Inchmarnock Archaeological Research Project

Inchmarnock

Argyll and Bute

Geophysical Survey

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Summary

A geophysical survey (magnetic and resistance) was carried out in a field to the west of St Marnock's chapel on the island of Inchmarnock off the west coast of Bute. Low resistance anomalies indicative of field drains and other modern services have been identified. Areas of high and low resistance are thought to reflect geological variations and localised waterlogging respectively. Other low resistance anomalies could locate ditches identified in earlier trial trenching evaluations. However, an archaeological interpretation should be regarded at best as tentative. The magnetic survey has not identified any archaeological anomalies.

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1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned, by Dr Chris Lowe of Headland Archaeology Ltd, to carry out a geophysical evaluation of land immediately west of the remains of St Marnock's Chapel, at the southern end of Inchmarnock, an uninhabited island approximately 1km off the west coast of Bute (see Fig 1).

1.2 The evaluation area, centred at NS 022 597, covered approximately 1 hectare and comprised part of a single field (see Fig. 2) under permanent pasture measuring approximately 180m by 60m. The survey area was delimited by fences/hedges to three sides whilst a very boggy area defined the western edge. No problems were encountered during the survey which was carried out on June 3rd and 4th 2003.

1.3 Topographically the evaluation area formed a relatively flat plateau at about 20m Above Ordnance Datum (AOD) with the land sloping down to the coast to the east and up to the highest part of the island to the west, immediately beyond the survey area. The solid geology comprises metamorphic Upper Dalradian schist and slates.

1.4 St Marnock's Chapel is thought to have been built in the late 12th century but was robbed of much of its stonework in the early 18th and 19th centuries. In the early 1970s the site was rediscovered and partially excavated and these excavations recovered many carved stones dating from the 7th or 8th century. These stones indicate the presence of an early Christian monastery associated with St Marnock.

1.5 Since the summer of 2001 the chapel site (in the old stack-yard at Midpark) has been seasonally excavated by Headland Archaeology Ltd as part of the Inchmarnock Research Project, an ongoing study of the archaeology and history of the island. These excavations have identified evidence indicative of a 'craft zone', north-west of the chapel, which is thought to be associated with the Early Christian monastic settlement. A unique assemblage of decorated and inscribed slate pieces and stone gaming boards has also been recovered that is thought to date to the 8th or 9th centuries. Metalworking debris, at least two buildings, graves, stone paths and a second possible 'craft zone' indicate the level of activity adjacent to the chapel.

1.6 Trial trench evaluation in 2000 in the field to the west of the chapel site revealed the line of a ditch. Two years later further excavation to the north-west of the chapel identified a second substantial ditch whose fill contained a cross-incised slab. Two pieces of inscribed slate were also recovered from the upper fill. Radiocarbon dating has given a date of deposition for the slates and sculpture after AD 780 -1000. A cist was also exposed but not excavated.

2. Methodology and Presentation

2.1 The general survey objectives were to establish the presence, extent and character of any archaeological features in the field to the west of the chapel in order to provide targets for investigation during the final season of excavation.

2.2 A more specific aim was to determine whether the ditch identified north-west of the chapel in 2002 (Ditch 4014) relates to those identified in the trial trenches in 2000, the latter of which are located within the current survey area (see Figs 3 and 4). In order to achieve these aims both detailed magnetic and resistance surveys were undertaken. A magnetic susceptibility survey was also carried out.

2.3 Comprehensive technical details on the underlying principles of magnetic and resistance survey, the equipment used and general survey methodology are given in Appendix 1 and Appendix 2. The survey set-out procedures, tie-in information and all other survey location information is presented in Appendix 3.

2.4 General and detailed site location plans incorporating Ordnance Survey mapping are shown in Figures 1 and 2. More detailed (1:12500) site location plans showing the magnetic and resistance data superimposed onto a scanned Ordnance Survey base map supplied by the client are presented as Figures 3 and 4. The resistance data is displayed in greyscale format at a scale of 1:500 in Figure 5 with an accompanying interpretation at the same scale as Figure 6. The magnetic data is displayed in greyscale format, at a scale of 1:500, in Figure 7 with an interpretation of the anomalies at the same scale in Figure 8. Figure 9 is an X-Y trace plot of the ‘raw’ magnetic data and the results of the magnetic susceptibility study are presented in Figure 10.

2.5 The survey methodology and report presentation use the recommendations outlined in the English Heritage Guidelines (David 1995) as a minimum standard. All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty’s Stationery Office, © Crown copyright.

The interpretative figures should not be looked at in isolation but in conjunction with the relevant discussion section and with the information contained in the Appendices.

3. Results

3.1 Resistance Survey (Figs 3, 5 and 6)

3.1.1 In general terms the background resistance is lower across the northern half of the survey area than across the southern half, with areas of particularly low resistance in the north-western corner and down the western edge. It is thought that these low readings are due to the high water content of the topsoil in these areas, as evidenced by the spread of rushes across these parts of the site and the presence of standing water. As water is a good conductor (therefore offering little resistance to an electric current) the current will pass more readily through a saturated or waterlogged soil than through a free draining soil thus leading to a low resistance reading.

3.1.2 Several areas of particularly high resistance have also been noted. Despite the apparent linearity of some of the edges to these high resistance anomalies it is considered likely that they are due to outcropping geology rather than to any structural feature.

3.1.3 Several well-defined linear low resistance anomalies have been identified in the southern half of the site. These anomalies are interpreted as being caused by infilled cut features. In these instances the electric current will pass more readily through the relatively uncompacted (and therefore more moisture retentive) fill material than it will the undisturbed topsoil/subsoil surrounding the feature. In the south-western corner of the site a series of possibly intersecting low resistance linear anomalies (Fig. 6 – A, B and C) are interpreted as modern features, probably field drains; indeed Anomaly C corresponds with the location of a modern feature identified at the south-western end of one of the trial trenches opened in 2000 (see Fig. 3). Anomaly D is also caused by a pipe (see para. 3.2.3 below).

3.1.4 The two most southerly trial trenches from 2000, aligned from south-west to north-east, are also just discernable as low resistance anomalies (Fig. 6 – E and F) although the most northerly trench aligned from east to west has not been detected.

3.1.5 In the northern half of the site several linear trends have been identified. It is not clear what is causing these trends although the three alternating bands of high and low resistance parallel with the northern field boundary (Fig. 6 – Anomaly G) could be caused by ridge and furrow ploughing.

3.1.6 A faint low resistance anomaly approximately 50m in length, aligned from north-west to south-east, can be seen in the centre of the site (Fig. 6 – Anomaly H). This anomaly approximately corresponds with the position and alignment of a ditch identified in the two most northerly trial trenches (see Fig. 3) and is therefore tentatively interpreted as an archaeological ditch.

3.1.7 In the north-east corner of the survey area several areas of high resistance and two possible low resistance linear anomalies have been identified (Fig. 6 – Anomaly I and J). Anomaly J aligns with Ditch 4014 (see Fig. 3) and appears to cut through an area of high resistance. This anomaly may be a continuation of Ditch 4014. Anomaly J could be the same ditch turning to the north.

