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# BISHOP'S PALACE GARDEN, PETERBOROUGH CATHEDRAL, CAMBS REPORT ON RESISTIVITY SURVEY, SEPTEMBER 1996

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Andrew Payne

**Summary**

A resistivity survey was carried out over the south lawn of the Bishop's Garden in the grounds of Peterborough Cathedral in an attempt to resolve the course of the western boundary of the Anglo-Saxon *burh*. Even over the small 60x20m area investigated, there was considerable variation in the measured resistance and a number of anomalies possibly indicative of artificial structures were located. Of these a distinct high resistance linear anomaly is in a position and orientation coinciding with the expected course of the western section of the burghal defences.

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# Peterborough Cathedral, Bishop's Garden, Cambridgeshire

## Report on Geophysical Survey, September 1996

### INTRODUCTION

In September 1996 the Ancient Monuments Laboratory (AML) carried out a small geophysical survey in the grounds of the Bishop's residence at Peterborough cathedral (SAM Cambs 140) at NGR TL 193/985. The survey was requested by Don Mackreth for the purpose of locating the south-western defences of the Anglo Saxon *burh*, while the Bishop's Palace was temporarily untenanted (thus avoiding any inconvenience to the occupants). According to documentary sources, the south-west corner of the *burh* should lie within a zone 20m wide to the west of the main west front of the cathedral (Mackreth *pers comm*). On this premise, the course of the boundary (assuming remains of it still survive) should run under what is now the south lawn of the Bishop's Garden. A resistivity survey was therefore carried out over the lawn area (see Figure 1) in an attempt to determine if any broad linear anomalies were present on a north-south alignment. The site is in an urban setting and therefore the local geology is not mapped at a detailed scale, but as far as is ascertainable from the larger scale 1:625000 geology map (BGS 1979), the Cathedral area is situated on riverine deposits over middle to upper Jurassic limestone and clays.

Sections of the *burh* defences have previously been identfied in excavation trenches in various parts of the cathedral precincts. Excavations north of the Deanery Garden revealed that the boundary consisted of a clay rampart into which a wall had been inserted with an external ditch. In some cases the only trace left of the wall was a robber trench (Mackreth *pers comm*). In addition to the excavation record, previous geophysical investigations were conducted by the AML in 1987 in an attempt to locate the northern boundary of the *burh* in the Deanery Garden of the cathedral (Shiel and Haddon-Reece 1988). The latter survey consisted of a single traverse of twin electrode resistivity measurements supplemented by auger borings. The survey was apparently successful in tracing the eastward continuation of the northern boundary of the *burh* from a point where it had earlier been recorded in two excavated trenches immediately north of the northern boundary of the Deanery Garden (Mackreth *pers comm*). The 1987 AML survey followed a series of initial resistivity tests (again using separate traverses) but with different probe configurations (Wenner and Double-Dipole) undertaken by Adrian Challands. The results of both geophysical surveys indicated the generally disturbed nature of the site and, in addition to the high resistance anomaly apparently on the line of the northern *burh* wall, other substantial high and low resistance anomalies were recorded suggesting the presence of further unexplained buried features in the vicinity of the *burh* wall and ditch.

### METHOD

The survey reported on here covered the majority of the southern part of the Bishop's Garden excluding those areas planted with trees. A grid was set out on the south lawn south of, and parallel with, the east-west gravel path that divides the lawn area in two (Figure 1). The survey area was limited to two adjacent incomplete 30x30m grid squares with the long (60m) axis of the grid orientated east-west. Instrument readings were taken on successive 30m traverses spaced 1m apart aligned perpendicular to the north-south grid lines.

Twin Electrode resistivity measurement was carried out with a Geoscan Research RM15 meter, PA5 multiple probe array and MPX15 multiplexer. Readings were taken at 0.5m x 1.0m intervals using a 0.5m mobile probe spacing; and an additional set of readings were taken using a mobile probe spacing of 1.0m at intervals of 1.0m x 1.0m. to give a greater depth of current penetration (approx 1.5m).

The results are presented as a series of greyscale and X-Y traceplots in Figure 2.

