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ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE
REPORT ON GEOPHYSICAL SURVEY, MARCH 2007

Louise Martin and Paul Linford

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Research Department Report Series 51/2007

St Oswald's Church, Widford, Oxfordshire Report on Geophysical Survey, March 2007

Louise Martin and Paul Linford

Summary

Magnetometry and earth resistance surveys were conducted around St Oswald's Church, Widford, Oxfordshire to investigate both the source of damp affecting the N wall of the church and to identify any archaeological remains in the vicinity. There was no geophysical evidence for land drains, broken or otherwise, to the N of the church but an area of low resistance is thought to be associated with a nearby spring. A concentration of anomalies around the church is indicative of settlement activity, though the responses were not clear enough to suggest to what period they may relate.

Keywords

Geophysical Survey
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Magnetometer
Fluxgate
Gradiometer
Roman
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ST OSWALD'S CHURCH, WIDFORD, Oxfordshire.

Report on geophysical survey, March 2007.

Introduction

Geophysical surveys of an area of approximately 0.7 hectares were conducted over part of a purported deserted medieval village immediately surrounding St Oswald's Church, Widford, Oxfordshire (Monument No. 30828). A number of earthworks are visible at the site and have been recorded on the 1:2500 Ordnance Survey (OS) mapping (see Figure 1). The east end of the church is known to sit on a Roman tessellated floor which may have once belonged to part of a bathhouse (National Monument Record, number SP21 SE3, HOB UID 332334). The north wall of the church is currently suffering from damp which, as well as potentially affecting the structure of the building, is in danger of damaging important 13th and 14th century wall paintings uncovered during restoration work in 1904 (NMR no SP21 SE69, HOB UID 765230). The origin of the water ingress is not known although it may relate to either nearby land drains thought to have been laid in the area or to natural springs, one of which exists ~60m N of the church: raising the possibility that water was diverted as a water source for the Roman bathhouse.

The aim of this geophysical survey, requested by the local English Heritage Inspector of Ancient Monuments, Chris Welch, was to investigate the land around the church in an attempt to discover the origin of the water causing the damp in the church and to identify any archaeological remains in its vicinity.

The site (centred on SP273121) lies on a S facing slope just above the River Windrush, on shallow well drained brashy calcareous fine loamy soils of the Elmton 1 association (Soil Survey of England and Wales 1983), developed over Great Oolite (British Geological Survey 1947). The area immediately north of the church is a graveyard and excluded from the scheduling and this survey. The wider area around the churchyard is used for cattle pasture though cleared of stock at the time of the survey.

Method

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

Earth resistance survey

The prime focus of the survey was to map anomalies relating to ground water, therefore an earth resistance survey was chosen as this technique relies on differing moisture content of the soil. It was hoped this would be able to record both damper areas and those where building remains were present. The survey was undertaken with an MSP40 wheeled resistance square array over the hatched area in Figure 1. The resistance data was collected with a Geoscan RM15 in the square array configuration (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 each processed independently using an adaptively thresholded median filter, applied multiple times, to remove extreme readings due to poor contact resistance (Scollar *et al.* 1990, 492). All other erroneous earth resistance measurements of less than 0 ohms were also deleted and replaced using a local averaging algorithm (Scollar *et al.* 1990, 492). Each dataset was also processed to correct for line displacement errors caused by slippage of the cart's odometer wheel. This was achieved by shifting adjacent traverses longitudinally to maximise their correlation. In the case of two grids to the east of the church, traverses also had to be corrected for stretching using cubic spline interpolation as part of this process, owing to a temporary fault that developed with the distance measuring sensor. Details of these line displacement techniques are described by (Eder-Hinterleitner *et al.* 1996).

The beta dataset was additionally corrected for the 0.25m positional offset in its measurements relative to the alpha dataset using cubic spline interpolation. A combined dataset was then produced by overlaying the processed alpha and beta datasets and averaging the two corresponding measurements at each position. To accentuate anomalies on an archaeological scale relative to geological and hydrological changes across the survey area, a high pass filtered version of the combined dataset was created using a Gaussian convolution mask with a cutoff radius of 7m.

