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GREYFRIARS, DUNWICH, SUFFOLK, REPORT ON GEOPHYSICAL SURVEY, MARCH/APRIL 1994.

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Summary

Coastal erosion at the village of Dunwich in Suffolk has led to the precinct of the Franciscan priory of Greyfriars being threatened with collapse into the sea. For this reason a geophysical survey of the site was requested to help assess the quality of the archaeological resource under threat and develop a strategy for excavation. Whilst conditions were not ideal for detecting buried masonry, many anomalies were detected that were likely to have been caused by the buried remains of medieval structures. Whilst the area covered by these anomalies reveals the priory to have been a substantial establishment, it was not possible to obtain a clear plan of the buildings.

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Introduction

Dunwich in Suffolk was a thriving seaport in the medieval era when it was a large town boasting three monastic establishments including the Franciscan Greyfriars Priory (TM 478 704). However, the siting of the town, on unconsolidated shelly micaceous sand cliffs, has made it one of the most dramatic victims of coastal erosion on the east coast of England. Almost the entire town has now fallen into the sea leaving only a small village around what was the western fringe of the original town.

Violent storms in recent years have increased the rate of cliff erosion to the point where the eastern edge of the precinct of Greyfriars Priory is in imminent danger of being lost to the sea, the cliff edge now being but a few feet away. The Suffolk Shoreline Management Plan suggests that the sea will have reached the west wall of the friary precinct in little over 70 years, resulting in the loss of all major structures within its interior. For this reason, a geophysical survey was requested by Suffolk County Council to complement the earthwork survey being carried out by the Royal Commission on the Historic Monuments of England (RCHME). These two surveys were intended to inform later excavation at the site to recover as much evidence about the friary as possible before it is lost to the sea.

Geologically, Greyfriars is situated on Coralline Crag which lies on top of the Upper Cretaceous Chalk (British Geological Survey, 1996). However, this solid geology is overlain with a considerable thickness of drift (up to 60m) which thus effectively determines the geophysical characteristics of the site. To the north of the standing ruins this consists of mainly fine grained buff to brown locally shelly micaceous sands with local rounded flint gravels. To the south this changes to Lowestoft Till which is mainly a chalky, pebbly, sandy clay. The soil association is NEWPORT 4 (511g) which is described as a deep well drained sandy soil (Soil Survey of England and Wales 1983). The well drained sandy soil might be expected to be electrically resistive thus buried masonry remains, which are also electrically resistive, may exhibit only a slight contrast making their detection difficult.

Method

Field Procedure

A grid of forty-four 30 metre squares was established in the area enclosed by the priory wall. The location of this grid was determined by tape measurement to the precinct walls and it is depicted in Figure 1. Note that grid square 38 was extended over the eastern boundary of the priory site onto the cliff headland to test whether remains could be detected beyond the priory in this direction. This particular square was chosen as trees had recently been cleared from the cliff top here.

All the squares were surveyed using a Geoscan RM15 earth resistance meter with a mobile electrode separation of 0.5m. Readings were take at 1m by 1m sample intervals according to the technique outlined in Annex 1. Most of squares 9 and 10 as well as all of square 16 were then resurveyed using an Geonics EM38 electromagnetic instrument, as depicted in Figure 1. The electromagnetic survey was repeated twice, first with the instrument in horizontal coil orientation to detect near surface anomalies, then in vertical coil orientation to detect deeper anomalies. In both cases the quadrature (conductivity) phase was logged, so the results should be comparable with the resistivity survey of the same area.

Data Processing and Presentation

The unprocessed resistivity measurements were treated with an adaptive thresholding median filter to replace measurements of extreme magnitude, caused by poor electrode contact, with a local median calculated over a 1m by 1m rectangular window. The results after this operation are depicted at 1:1000 scale as a trace plot in Figure 2 and as a linear greyscale plot in Figure 3. Figure 4 depicts the same survey as a series of shaded relief plots at 1:3000 scale. This technique, explained in the figure, often helps to emphasise linear features in earth resistance surveys, where they can be obscured by regional background effects.

The results of the electromagnetic survey are depicted unprocessed in Figure 6, parts a) and b) and are compared with the earth resistance survey of the same area in part c).

