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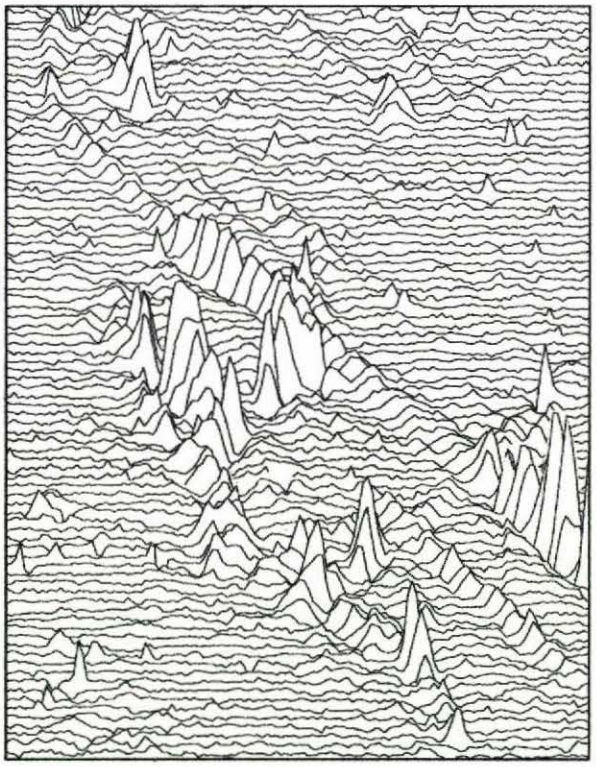
ARCHAEOLOGICAL
SERVICES
WYAS

Marsh Leys Farm
Kempston
near Bedford

Gradiometer Survey



January 1999

Report No. 670

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Bedfordshire County Archaeology Service

1. Introduction & Archaeological Background

1.1 Archaeological Services (WYAS) was commissioned by Mr M. Luke of Bedfordshire County Archaeology Service (BCAS) to carry out a gradiometer survey over the site of a proposed industrial development at Marsh Leys Farm, Kempston, near Bedford (see Figs 1 & 2).

1.2 The proposed development area of *c.*51 hectares comprises six large fields surrounding Marsh Leys Farm, being bounded to the north and west by the A421(T), to the east by the Wellingborough to Luton railway and to the south by the road to Kempston Hardwick.

1.3 The site is very flat, lying on or about the 30m contour line, with the underlying geology comprising Oxford Clays overlain in the south-eastern corner of the site by alluvium deposited during the periodic flooding of Elstow Brook which forms the boundary between the two fields in this part of the site.

1.4 At the time of survey (December 7th to 16th 1998) the greater part of the site was under a young cereal crop with the exception of the field in the south-western corner of the site, which was under a low growing root crop. No specific problems were encountered during the survey although the fields adjacent to Elstow Brook were extremely heavy underfoot.

1.5 The archaeological interest in the site principally comes from the linear features (thought to relate to medieval land division) which are presumed to be the cause of crop marks identified to the north and east of Marsh Leys Farm. Immediately to the north-east of the farm are other crop marks which could indicate a small ditched enclosure. The location of this correlates with a concentration of Roman pottery sherds collected during a field walking evaluation (BCAS 1998). Other crop marks to the south-west of the farm are thought to be indicative of ditched enclosures and other linear features which are thought to be of Roman or later date. The field containing these crop marks was not field walked as it was under crop at the time of the evaluation. Immediately outside the site to the north-east is another substantial crop mark complex made up of enclosures and other linear features. Elsewhere along Elstow Brook similar features have been proven to be of later prehistoric and Roman date.

1.6 The primary aim of the geophysical survey was therefore to identify broad areas of archaeological activity by gradiometer scanning so that such areas could be further defined and interpreted by selected detailed survey.

