GEOPHYSICAL SURVEYS FOR THE A66 SCOTCH CORNER TO MELSONBY CROSSROADS ROAD IMPROVEMENTS, NORTH YORKSHIRE

A programme of research carried out
on behalf of

BHWB

by

GeoQuest Associates

1 INTRODUCTION

1.1 This report presents the results of a programme of geophysical research which has been carried out at specific locations along the A66 between Melsonby Crossroads (NGR: NZ19000660) and Scotch Corner (NGR: NZ21400530), North Yorkshire (Phase 1), in order to provide further information concerning sub-surface archaeological features prior to proposed road improvements. The area of investigation was later extended westwards to near Warreners Lane, Carkin Moor (Phase 2). Both phases of the work are reported in this document.

1.2 The research was carried out by GeoQuest Associates on behalf of Barton Howe Warren Blackledge (BHWB) according to instructions supplied by Mr Ed Dennison, archaeological consultant to BHWB.

1.3 Figures 1a-g show the locations of each survey area on plans derived from digital map data supplied by North Yorkshire County Council (NYCC). Figure 1 also depicts the full extent of new road proposals, as at December 1998.

1.4 The locations of the Phase 1 geophysical survey areas were largely determined by the proposed road improvements, the results of a previous archaeological desk-top survey (Northern Archaeological Associates, 1997) and by subsequent research and a ground condition survey by BHWB which identified a number of areas of archaeological interest within the section of proposed road improvements. The locations of the surveys that comprise Phase 2 of the project have been in part determined by this previous research and partly by the changing road proposals.

1.5 For much of its length the present A66 follows the course of the former Roman road which ran from Dere Street across Stainmore and into the Eden Valley. A number of small pre-Roman Iron Age settlements and field systems have been identified on or near to the present road which suggests that the Roman road may have followed the course of an earlier road. There is also a Roman fort at Carkin Moor, just beyond the western end of the survey area. Cropmarks seen on aerial photographs suggest the presence of a complex of rectilinear ditched enclosures and field boundaries in the fields immediately northwest of Scotch Corner, between the A66 and Violet Grange Farm. A geophysical survey of this area in 1995 identified a cluster of enclosures and linear ditches suggestive of a field system probably of Iron Age/Romano-British date (Casey *et al.*, 1995).

1.6 The number, distribution and nature of previously identified sites therefore suggests that there is a high potential for the discovery of further sites within the proposed development corridor.

1.7 Scheduled Monument Consent was obtained to survey in the area of Scots Dyke (EH ref AA/12020/5).

2 SURVEY LOCATIONS: LANDUSE, TOPOGRAPHY AND GEOLOGY

2.1 Twenty-seven surveys, totalling *ca.*21ha, have been carried out in 14 areas of likely archaeological interest (see Figures 1a-g). Poor weather conditions prevailed throughout the fieldwork period of this project (September to November 1998) leaving standing water in many parts of the survey fields, both arable and pasture. Each area is briefly described below.

2.2 The locations of Areas S1 to S3 are shown on Figure 1a; Areas S4 to S7 on Figure 1b; Areas S8 and S9 on Figure 1c; Areas S10 and S11 E on Figure 1d; Areas S11 W+C and S12 E+C on Figure 1e; Areas S12 W and S13 E on Figure 1f; Areas S13 W and S14 on Figure 1g.

2.3 **Area S1** (S1 E: 160x40m; S1 W: 140x40m) This area comprised two surveys in the field occupying the northwest quarter of Melsonby Crossroads. The predominantly level field carried cereal stubble at the time of the S1 survey, and then a young cereal crop during the S1 W survey.

2.4 **Area S2** (240x40m) This survey occupied a relatively flat, oil seed rape field northeast of Melsonby Crossroads.

2.5 **Area S3** (340x20m) This survey also occupied a relatively flat, oil seed rape field on the northern side of the A66, to the west of Kirklands Garage.

2.6 **Area S4** (S4 W: 80x20m+100x40m; S4 C: 60x60m; S4+S4 E: 100x60m) Three surveys were undertaken within this former potato field, which had been recently ploughed at the time of survey. The predominantly level field lies on the northern side of the A66 opposite Sedbury Home Farm.

2.7 **Area S5** (S5: 180x40m; S5 N: 180x40m) This area comprised two adjoining surveys within a level field carrying cereal stubble on the northern side of the A66, northeast of Sedbury Home Farm.

2.8 **Area S6** (S6: 160x40m; S6 N: 160x20m) This area also comprised two adjoining surveys in a pasture field north of the A66.

2.9 **Area S7** (S7 W2: 200x40m; S7 W1: 160x40m; S7 E1: 160x40m; S7 E2: 100x40m) Four discrete surveys were undertaken within this relatively level area on the northern side of the A66 opposite Sedbury Lay-by. Area S7 W2 had recently been subjected to subsoil ploughing while the other survey areas carried cereal stubble.

2.10 **Area S8** (450x40m) This survey area occupied a gently undulating field of young cereal on the northern side of the A66, immediately west of area S1 W.

2.11 **Area S9** (140x40m) This area lay within a relatively flat field of young oil seed rape on the northern side of the A66, west of S8.

2.12 **Area S10** (600x40m + 100x40m) This survey occupied a gently undulating field of young cereal on the northern side of the A66 east of the B6274/A66 crossroads. This field was particularly wet and a large area of standing water towards the western end prevented survey of the whole area.

2.13 **Area S11** (S11 W: 60x40m; S11 C: 160x40m; S11 E: 80x40m + 40x20m) Three discrete surveys were undertaken in this area south of the A66, on either side of the B6274 road to Gilling West. The surveys occupied level ground carrying a young cereal crop.

