ARCHAEOLOGICAL
SERVICES
WYAS

Long Lane Quarry, Barnsdale Bar, North Yorkshire

Gradiometer Survey

May 1997

CLIENT

Darrington Quarries Ltd.

West Yorkshire Archaeology Service
14 St John's North, Wakefield WF1 3QA

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Long Lane Quarry,

Barnsdale Bar,

North Yorkshire.

Gradiometer Survey

by

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Contents

Long Lane Quarry,

Barnsdale Bar,

North Yorkshire.

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Gradiometer Survey

1. Summary

Client
Darrington Quarries Ltd.
Darrington Leys
Cridling Stubbs
Knottingley
Yorkshire
WF11 OAH .

Objectives
To gather sufficient information to establish the location and extent of any archaeological features within the proposals area , and to characterise any archaeology located in this way.

Method
A detailed gradiometer survey was carried out over an area measuring *c.*2.5 hectares east of Long Lane Quarry using a Geoscan FM36 fluxgate gradiometer.

Results & Conclusion
Positive linear anomalies, possibly the sub-surface remains of a ditched enclosure and associated field system, have been identified. Discrete positive anomalies may indicate pits or small areas of burning. Many of the weaker anomalies that have been identified are probably caused by water formed geological features in the limestone bedrock and by early agricultural practice.

The results of the survey continue the pattern of anomalies identified in previous geophysical surveys in the Barnsdale Bar area.

2. Introduction & Archaeological Background

2.1 Archaeological Services (WYAS) was commissioned by David Harper on behalf of Darrington Quarries Ltd. to undertake a gradiometer survey on a site to the east of Long Lane Quarry (see Fig. 1) in advance of a proposed quarry extension. The site is bounded by Long Lane Quarry to the north and west, and agricultural land , including Wooddle Hole Plantation and Old Whin Fox, a second plantation, to the south and east.

2.2 The site lies just inside the boundary of North Yorkshire immediately adjacent to where it meets South and West Yorkshire (see Fig. 1). In the 9km^2 around the proposed quarry extension 30 archaeological sites have been identified (Boucher 1996) primarily from cropmark evidence. More recently an extensive field/enclosure system has been identified by gradiometer survey to the south of Wooddle Hole Plantation (Cottrell 1996).

2.3 The site slopes gradually down from south to north and is situated on cultivated land. The soils are classified as Brown Calcareous, typical of the region, with the underlying geology comprising Magnesian Limestone with outcropping sands and gravels.

2.4 Work on site was carried out between 27th and 28th April 1997.

3. Results & Discussion *(Figs 2 & 3)*

3.1 ***The Presentation of the Results***

3.1.1 The gradiometer data is presented as a 1:2500 greyscale plot overlain on Ordnance Survey map base in Figure 2 with an interpretation of the anomalies shown in Figure 3. Dot density and X-Y trace plots of the gradiometer data are presented at a scale of 1:500 in Appendix 3.

3.2 ***The Detailed Gradiometer Survey***

3.2.1 Isolated dipolar anomalies, (iron "spikes" - >+/- 100nT) occur across all parts of the site. These responses are caused by ferrous material in the topsoil usually introduced as a result of manuring. They are not usually indicative of archaeological activity.

3.2.2 The most obvious trend in the data is the variation in background soil "noise" across the site. In the most northerly 75m of the site and again for 70m at the southern end of the site the background responses are very flat. This is most obvious from the X -Y trace plot in Appendix 3. This could be a function of the topography of the site; movement of topsoil downslope leading to a greater depth of topsoil in these places and a consequent masking of weaker responses.