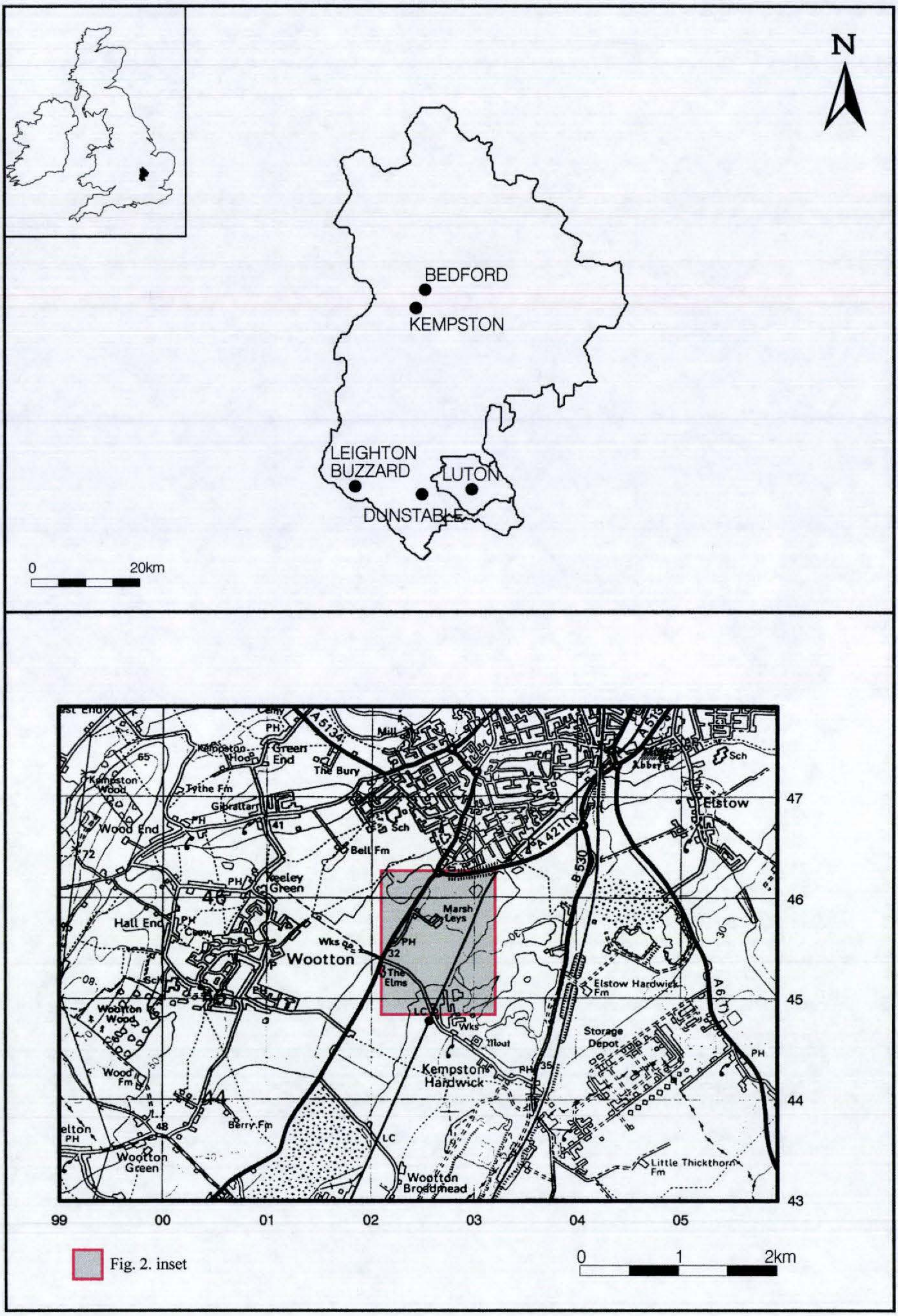


Fig. 1. Site Location

2. Results of Magnetic Scanning

2.1 All of the site was scanned on traverses approximately 12m to 15m apart with the exception of the field in which Blocks B and C were located (see Fig. 2), which, it was assumed, would be covered by detailed survey at a later stage. Any observed fluctuations in magnetic response were investigated and those deemed to be of possible archaeological potential were located on plan (together with the orientation and magnitude of response) and in the field using bamboo canes.

2.2 The scanning indicated a very quiet magnetic background, generally +/- 0.5nT, although in the fields immediately north and south of Elstow Brook this became noticeably more quiet, probably due to the homogeneity of the alluvial deposits.

2.3 It had been anticipated that the ridge and furrow, which had been interpreted from aerial photographs over much of the site (BCAS 1998), could possibly 'mask' less strong responses from archaeological features. However, in practice the scanning did not detect any responses attributable to the ploughed out remnants of the ridges or the infilled furrows and this was subsequently borne out by the data from the detailed survey.

2.4 Overall the scanning proved to be uniformally negative with no probable archaeological anomalies detected with the notable exception of the extremely strong linear and isolated responses detected around the centre of Block A, some of which were in excess of 10nT.

2.5 On completion of the scanning a site meeting was attended by Mike Luke (Project Manager BCAS), Martin Oake (Planning Archaeologist BCC) and Alistair Webb (Project Manager Archaeological Services - WYAS) at which it was agreed that a detailed survey covering 10 hectares (20% of the application area) should be sufficient to achieve the aims of the geophysical evaluation (see below).

2.6 The stated aims of carrying out a detailed survey of this size were

- to determine the limit of the archaeological anomalies around the two 'enclosures' (Blocks **A** and **B**) identified from air photographs and through scanning
- to investigate the linear crop marks south-east and north-west of Marsh Leys Farm
- to determine whether there were any linear features running into the site from the known crop mark complex north-west of the application area
- to test apparently 'blank' areas (*i.e* where there were no crop marks and/or scanning was negative)

3. Results of the Detailed Magnetic Survey

3.1 The areas of detailed survey have been termed Blocks **A** to **K**; the relative positions of each block are shown in Figure 2. Dot density and interpretative overlays are presented at a scale of 1:1250 in Figures 3-6 inclusive and at a scale of 1:1500 in Figures 7 to 9 inclusive. Large scale (1:500) dot density and X-Y trace plots are included in Appendix 3.

3.2 It should be noted that only the strongest 'iron spikes' have been shown on the interpretative overlays as to highlight them all would unduly clutter the interpretation; unless otherwise stated these are assumed to be non-archaeological in origin.