3.2 Magnetometer Survey (Figs 4, 7, 8 and 9)

3.2.1 The most obvious characteristic of the data set is the prevalence of discrete areas of magnetic enhancement visible across almost the whole of the survey area. Two obvious exceptions, where the magnetic background is extremely 'quiet', are the north-west corner and a larger area in the south-east corner. Although these type of anomalies could be caused by infilled archaeological features or by areas of burning it is thought more likely that these anomalies are caused by natural features and/or the presence of stone in the topsoil/subsoil with a strong natural magnetism.

3.2.2 The three backfilled trial trenches from the 2000 excavation can just be discerned as extremely weak anomalies. However, the ditch/es located in these trenches have not been detected.

3.2.3 Only one other anomaly (Fig. 8 - Anomaly K) has been identified and this is caused by a ferrous pipe. It was also detected as a low resistance anomaly (Fig. 6 – Anomaly D).

3.3 Magnetic Susceptibility Survey

3.3.1 The results of the magnetic susceptibility survey tend to mirror the pattern of background resistance in that the lowest readings are recorded in the northern half of the site, particularly the north-western corner, and the highest readings in the southern half. It is thought that this pattern is primarily a reflection of the degree of saturation of the soil across the site. In the waterlogged areas a greater proportion of the soil volume being measured will be occupied by water leading to a relatively depressed reading relative to an area where the percentage of water in a given volume of soil is much lower.

3.3.2 The high readings in the south-west corner are thought to be caused by the ferrous pipe and by modern activity associated with the installation of the pipe and the land drains.

4. Discussion and Conclusions

4.1 Overall the results of the surveys have been disappointing. The magnetic survey has not been able to identify either the ditches identified in the previous trial trenching or the modern drainage features at the southern end of the site that were readily identified by the resistance survey. Indeed, there was no correlation between the results of the magnetic and resistance surveys other than the identification of a modern ferrous pipe on the south-western edge of the survey area.

4.2 Although there appears to be a significant presence of naturally magnetic material in the topsoil across the majority of the site it is not considered sufficient to have prevented the detection of infilled archaeological features, specifically ditches, had there been a reasonable magnetic contrast between the fill of the features and the topsoil. Context information on the ditch fills provided by the client suggests that there was little obvious difference between the fill of the ditches and the subsoil into which the ditch had been cut. This lack of magnetic contrast, combined with the described degree of truncation of the features, almost certainly explains the disappointing magnetic results.

4.3 The results of resistance surveys are often difficult to interpret with the majority of observed anomalies usually attributable to variations in the topsoil and solid geology and the effects these changes have on the amount of water retained in the soil. Infilled features such as ditches are particularly difficult to detect and interpret confidently except in ideal circumstances. Consequently although vague linear low resistance anomalies, on the same approximate alignment and in the same approximate location as both the ditch identified in the most recent excavations and those identified during the earlier trial trenching, have been identified, the interpretation of these anomalies as archaeological should be seen as, at best, tentative.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

Bibliography

David, A. 1995. *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines* No. 1. English Heritage.

Acknowledgements

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Figures

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Appendix 2	Resistance Survey: Technical Information and Methodology
Appendix 3	Survey Location Information
Appendix 4	Geophysical Archive

Appendix 1

Magnetic Survey: Technical Information

1. Magnetic Susceptibility and Soil Magnetism

1.1 Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed ***magnetic susceptibility***. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

1.2 In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level.

1.3 The magnetic susceptibility of the soil can also be enhanced significantly by heating. This can lead to the detection of features such as hearths, kilns or burnt areas.

2. Types of Magnetic Anomaly

2.1 In the majority of instances anomalies are termed ***'positive'***. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as ***'negative'*** anomalies that, conversely, means that the response is negative relative to the mean magnetic background. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geologies.

2.2 Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

2.3 It should be noted that anomalies that are interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

2.4 The types of response mentioned above can be divided into five main categories which are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic ‘spiky’ trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. This type of anomaly is characterised by very strong, ‘spiky’ variations in the magnetic background. A modern origin is usually assumed unless there is other supporting information.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. An agricultural origin, either ploughing or land drains is a common cause.

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an X–Y trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic of an area of magnetic disturbance or of an ‘iron spike’ (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post holes or by kilns, with the latter often being characterised by a strong, positive double peak response. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

3. Methodology

3.1 Magnetic Susceptibility Survey

3.1.1. There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

3.2 Gradiometer Survey

3.2.1. There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as ***scanning*** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10-15m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey.

3.2.2. The second method is referred to as ***detailed survey*** and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.5m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation.

3.2.3. The Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used for the detailed gradiometer survey. Readings were taken, on the 0.1nT range, at 0.5m intervals on zig-zag traverses 1m apart within 20m by 20m square grids. The instrument was facing north for improved data quality and was checked for electronic and mechanical drift at a common point after every three grids and calibrated as necessary. The drift from zero was not logged.

3.2.4. The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats. The former option shows the ‘raw’ data with no processing other than grid biasing.

3.2.5. An X-Y plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a ‘stacked’ plot. A hidden line algorithm has been employed to block out lines behind major ‘spikes’ and the data has been clipped at 10nT. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the ‘shape’ of individual anomalies can be discerned and potentially archaeological anomalies differentiated from ‘iron spikes’. In-house software (XY3) was used to create the X-Y trace plots.

3.2.6. In-house software (Geocon 9) was used to interpolate the gradiometer data so that 1600 readings were obtained for each 20m by 20m grid. Contors software (University of Bradford) was used to produce the greyscale images. All gradiometer greyscale plots are displayed in the range –1nT to 2nT, unless otherwise stated, using a linear incremental scale.

Appendix 2

Resistance Survey: Technical Information and Methodology

4. Soil Resistance

4.1 The electrical resistance of the upper soil horizons is predominantly dependant on the amount and distribution of water within the soil matrix. Buried archaeological features, such as walls or infilled ditches, by their differing capacity to retain moisture, will impact on the distribution of sub-surface moisture and hence affect electrical resistance. In this way there may be a measurable contrast between the resistance of archaeological features and that of the surrounding deposits. This contrast is needed in order for sub-surface features to be detected by a resistance survey.

4.2 The most striking contrast will usually occur between a solid structure, such as a wall, and water-retentive subsoil. This shows as a resistive high. A weak contrast can often be measured between the infill of a ditch feature and the subsoil. If the infill material is soil it is likely to be less compact and hence more water retentive than the subsoil and so the feature will show as a resistive low. If the infill is stone the feature may retain less water than the subsoil and so will show as a resistive high.

4.3 The method of measuring variations in ground resistance involves passing a small electric current (1mA) into the ground via a pair of electrodes (current electrodes) and then measuring changes in current flow (the potential gradient) using a second pair of electrodes (potential electrodes). In this way, if a structural feature, such as a wall, lies buried in a soil of uniform resistance much of the current will flow around the feature following the path of least resistance. This reduces the current density in the vicinity of the feature, which in turn increases the potential gradient. It is this potential gradient that is measured to determine the resistance. In this case, the gradient would be increased around the wall giving a positive or high resistance anomaly.

