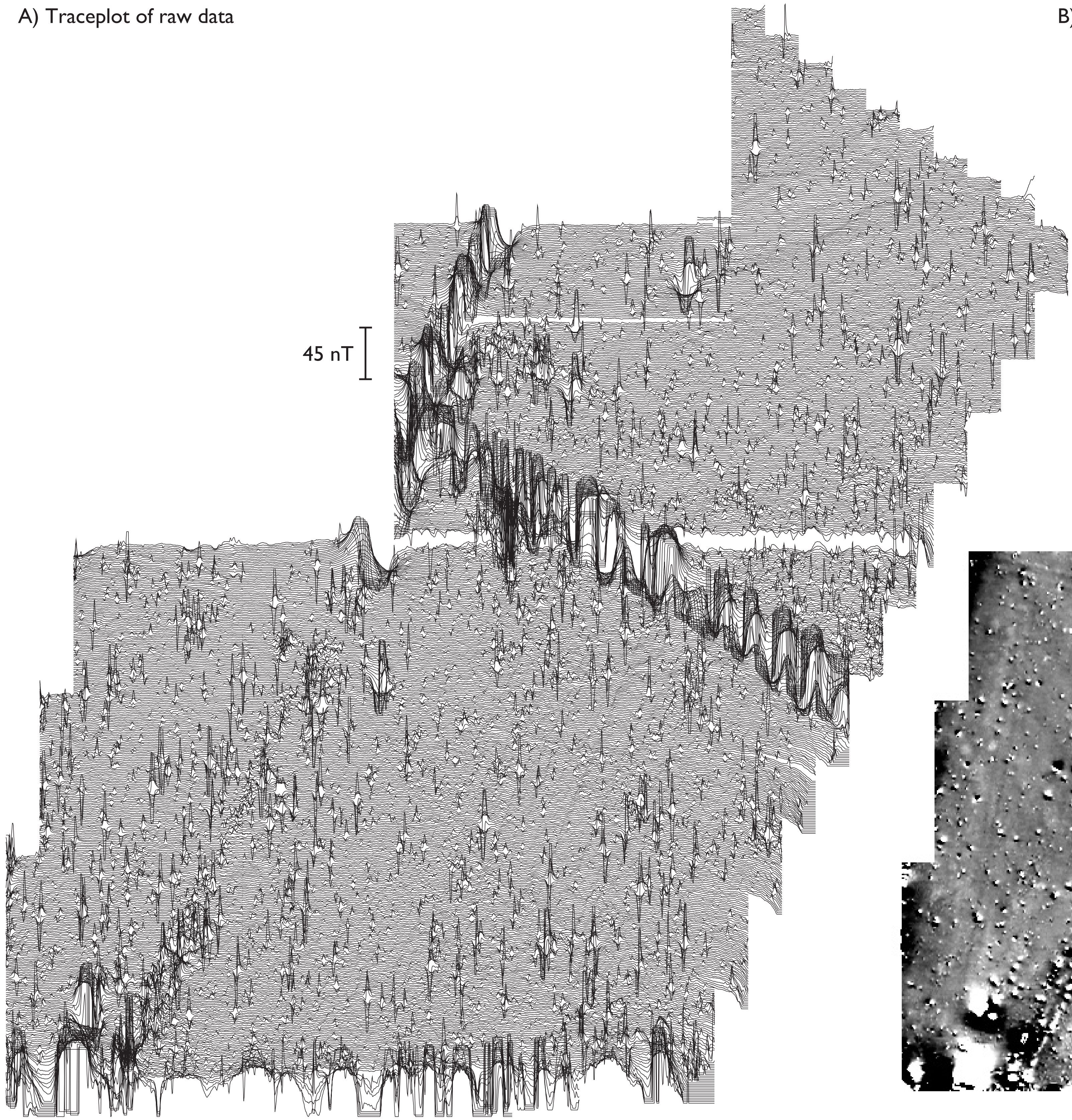
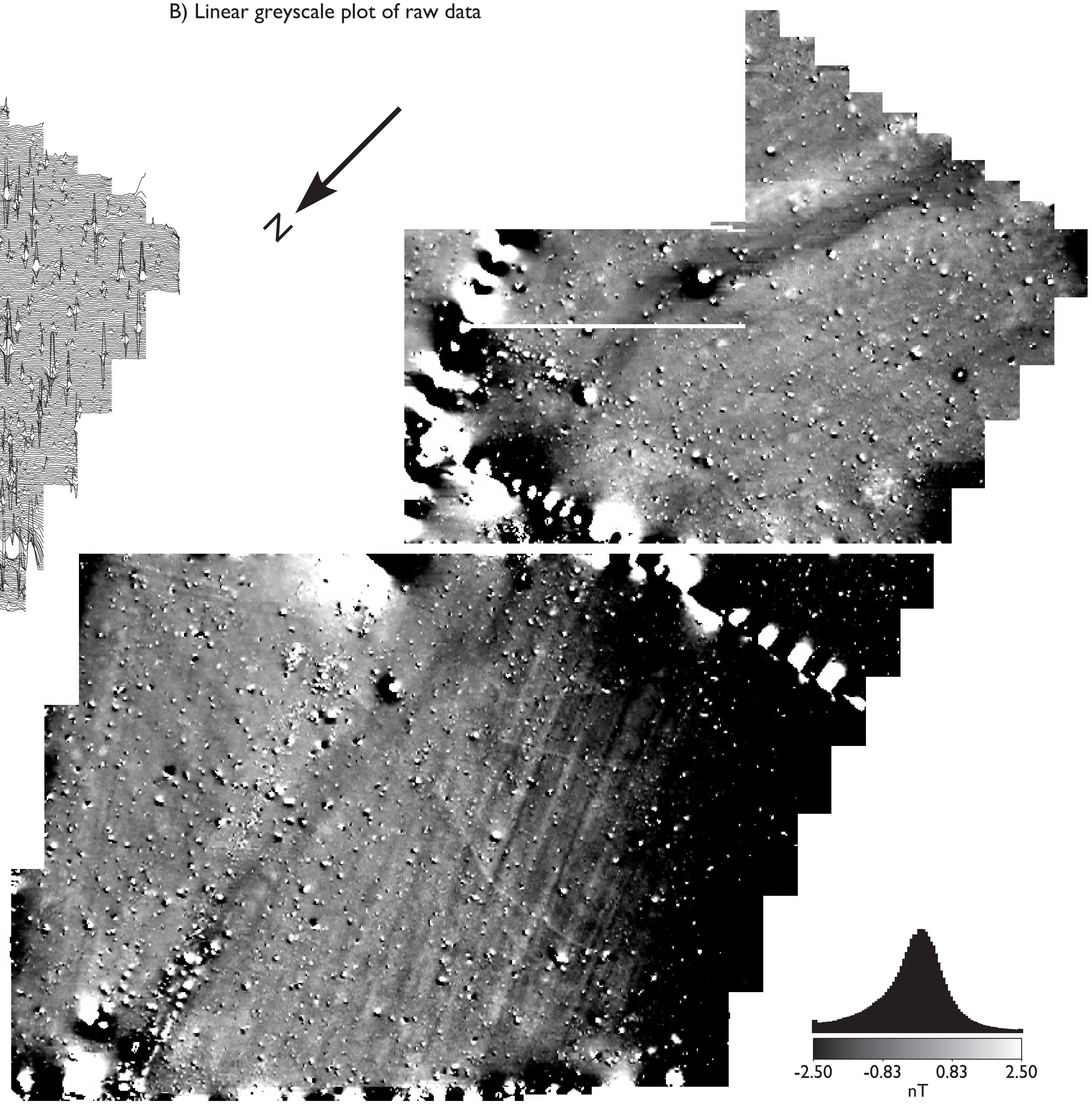
Caesium magnetometer survey, April 2008