3.3 Other faint linear anomalies along the line of traverse, which are also not highlighted, are not 'real' having been artificially created by the data processing. These anomalies could have been removed by additional processing but this could have lead to the removal of some of the weaker, archaeological anomalies.

3.4 Block A

3.4.1 This block was positioned to establish the presence and extent of any features associated with the crop marks identified from the air photographs and confirmed by magnetic scanning.

3.4.2 The main anomalies identified in the gradiometer data broadly correlate with the transcribed features interpreted from the air photographs although many additional linear and discrete anomalies have also been identified in the data.

3.4.3 At the centre of the complex is a weak, L-shaped anomaly (**A**), on a north-east/south-west/south-east/north-west axis which corresponds closely with a crop mark. Crossing this at a slightly oblique angle is a much stronger (>8nT) reverse L-shaped anomaly, **B**, parts of which had been noted from the aerial photographs. Within the area enclosed by **A** and **B** are two weak D-shaped anomalies, **F** and **G**, and many isolated positive responses.

3.4.4 Parallel with, and 10m to the north-east of, **B** is another linear anomaly, **C**, with a third, **D**, a further 10m north-east again. Immediately south-east of where **B**, **C** and **D** cross **A** is a small recti-linear anomaly and other less definable areas of extremely strong magnetic response.

3.4.5 At the other (southern) end of the block is another L-shaped anomaly, **H**, with isolated responses both inside and immediately outside. Other very strong responses have been highlighted as Anomaly **E**.

3.4.6 Three linear anomalies on a north-west/south-east alignment in the south-western corner of the block have also been identified. These are probably

KEY

TYPE OF ANOMALY	INTERPRETATION
DIPOLAR, ISOLATED	FERROUS MATERIAL IN TOPSOIL
MAGNETIC DISTURBANCE, AREA	FERROUS MATERIAL IN TOPSOIL/SUBSOIL
NEGATIVE, LINEAR	NON-FERROUS PIPE?
POSITIVE, LINEAR	RIDGE AND FURROW
POSITIVE, ISOLATED	ARCHAEOLOGICAL/ GEOLOGICAL?
POSITIVE, LINEAR	ARCHAEOLOGICAL/ AGRICULTURAL?
POSITIVE, ISOLATED	ARCHAEOLOGICAL/ AREA OF BURNING?
POSITIVE, LINEAR	ARCHAEOLOGICAL DITCH?