2.14 **Area S12** (S12 W: 160x40m; S12 C: 220x40m; S12 E: 320x40m) This area comprised three surveys in three undulating pasture fields on the north side of the A66, west of the B6274/A66 crossroads.

2.15 **Area S13** (S13 W: 240x40m; S13 E: 240x40m) Two discrete surveys were undertaken here, S13 E on a west-facing slope in a pasture field and S13 W in a gently sloping field of young cereal.

2.16 **Area S14** (140x40m) This survey occupied a relatively flat pasture field on the northern side of the A66 south of Carkin Moor.

2.17 The solid geology underlying the whole of this section of the A66 improvements comprises Carboniferous Sandstone which is overlain by drift geology largely comprising boulder clay and morainic drift. There are no rock outcrops within the survey areas.

3 THE GEOPHYSICAL SURVEYS

3.1 Field Methods

3.1.1 Measurements of vertical geomagnetic field gradient were recorded using Geoscan FM36 fluxgate gradiometers. A zig-zag traverse scheme was employed and data were logged in grid units of 20x20m at 1.0x0.5m intervals, thus providing 800 measurements per grid. Appendix A provides further information about the technique.

3.1.2 Data were downloaded on-site into a Toshiba Satellite 110CT laptop computer for processing, printing and storage. These data were subsequently transferred to a laboratory computer for further processing, interpretation and archiving.

3.2 Data Processing

3.2.1 The GeoQuest **InSite®** software was used to process the geophysical data and to produce continuous tone grey-scale images of the raw data at a scale of 1:1000. These results are shown in Figures 2a-2g on plans that have been derived from digital map data supplied by North Yorkshire County Council. A convention is used that shows positive magnetic anomalies as dark grey and negative magnetic anomalies as light grey. Figures 2a-2g include keys which relate the grey-scale intensities to anomaly values in nano Tesla per metre.

3.2.2 The following basic processing steps were applied to the data:

Removal of striping artifacts in the geomagnetic images caused by alternating changes in level between zig-zag traverses.

Removal of Random 'Spikes' present in the geomagnetic data due to small ferrous objects or fired stone on or near the ground surface. This process replaces spikes with the mean of near-neighbours.

DeShear corrects for apparent shear in strong geomagnetic anomalies surveyed by zig-zag traversing.

Correction for drift in magnetometer calibration with time.

Adjustment of grid mean values to achieve an optimum match along the lines of contact between data grids.

Interpolation of the data, using a bilinear function, to generate a regular mesh of values at 0.25 x 0.25m intervals.

3.2.3 The geophysical images were printed on a Hewlett Packard HP650C Designjet plotter with 256 grey shades and 600 dpi resolution. A sigmoid function was used to map the data to printed grey tones since this provides a measure of contrast equalisation. Appendix B provides more information about data processing and itemises the algorithms that were applied to produce the grey-scale images in Figure 2.

3.3 Key to Figures

3.3.1 A number of significant anomalies have been detected in the data and these are presented on 1:2500 geophysical interpretation plans using coded colours and patterns (Figures 3a-3g). The following types of anomaly have been distinguished:

Green Significant regions of anomalously high or positive magnetic field gradient which might be associated with high susceptibility, soil-filled structures such as pits and ditches.

Blue Areas of anomalously low or negative magnetic field gradient, corresponding to features of low magnetic susceptibility, such as concentrations of sedimentary rock rubble and field drains.

Red Strong dipolar magnetic anomalies (paired negative-positive) which may reflect structures with thermoremanent magnetisation, such as kilns, hearths and recent bonfires or dumps of material with very high susceptibility. Smaller examples are almost certainly due to near-surface iron objects such as horseshoes and have been ignored in the subsequent archaeological interpretation.

3.3.2 Archaeological interpretation plans at 1:2500 are presented in Figures 4a-4g.

4 INTERPRETATION

4.1 Area S1

4.1.1 Two surveys have been carried out in this field. A field boundary shown on NYCC plans that would once have separated the two areas is no longer present and has not been detcted geophysically.

4.1.2 Occasional small dipolar magnetic anomalies in these surveys almost certainly indicate the locations of pieces of ferrous litter in the soil.

4.1.3 A magnetic 'texture' is evident in the grey-scale images for both of these surveys. This texture is believed to be associated with the present ploughing regime, aligned parallel to the existing A66.

4.1.4 Several curvilinear positive magnetic anomalies have been detected in the western part of S1 E. These anomalies reflect high susceptibility material, probably soil-filled ditches and may require further investigation. Some of the anomalies may be parts of ring-ditches and a double-ditched trackway. These features may well be associated with the nearby Rock Castle Iron Age farmstead and field system that was partially excavated in 1987 (Fitts *et al.*, 1994).

4.1.5 Some amorphous positive magnetic anomalies which have been detected in the eastern part of this area are also likely to reflect soil-filled features. These may be the result of small-scale quarrying or possibly reflect natural variations in the rockhead topography.

4.1.6 A positive magnetic lineation detected in S1 W almost certainly represents the remains of a soil-filled ditch, possibly associated with the Rock Castle field system.

4.2 Area S2

4.2.1 Unfortunately the most prominent geomagnetic anomaly in this area is that associated with a steel pylon towards the eastern end of the survey. However, a positive magnetic anomaly has been detected aligned northeast-southwest on the southern side of the pylon and broadly north-south on the northern side of the pylon. The nature of this anomaly almost certainly indicates a soil-filled ditch which in this case measures up to *ca.*4.5m in width. It is likely that this feature is part of Scots Dyke (SAM 26946), a linear earthwork extending for over 14km from the River Swale to the River Tees which goes through a prominent change of alignment at this point. The dyke is thought to have been built during the 6th-7th centuries AD to consolidate territorial boundaries.

4.2.2 Several other linear positive magnetic anomalies have been detected in this survey area. These anomalies are aligned northwest-southeast and are also believed to reflect soil-filled ditches which may or may not be associated with Scots Dyke.