The filtered combined data-set is presented as an equal area greyscale plot superimposed over the OS base map (1:1000) in Figure 2. Plots of both alpha and beta data-sets are additionally presented as equal area greyscale, at a scale of 1:1000 in Figure 3 along with a traceplot and equal area greyscale plot of the raw combined data-set and an equal area greyscale plot of the filtered combined data-set.

Magnetometer survey

In an attempt to provide further information about the medieval settlement and any modern drainage a simultaneous magnetometer survey was conducted over the shaded area in Figure 1 using a single Geoscan FM256 fluxgate gradiometer mounted on the MSP40 cart, with data collected at 0.25m intervals along traverses separated by 1.0m.

A plot of the data-set is superimposed over the base OS map at a scale of 1:1000 on Figure 4. Additionally an X-Y traceplot and linear greyscale plot of the data are presented at a scale of 1:1000 on Figure 5.

Corrections made to the measured values displayed in the plots were to zero the median of each instrument traverse to correct for instrument heading errors and to remove high frequency noise using a 1D, 0.5m radius polynomial filter oriented parallel to the instrument traverses. All grids were 'despiked' through the application of a 2m by 2m adaptive thresholding median filter (Scollar *et al.* 1990, 492). This latter operation reduces the distracting, localised, high-magnitude effects produced by surface iron objects. As with the earth resistance data, two grids to the east of the church were corrected for line displacement errors caused by the fault in the distance measuring sensor using the same shifting and interpolation procedures described above. To improve the visual intelligibility of the traceplot presented in Figure 5A, the data-set has had the magnitudes of extreme values truncated to ±30nT.

Results

Earth resistance

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

The earth resistance survey responded well at this site with a clear variation in response across the data-set. A high resistance linear anomaly [R1] runs NNW-SSE and then turns to the NE parallel with and adjacent to the current wall to the N of the graveyard, along the line of an earthwork recorded on the OS map. This linear anomaly may well be the foundations of a former wall and defines a change in response from very uniformly low resistance to the N of the church and a dense collection of high resistance anomalies extending ~40m around all other sides. In the area of lower response only a few slightly raised resistance anomalies [R2] have been recorded, some of which correlate with the position of a recorded earthwork running towards the spring.

A rectilinear high resistance anomaly [R3] adjoins part of [R1] immediately W of the churchyard. S of here numerous high resistance anomalies have been recorded which exhibit no obvious patterning but are suggestive of settlement activity. One area of high resistance [R4] correlates with a recorded earthwork, but two other nearby surface features are not mirrored in the resistance data. A linear high resistance anomaly [R5] runs ~NE-SW along the line of another recorded earthwork and also appears to form the W boundary of the area of dense anomalies.

To the E of the church a weak high resistance linear anomaly [R6] may be a continuation of [R1], but as the area between these two anomalies was not surveyable due to a fenced-off recent tree plantation it is not possible to be certain of any association between these two. S of here the pattern of dense anomalies continues including an annular response [R7] correlating with a recorded earthwork. Inside this a discrete high resistance response has been recorded. However, several other earthworks in this vicinity again have no apparent resistance anomalies. An area of lower background response containing only sporadic slightly raised anomalies has been recorded E of the high resistance area; there is no obvious linear boundary between the two zones.

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 low but varied, possibly due to instrument noise, with background levels >±1nT/m. Evidence for modern disturbance is limited, with only sporadic instances of isolated dipolar responses indicative of near-surface ferrous litter. However, a curvilinear anomaly [M1] in the S of the survey area is likely to be a modern service pipe. NE of here is a primarily negative linear anomaly [M2]. This is a very unusual response being predominantly strongly negative with few associated positive readings suggesting that it is unlikely to be caused by induced magnetisation in the ambient geomagnetic field. A possible interpretation of a drainage trench filled with a non-magnetic material is refuted by the strength of the average negative value, -20nT. This might be caused by a ferrous or ceramic pipe exhibiting (very unusually) a consistent downward directed remanent magnetisation or it could be due to the magnetic field produced by a DC power cable. Neither [M1] nor [M2] show a corresponding ditch-type response in the resistance survey.