N

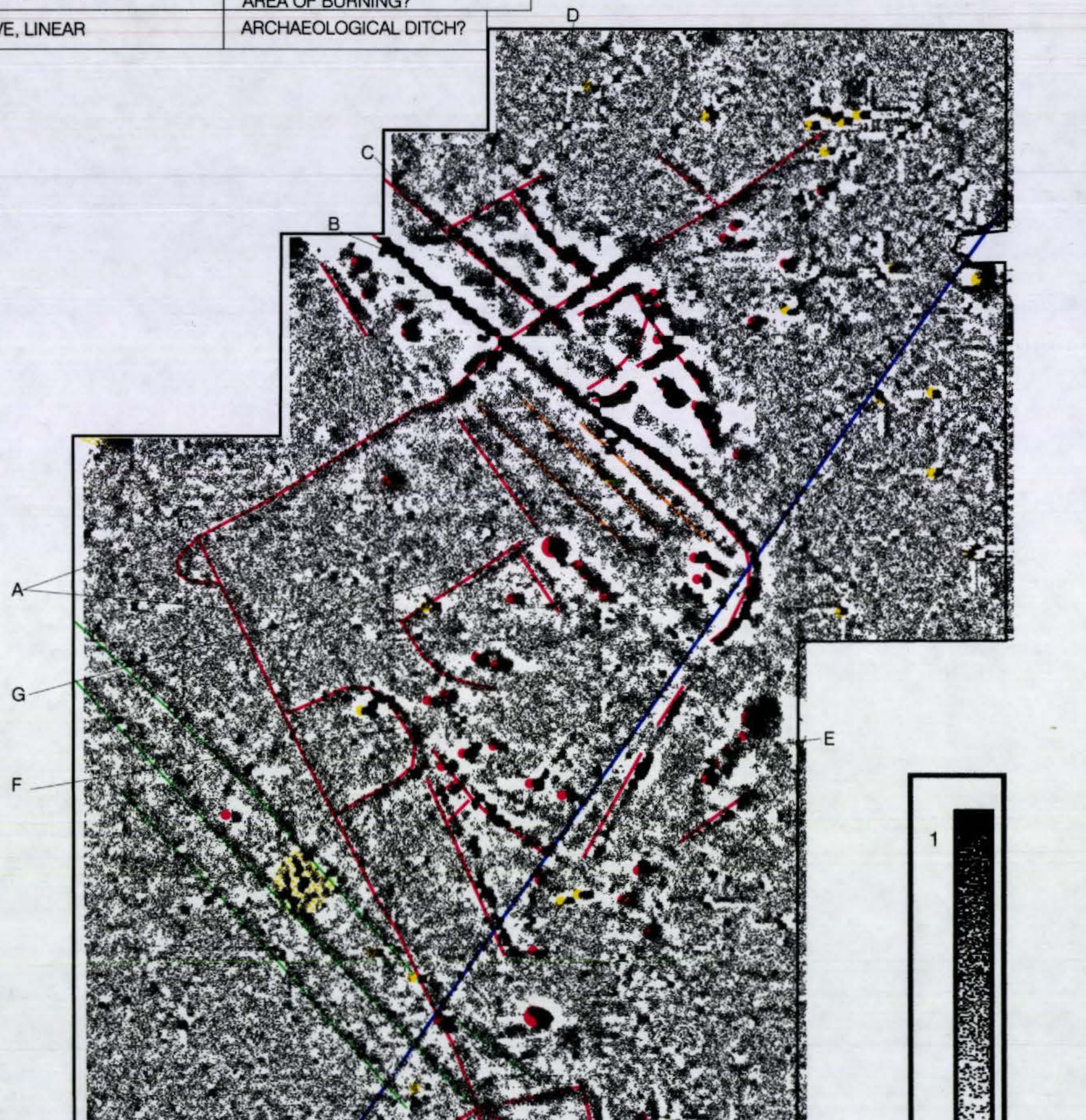


Fig. 3. Interpretation of gradiometer data (Block A)

Fig. 4. Gradiometer data (dot density, 1:1250)

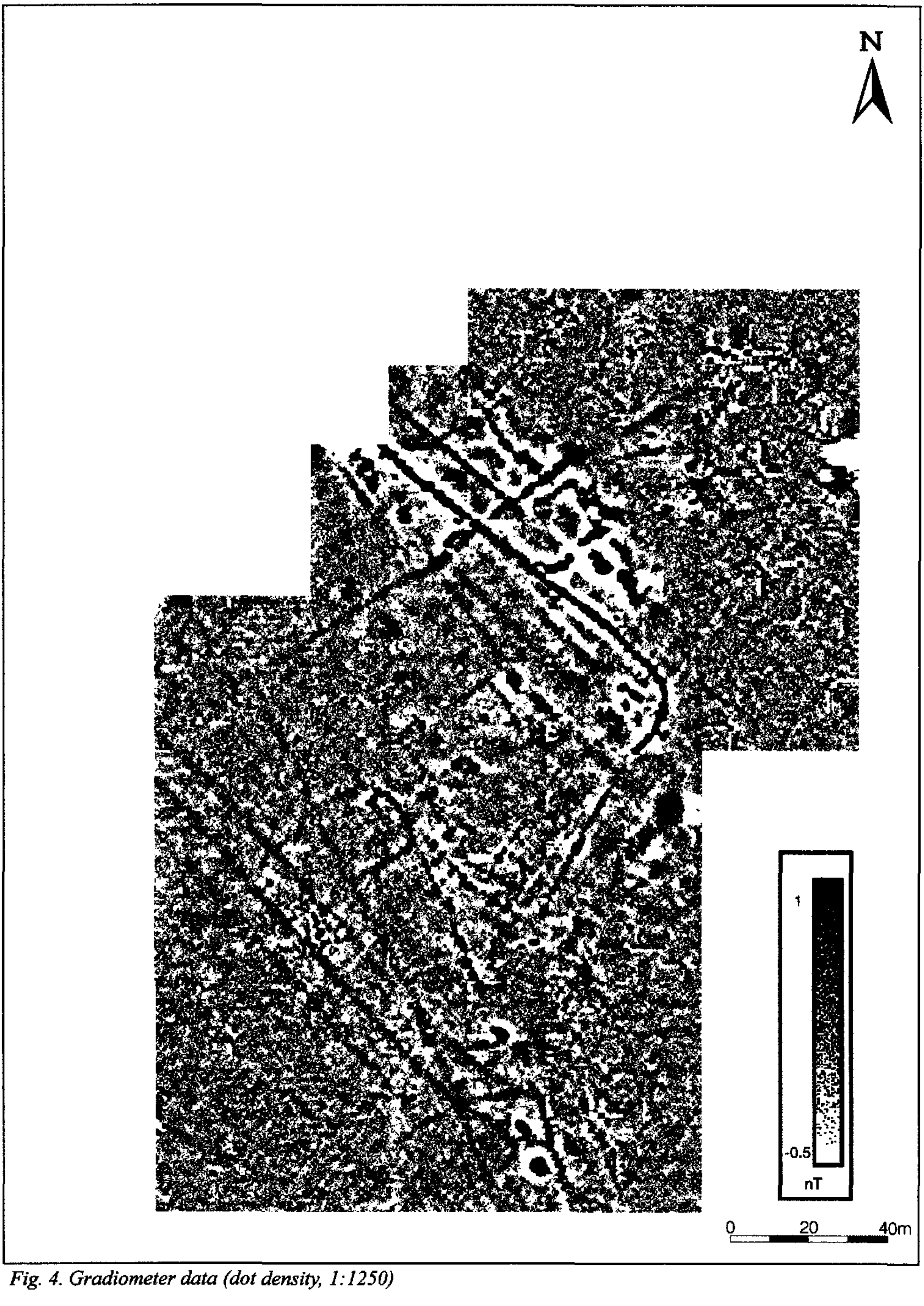


Fig. 4. Gradiometer data (dot density, 1:1250)

magnetic remnants of ridge and furrow ploughing. It is possible that one or two other linear anomalies in the centre of the complex are also caused by this method of ploughing. Ploughing, either recent or otherwise, may account for the discontinuous nature of some of the observed anomalies.