## RESULTS

Despite the limited extent of the survey coverage (20x60m), there is a considerable range of resistivity variation in the area examined. Readings are generally higher towards the eastern, western and south-western extremities of the area with an abrupt fall in resistance towards the center of the survey (marked A on plot 2(a) of Figure 2). Because these patterns of broader resistivity variation probably extend beyond the confines of the survey, their significance is hard to assess. They may be a product of the local fluvial geology or a history of garden landuse in the area. The generally disturbed nature of the ground suggested by the variability in the resistance is consistent with the response encountered by the earlier resistivity survey in the Deanery Garden in 1987 (Shiel and Haddon-Reece 1988).

Perhaps of greater potential archaeological interest is a 2 metre wide linear high resistance anomaly (20-30 Ohms above background readings) running on a north-south alignment through the central zone of predominantly lower resistance (marked B on plots 2(a) and (b) of Figure 2). Anomaly B coincides with a slight scarp visible on the ground surface and is in a position that concords well with the expected line of the western *burh* defences. Projecting the course of the anomaly northwards places it close to its expected position with relation to the west front of the cathedral (see Figure 3). The validity of this interpretation will however require confirmation by excavation.

The magnitude of anomaly B varies in strength and it therefore does not appear as a continuous alignment in the greyscale plots of Figure 2. However, the linear nature of anomaly B is clear in the equivalent traceplot representations of the data (Figure 2b, 2d). The variable anomaly strength may indicate the presence of a wall that has been robbed or partially demolished and the low resistance to either side (A) may be significant in this respect – possibly indicating trenches dug down to rob the foundations. Alternatively, the low resistance could indicate the more water retentive clay construction material of the rampart into which the wall was inserted (known from excavation at other locations) or boundary ditches associated with the *burh* defences. Anomaly B is still well defined in the 1.0m probe spacing data-set suggesting that the source of the anomaly is not a superficial garden feature.

In addition to anomaly B, a number of other potentially significant resistivity anomalies are present. These include a rectilinear grouping of high resistance anomalies at (C) on a distinctly different alignment (SW-NE) to linear anomaly (B). It is possible that this pattern relates to a structure with dimensions of approximately 14x10m, but because the survey could not be expanded further south due to dense tree cover, its full southward extent is unclear. There are a number of other localised but quite pronounced high resistance anomalies within this area and immediately outside it to the north.

An east-west low resistance linear anomaly (D) parallel to the present gravel path could represent a drainage feature of relatively recent origin or – perhaps of greater archaeological significance – a filled-in former ditch.

## CONCLUSIONS

Reliable interpretation of 'key-hole' geophysical surveys such as this, located in garden areas around ecclesiastical buildings, is often problematic. Such sites generally have a long history of ground disturbance resulting in a palimpsest of anomalies which are difficult to interpret in the absence of additional information. The survey in the grounds of Peterborough Cathedral is no exception to these problems, but the presence of a linear high resistance anomaly in the correct orientation and position to represent the remains of the western burghal defences is an encouraging result. Some caution must nevertheless be exercised in attaching too much significance to this result without the support of excavation.

Surveyed by : Andrew Payne 13th September 1996
Sharon Strong

Reported by : Andrew Payne 4th August 2000

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### References

British Geological Survey, 1979 Geological Survey Ten Mile Map, South Sheet, Third Edition (Solid), Scale 1:625 000.

Shiel, D, and Haddon-Reece, D, 1988 Geophysical survey at Peterborough Deanery Garden, *Ancient Monuments Reports Series*, **20/88**.

### List of enclosed figures

Figure 1 Location of survey (scale 1 : 1250).

Figure 2 Greyscale and X-Y traceplots of raw and enhanced 0.5m and 1.0m mobile probe spacing resistivity data.

Figure 3 Greyscale plot of raw 0.5m probe spacing resistivity data in geographical setting showing estimated northward projection of Anomaly B (the possible eastern boundary of the *burh*). 1 : 1250 scale.

**Note 1 : Resistivity survey**

The ability of a soil mass to conduct electricity depends on the presence of salts and humic acids, which dissolve in water into +ve and -ve ions, allowing electrolytic current flow through the soil. The resistance of soils to the passage of an electric current differs according to the concentration of salts and acids in solution they contain and their relative dampness. The latter is determined by the granulometric composition of the soil and climatic factors. The grain size composition of soils determines their porosity and water holding capacity and therefore soils of varying grain size absorb and retain water at different rates; for example coarse well drained soils such as sands and gravels will generally have a higher resistance compared to close-textured water retaining soils such as clays. The development of localised changes in moisture content in archaeological features is similarly due to differences in the grain size of features and surrounding deposits. Moisture tends to collect in fine-grained ditch and pit silting resulting in lower resistivity particularly in cases where the features are cut into rocky subsoil. In contrast non-porous stone wall footings will not absorb water and will therefore be much dryer than the damper soil around them. Buried stonework will thus generally give rise to high resistance anomalies.