Various raised linear magnetic anomalies were recorded across the survey area but none appear to correlate with the recorded earthworks or form clear arrangements, therefore interpretation in terms of archaeological origin is difficult. However, the raised linear response [M3] corresponds with part of [R1] indicating some magnetic material has been incorporated within this resistive feature. Additionally, some of the stronger linear anomalies [M4] recorded in the field E of the church are possibly suggestive of enclosures and correlate with areas between high resistance anomalies. This may mean that they are later features cut through the resistance anomalies, or that they are the fill of ditches; however, their relative magnitude, compared to other anomalies at the site suggests they are unlikely to be caused by a natural silting of older features. It is possible that, like [M2] to which they are parallel, these linear anomalies represent some sort of drainage channels established to deal with run off from the spring down the slope to the River Windrush.

Conclusion

The primary aim of the survey was to identify possible sources for the water causing rising damp in the walls of the church. A second goal was to identify any sub-surface archaeological remains that might be affected by any works to improve drainage around the church. Both geophysical techniques have detected clear anomalies in the ~80 m by 40 m area surveyed and whilst their interpretation is not clear-cut, they have provided evidence to help address these two questions:

Evidence for water drainage

One postulated cause for the damp in the church was a ruptured field drain in the area upslope to the N. However, neither survey technique has detected any linear anomaly that could be associated with a drainage feature in this area. Over other parts of the site the magnetometer has detected linear anomalies likely to represent drainage ditches and the earth resistance meter has detected anomalies typically caused by buried masonry. It seems unlikely that the geophysical instruments have simply failed to detect an extant drain and it is more probable that no field drain exists here. On consultation with the landowner, Mrs Buxton, the existing drainage maps for the field indicated that the only recorded land drains were some 100m W of the church.

What is notable is that apparent resistivities in the area immediately N of the church graveyard are uniformly very low, typically around 19.3 Ωm. This is under half the mean value of 40 Ωm recorded at the base of the slope (calculated excluding obvious high resistance anomalies) and previous experience suggests this latter value is typical of soils on similar sites surveyed in winter to mid-spring. Therefore, the much lower soil resistance values are likely to be due to high volumetric water content, probably caused by seepage from the spring observed in a fenced-off area 60m upslope from the church (indicated on Figure 6). At the time of the survey, much of the water issuing from the spring appeared to soak away into the field to the E. However, the earth resistance results suggest that some water might percolate directly down the slope towards the church, probably via the un-surveyed fenced-off corridor of land recently planted with trees which runs down the slope from the spring to the N corner of the graveyard wall.

It was not possible to survey the small strip of land within the graveyard immediately N of the church to confirm that the very low soil resistivities continued into this area but (an admittedly non-expert) visual inspection of the walls inside the church suggested the rising damp was most acute on the N wall, particularly towards its eastern end closest to the spring. This would be consistent with the above findings and suggests further investigation might be merited to determine whether the French drain surrounding the church needs to be supplemented by drainage works higher up the slope to divert the flow of water.

Archaeological evidence

The churchyard appears to be the focus for a complex of high resistance anomalies which surround it on the E, S and W sides and are consistent with those caused by buried stone features. Whilst it is possible that some of these are due to outcropping of the underlying geology or perhaps quarrying (e.g. those around [R4-5]) others appear more regular ([R3] and possibly [R7]). An interesting possibility, leant weight by the evidence for remains of a Roman mosaic within the church, is that it is built on the footings of an earlier masonry structure or structures. Unfortunately, no clear ground plan can be discerned from the earth resistance survey so it is impossible to suggest whether the putative remains may be medieval or Roman in origin. Specifically, no anomalies indicative of a Roman bathhouse are readily apparent although [R7] is intriguing due to its position and unusual ovoid/hexagonal shape.

It is also of interest to note that the earth resistance anomalies have only a weak correlation with the surface topography suggesting that the latter might relate to more recent activity. Furthermore, the magnetometer survey has responded to very few of the anomalies detected by the earth resistance survey and has mainly identified modern services and linear ditch-type anomalies running down the slope which thus probably represent past drainage features.

Surveyed by: P Linford
L Martin

Date of survey: 23-25/4/2007

Reported by: L Martin
P Linford

Date of report: 11/6/2007

Geophysics Team,
English Heritage.

List of enclosed figures.

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

Figure 2 Equal area greyscale plot of filtered combined earth resistance data over base OS map (1:1000).

Figure 3 Traceplot and equal area greyscale plots of raw and filtered earth resistance data (1:1000).