4.3 Area S3

4.3.1 Two very weak, linear positive magnetic anomalies have been detected in the central third of this survey area. Although these anomalies are weak they may represent the remains of former ditches.

4.3.2 A considerable number of small dipolar magnetic anomalies are present in the data, indicating the presence of near-surface ferrous litter.

4.4 Area S4

4.4.1 Due to the very poor weather conditions prior to and during the fieldwork part of this project this field had become particularly badly rutted by tractor wheels and the ruts had subsequently filled with water. Consequently it was not possible to collect data within the southeastern corner of area S4 W.

4.4.2 A weak, diffuse magnetic lineation has been detected traversing areas S4 W and S4 C broadly east-west. This anomaly follows the assumed course of the Roman road from Kirklands Garage to a point *ca.*250m north of the existing A66/A1 junction at Scotch Corner. It seems likely therefore that the anomaly does represent the ploughed-out remains of the Roman road. Modern ploughing has disturbed the

underlying rockhead here and so will have severely damaged any archaeological features that were not cut into the bedrock.

4.4.3 Some discontinuous linear positive magnetic anomalies are discernible in the grey-scale image for S4 W. These anomalies almost certainly reflect soil-filled features, probably the truncated remains of furrows from ridge and furrow farming.

4.4.4 A weak, subcircular positive magnetic anomaly has also been identified in S4 W, with a maximum diameter of ca.10m. This could represent the remains of a heavily ploughed ring ditch.

4.4.5 A considerable number of dipolar magnetic anomalies are present in the data, indicating the presence of near-surface ferrous litter.

4.5 Area S5

4.5.1 A number of broadly parallel positive magnetic lineations have been detected within this area, particularly in the southeastern quarter. These anomalies are aligned northwest-southeast and are spaced at *ca.*2.5-4m intervals. It is most likey that the anomalies reflect the furrows from a ridge and furrow farming system. Another positive magnetic lineation detected perpendicular to the furrows at the eastern end of the survey area appears to represent the former headland. Further, weaker magnetic lineations which have been detected in this survey area have the same orientation as the ridge and furrow and may represent more of the same system.

4.5.2 Two relatively intense, curvilinear positive magnetic anomalies have been detected at the southern limit of this area. These anomalies reflect concentrations of high magnetic susceptibility material and almost certainly represent soil-filled ditches.

4.5.3 A few dipolar magnetic anomalies are present in the data, almost certainly indicating the locations of ferrous debris in the soil. However, one such anomaly in the western part of the survey area has a negative magnetic 'shadow' on the northern side of the primary positive magnetic anomaly, indicating that the target giving rise to the anomaly may have acquired its magnetisation *in situ*. In such instances it is possible that the anomaly represents a kiln, the feature acquiring a thermoremanent magnetisation the last time it was fired.

4.6 Area S6

4.6.1 Two former quarries are evident in this field as sub-rectangular and sub-circular depressions. It has not been possible to conduct the survey in the smaller, eastern quarry due to the vegetation cover. The geomagnetic survey around these depressions does not appear to have detected any evidence for buildings or other structures which might once have been associated with the quarries.

4.6.2 Several positive magnetic lineations have been detected across this survey area, some of which are perpendicular to one another. These anomalies all reflect material with high magnetic susceptibility, almost ceratainly soil with a high humic content in the fills of former ditches. In the northern part of this area four such ditches form a rectangular enclosure measuring *ca.*22x17m. The other lineations are likely to represent former ditched land boundaries. A complex of rectilinear ditched enclosures and field boundaries is evident on aerial photographs taken over fields to the east, between the A66 and Violet Grange Farm. Some of these features have been further characterised by geophysical surveying (Casey *et al.*, 1995) and it seems likely that the enclosure and field boundaries identified during the present survey are part of this larger complex, believed to be Iron Age/Romano-British in date.

4.6.3 There is a relatively high concentration of dipolar magnetic anomalies in the area around the quarries, probably reflecting ferrous debris from the quarrying activities. One of the larger dipolar anomalies here could possibly represent kiln remains.

4.7 Area S7

4.7.1 Four geomagnetic surveys have been carried out in this area north of the A66 opposite Sedbury Lay-by. The area has been subjected to subsoil ploughing and it is suspected that any archaeological features here will be badly damaged. The surveys of this area have, on the whole, produced very smooth data.

4.7.2 Several parallel positive magnetic lineations have been detected in the western part of S7 W2. The anomalies are aligned approximately north-south and are regularly spaced at *ca.*7m intervals. These lineations appear to represent the furrows from a former ridge and furrow farming system.

4.7.3 A large positive magnetic anomaly has also been detected in this area on the southern limit of the survey. This anomaly probably reflects a concentration of high magnetic susceptibility soil filling a large pit of some sort, perhaps small-scale quarrying.

4.7.4 An intense dipolar magnetic anomaly has been detected in the northwestern part of S7 E1. This anomaly corresponds to the location of a reinforced concrete slab.

4.7.5 Two short positive magnetic lineations which have been detected in S7 E2 may represent the remains of two ditches or one right-angled ditch.

4.7.6 A zone of high magnetic field gradient and an intense dipolar anomaly have also been detected in S7 E2. These anomalies almost certainly reflect an adjacent building and buried ferrous debris respectively.

4.8 Area S8

4.8.1 Two irregularly-shaped zones of weak, positive magnetisation have been detected in this area. These areas contain relative concentrations of high magnetic susceptibility material, presumably soil which has been deposited in hollows. The more westerly zone corresponds to a marked depression in the field and it is likely that these anomalies represent former areas of quarrying.