3.4.7 A single linear, negative anomaly running through the whole block from south-west to north-east is probably caused by a non-ferrous pipe.

3.4.8 Two areas of magnetic disturbance have also been highlighted.

3.5 Block B

3.5.1 This block was positioned to establish the presence of a possible enclosure and trackway interpreted from the air photograph assessment and to determine the extent of any associated features. A significant assemblage of Roman pottery was also found in the immediate vicinity of the 'enclosure'.

3.5.2 The magnetic anomalies in this area appear to be centred around or adjacent to a linear anomaly, **I**, which is orientated from south-west to north-east. This is parallel to, and 20m south of, the drain which forms the current field boundary. Indeed a possible similar anomaly can be seen on the northern side of the drain. Radiating at right angles south-eastwards from **I** are three other linear anomalies, **J**, **K** and **L** and a rectangular anomaly, **M**.

3.5.3 Between **I** and the drain are a series of short discontinuous linear, curvi-linear and recti-linear anomalies as well as isolated anomalies, including the sub-rectangular anomaly, **N**.

3.5.4 The areas of magnetic disturbance are probably associated with the adjacent farm buildings.

3.5.5 There are no anomalies in the south-eastern corner of this block contrary to the evidence from the aerial photographs.

3.6 Block C

3.6.1 This series of grids was surveyed in order to determine whether any features from the crop mark complex immediately north-east of the site continued into the current application area.