Figure 4 Linear greyscale plot of magnetometer data over base OS map (1:1000).

Figure 5 Traceplot and linear greyscale plot of magnetometer data (1:1000).

Figure 6 Graphical summary of significant earth resistance anomalies over base OS map (1:1000).

Figure 7 Graphical summary of significant magnetometer anomalies over base OS map (1:1000).

Annex 1: Notes on standard procedures

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

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

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

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

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

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

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

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

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

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Figure 1

ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE
Location of geophysical survey, April 2007.

SP2712

Magnetometer survey

Earth resistance survey

0 90m

1:2500

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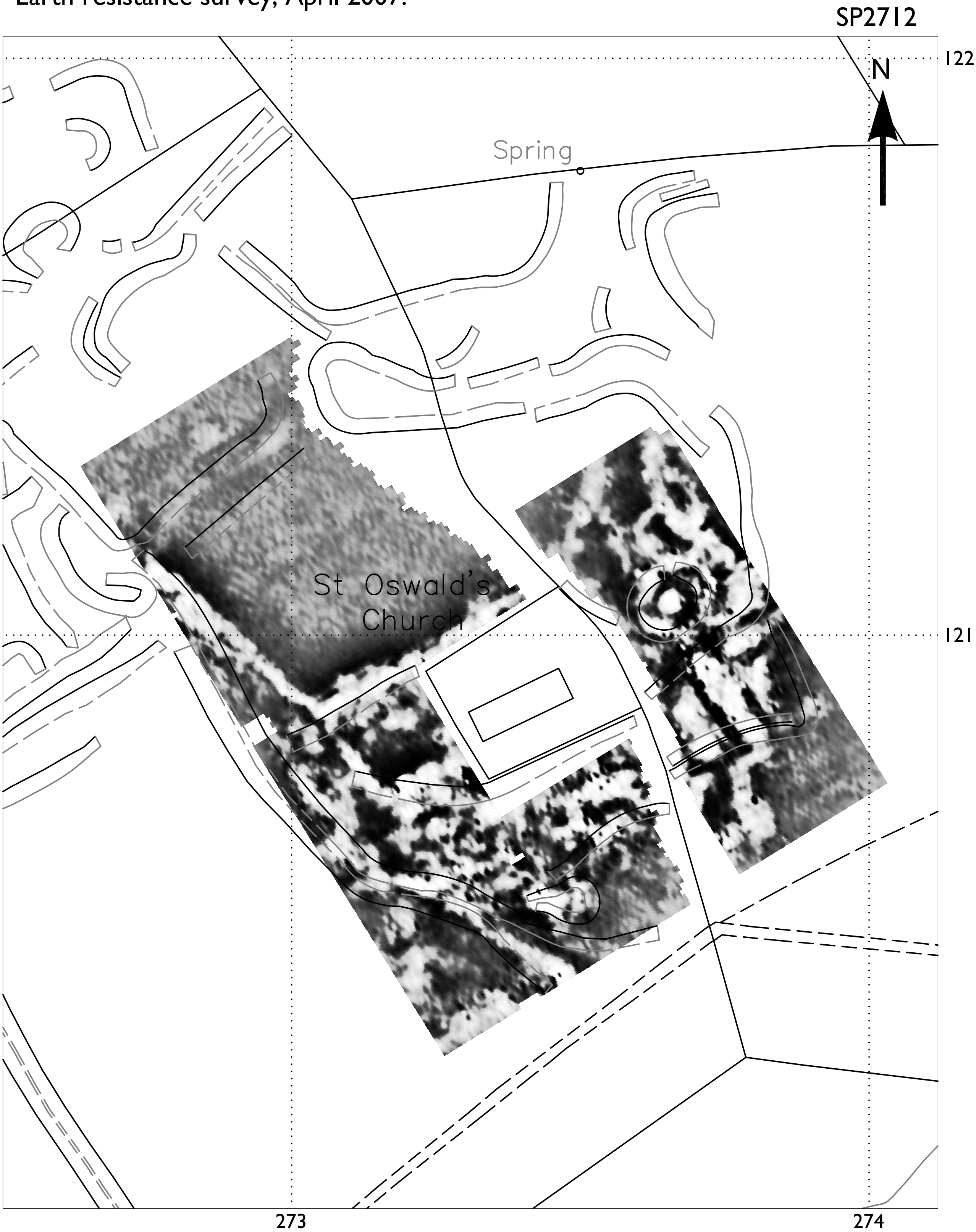
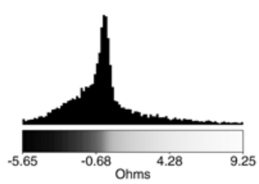
Figure 2

ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE

Earth resistance survey, April 2007.