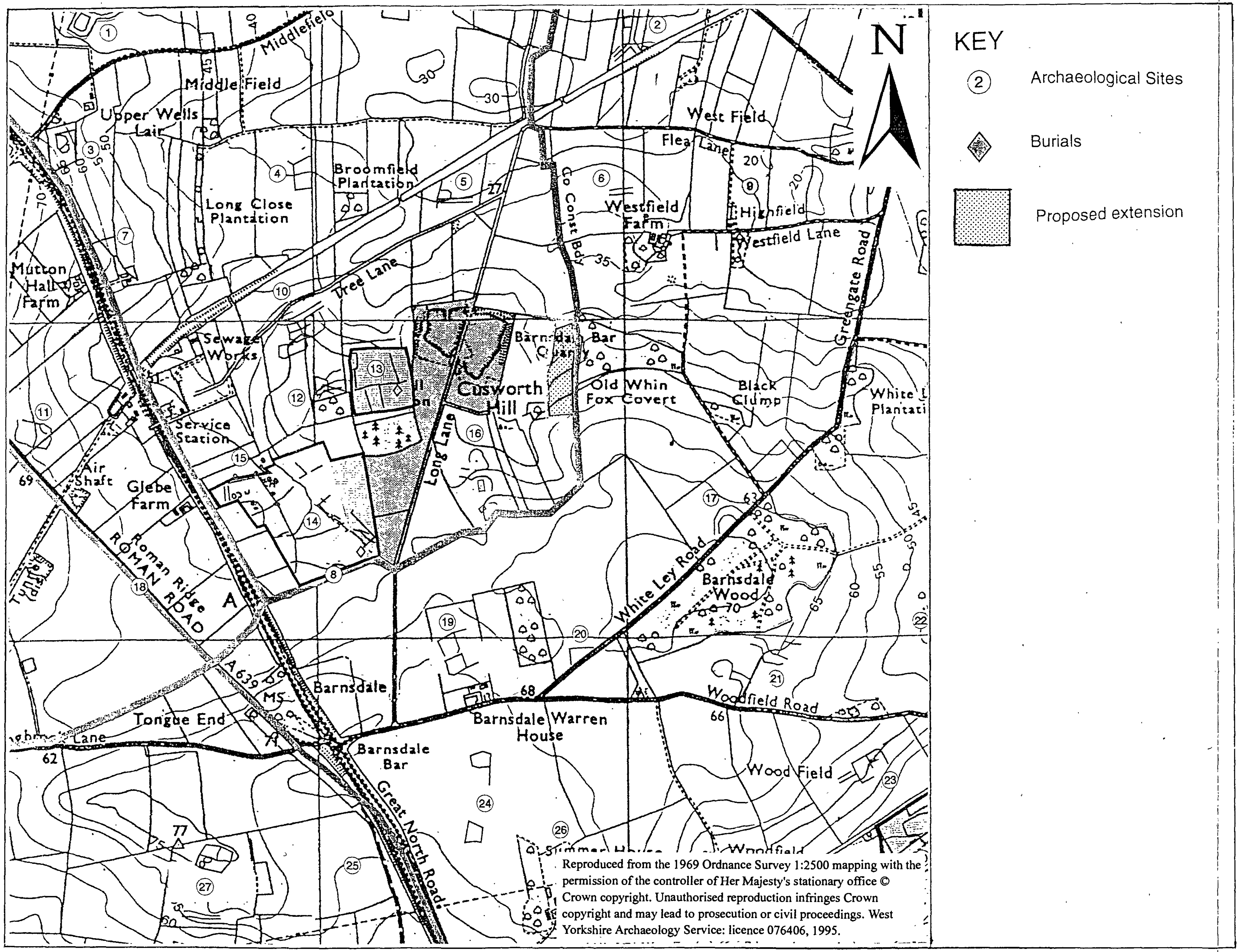

Fig. 1 Site location showing other known archaeological sites

Fig. 2 Site location showing gradiometer data

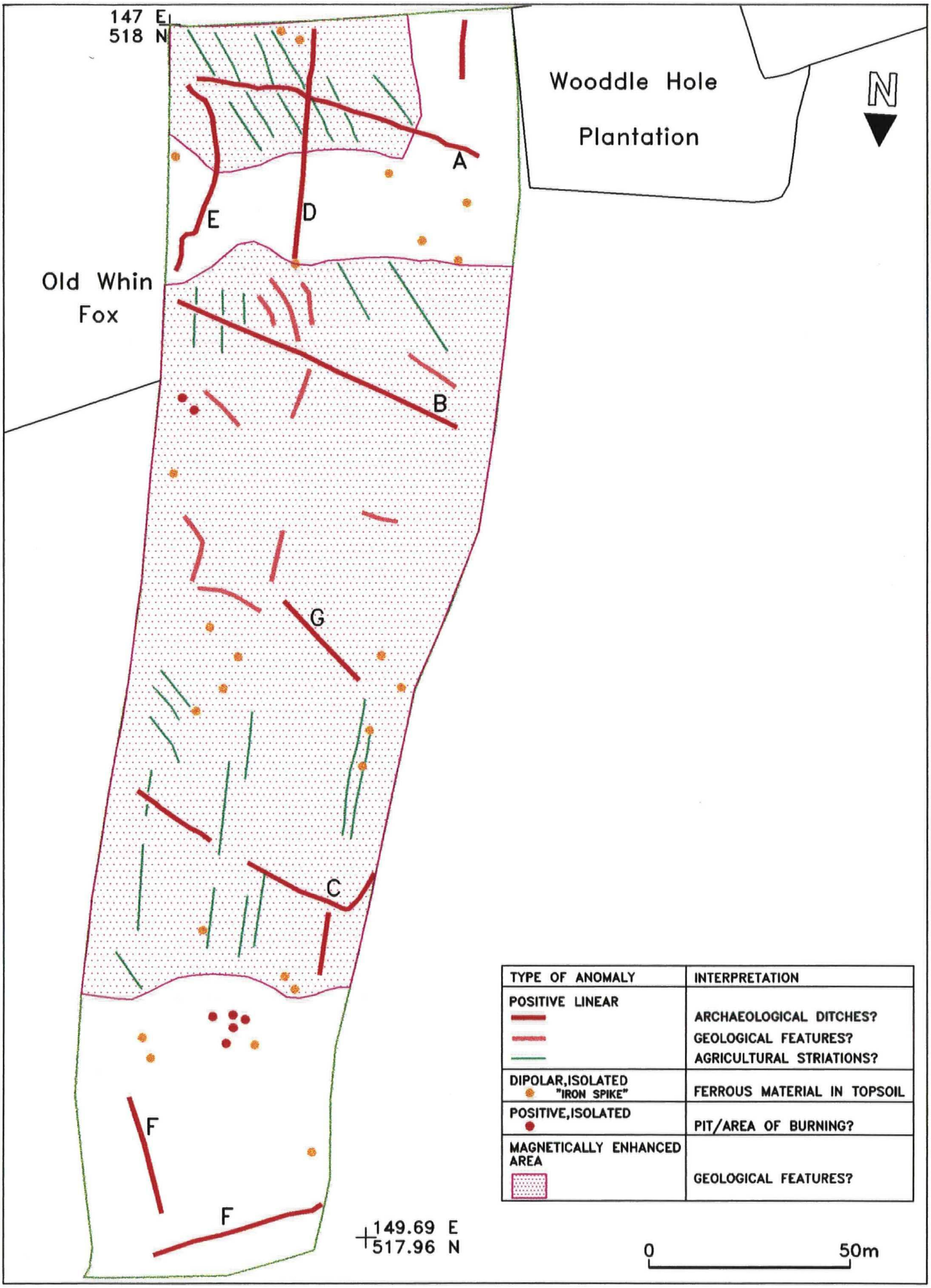

Fig.3 Interpretation of gradiometer data

3.2.3 By contrast between these two areas the responses in the central part of the site show a general enhancement. In this "noisy" background it is difficult to interpret coherent anomalies. Some of the more coherent are the weak linear responses orientated from north to south. These are parallel with the current field boundaries and probably reflect wheelings or striations caused by the most recent ploughing regime.

3.2.4 As can be seen from Section 3.2.3 above, the "noisy" background and abundance of incoherent "anomalies", not all of which are marked on the interpretation diagram, could be due to the reduced amount of topsoil covering this part of the site caused by the effects of ploughing on a slope and the effects of sheetwash and other processes leading to a general migration of material downslope. In this case the effects of the solid geology could have a greater effect on the data than at the extreme ends of the site where the topsoil is possibly deeper.

3.2.5 Some of the shorter linear anomalies detected in this central part of the site could be due to infilled ditches which could have formed part of a system of enclosures or land divisions of unknown date. In this case the fill of these features has a higher magnetic susceptibility than the surrounding topsoil and therefore is detected as a positive anomaly. The discontinuous nature of some of these anomalies could be due to plough damage, perhaps exacerbated by the shallow depth of topsoil pertaining in this area. It should, however, be noted that limestone is a substrate particularly prone to erosion by water and that many of the anomalies, both linear and isolated, could be due to fluvial features such as stream beds and solution hollows.

3.2.6 The most prominent (+3nT), and coherent, responses in this central area are from the L-shaped anomaly (Fig. 3 - **C**) which runs roughly from east to west across the whole site. It is possibly caused by an infilled enclosure ditch. There is a prominent gap half way across the anomaly possibly suggesting an entrance. However, plough damage causing differential survival of the sub-surface features could also account for this.

3.2.7 On the same alignment as **C** is a similar anomaly, **A,** at the southern end of the site. This is crossed at right angles by **D** and is joined at its eastern end by a curvi-linear anomaly, **E**. Likewise, these anomalies may be the infilled remnants of enclosure ditches.