Results

The earth resistance survey

The anomalies described in this section are all indicated in Figure 5 which provides an interpretation plan for the earth resistance results at 1:1000 scale. Numbers in bold type below (eg **[1]**) refer to numbered features in this figure.

It is immediately clear from Figure 3 that there has been significant modern intervention on the site and this has hampered the identification of archaeological anomalies. A number of very high resistance areas have been indicated in Figure 5 distributed across the site and it is likely that these represent either the remains of military installations dating from the second world war, when the site was used as an anti-aircraft battery, or areas of particularly dry soil. Anomalies caused by the fences enclosing the path to the standing remains have also been marked, as has the line of a trench which the electromagnetic survey indicates carries a highly conductive element such as a metal cable (see below). This latter is probably associated with the military presence on the site.

Despite the modern interference, archaeological anomalies can be discerned. The line of Pales Dyke is visible running roughly north-south inside the eastern boundary of the priory. To the north of the standing remains of the priory a number of strong, linear, high resistance anomalies have been detected which are likely to be caused by the masonry footings of further structures associated with the priory. A network of fainter high resistance linear anomalies have also been detected, predominantly to the east of those just described. Owing to their alignment it is likely that they are also associated with the priory buildings. They probably represent the remains of footings that have been largely robbed out, the small amount of surviving masonry contrasting poorly with the well drained, resistive soil.

Two *caveats* should be noted with respect to the foregoing. The anomalies near **[1]** are obscured by a near surface high resistance area caused by compaction of the soil by the feet of visitors to the monument; this makes their interpretation tentative. Further, the anomalies at **[2]** are close to the position where a later building is marked on early maps (Gardner 1754) of the priory ruins, so these remains may post date the medieval buildings.

Three parallel ditch anomalies have been indicated at **[3]**. Although in approximately the same alignment as the east-west priory walls, it is not clear if they are the remains of a medieval structure or of more recent construction dating from wartime military or market gardening usage of the site. West of these in the area around **[4]** parallel linear anomalies suggesting ridge and furrow can be discerned. Some of the strongest of these have been marked near the southern wall of the precinct.

Finally, at **[5]** some linear, low resistance anomalies have been marked. These are close to the position where a building was marked on early maps (*ibid.*) of the site, suggesting that its walls may have been subsequently robbed out. Unfortunately no significant anomalies were noted to the east of the precinct wall in square 38 on the cliff headland.

The electromagnetic survey

The results of this survey are depicted in Figure 6 where they are also compared with the corresponding part of the earth resistance survey. Part d) of this figure presents an interpretation diagram of the anomalies described in this section.

As the EM38 measures electrical conductivity the results should be inversely correlated with the earth resistance survey. It is clear from Figure 6 that this is broadly true, although neither coil orientation has detected the same level of detail as the earth resistance survey. The instrument effectively averages the conductivity over a larger volume of the subsurface than the resistance meter which perhaps explains the comparative lack of fine resolution. The vertical coil orientation is the clearer of the two electromagnetic surveys, suggesting that the remains are not confined to the immediate subsurface.

The electromagnetic survey has been of value in detecting the highly conductive nature of the diagonal linear anomaly in the north west corner of the surveyed area and thus identifying it as a probable cable (or pipe?) trench.

Conclusions

Despite the dry conditions at the time of the survey and the well drained sandy soil, it has been possible to detect anomalies likely to be caused by surviving wall footings of the medieval friary. Nevertheless, no clear plan of the Franciscan priory can be discerned, only fragmentary remains. Thus it is possible to identify the general area in which most of the medieval structures must have been situated but it is not possible to suggest a layout for the priory as a whole from the geophysical evidence. It is possible that the stone has been robbed from many of the footings leaving little evidence for the earth resistance survey to detect. However, the electrical contrast between buried masonry and the dry sandy soil would not be expected to be strong, so this is must remain a conjecture.

A number of other anomalies have been identified in the survey that probably relate to use of the site after the priory was dissolved. Indeed some were possibly caused by anti aircraft installations constructed during the last war. The ridge and furrow that is visible in the southern part of the site may also relate to recent use of this area for market gardening although a medieval explanation cannot be ruled out.