Figure 3

A) Traceplot of raw data



B) Linear greyscale plot of raw data



0 90m
1:1250

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Figure 4

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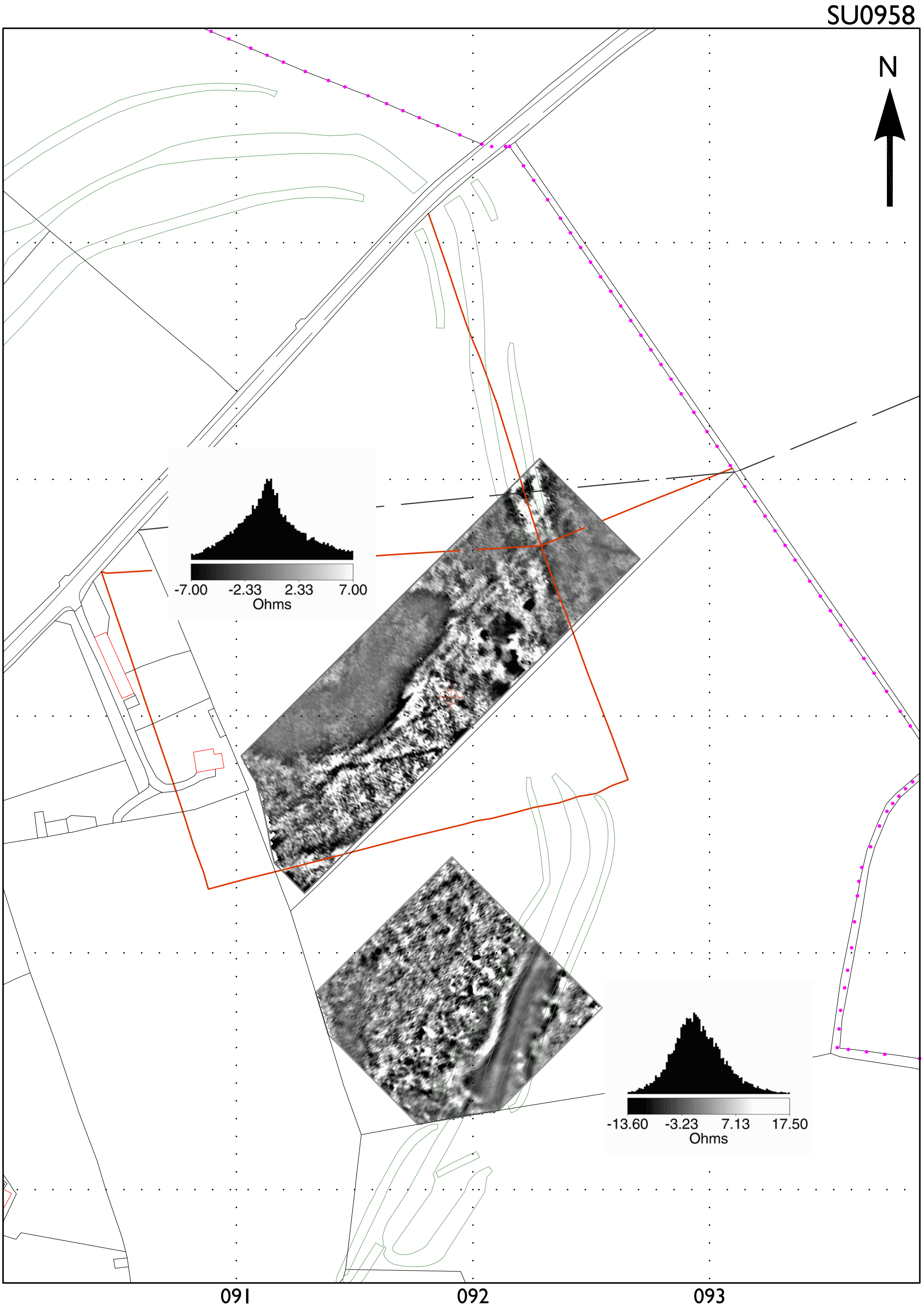
Earth resistance surveys, April 2008.



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Historic OS map key:

- Field boundary
- Footpath
- Hatfield Barrow

0 90m

1:2500

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Square Array Earth Resistance Survey, April 2008