3.2.8 The most prominent anomaly at the northern end of the site is a second L-shaped anomaly, **F**. From the grey-scale plot of the data (Fig. 2) it can be seen that this anomaly is less well defined than the other linear anomalies discussed above. This can be typical of a natural feature such as a fissure or a change in the underlying bedrock. An infilled dry river valley might also cause this response. However, as with the other interpretations made above it is not possible to categorically assert the cause of each anomaly without an intrusive investigation.

3.2.9 Another anomaly, **G**, on a slightly different alignment to those described above can also be seen in the centre of the site.

3.2.10 Several isolated positive anomalies have been identified on site, particularly at the northern end. These could be due to pits, where the fill comprises magnetically enhanced material, or to localised areas of burning, either interpretation suggestive of human activity.

Experience of similar responses on limestone bedrock suggests they can also be due to natural features such as solution holes.

4. Conclusion

4.1 Detailed gradiometer survey has identified a variety of positive linear anomalies some of which are thought to indicate the presence of infilled ditches possibly forming part of a system of land division and/or enclosure. These may be a continuation of an ancient field system and associated enclosures located to the south of Wooddle Hole Plantation (Cottrell, 1996). Similar anomalies detected by gradiometer survey, and subsequently excavated, to the west of Cusworth Hill were of Iron Age or Romano-British date. It should be noted that the nature of the limestone bedrock results in the formation of natural features which are difficult to differentiate from anthropogenic (archaeological) features without intrusive investigation.

The results and subsequent interpretation of geophysical surveys should not be treated as an absolute representation of the underlying archaeology. It is normally only possible to prove the archaeological nature of anomalies through intrusive means such as by trial trenching.

Bibliography

Cottrell, P., 1996, *Barnsdale Bar Quarry, Kirk Smeaton: Geophysical Survey Report* , WYAS R320

Boucher, A., 1996, *Land at Barnsdale Bar Eastern Quarry Extension: Preliminary Archaeological Assessment*, WYAS R303

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Appendices

Appendix 1: Gradiometer Survey: technical information and methods

Appendix 2: Survey tie-in information

Appendix 3: 1:500 Gradiometer data plots

Appendix 1

Gradiometer Survey: technical information and methods

1. *Technical Information*

1.1 Iron makes up 6% of the Earth's crust mostly dispersed through soils, clays and rocks as chemical compounds which are weakly magnetic. Human activities can redistribute these compounds and change (enhance) others into more magnetic forms. These anthropogenic processes result in small localised anomalies in the Earth's magnetic field which are detectable by a 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 the 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 (iron minerals) to concentrate in the topsoil thereby making it more magnetic than the subsoil or bedrock. Linear features cut into the subsoil or solid geology, *e.g.* ditches, that have silted up or been backfilled with topsoil will produce a positive magnetic response relative to the background soil levels. Discrete features such as pits can also be detected. Less magnetic material such as masonry or plastic service pipes which intrude into the topsoil will give a negative magnetic response relative to the general background level.

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

1.4 The highest responses are usually due to iron objects in the topsoil. These produce a response characterised by a rapid change from positive to negative readings (iron "spikes").

1.5 The types of response mentioned above can be divided into five main categories which are described below:

1. **Iron Spikes (Dipolar Anomalies)**
   These responses are referred to as dipolar and are caused by buried iron objects. Little emphasis is usually given to such responses as iron objects of recent origin are common on agricultural sites.

2. **Rapid, strong variations in magnetic response**
   Also referred to as areas of magnetic disturbance these can be due to a number of different types of features. They are usually associated with burnt material such as industrial waste or other strongly magnetic material. It is not always easy to determine their date of origin without supporting information.

3. **Positive linear responses**
The strength of these responses varies depending on the underlying geology. They are commonly caused by ancient ditches or more recent field drains.

4. **Isolated positive responses**
These exhibit a magnitude of between 2nT and 300nT and, dependent on the strength of response, can be due to pits, hearths, ovens or kilns. It is, therefore, very difficult to establish an anthropogenic origin without an intrusive means of examining the features.

5. **Negative linear anomalies**
These are normally very faint and are commonly caused by features such as plastic water pipes which are much less magnetic than the surrounding soils and geology.

2. *Methodology*

2.1 There are two methods of using the fluxgate gradiometer. The first of these is referred to as *scanning* and requires the operator to visually identify anomalous responses on the instrument display whilst covering the site in widely spaced traverses, typically 10m - 15m. The instrument logger is not used and there is therefore no data collection. This method is used as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be surveyed. Scanning can also be used to map out the full extent of features located during sample detailed survey.