Surveyed by:	N. Linford P. Linford	Dates: 28th March-9th April 1994
Report by:	P. Linford	Date: 12th June 2000

References

Gardner, T., 1754, An Historical Account of Dunwich, Blithburgh, Southwold, London.

Geological Survey of Great Britain, 1996,
1:50,000 Solid and Drift Edition, Sheet 191, Saxmundham.

Soil Survey of England and Wales, 1983,
(Sheet 4) Legend for the 1:250,000 Soil Map of England and Wales.

Enclosed Figures and plans

Annex 1: Notes on standard procedures

1) **Resistivity Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all aligned parallel to one pair of the 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 square edge. Readings are taken along each traverse at 1 metre intervals, the first and last readings being 0.5 metres from the nearest 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 resistivity 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 Ancient Monuments Laboratory using desktop workstations.

2) **Magnetometer Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all parallel to that pair of square edges most closely aligned with the direction of magnetic North. 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 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 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. However, the magnetometer is always kept facing in the same direction, regardless of the direction of travel, to minimise heading error.

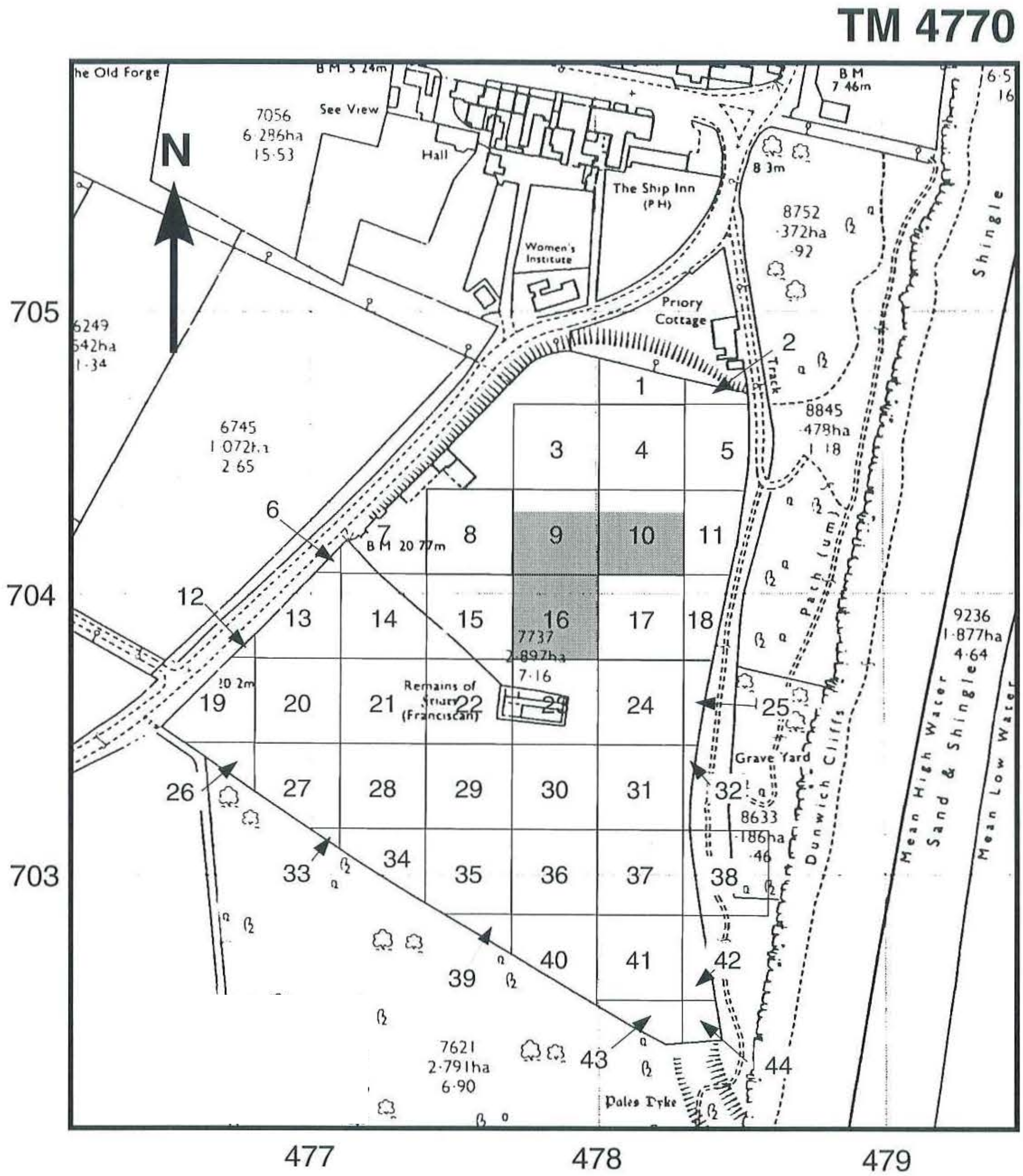
   Unless otherwise stated the measurements are made with a Geoscan FM36 fluxgate gradiometer which incorporates two vertically aligned fluxgates, one situated 0.5 metres above the other; the bottom fluxgate is carried at a height of approximately 0.2 metres above the ground surface. The FM36 incorporates 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 Ancient Monuments Laboratory 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) Greyfriars, Dunwich, Suffolk, March/April 1994: Location of geophysical survey.