3.6.2 With the exception of a short linear anomaly in the north-eastern corner no magnetic anomalies were identified.

3.7 Blocks I to J

3.7.1 All these blocks were located in areas in which no crop marks had been identified and which had scanned negeative.

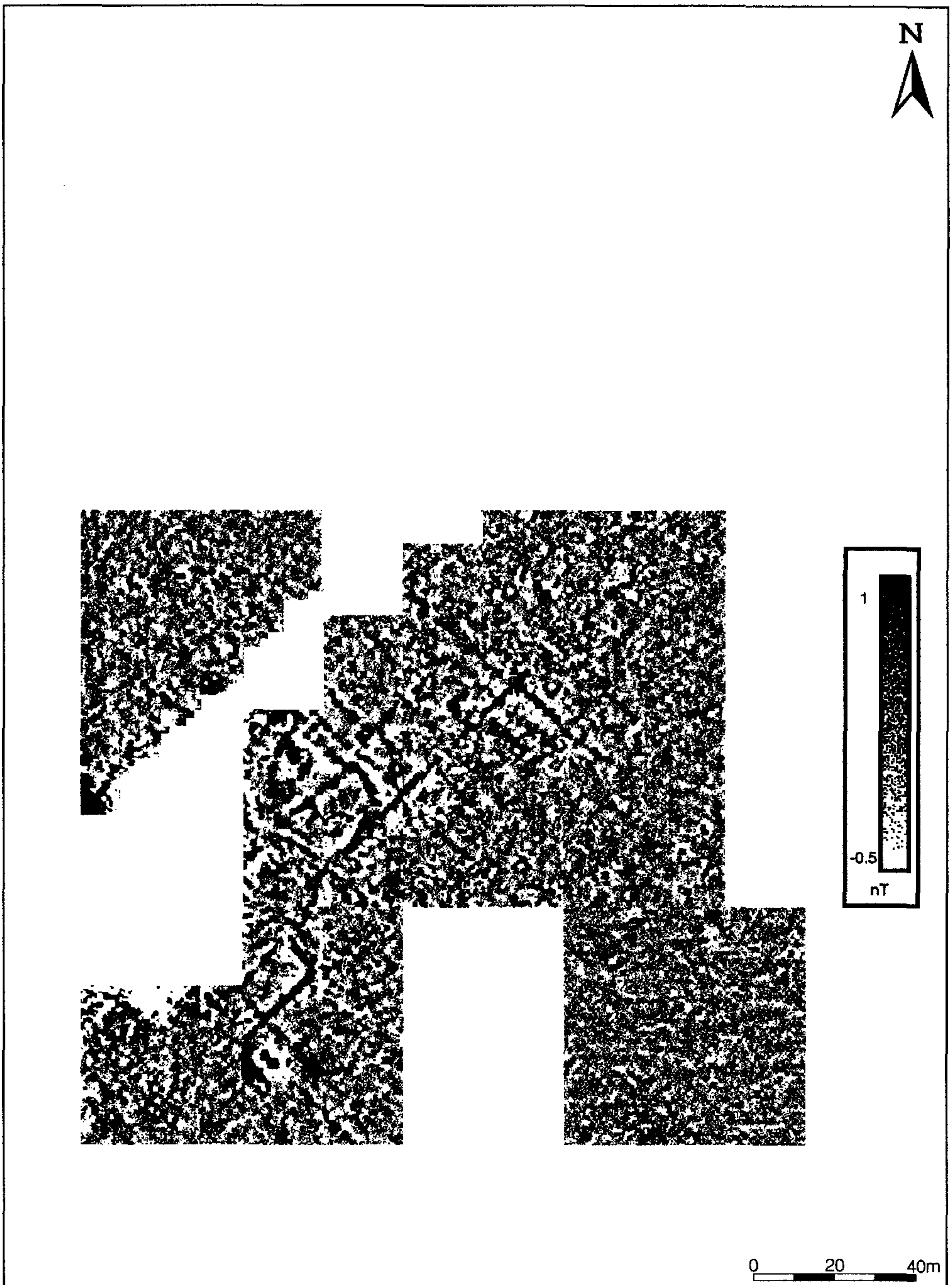


Fig. 6. Gradiometer data (dot density, 1:1250)

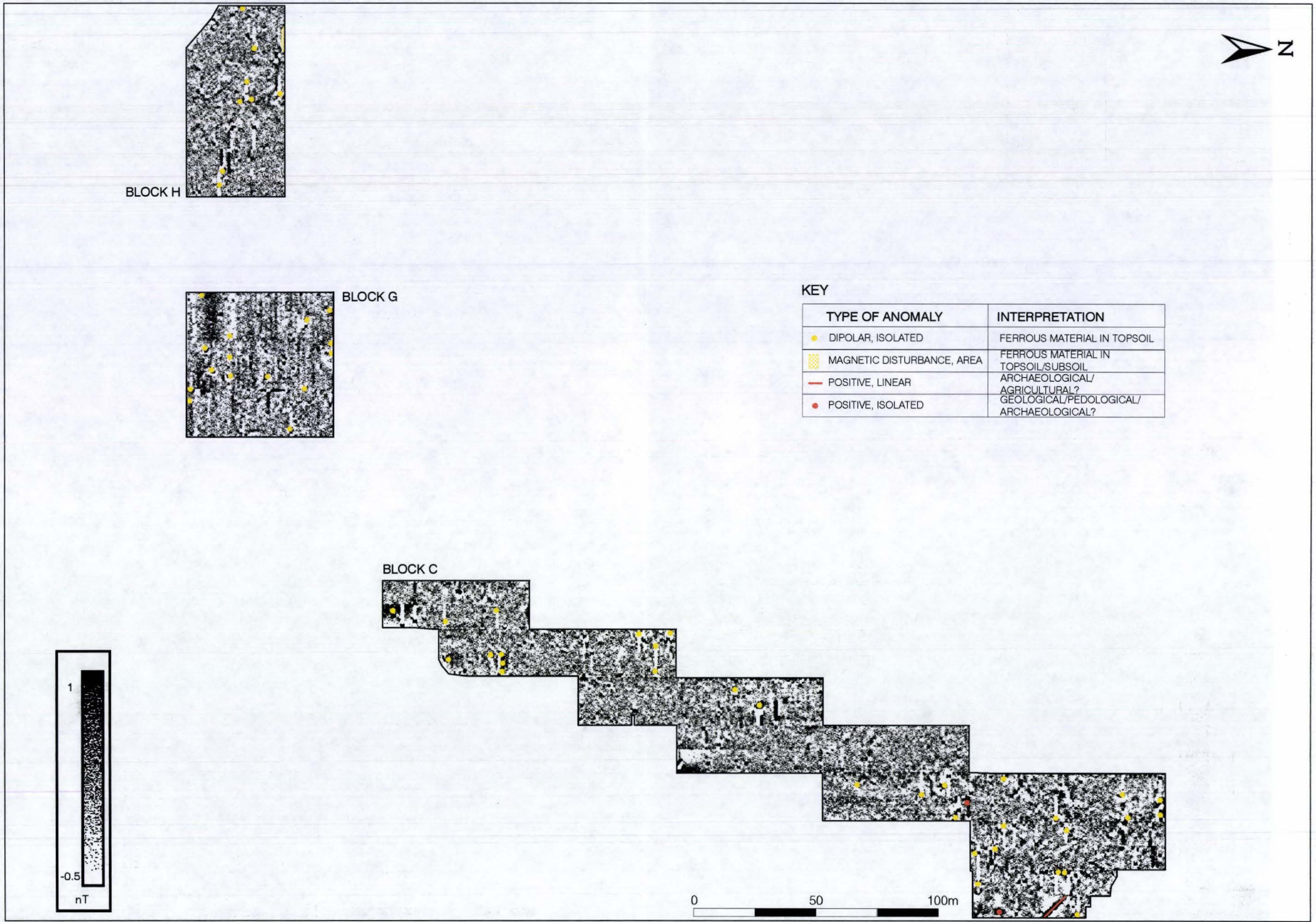
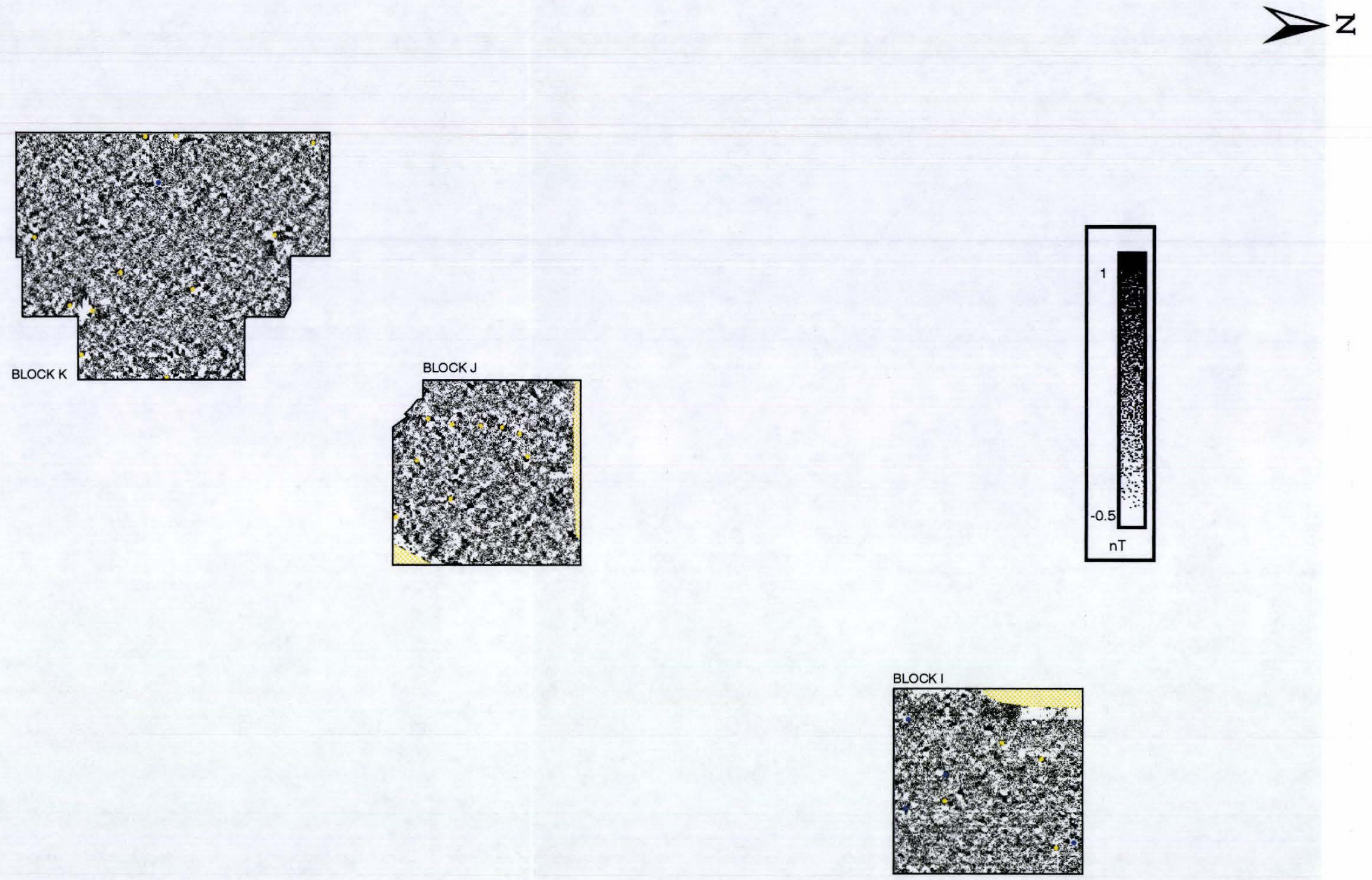