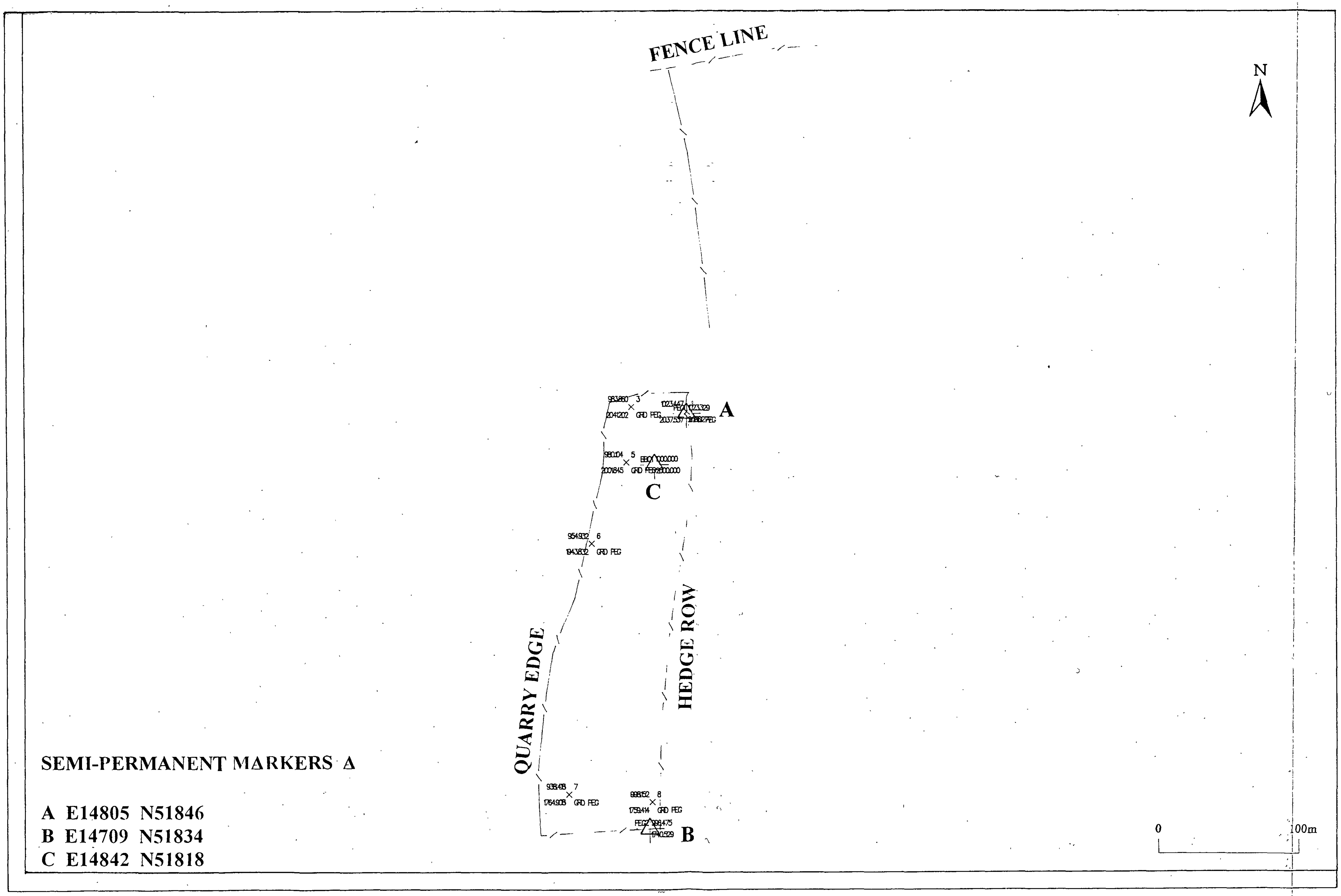
2.2 The second method is termed *detailed survey* and this employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.5m intervals, on zig-zag traverses usually 1m apart. These readings are stored in the memory of the instrument and are later dumped to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

2.3 A Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used to take readings at 0.5m intervals 1m apart within grids measuring 20m by 20m, 800 readings therefore being taken within each grid square. In-house software (Geocon Version 9) was used to interpolate the "missing" line of data so that 1600 readings in total were obtained for each complete grid.

Appendix 2

Survey tie-in information

The area of survey and immediate features of the landscape, *i.e.* field boundaries, and fence lines were tied in using a Geotronics 600 Geodimeter. The western chimney of Ferrybridge power station, lying to the north of the site, was used as a surveying reference object. Additional local grid and O.S. co-ordinates for semi-permanent markers remaining on site are presented overleaf.



Survey Tie-In Information

Appendix 3

1:500 Gradiometer Data Plots