Grid covered by resistivity survey.

Area also covered by EM38 survey.

0 90m

1:2500

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Figure 2) Greyfriars, Dunwich, Suffolk, March/April 1994: Trace plot of resistivity survey.

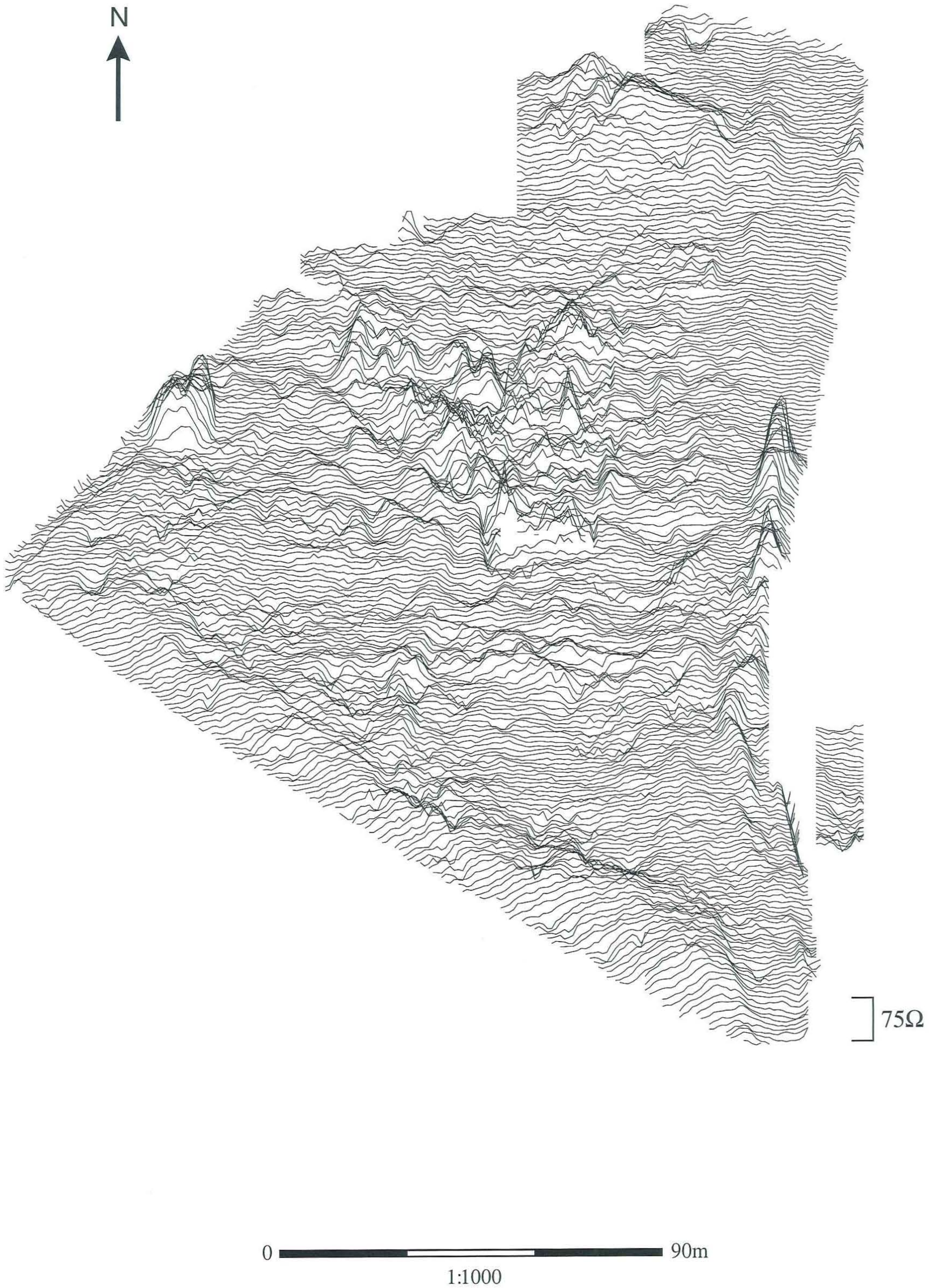

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Figure 3) Greyfriars, Dunwich, Suffolk, March/April 1994: Linear Greyscale plot of resistivity survey.

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Figure 4) Greyfriars, Dunwich, Suffolk, March/April 1994: Shaded relief plots of resistivity survey to enhance linear edges.

These plots were generated by equating the resistivity measurements with vertical relief, the higher the resistivity value the higher the assumed elevation at that point. This topographic surface can then be shaded as if illuminated by a low inclination light source which can be positioned at various azimuthal angles. Eight such shaded relief plots of the 0.5m mobile electrode separation survey are presented with azimuthal angles ranging from 0°to 360° in 45° increments. In each case the position of the plot relative to the sun at the centre of the page indicates the angle of illumination (ie: the topmost plot was illuminated from the south).