These variations are detectable by resistivity survey which involves the measurement of sub-surface changes in the resistance of the soil to the passage of an electric current injected through the surface of the ground using probes or electrodes. One pair of electrodes is used to measure the potential gradient set up by the passage of current between two others, enabling the resistance to be derived from Ohm's Law. Variations in the measured resistance reflect the presence of buried archaeological structures such as walls and ditches. Although resistivity is slower than other archaeological prospecting techniques (such as magnetometer survey) due to the requirement to place electrodes in the ground, it is the most suitable and favoured technique for location of buried stonework.

Unless otherwise stated in the main report text, resistivity measurements are made with a Geoscan RM15 constant current earth resistance meter incorporating a built in data-logger, using the Twin Electrode probe configuration (or array) normally with a 0.5m mobile probe separation. The mobile probe separation conditions the depth of investigation, and therefore in circumstances where deeper buried remains are suspected a 1.0m probe spacing can be used. The wider probe separation gives deeper ground penetration of the current flowing into the soil allowing a greater depth of investigation (in the region of 1.5 - 2.0m compared to 0.75 - 1.0m for a 0.5m probe separation).

The Twin Electrode array is particularly well suited to archaeological targets and measures the earth resistance of the volume of ground immediately below the mobile current-potential probes with the addition of a constant, and thus negligable contribution from the remote current-potential electrodes. The Twin Electrode system is a variant of the Wenner array, whereby one current-potential pair of electrodes (C1P1 - the "mobile" probes) - mounted ridgidly on a movable frame - are separated from the other pair (C2P2 - the "remote" probes) by a factor of 30a when a is the spacing between C1 and P1. At this distance, the contribution from C2P2 is insignificant in relation to changes in resistance which are measured by moving the C1P1 electrode pair. This enables two electrodes (the remote C2P2 pair) to remain stationary while the other two mobile probes (C1P1) are moved over the survey grid from one measuring station to the next, enabling a more rapid rate of survey than traditional arrangements (eg. Wenner, Double Dipole arrays) where both sets of electrodes have to be moved each time a reading is made. The method takes advantage of the steep potential gradient and consequent enhanced sensitivity between each current/potential pair. By minimising the movement of electrodes the method combines ease of operation with speed of data aquisition and it is therefore particularly well adapted to carrying out large area surveys of archaeological sites for mapping purposes. The Twin Electrode array also has the advantage of clarity/unambiguity of response over other electrode arrays.

It is generally necessary to relocate the remote (C2P2) probes to a new position during the course of a survey and also to normalise for differences between the two locations (because of differences in the depth of subsoil for instance) by altering the spacing between C2 and P2, so that P2 is measuring the same potential as it previously was. Such adjustments alter the geometry factor of the array, and in combination with inhomogeneity of the ground beneath the fixed electrodes and the inclusion in the readings of deep geology, produces resistance readings (measured in Ohms or Ω) of quite arbitrary absolute values which cannot be converted to true apparent resistivity values (measured in units of Ohm-m or Ω-m). Such relative changes in resistance are perfectly adequate for the purpose of searching for anomalies, but mean that Twin Probe readings can only be regarded as comparative within the bounds of a single survey.