Figure 5

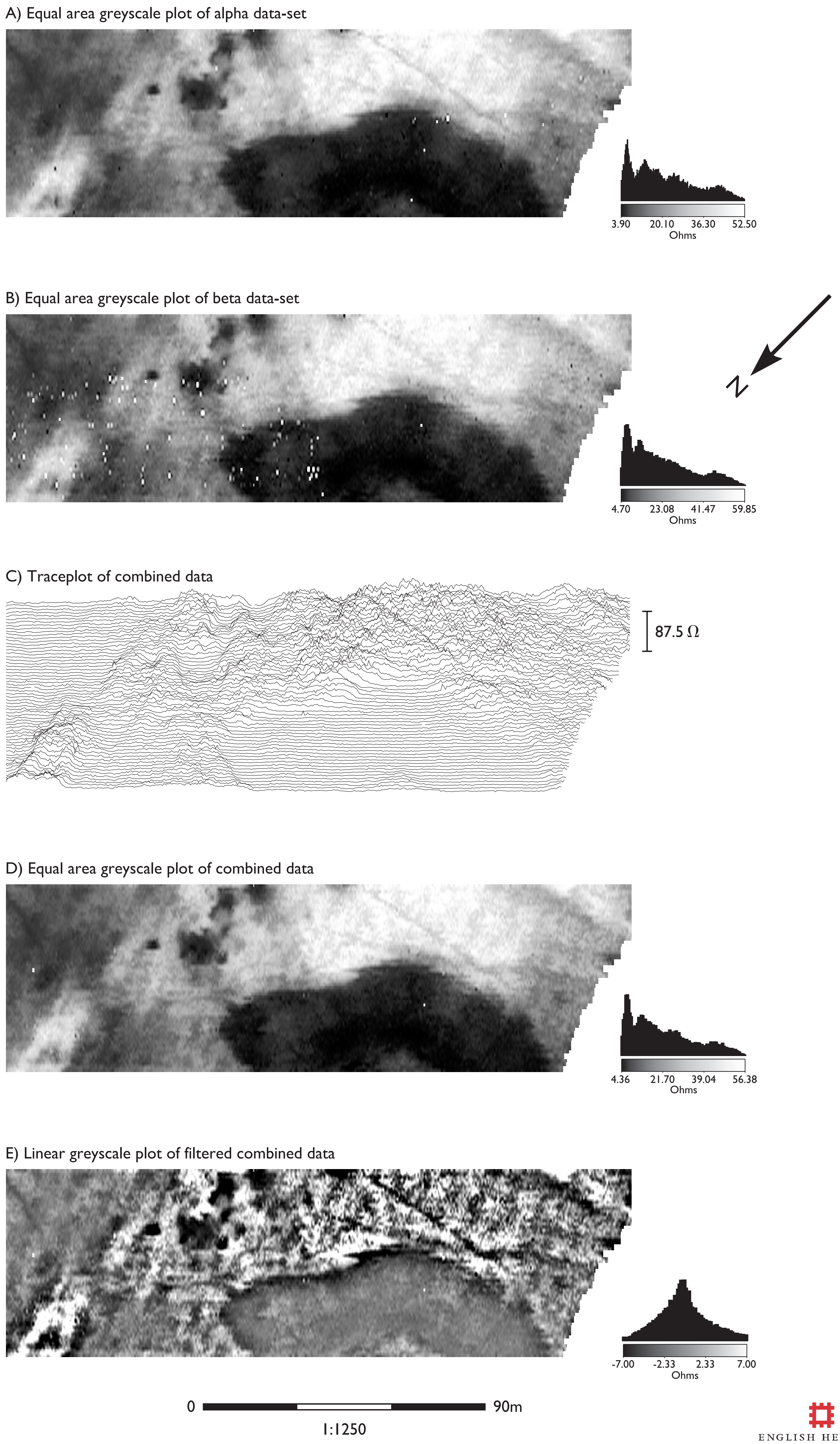

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