4.8.2 Two broad positive magnetic lineations *ca.* 10m apart have been identified between the two disturbed areas above. Both anomalies almost certainly reflect soil-filled ditches, which may originally have flanked a track or droveway, although there is no magnetic evidence for a metalled surface between the ditches.

4.8.3 A narrow positive magnetic anomaly has also been detected in the western part of this survey area. The anomaly almost certainly represents another soil-filled ditch, perhaps a former field boundary.

4.8.4 A scatter of small dipolar magnetic anomalies has been detected across this area, particularly along the southern side adjacent to the present A66. These anomalies almost certainly reflect near-surface ferrous litter.

4.9 Area S9

4.9.1 The survey of this area has not detected any features of likely archaeological interest. Several small dipolar magnetic anomalies, indicating ferrous litter, have been detected towards the road side of the area.

4.10 Area S10

4.10.1 This survey was hampered by very boggy ground conditions and a large area of standing water near the western end of S10 area prevented survey in that part.

4.10.2 Two sets of parallel positive magnetic lineations have been detected in the western part of the survey, either side of the waterlogged area. In each case the lineations are evenly spaced at *ca.* 12m intervals. Each lineation comprises a chain of very small positive magnetic anomalies, each reflecting a relatively high magnetic field gradient. In this case the anomalies almost certainly represent land drains made of short sections of fired clay pipe.

4.10.3 A scatter of small dipolar magnetic anomalies is present across the area, again concentrated along the southern side of the survey adjacent to the present road. These anomalies reflect ferrous litter within the soil.

4.10.4 Two apparently intense positive magnetic lineations are evident in the data for this area. The nature of these anomalies indicates that they are almost certainly artefacts in the data caused by the instrument operator rather than anomalies reflecting sub-surface features.

4.11 Area S11

4.11.1 A chain of intense dipolar magnetic anomalies has been detected traversing area S11 C. This anomaly almost certainly reflects the presence of a ferrous service pipe.

4.11.2 A large dipolar anomaly detected at the northeastern limit of S11 C reflects the presence of a metal gate and parked car.

4.11.3 A weak and diffuse positive magnetic anomaly has been detected in S11 W. This anomaly is similar in nature to those described in S8 (4.8.1) and may reflect small-scale quarrying or geological features.

4.11.4 A low concentration of small dipolar magnetic anomalies, reflecting ferrous litter, has been detected in each survey area.

4.12 Area S12

4.12.1 A large and intense positive magnetic anomaly detected on the southern limit of S12 E almost certainly reflects the presence of a nearby ferrous object, probably a large metal road sign. Some positive magnetic lineations detected in this area may reflect ditch remains.

4.12.2 An intense dipolar magnetic lineation has been detected at the westernmost limit of S12 C, running alongside the wire fence field boundary. This anomaly almost certainly represents a ferrous water pipe associated with a metal access cover noted in the southeastern corner of the field. Another ferrous pipe is believed to run along the southern edge of the field between the survey area and the field boundary.

4.12.3 Several short positive magnetic lineations have been detected in S12 C. These anomalies reflect high magnetic field gradients and probably represent soil-filled gullies or ditches, perhaps drains or minor land divisions.

4.12.4 A sub-circular positive magnetic anomaly measuring *ca.*8m in diameter has been detected towards the west end of S12 C. This anomaly reflects a concentration of high magnetic susceptibility material, probably the humic soil fill of a large pit, possibly of archaeological interest.

4.12.5 Intense magnetic anomalies along the southern limit of S12 W almost certainly reflect the presence of a ferrous water pipe and steel gate. A narrow positive

magnetic lineation immediately north of these features could indicate the location of a gulley or drain.

4.12.6 Some weak and diffuse positive magnetic anomalies in this area probably reflect geological structures but may warrant further investigation.

4.13 Area S13

4.13.1 A set of parallel positive and negative magnetic lineations is evident in S13 E, particularly at the eastern end of the area. These anomalies, which are aligned approximately east-west and are spaced at *ca.*3m intervals, almost certainly reflect ridge and furrow farming remains. An intense magnetic lineation at the southern limit of the ridge and furrow may represent a former land boundary.

4.13.2 An intense dipolar magnetic lineation has been detected running along the southern limit of S13 E and S13 W. This is almost certainly a continuation of the ferrous water pipe that was evident in the fields to the east of this survey.

4.13.3 A set of very weak magnetic lineations aligned northeast-southwest in S13 W provide a magnetic 'texture' which reflects the recent ploughing of this field.

4.13.4 A scatter of small dipolar magnetic anomalies is present across the area. These anomalies almost certainly reflect ferrous litter within the soil.

4.14 Area S14

4.14.1 An intense dipolar magnetic lineation has been detected running along the southern limit of this area. This is almost certainly a continuation of the ferrous water pipe that was evident in the fields to the east of this survey.

4.14.2 The survey of this area has not detected any features of likely archaeological interest.

5 SUMMARY AND CONCLUSIONS

5.1 A programme of geophysical investigation has been carried out along the A66 between Scotch Corner and Melsonby Crossroads in North Yorkshire, in order to identify features of archaeological interest prior to the proposed upgrading of the A66 to dual carriageway in this area. After the completion and assessment of these surveys the study area was extended westwards as far as Warrener Lane.

5.2 Several anomalies in S1 appear to represent ditch features, some of which may be parts of ring-ditches and a double-ditched trackway. These features may well be

associated with the nearby Rock Castle Iron Age farmstead and field system that was partially excavated in 1987 (Fitts *et al.*, 1994).

5.3 A broad ditch feature in S2 is almost certainly part of the Scots Dyke earthwork. Several smaller ditches have also been identified in this area.