Figure 1

# BISHOP'S PALACE GARDEN, PETERBOROUGH CATHEDRAL

## Location of Resistivity Survey, 1996

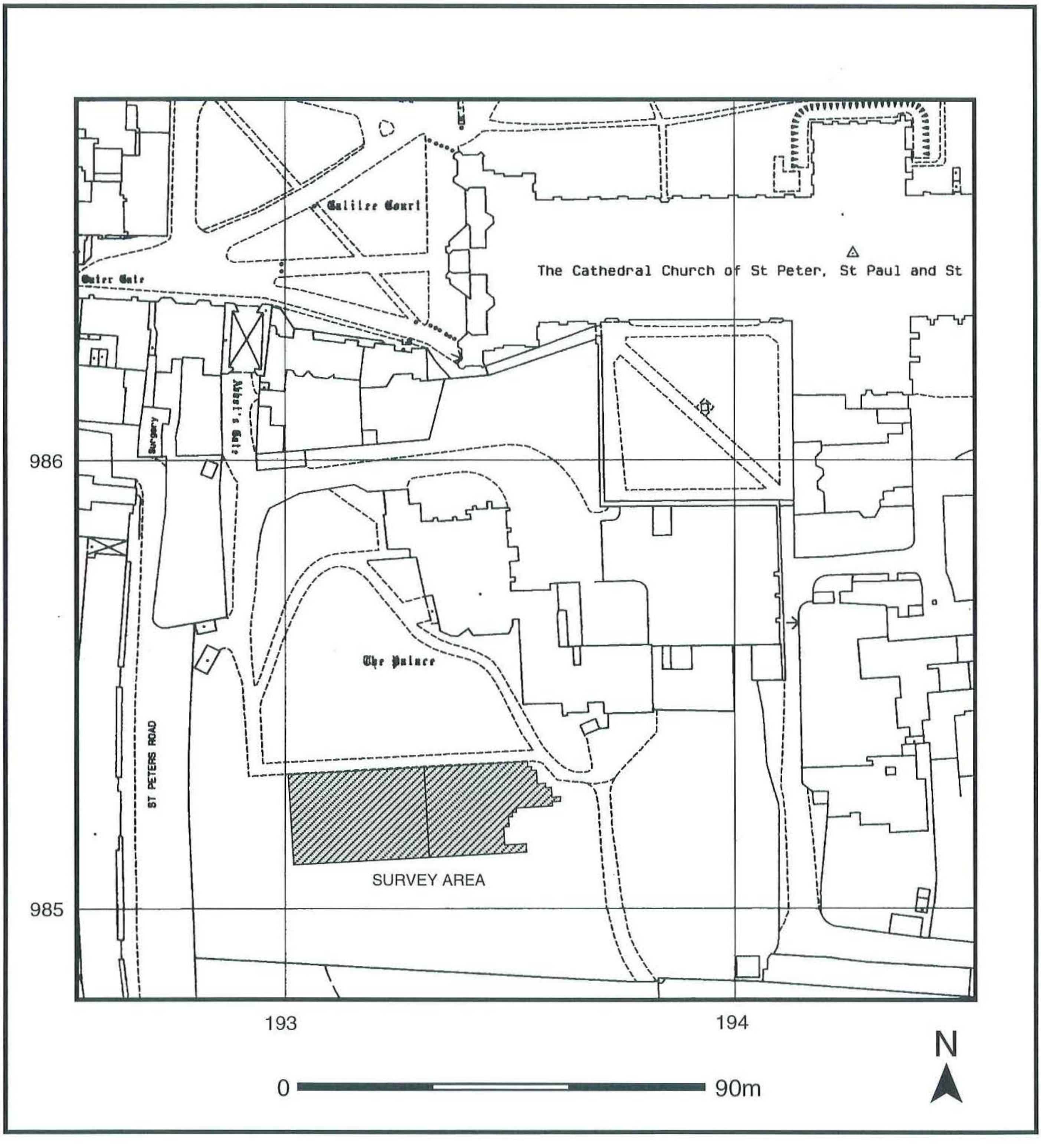
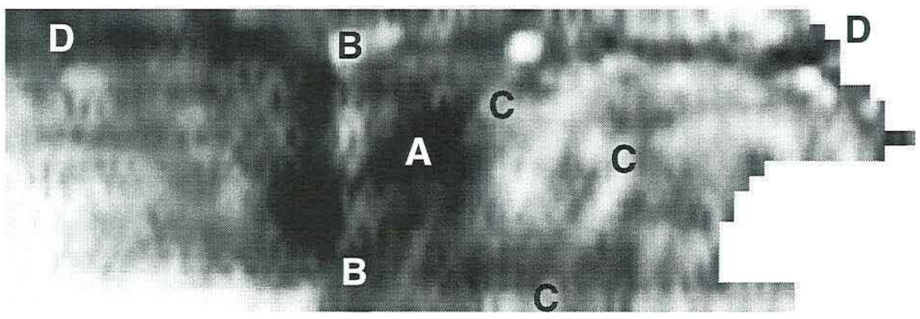