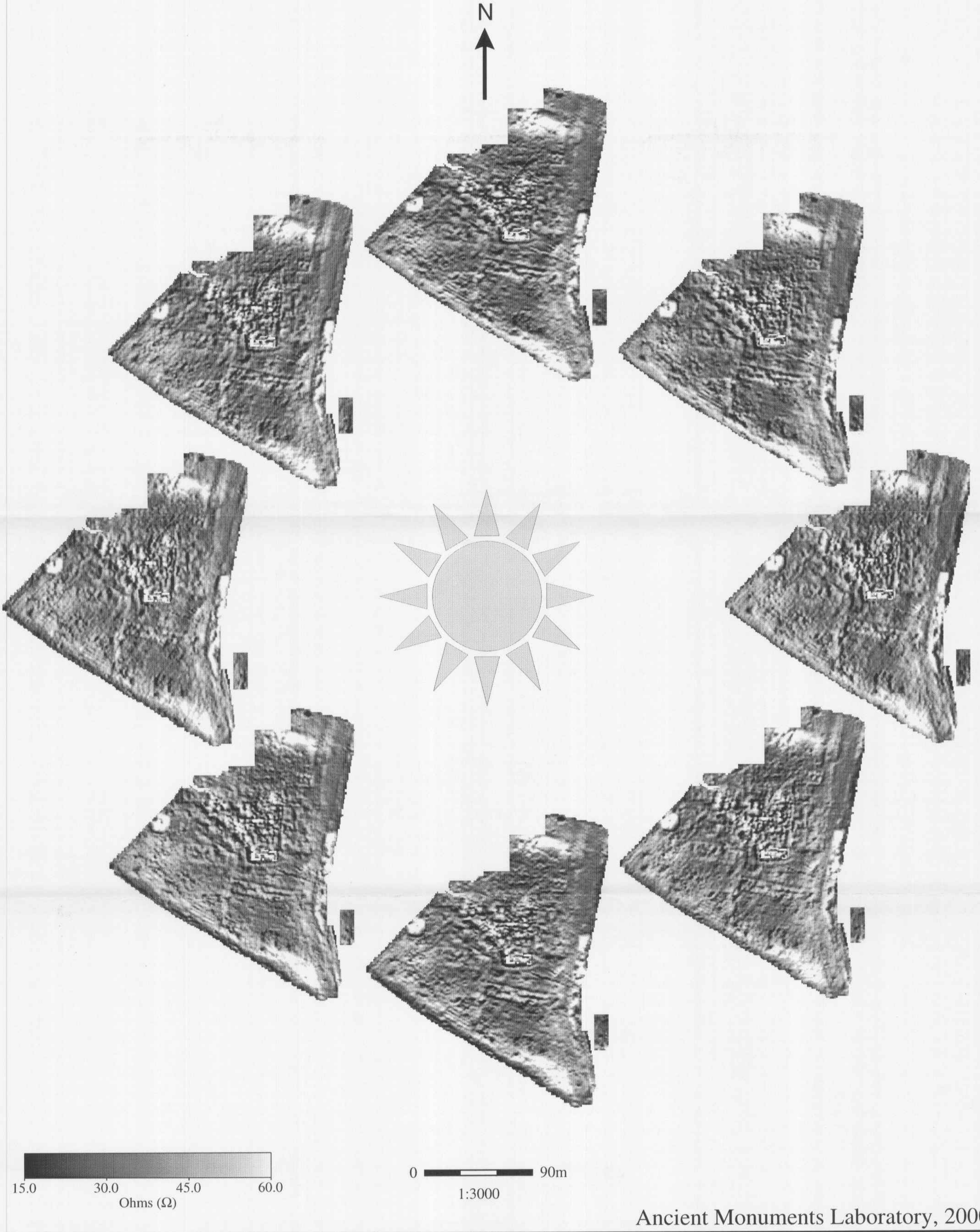

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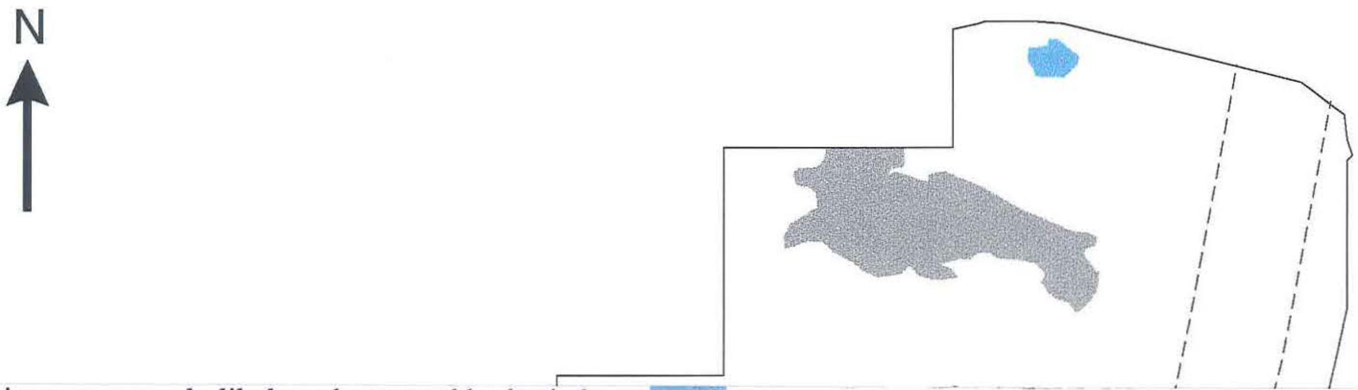
Figure 5) Greyfriars, Dunwich, Suffolk, March/April 1994: Interpretation plan of resistivity survey.



- High resistance anomaly likely to be caused by buried masonry.
- High resistance anomaly tentatively interpreted as being caused by buried masonry.
- High resistance anomaly possibly caused by buried rubble spread.
- High resistance anomaly possibly caused by modern occupation or variations in soil drainage.
- Low resistance anomaly of possible archaeological significance
- Low resistance anomaly tentatively ascribed archaeological significance.
- Low resistance, linear anomaly caused by cable trench or wire fence.
- Postulated edges of Pales Dyke.
- Strong "ridge and furrow" effect.
- Standing remains of priory.
- ① Numbered location referred to in text.