4.4 In contrast a feature such as an infilled ditch may have a moisture retentive fill that is comparatively less resistive to current flow. This will increase the current density and decrease the potential gradient over the feature giving a negative or low resistance anomaly.

5. Survey Methodology

5.1 The most widely used archaeological technique for earth resistance surveys uses a twin probe configuration. One current and one potential electrode (the remote or static probes) are fixed firmly in the ground a set distance away from the area being surveyed. The other current and potential electrodes (the mobile probes) are mounted on a frame and are moved from one survey point to the next. Each time the mobile probes make contact with the ground an electrical circuit is formed between the current electrodes and the potential gradient between the mobile and remote probes is measured and stored in the memory of the instrument.

5.2 A Geoscan RM15 resistance meter was used during this survey, with the instrument logging each reading automatically at 1m intervals. The mobile probe spacing was 0.5m with the remote probes 15m apart and at least 15m away from the grid under survey. This mobile probe spacing of 0.5m gives an approximate depth of penetration of 1m for most archaeological features. Consequently a soil cover in excess of 1m may mask, or significantly attenuate, a geophysical response.

6. Data Processing and Presentation

6.1 All of the illustrations incorporating a digital map base were produced in AutoCAD 2000 (© Autodesk).

6.2 The resistance data is presented in this report in greyscale format with a linear gradation of values and was obtained by exporting a bitmap from the processing software (Geoplot v3.0; Geoscan Research) into AutoCAD 2000. The data has been processed and has also been interpolated by a value of 0.5 in both the X and Y axes using a sine wave (x)/x function to give a smoother, better defined plot.

Appendix 3

Survey Location Information

7. Survey Methodology

7.1 The site grid was laid out using a Geodimeter 600s total station theodolite and tied in to field boundaries and to two semi-permanent survey markers (ST3 and ST4) established by Headland. No co-ordinate information is available for these points.

7.2 The survey grids were then superimposed onto a scanned Ordnance Survey map base supplied by the client using common field boundaries and other fixed points. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.0m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes. Local grid co-ordinates can be supplied if required.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

Appendix 4

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Word 2000), and graphics files (CorelDraw6 and AutoCAD 2000) files.
- a full copy of the report

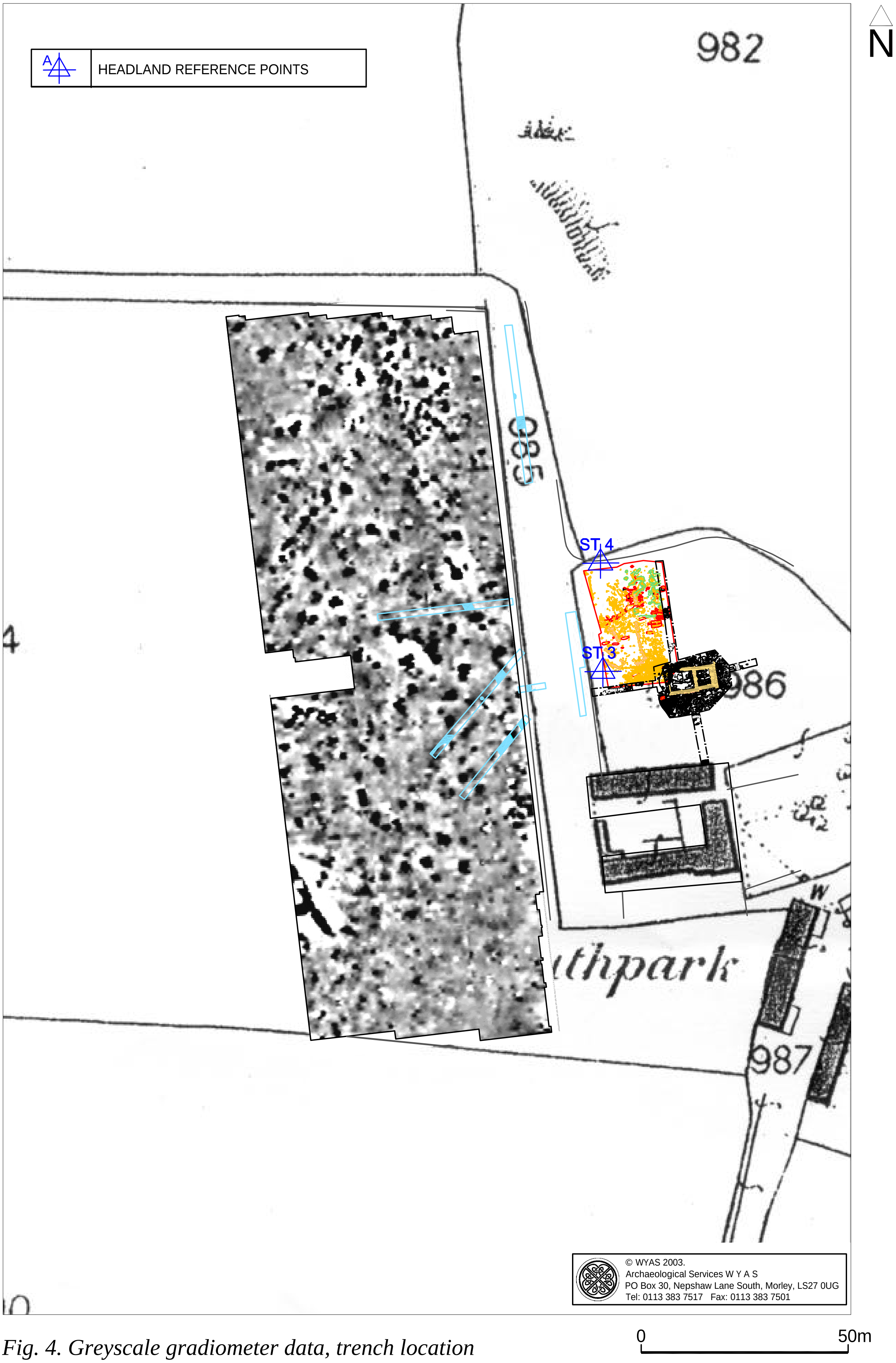

Fig. 4. Greyscale gradiometer data, trench location and excavated archaeological features