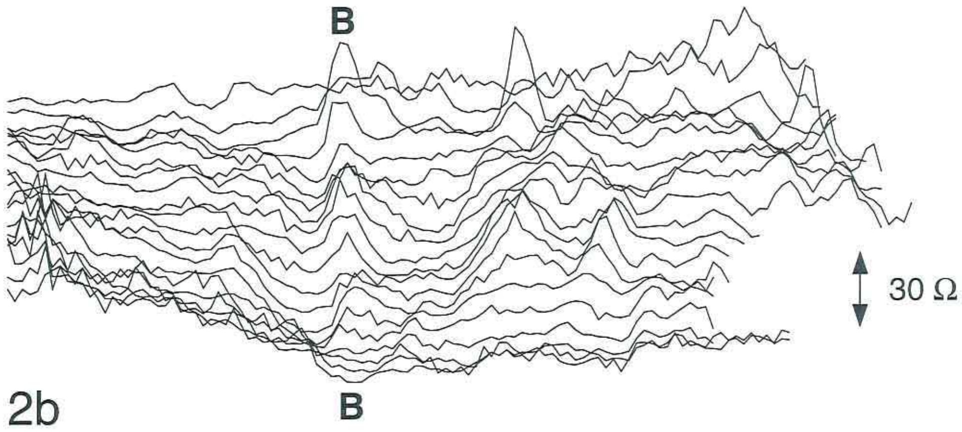
FIGURE 2

# PETERBOROUGH CATHEDRAL, BISHOP'S GARDEN Resistivity Survey, Sept 1996

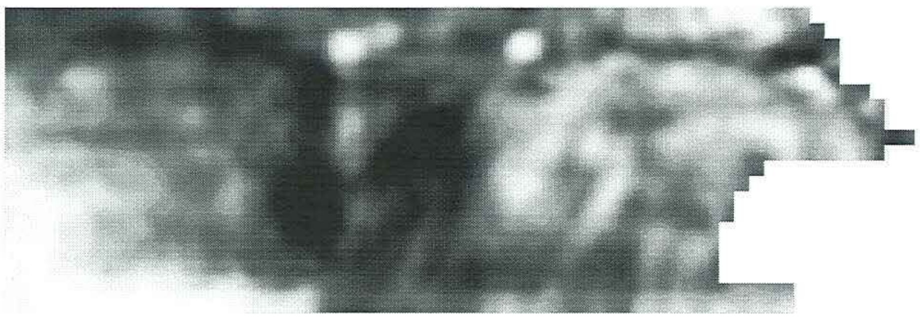
## Data from 0.5m mobile probe spacing



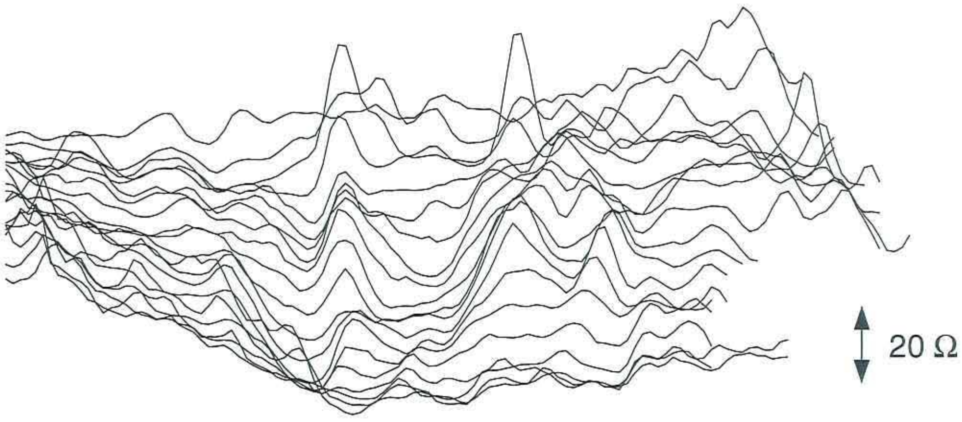

2a Plot range : min (black) 20 Ω, max (white) 64 Ω