5.4 Two possible ditch features have been detected in S3.

5.5 A magnetic lineation detected in S4 follows part of the assumed course of a Roman road from Kirklands Garage to a point *ca.*250m north of the existing A66/A1 junction at Scotch Corner. It seems likely therefore that the anomaly does represent the ploughed-out remains of the Roman road. Modern ploughing has disturbed the underlying rockhead here and so will have severely damaged any archaeological features that were not cut into the bedrock. The possible remains of a small plough-damaged ring-ditch and ridge and furrow farming have also been tentatively identified in S4 W.

5.6 The remains of ridge and furrow farming and an associated headland, almost certainly medieval in origin, have been identified in area S5. Two arcuate ditches are also evident at the southern limit of this survey. One of the larger dipolar anomalies here could possibly represent the remains of a kiln.

5.7 The geomagnetic survey of S6 does not appear to have detected any evidence for buildings or other structures which might once have been associated with the quarries in that area. However, several ditch features have been identified to the north of the quarries, four of which form a rectangular enclosure measuring *ca.*22x17m. The other ditches are likely to represent former land boundaries. A complex of rectilinear ditched enclosures and field boundaries is evident on aerial photographs taken over fields to the east, between the A66 and Violet Grange Farm and it seems likely that the features identified here are part of this larger complex, believed to be Iron Age/Romano-British in date. One of the larger dipolar anomalies detected here could also possibly represent kiln remains.

5.8 The probable remains of ridge and furrow farming and a large pit have been identified in the western end of S7 while two possible ditch features have been detected near the eastern limit of this area. The data for this area is generally very smooth, perhaps due to apparent subsoiling.

5.9 Two possible areas of small-scale quarrying, a possible double-ditched trackway and a third ditch have all been detected in area S8.

5.10 No features of apparent archaeological interest have been identified in S9, S10 or S11 with the possible exception of small-scale quarrying in S11 W.

5.11 Several possible ditch features and a large pit have been detected in the central part of S12.

5.12 Probable ridge and furrow farming remains and a possible former land boundary have been detected in S13.

5.13 No apparent features of archaeological interest have been identified in S14, despite the proximity of Carkin Roman fort and settlement.

5.14 The archaeological significance of many of the anomalies identified in this research may only be fully assessed by further investigations such as trial trenching.

6 REFERENCES

Casey, PJ, Howard, P & Wright, J (1995) The Scotch Corner (Violet Grange Farm) Geophysical Research Project. Unpublished report in the North Yorkshire Sites and Monuments Record.

Fitts, RL, Haselgrove, CC, Lowther, PC, & Turnbull, P (1994) An Iron Age Farmstead at Rock Castle, Gilling West, North Yorkshire. *Durham Archaeological Journal* vol 10, 13-42.

Northern Archaeological Associates (1997) A66 Upgrading to Dual Carriageway: Area A - Scotch Corner to Greta Bridge. Unpublished NAA report 97/16.

7 CREDITS

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Report: DN Hale
Date: 8th January 1999

APPENDIX A

PRINCIPLES OF GEOMAGNETIC SURVEYING

Geomagnetic prospecting detects subsurface features in terms of the perturbations or 'anomalies' that they induce in the Earth's magnetic field. In contrast to resistivity, seismic or electromagnetic surveying, no energy is injected into the subsoil and hence this is one of a class of *passive* geophysical techniques that includes gravity and thermal surveying. In an archaeological setting two types of magnetic anomalies can be distinguished:

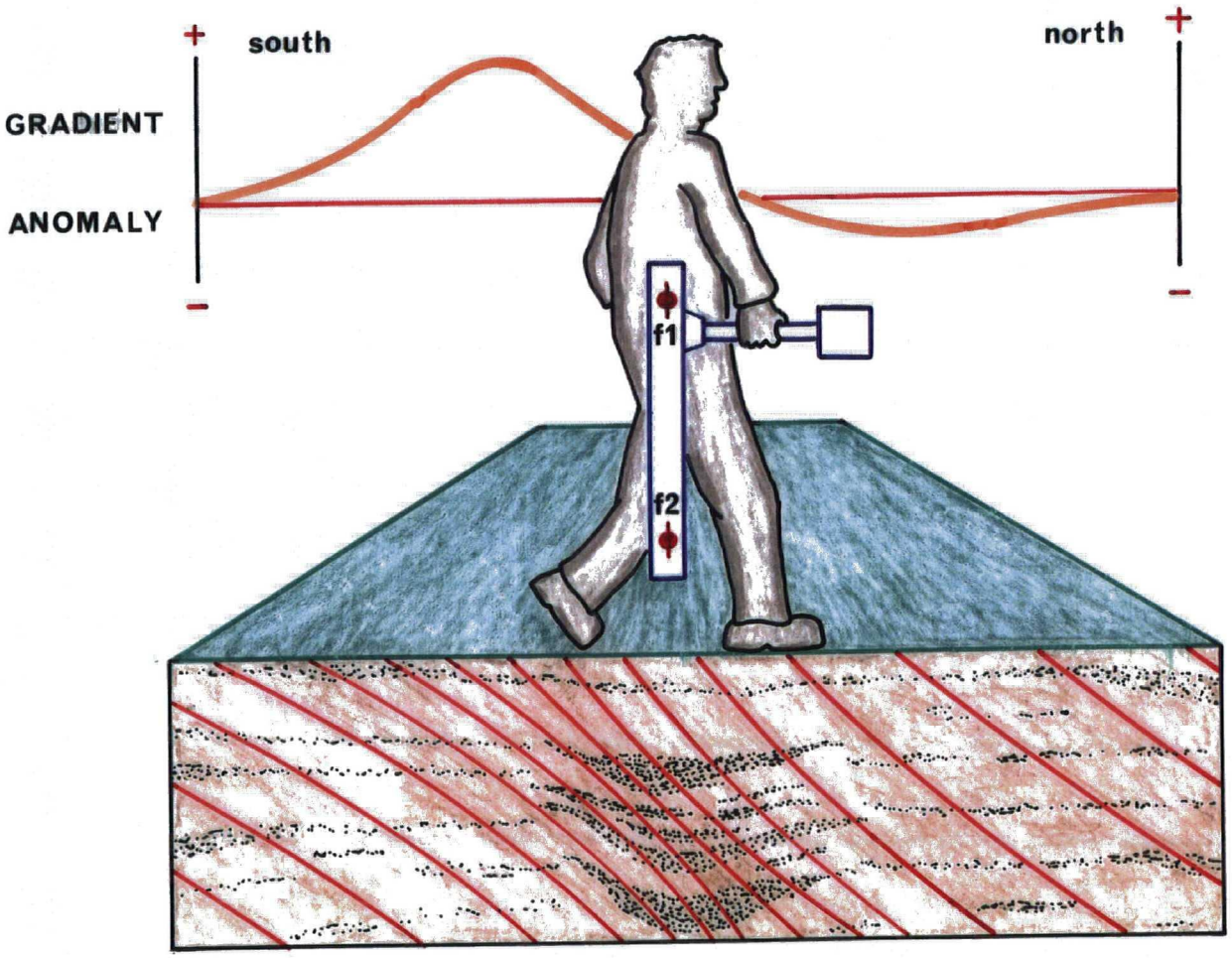
1 Anomalies arising from variations in *magnetic susceptibility* which will modulate the component of magnetisation *induced* in the subsurface by the Earth's magnetic field. For most archaeological sites, this is the dominant factor giving rise to geomagnetic anomalies. In general, susceptibility is relatively weak in sediments, such as sandstones and enhanced in igneous rocks and soils, especially those which have been burnt or stratified with organic material.