0 30m

1:1000

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ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE
Earth resistance Survey, April 2007

Figure 3

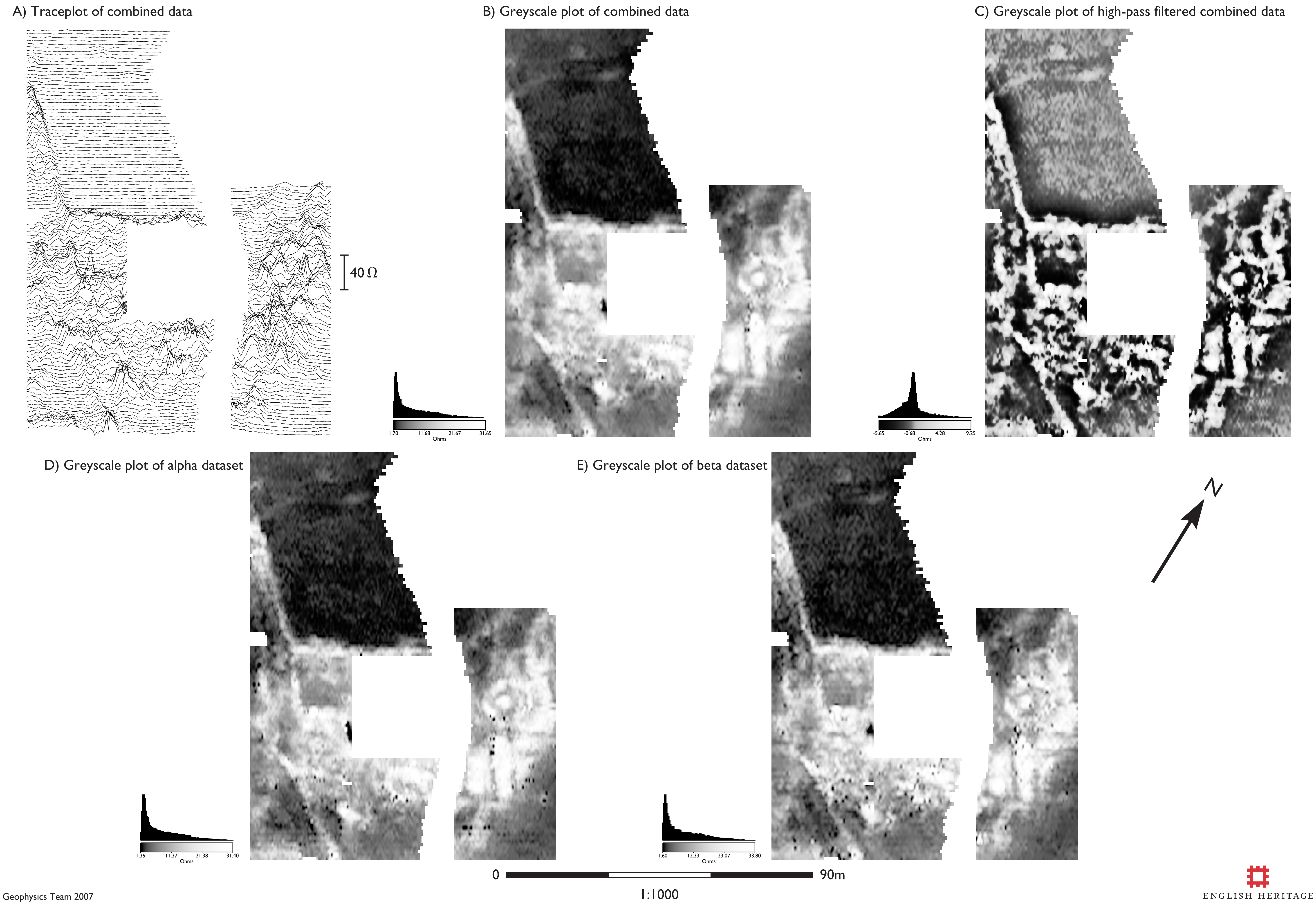

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Figure 4

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Magnetometer survey, April 2007.