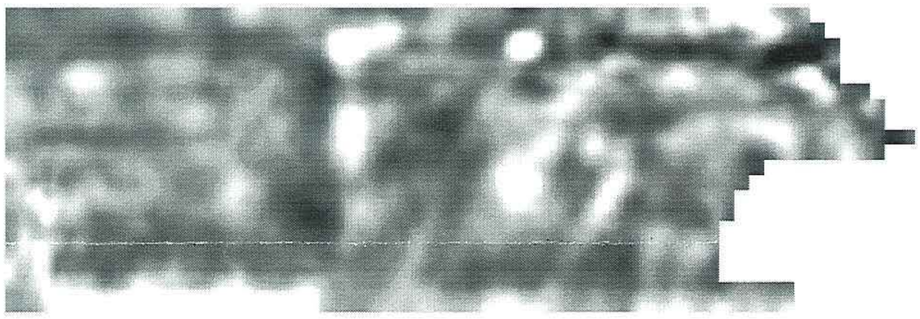

2b



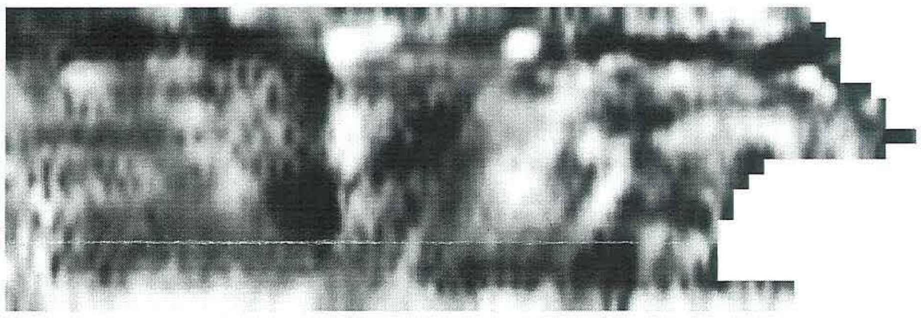
2c




2d

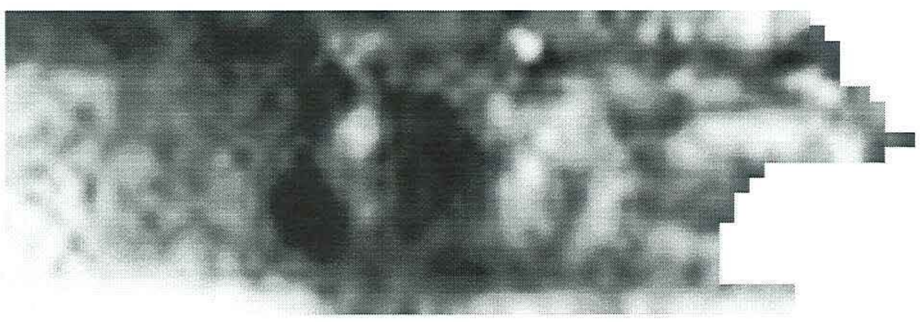


2e

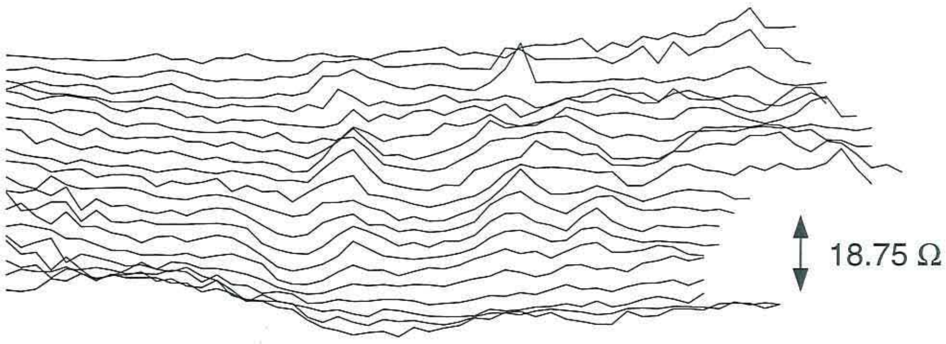


2f

## Data from 1.0m mobile probe spacing



2g Plot range : min (black) 12 Ω, max (white) 30 Ω




2h


DESCRIPTION OF PLOTS :