2 Anomalies due to large, *permanently magnetised* structures. Such permanent magnetisation or 'remanence' arises when earth materials are heated to above ~600°C and cooled in the geomagnetic field. Thus kilns and hearths are often detected as strong permanent magnets causing highly localised anomalies that dominate effects due to background susceptibility variations. Remanence can result from other physical and chemical processes but these give rise to anomalies that are usually unimportant for geophysical prospecting.

There are several approaches towards the practical measurement of geomagnetic anomalies. In this study measurements were made using a Geoscan FM36 fluxgate gradiometer which records the change with height in the vertical component of the Earth's magnetic field, as shown overleaf. This method has the advantage of being insensitive to diurnal variations while the Geoscan instrument also benefits from an integrated data logger. Note that in mid northern latitudes the magnetic anomaly will be asymmetric with the main peak displaced to the south of the archaeological feature. Thus, a ditch filled with a soil of enhanced susceptibility, for example, will generate a positive anomaly to the south, mirrored by a weak negative anomaly north of the feature. When portrayed as an area map of grey tones this gives rise to a 'shadowing' or pseudo relief effect which must be borne in mind when making an archaeological interpretation.

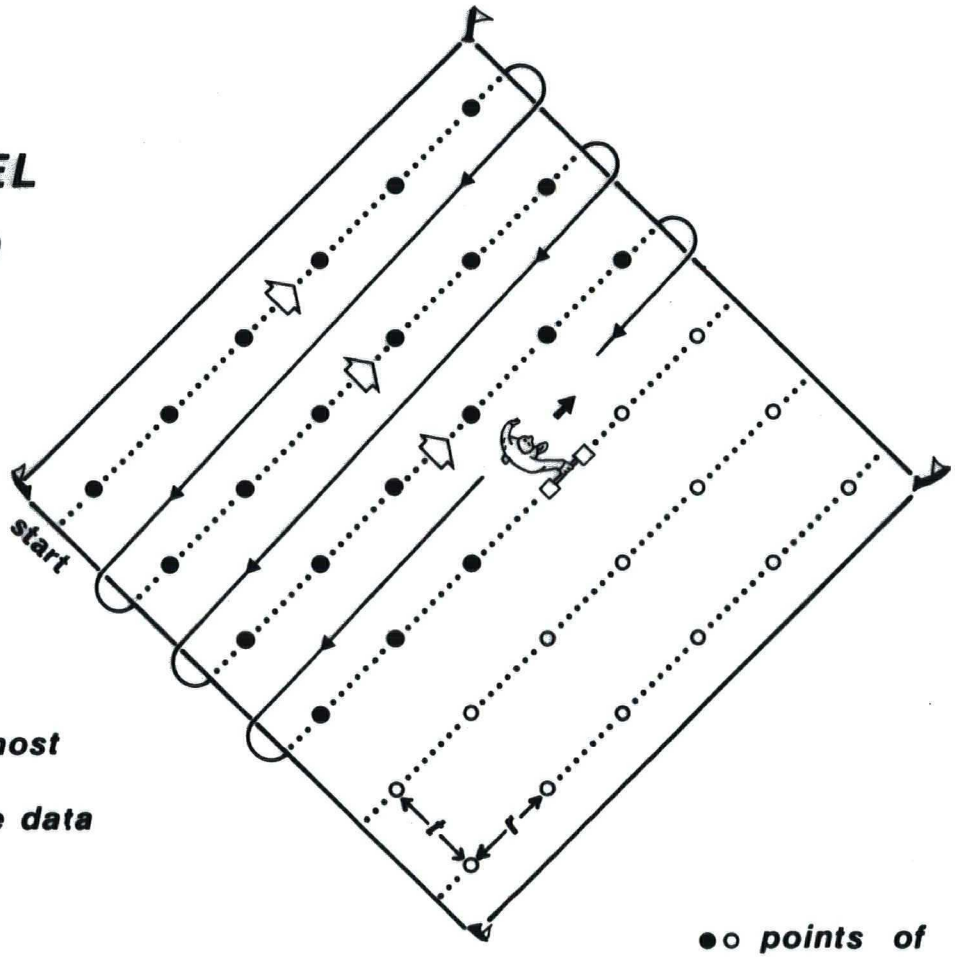
Two techniques can be used to survey gridded areas using the fluxgate magnetometer. In the parallel method the instrument is used to scan the area along traverses which are always in the same direction. This method minimises 'heading errors' due to operator and instrument magnetisation but is time consuming. The alternative zig-zag method is significantly faster and suitable for areas where anomalies are large compared to these and other sources of error.