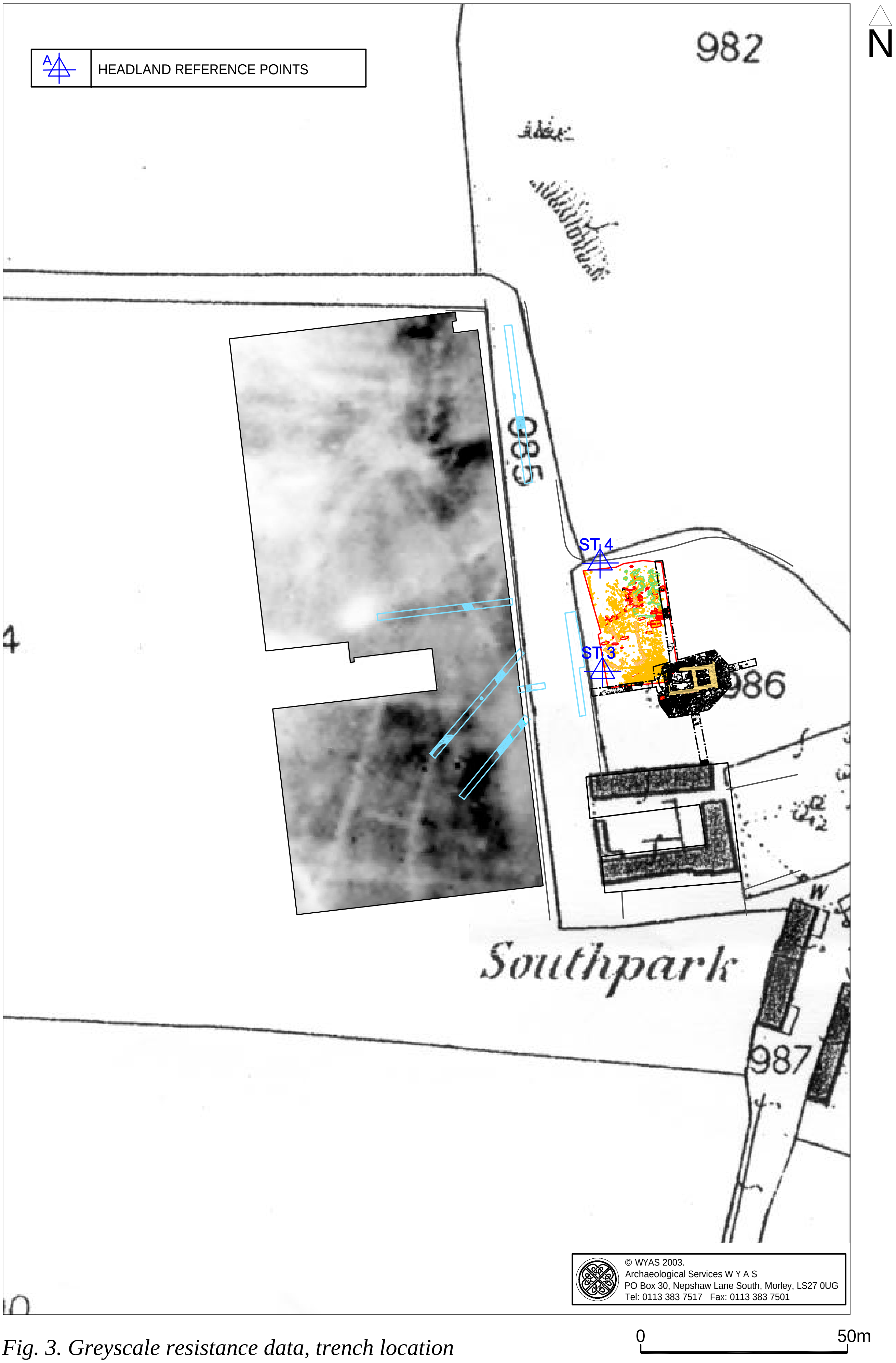

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Fig. 3. Greyscale resistance data, trench location and excavated archaeological features