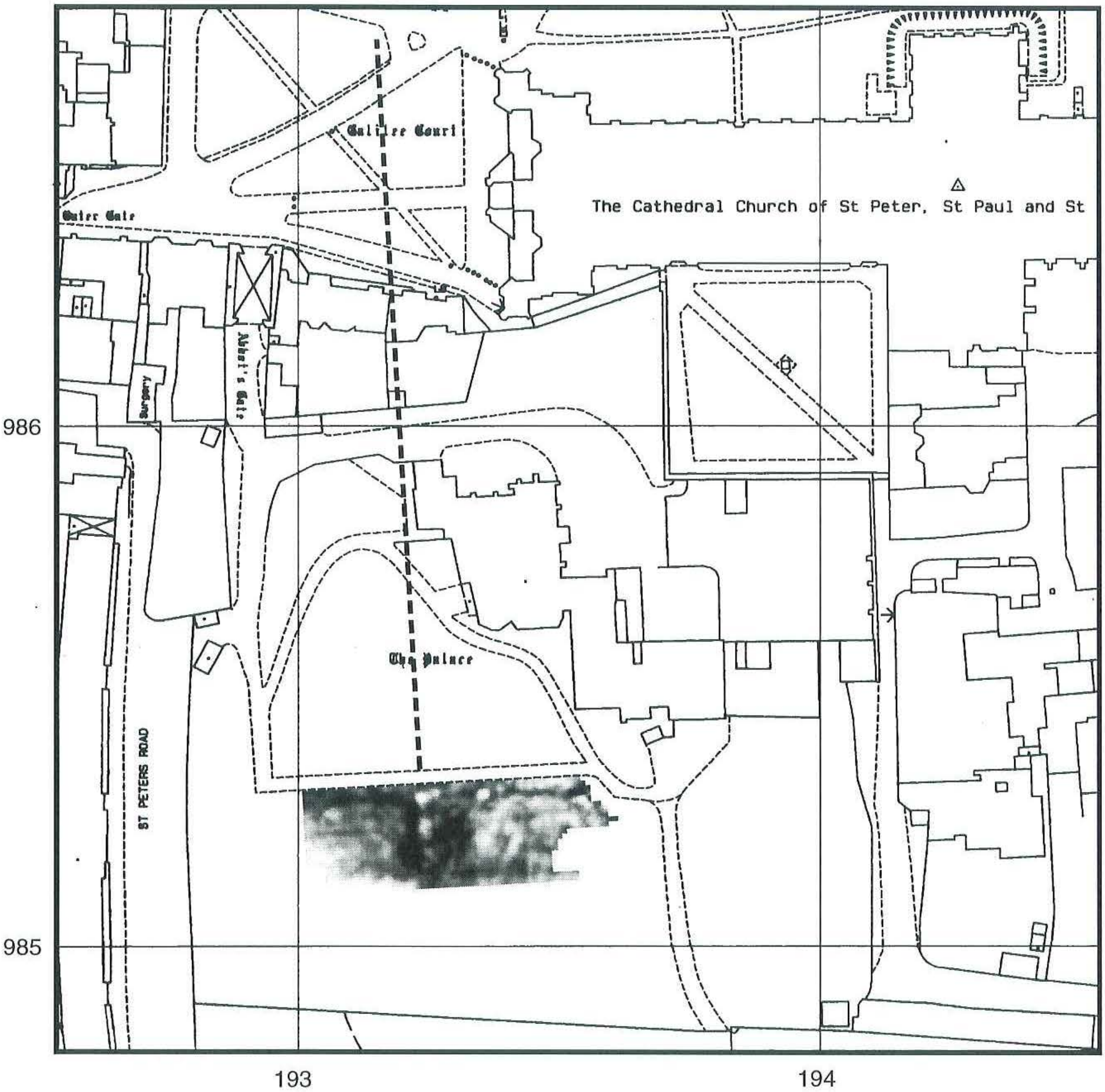
2a) greyscale plot of raw 0.5m mobile-probe spacing data
2b) traceplot of raw 0.5m mobile-probe spacing data
2c) greyscale plot of 0.5m data after slight smoothing by the use of a 0.5m radius Gaussian low-pass filter
2d) traceplot of data as for 2(c)
2e) linear greyscale plot of 0.5m data after treatment with a Gaussian high-pass filter (3m radius)
2f) linear greyscale plot of 0.5m data after contrast enhancement using Wallis Algorithm

2g) greyscale plot of raw 1.0m mobile-probe spacing data
2h) traceplot of raw 1.0m mobile-probe spacing data

**Figure 3**

# BISHOP'S PALACE GARDEN, PETERBOROUGH CATHEDRAL

## Location of Resistivity Survey, 1996




- - - - - - - - - - estimated northward projection of course of Anomaly B

0 90m

N