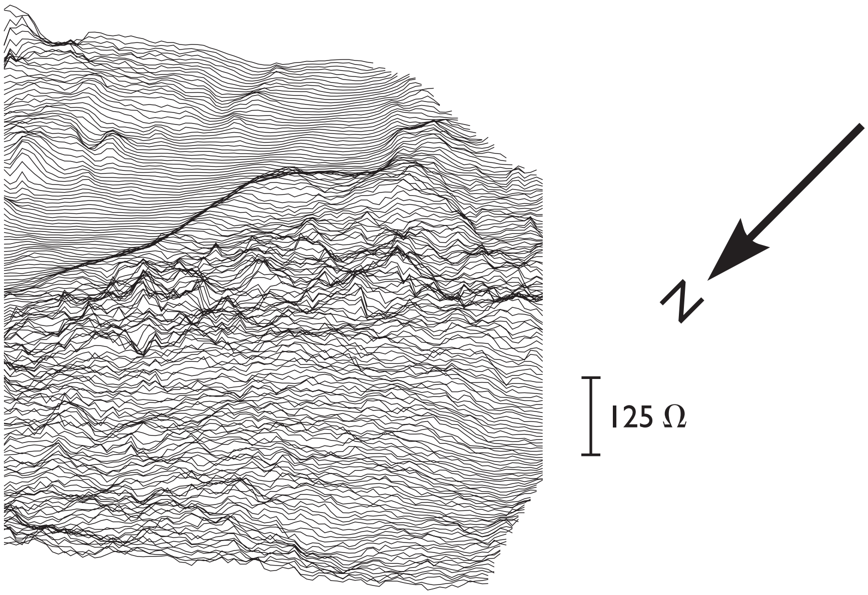
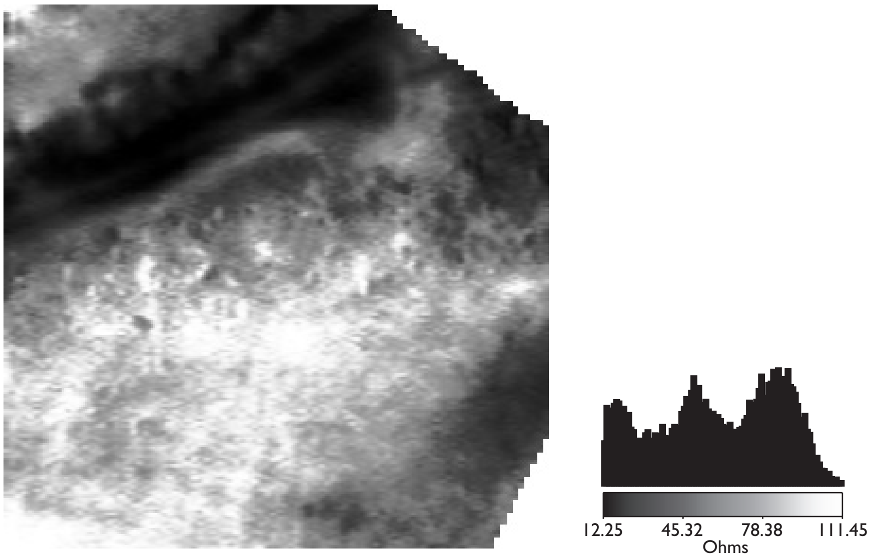
Figure 6