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Figure 5

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Magnetometer Survey, April 2007

A) Traceplot of raw data

B) Linear greyscale plot of raw data

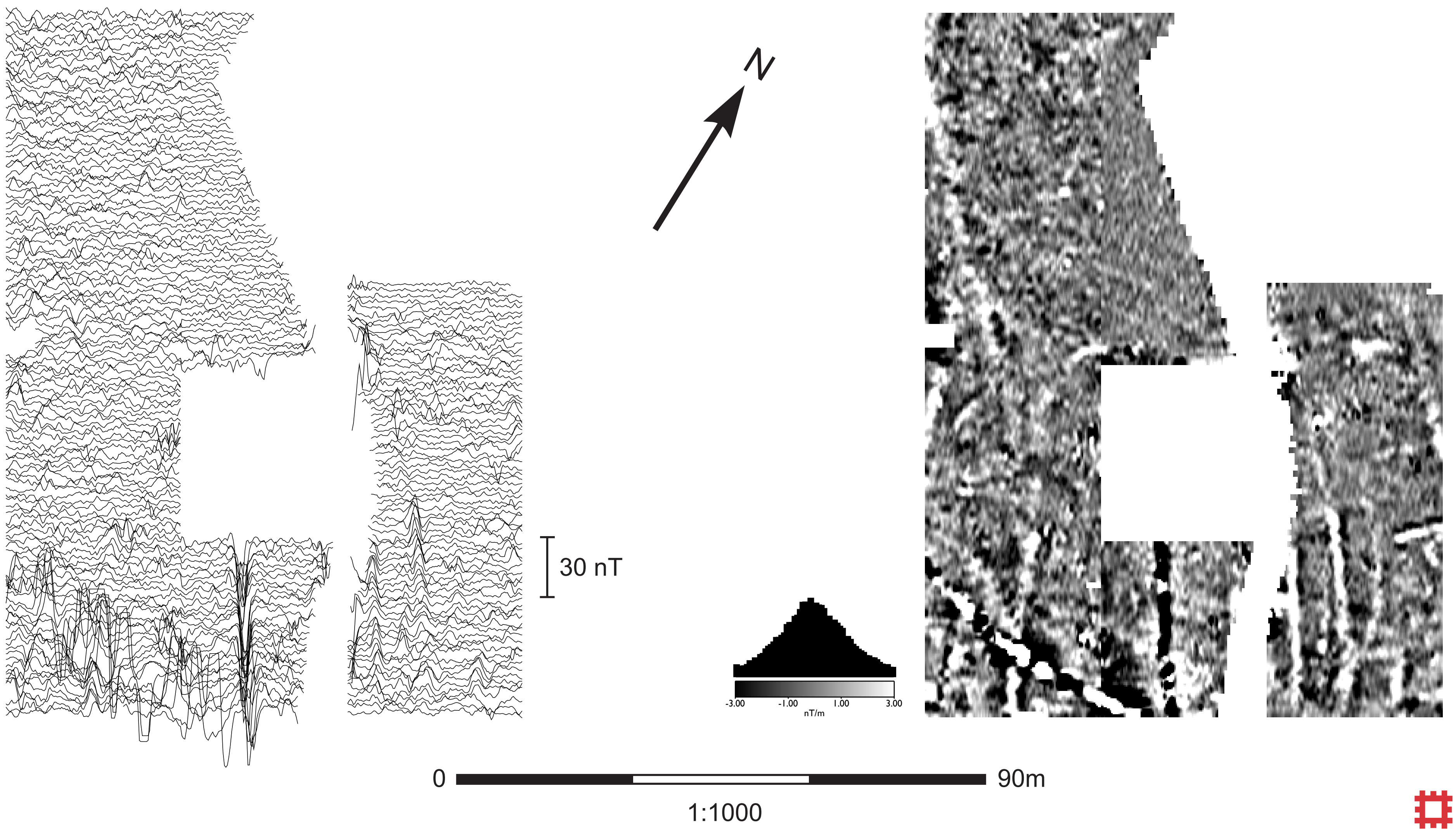

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Figure 6

ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE
Graphical summary of significant resistance anomalies, April 2007.