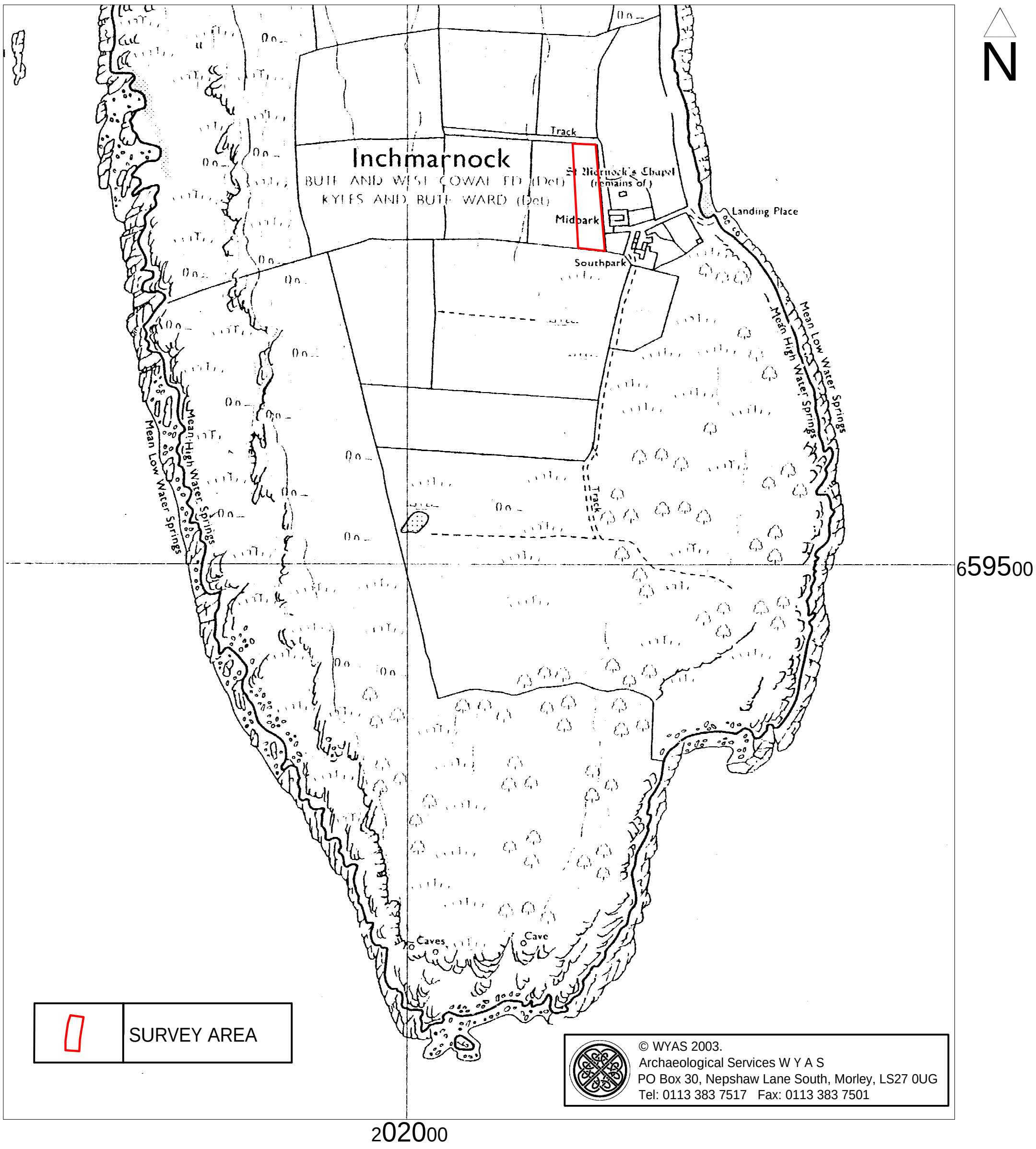

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Fig. 2. Site location

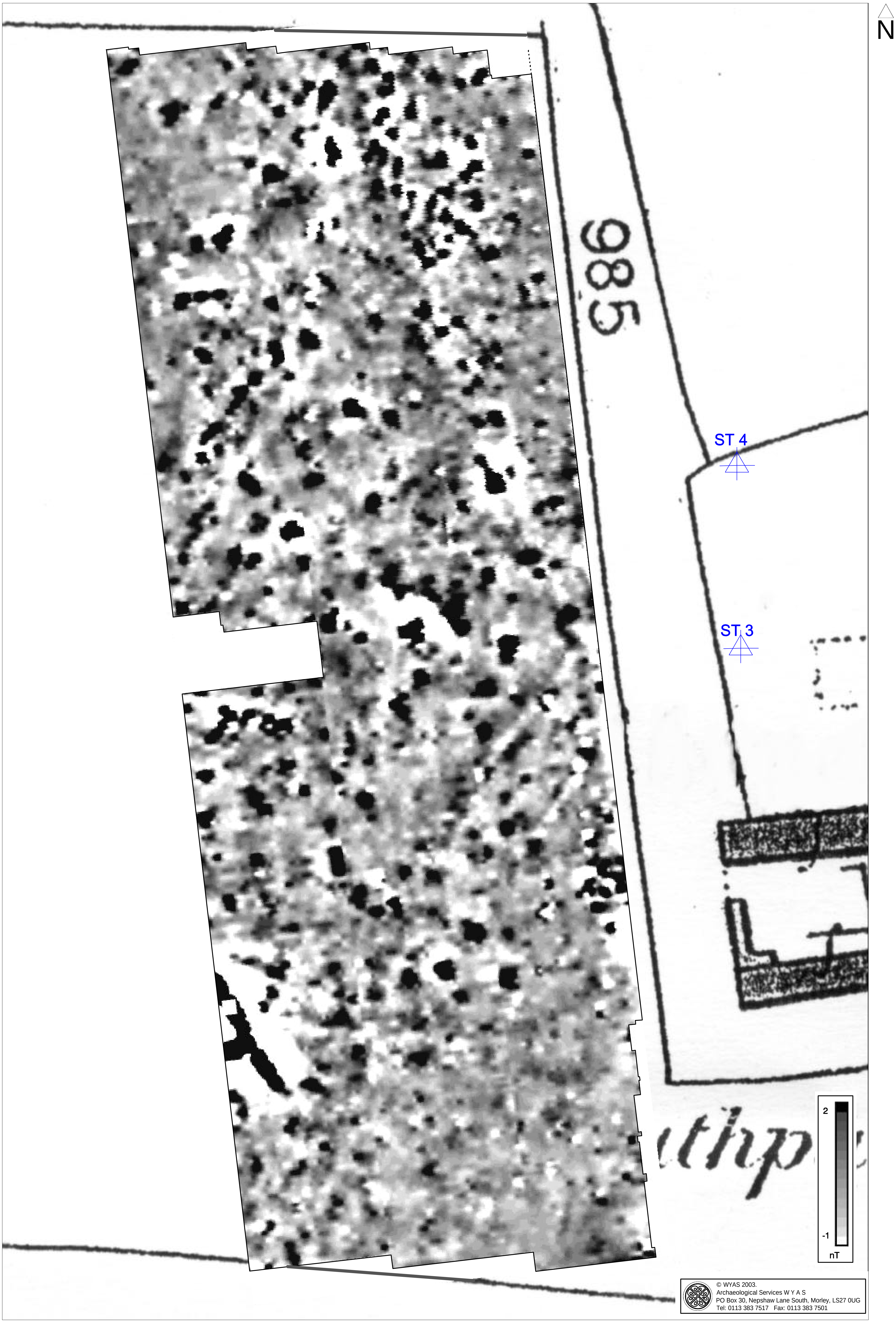


Fig. 7. Greyscale plot of gradiometer data

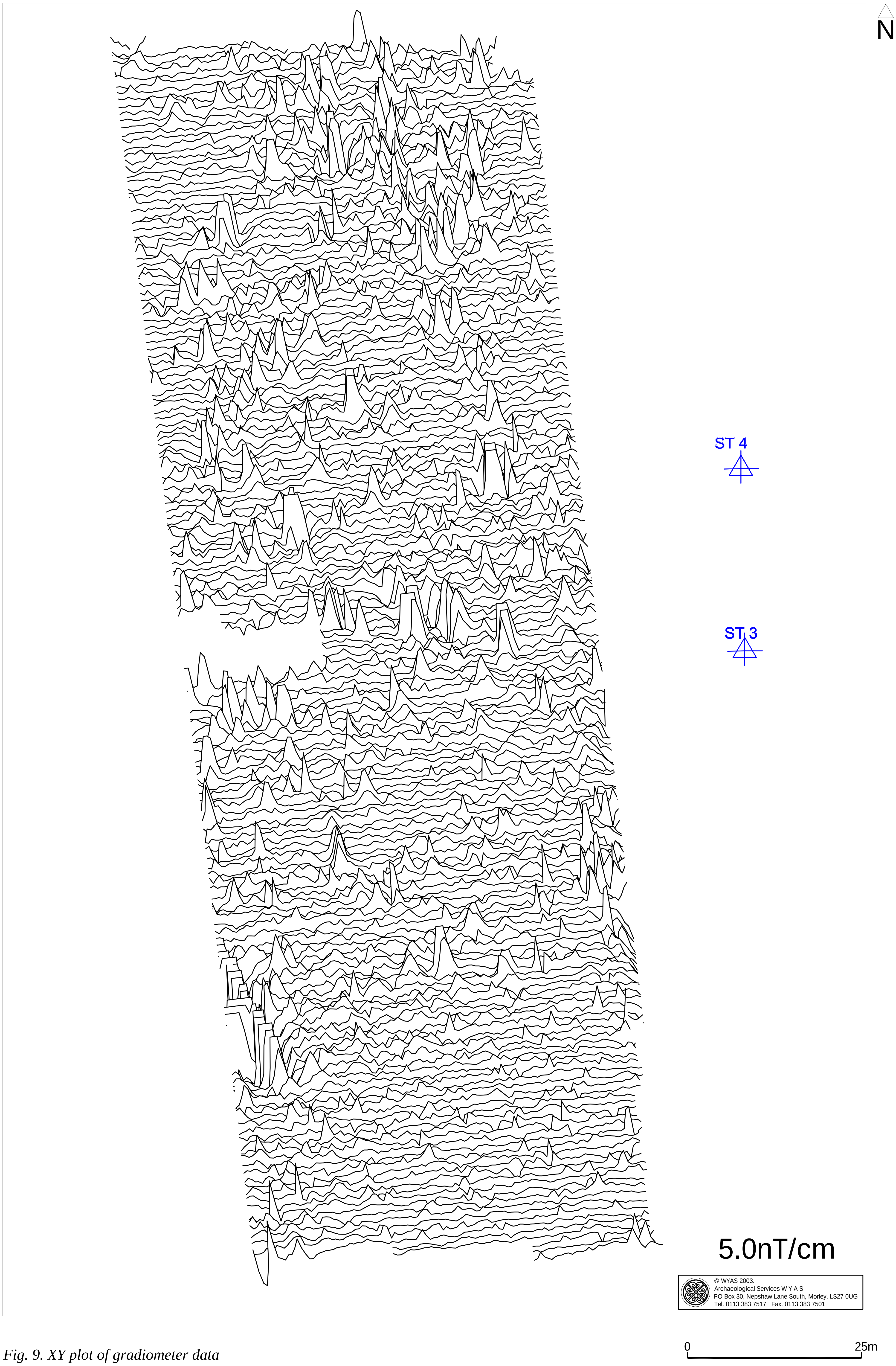
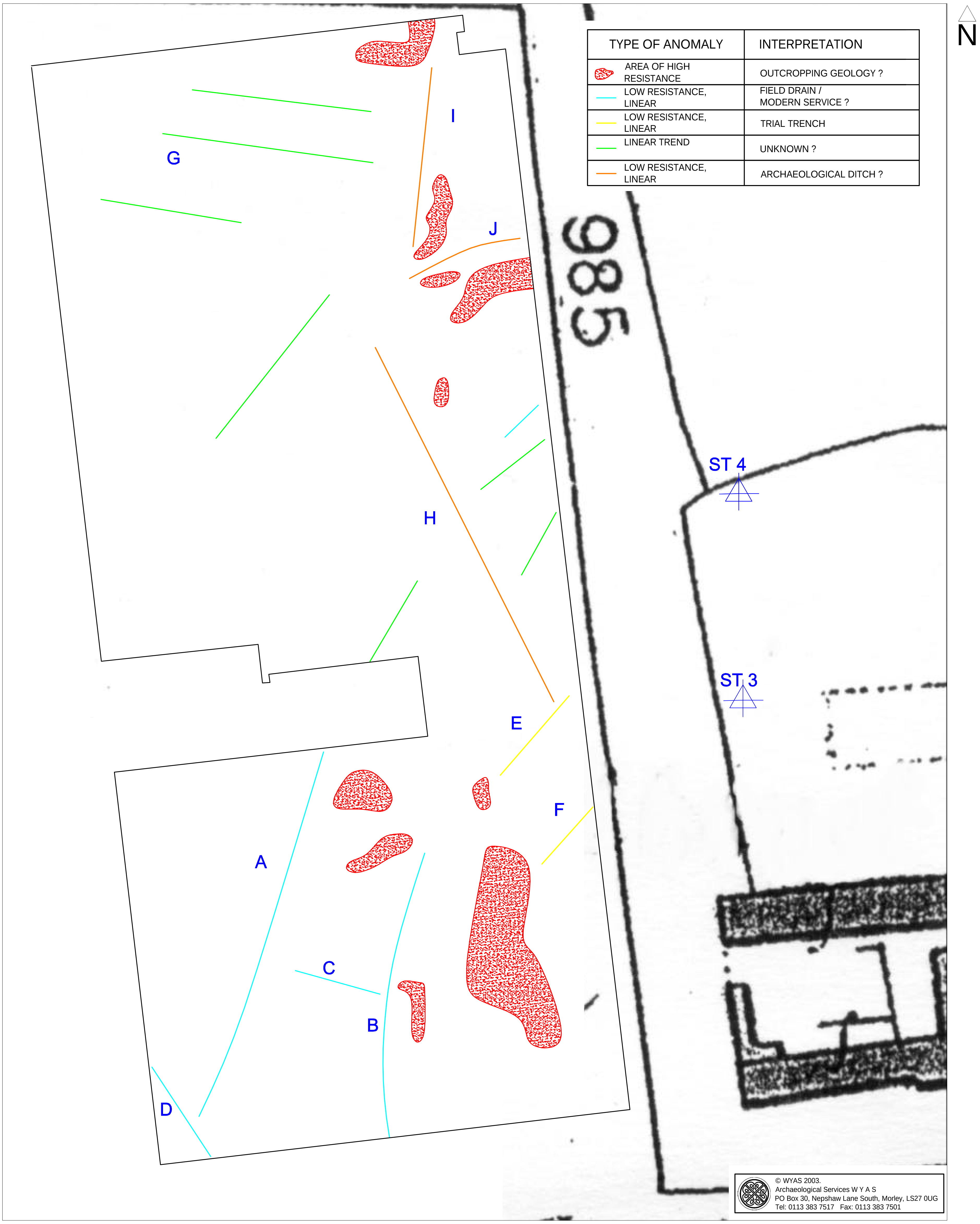


Fig. 9. XY plot of gradiometer data



TYPE OF ANOMALY	INTERPRETATION
AREA OF HIGH RESISTANCE	OUTCROPPING GEOLOGY ?
LOW RESISTANCE, LINEAR	FIELD DRAIN / MODERN SERVICE ?
LOW RESISTANCE, LINEAR	TRIAL TRENCH
LINEAR TREND	UNKNOWN ?
LOW RESISTANCE, LINEAR	ARCHAEOLOGICAL DITCH ?

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Fig. 6. Interpretation of resistance data