0 — 90m

1:1000

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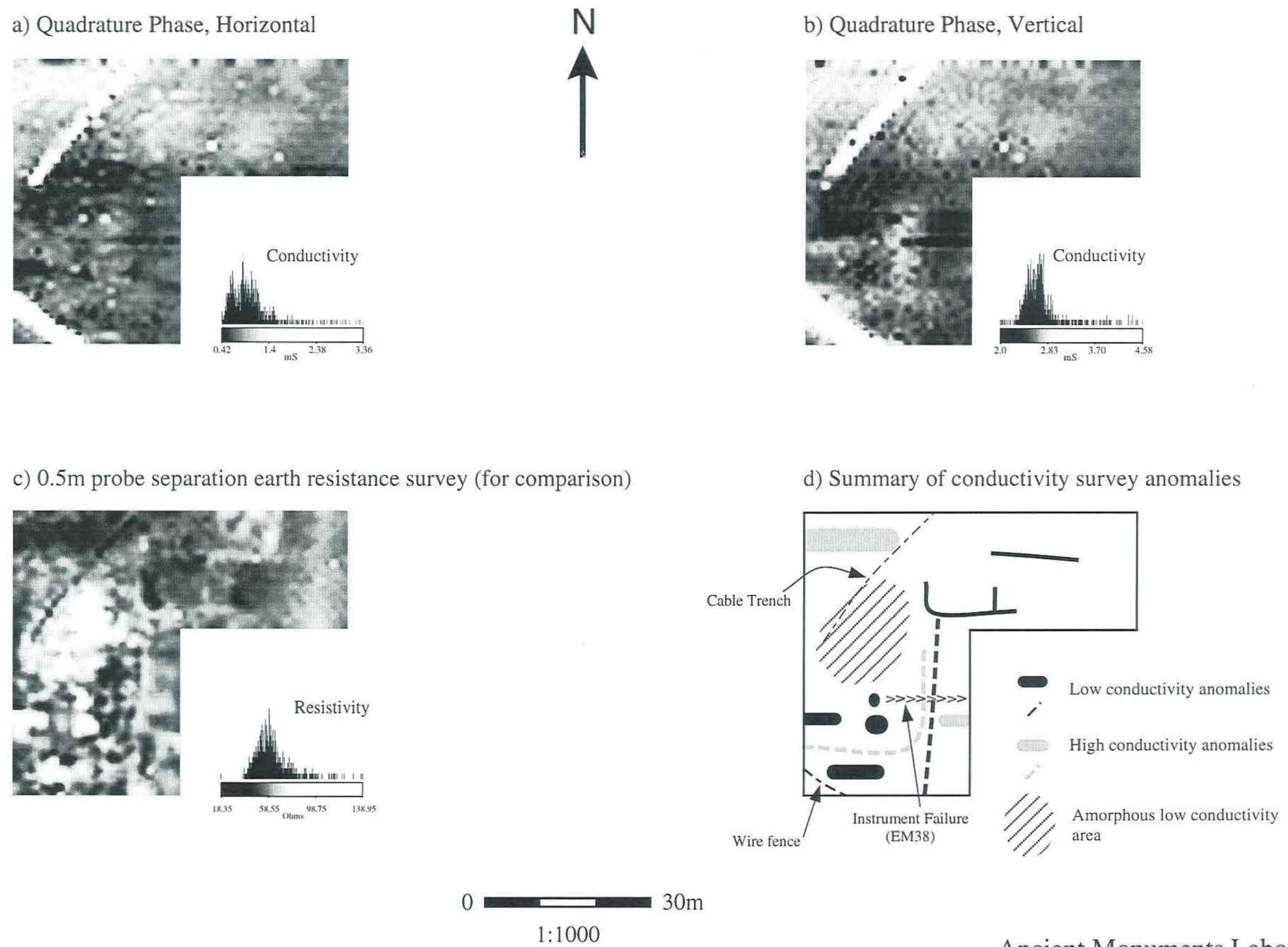
Figure 6) Greyfriars, Dunwich, Suffolk, March/April 1994: Comparison of quadrature phase (conductivity) EM38 surveys with resistivity survey.



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