High resistance anomaly probably due to buried stone

Very low resistance anomaly

Weak high resistance anomaly

0 30m
1:1000

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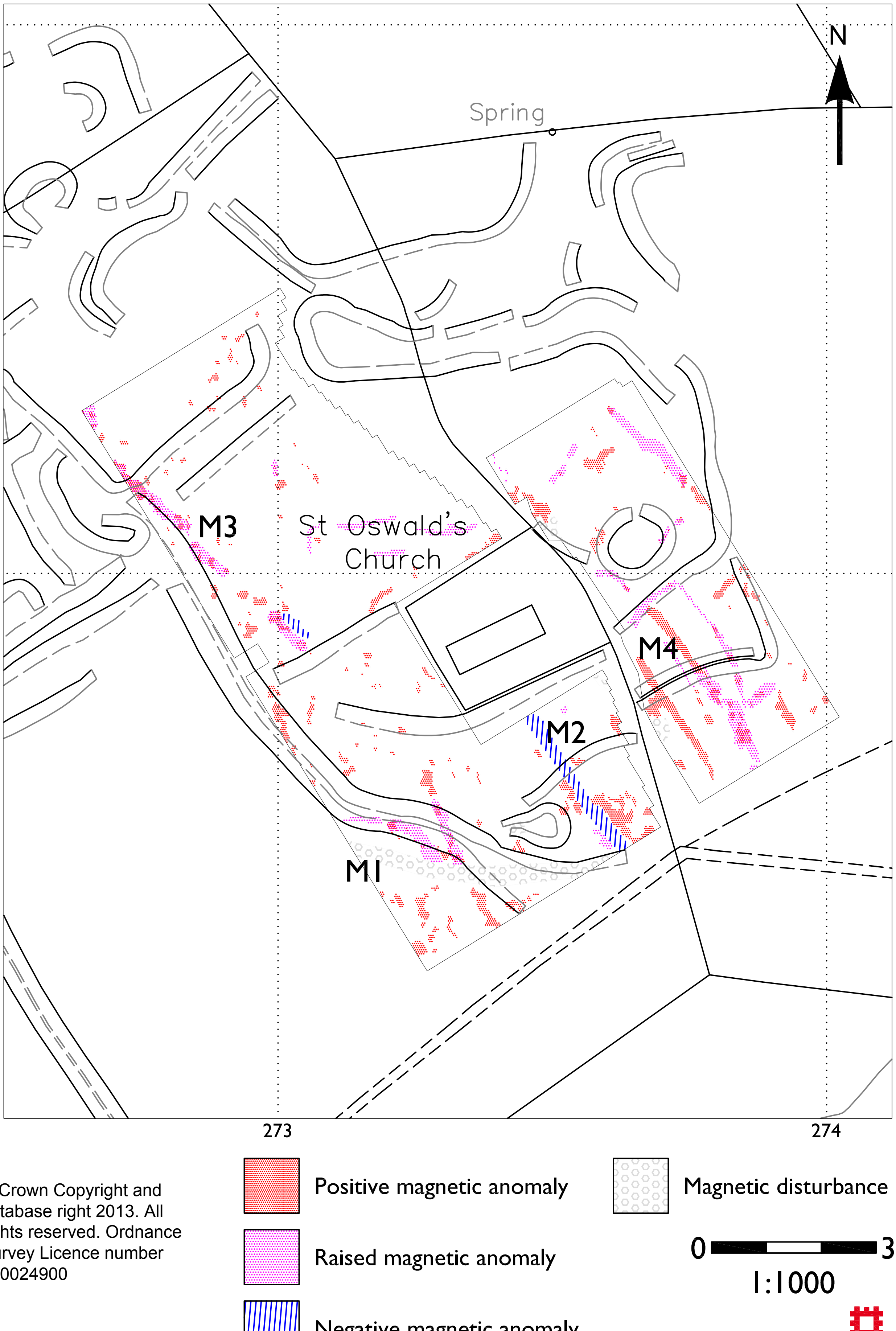
Figure 7

ST OSWALD'S CHURCH, WIDFORD, OXFORDSHIRE

Graphical summary of significant magnetic anomalies, April 2007.



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