Twin probe earth resistance survey at 0.5m mobile probe separation, April 2008

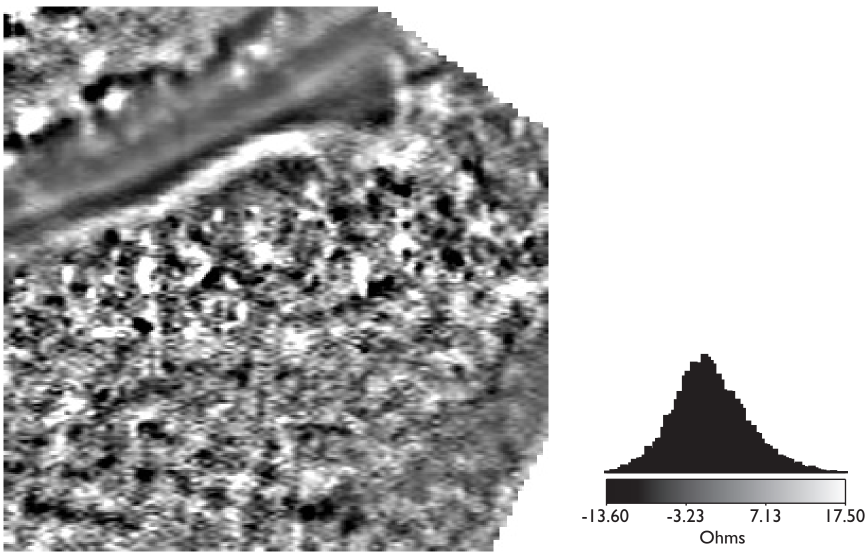
A) Traceplot of raw data



B) Equal area greyscale plot of raw data



C) Linear greyscale plot of filtered data



0 90m

1:1250

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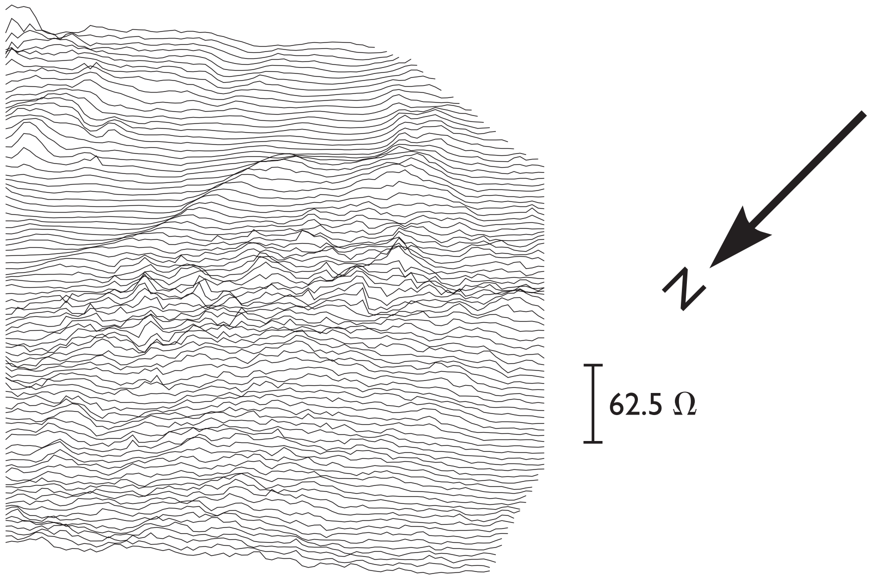
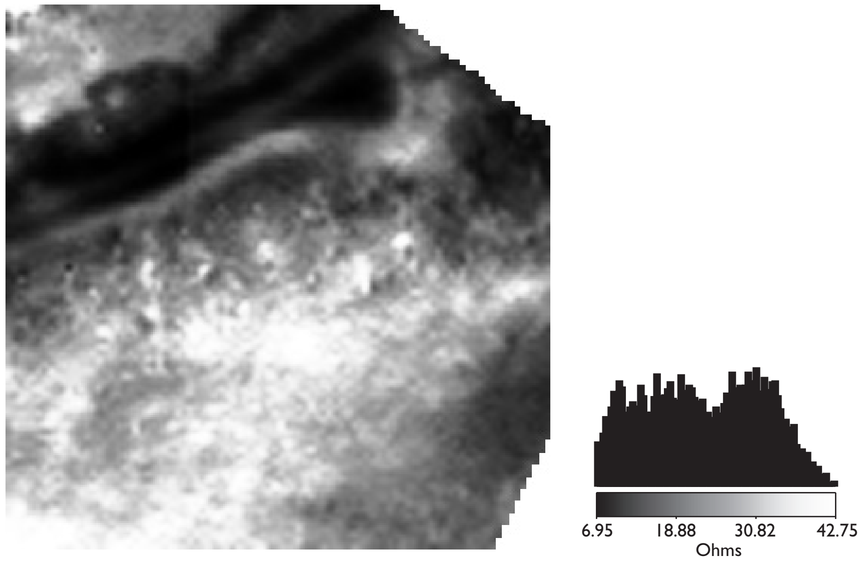
Figure 7

Twin probe earth resistance survey at 1.0m mobile probe separation, April 2008

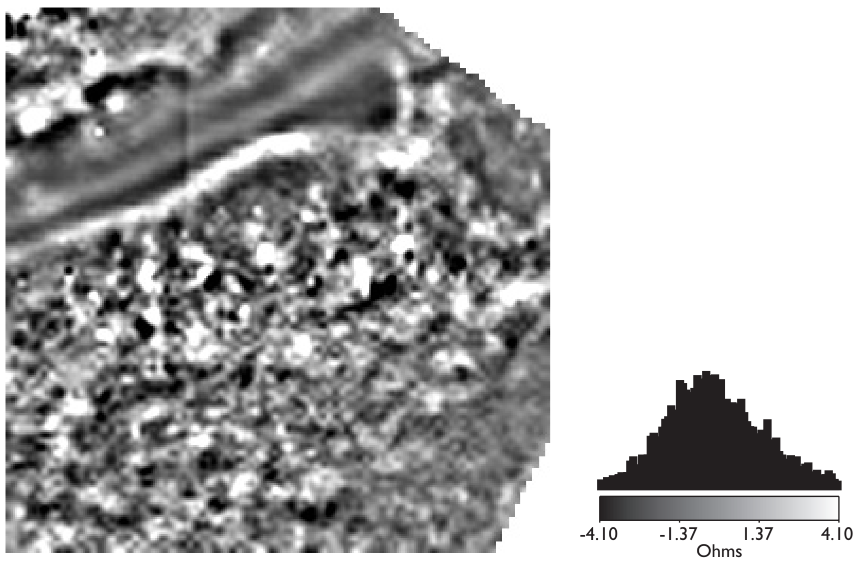
A) Traceplot of raw data



B) Equal area greyscale plot of raw data



C) Linear greyscale plot of filtered data



0 90m

1:1250

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Figure 8

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Graphical summary of significant magnetic anomalies, April 2008.