MAGNETIC SURVEYING



SURVEY SCHEMES

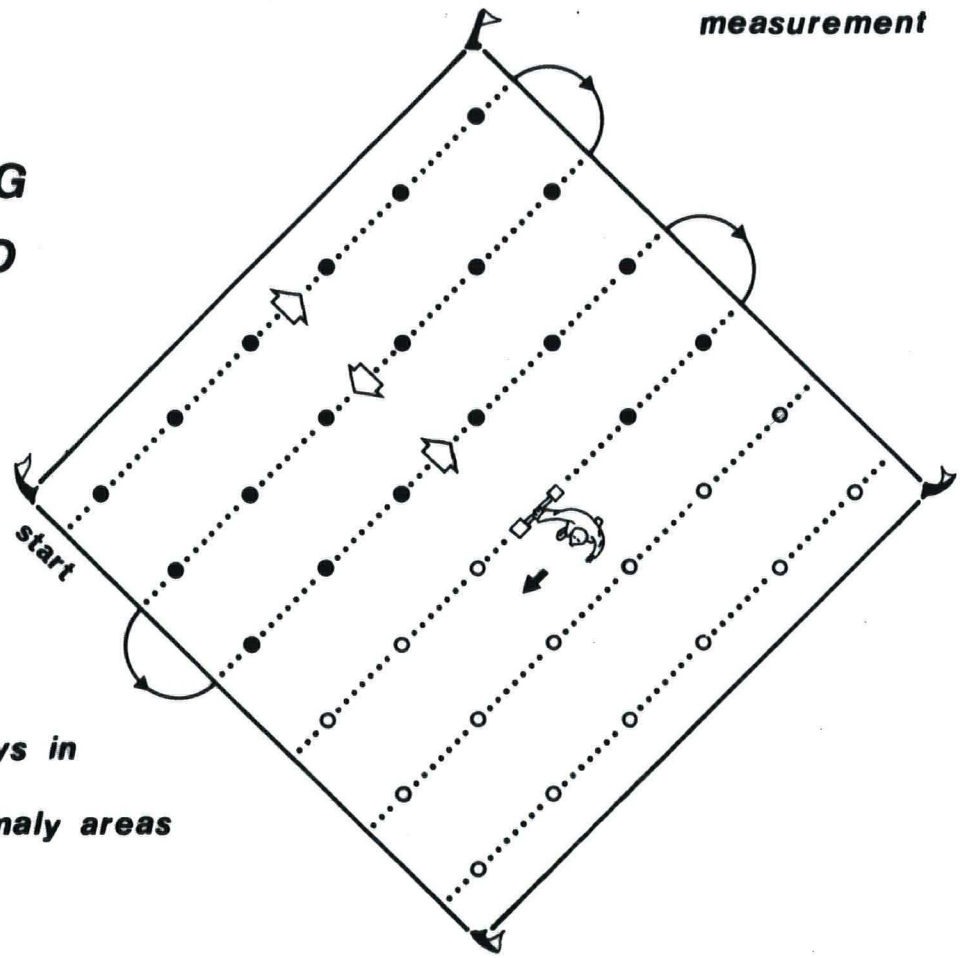
PARALLEL METHOD



slower but minimises most errors in the data

●○ points of measurement

ZIG-ZAG METHOD



suitable for rapid surveys in strong anomaly areas

APPENDIX B
DATA PROCESSING

PROCESSING THE SURVEY DATA

The geophysical images contained in this report were prepared within Microsoft Windows® using the **InSite®** program published by GeoQuest Associates. Geophysical images were then placed onto a map which was digitised from the Ordnance Survey, edited and then plotted using a computer aided drafting (CAD) system and colour inkjet printer.

Data were downloaded from the meter to a portable computer in the field for storage, visualisation and quality control (QC) assessment. These data were then transferred to a laboratory computer for final processing, printing and archiving.

A number of process steps have been applied to the geophysical data obtained during the survey and those which have been used are linked to the main flow path by arrows. Steps were applied in the order shown and are designed to reduce artifacts in the data and enhance geophysical features of archaeological interest. The following sections describe each step in more detail.

REMOVE STRIPING

Reduces a data artifact comprising alternating changes in level in readings logged along zig-zag traverses. This artifact is common in fluxgate magnetometer data. InSite uses a proprietary algorithm to reduce this error.

INFILL SMALL BLANK AREAS

Fills isolated blank data cells with the mean of near-neighbours or a suitable approximation entered manually. Small blank areas will have been logged if it was not possible to obtain a geophysical reading over, for example, a manhole cover in the case of a resistivity survey.

REMOVE SPIKES

Replaces isolated, anomalously high or low values with the mean of near neighbours or a suitable approximation entered manually. 'Spike' readings are commonly associated with ferrous litter or poor electrical contact in the case of geomagnetic and resistivity data, respectively.

REDUCE WALK HARMONICS

Reduces a regular oscillation in traverse data caused by walking movements of the operator during a geomagnetic survey. InSite employs a fast Fourier transform to determine the optimum amplitude and phase of the walk-induced harmonic which is then subtracted from each traverse.

REDUCE SHEAR ARTIFACTS

Corrects for apparent shear in geomagnetic anomalies surveyed by zig-zag traversing in a geomagnetic survey. The shearing effect arises from the interaction of the operator + magnetometer with the geomagnetic field and also from the lag in the instrument response to changes in the field. InSite uses a proprietary algorithm to reduce this error.