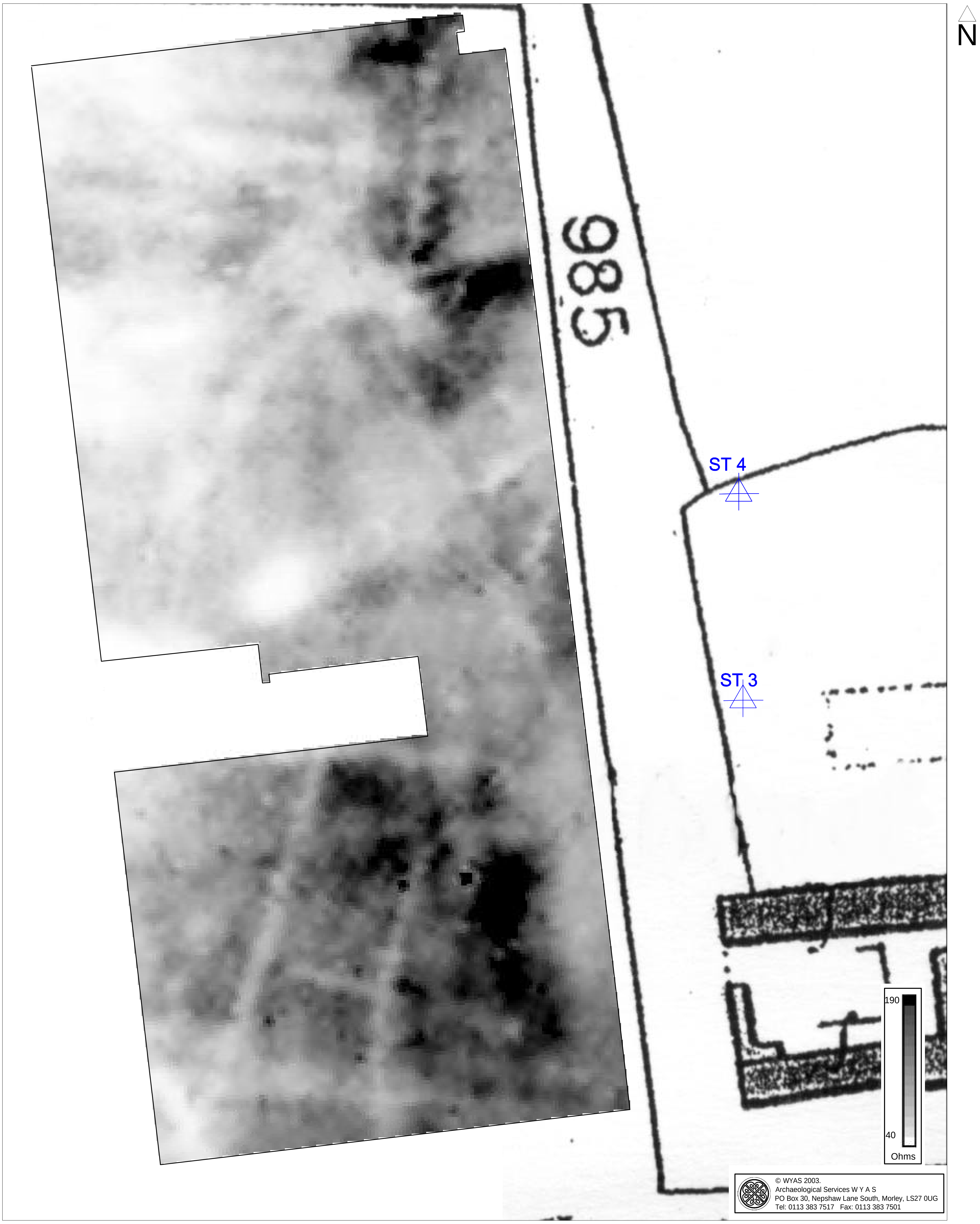

Fig. 5. Greyscale plot of resistance data

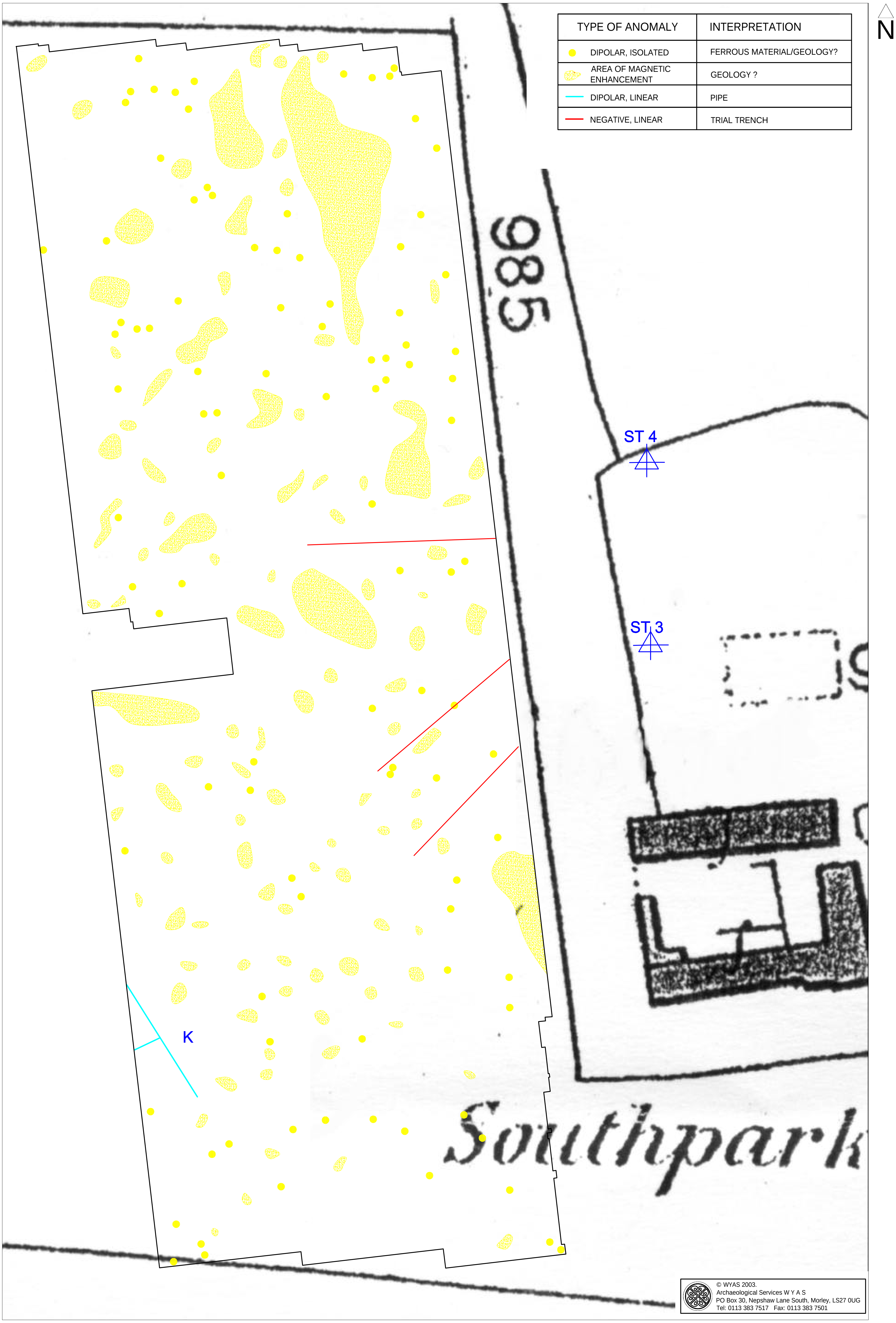

Fig. 8. Interpretation of gradiometer data

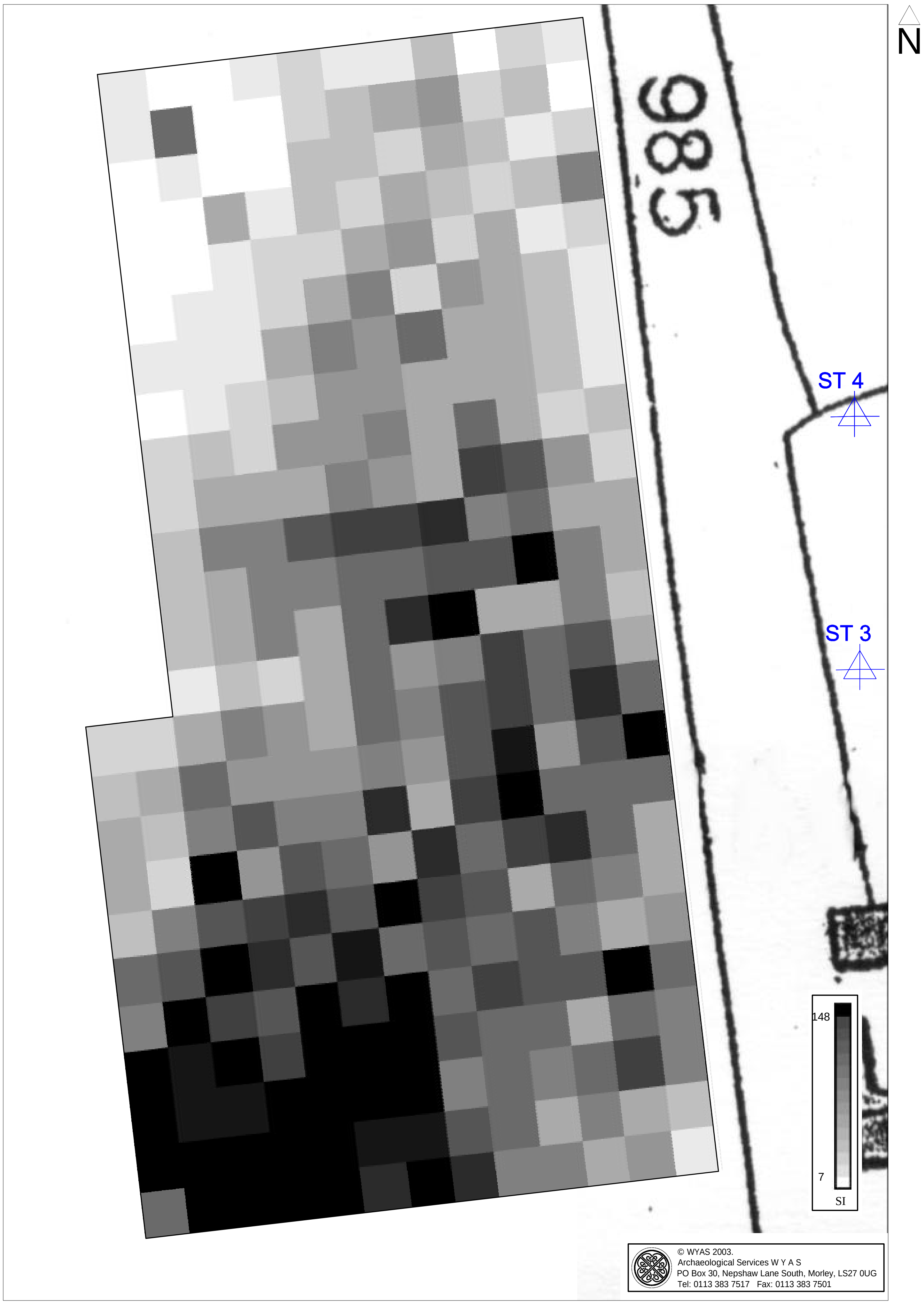

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Fig. 10. Greyscale plot of magnetic susceptibility data