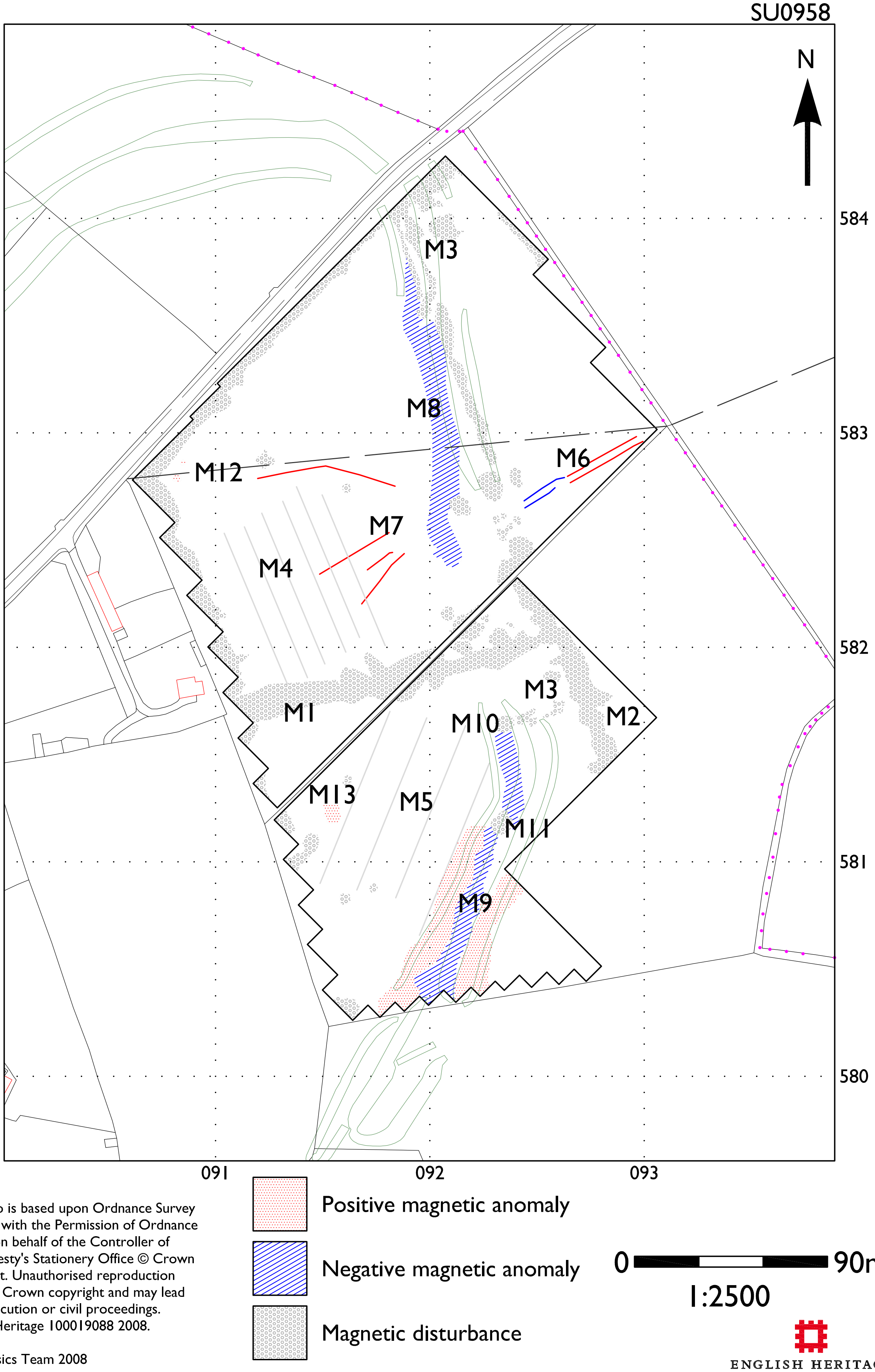

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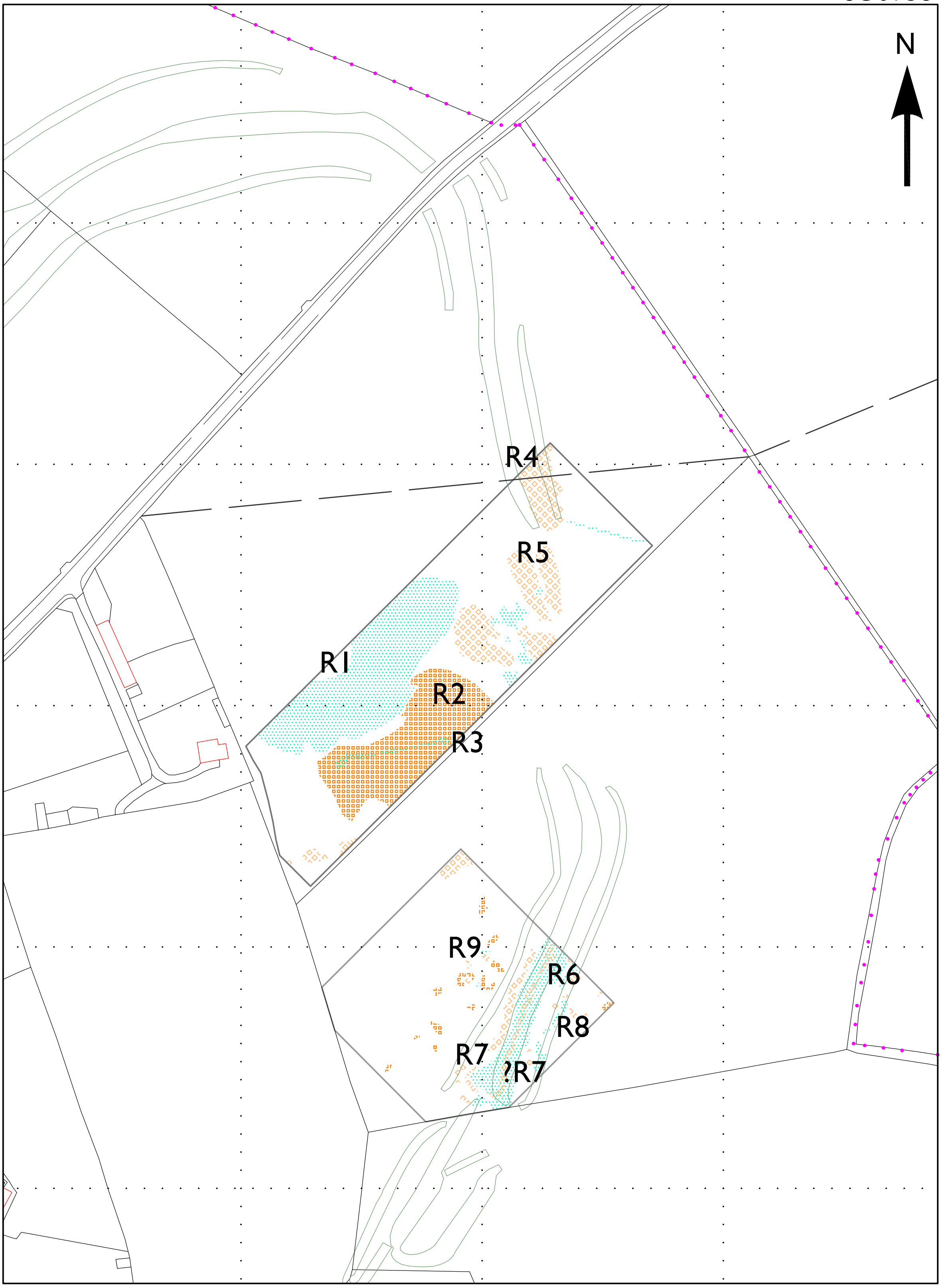
Figure 9

MARDEN HENGE, WILTSHIRE

Graphical summary of significant earth resistance anomalies, April 2008.



Strong high resistance anomaly

High resistance anomaly

Low resistance anomaly

0 90m

1:2500

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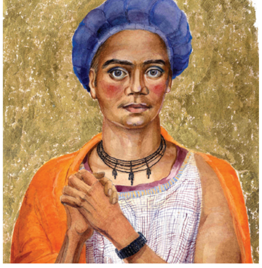



ENGLISH HERITAGE RESEARCH DEPARTMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.

The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:

* *Aerial Survey and Investigation*
* *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*

The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.

We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

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