CORRECT FOR METER DRIFT

Corrects for a linear drift in the meter calibration with time. Such drift is a common problem with fluxgate magnetometers, particularly during periods of rapid air temperature change. InSite uses least-squares regression on the mean of data along each traverse to estimate the change in calibration level across each grid. This gradient is then removed from the data.

ADJUST GRID MEAN LEVELS

Adjusts for differences in the mean level in data grids due to changes in instrument calibration (fluxgate magnetometer survey) or alteration in remote electrode spacing (resistivity survey).

INTERPOLATE AND COMBINE

Combines grids to form an array of regularly-spaced data on a square mesh. InSite uses bilinear interpolation to accomplish this.

LOW PASS FILTER

If this process task is indicated then a 3x3 or 5x5 boxcar filter has been used to smooth the data and reduce noise or 'speckle' seen in the original image.

HIGH PASS FILTER

If this process task is indicated then a 3x3 or 5x5 filter, with appropriate coefficients, has been used to pass short-wavelength information into the resulting image.

EDGE DETECT FILTER

Signifies that a Sobel, Laplace or other specialised filter has been applied to enhance significant lateral transitions in the geophysical image.

DIRECTIONAL FILTER

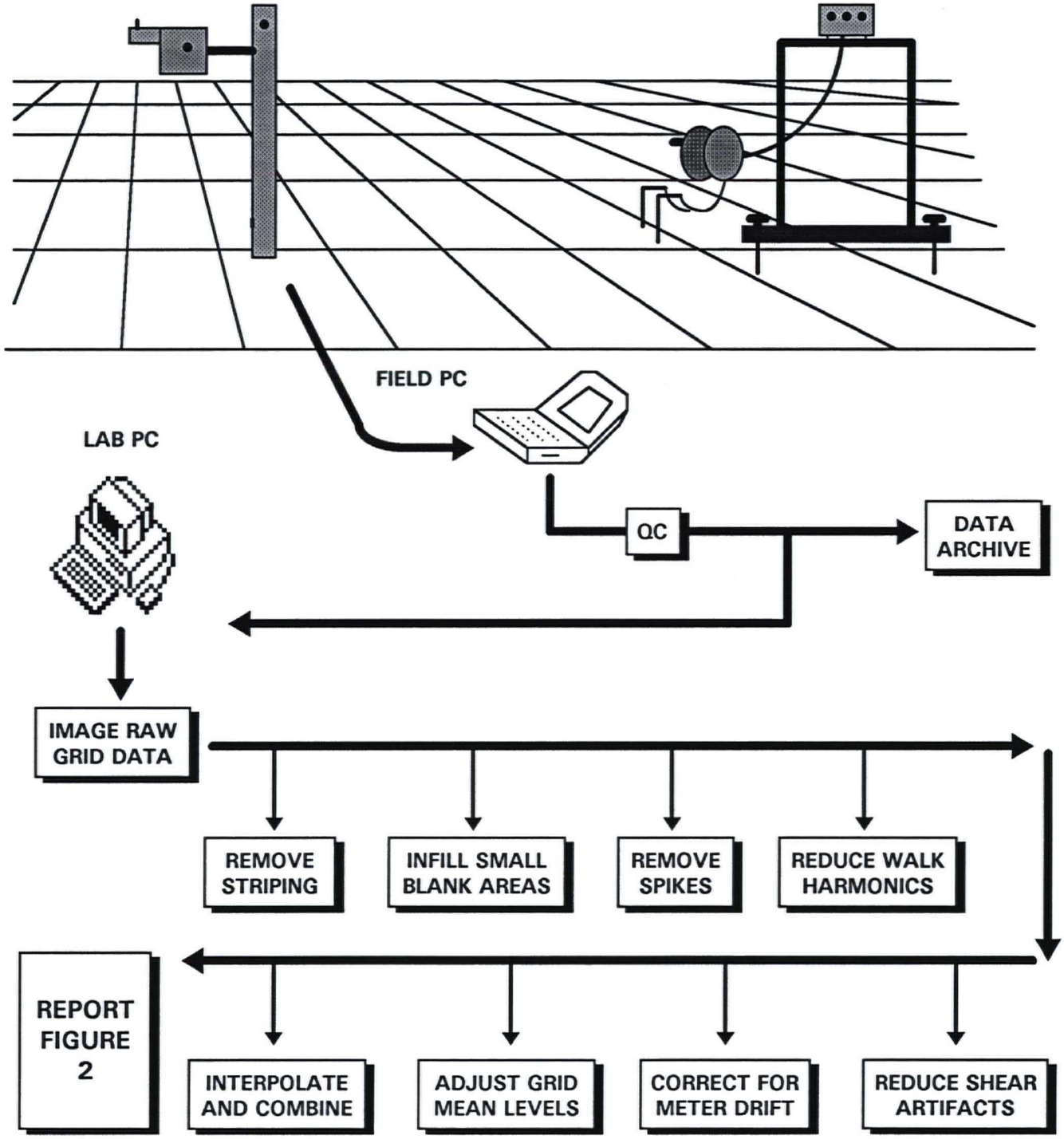
This filter is equivalent to illuminating the data from one direction to produce a pseudo-relief image. Directional filtering is usually employed to aid the identification of subtle anomalies in resistivity data. This filter highlights features trending at right angles to the direction of illumination.

NOTE

GeoQuest Associates can supply the geophysical images presented in this report in a variety of digital formats for visualisation on microcomputers running Microsoft Windows. These formats include the TIF, BMP and PCX standards. Please complete the request form at the rear of this report if you would like to receive such image files.

InSite

APPENDIX B
DATA PROCESSING



PROJECT: Scotch Corner -Melsonby

SITE: All sites