Inchmarnock Archaeological Research Project
Inchmarnock
Argyll and Bute

Geophysical Survey

August 2003

Report No. 1149

Headland Archaeology Ltd.

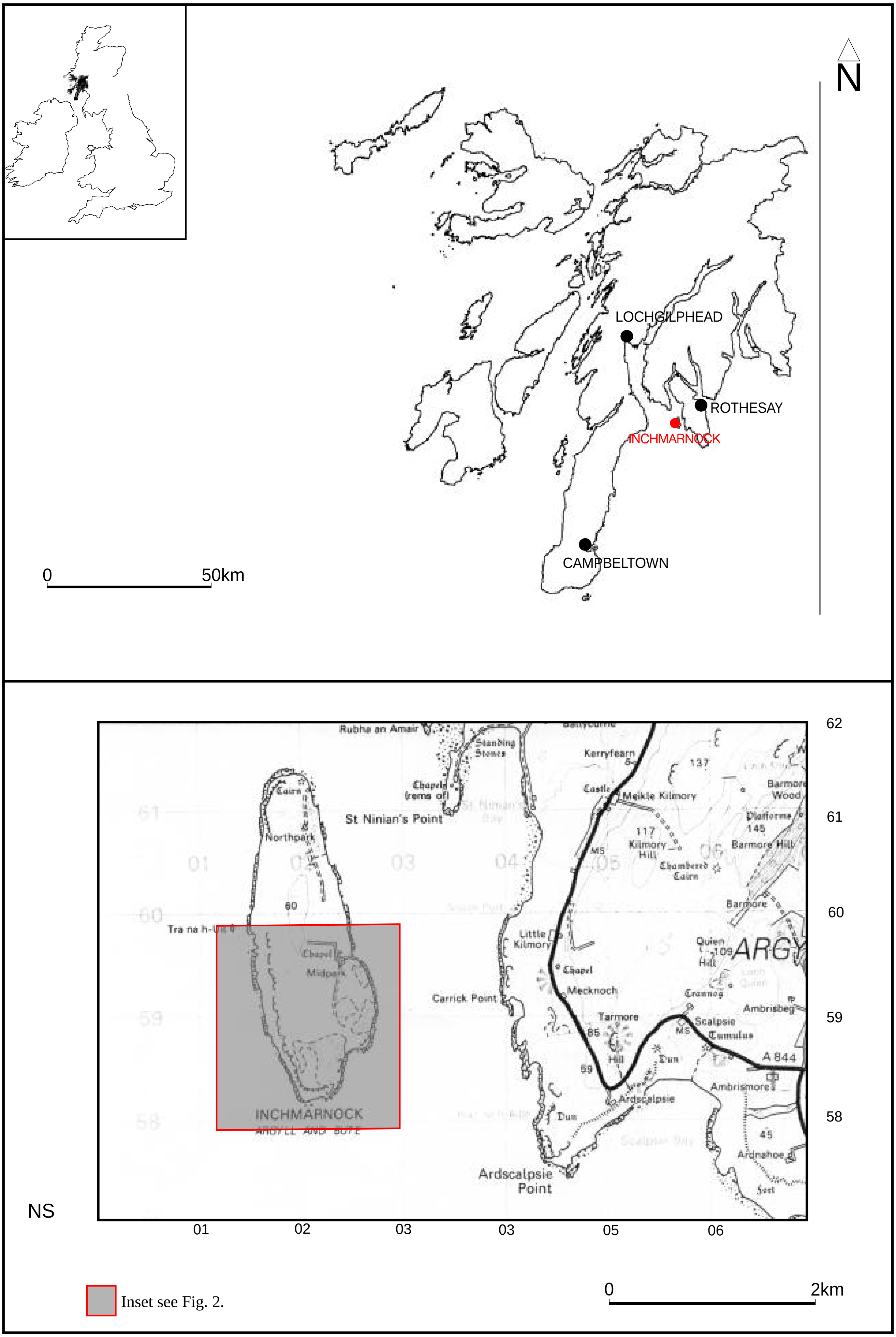

Fig. 1. Site location

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