Fig. 7. Blocks C, G and H dot density gradiometer data and interpretation (1:1500)



KEY

TYPE OF ANOMALY	INTERPRETATION
DIPOLAR, ISOLATED	FERROUS MATERIAL IN TOPSOIL
MAGNETIC DISTURBANCE, AREA	FERROUS MATERIAL IN TOPSOIL/SUBSOIL
POSITIVE/NEGATIVE, ISOLATED	PEDOLOGICAL/GEOLOGICAL?

Fig. 8. Blocks I, J and K dot density gradiometer data and interpretation (1:1500)

KEY

TYPE OF ANOMALY	INTERPRETATION
DIPOLAR, ISOLATED (yellow dot)	FERROUS MATERIAL IN TOPSOIL
POSITIVE/NEGATIVE, ISOLATED (blue dot)	PEDOLOGICAL/GEOLOGICAL?

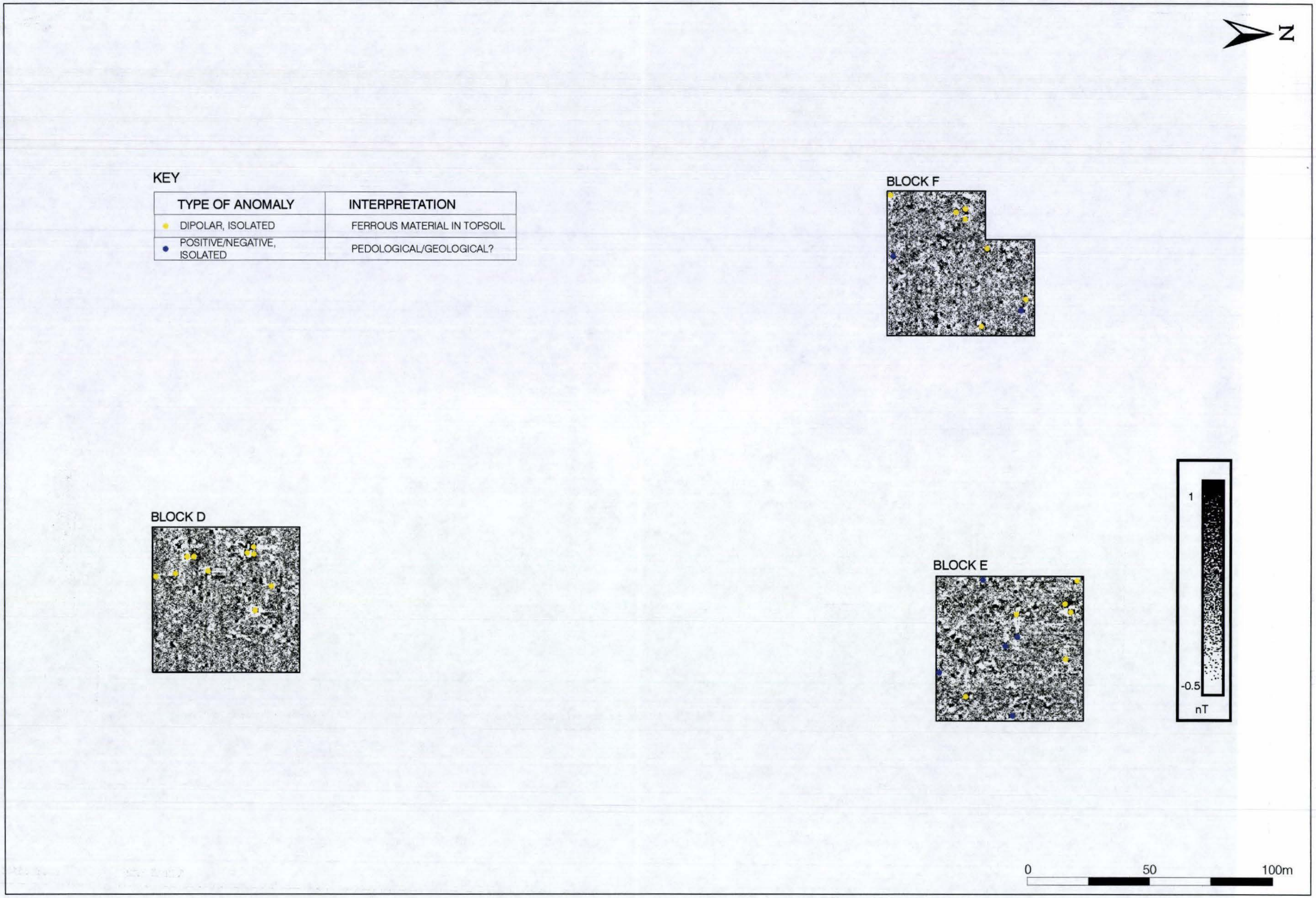


Fig. 9. Blocks D, E and F dot density gradiometer data and interpretation (1:1500)

3.7.2 No anomalies of possible archaeological origin were located in any of these blocks.

3.8 **Block K**

3.8.1 This block was located to evaluate the linear crop marks identified from aerial photographs (not detected during scanning).

3.8.2 No anomalies other than 'iron spikes' were identified.

4. Discussion & Conclusions

4.1 As at Stagsden (Webb 1998) magnetic scanning was successful in locating the strongest (>3nT) magnetic anomalies; essentially those at the centre of the complex in Block A which corresponded with the crop marks identified from the air photographs. Again scanning proved to be of limited use in identifying the much weaker anomalies that were subsequently detected during the detailed survey in this area.

4.2 Apart from within Block A (see above) no other magnetic anomalies were detected during the scanning, including in areas where linear crop marks had been identified. The negative results from the scanning were borne out by the complete lack of magnetic anomalies (other than 'iron spikes') in the sample blocks (D to K) that were surveyed in 'blank' areas.

4.3 The lack of a correlation between many of the transcribed crop marks and the magnetic data (scanned and detailed) could be accounted for in several ways:-

- the crop marks are caused by infilled cut features but the material filling them has a low magnetic susceptibility and/or has not been enhanced to the same extent as the material filling the stronger anomalies such as those identified in Block A. This means there is no measurable magnetic contrast between the feature and the topsoil thereby rendering them undetectable by gradiometry
- the features causing the crop marks have been either truncated or ploughed out since the aerial photographs were taken
- the features causing the crop marks were ephemeral agricultural features such as tractor wheelings

4.4 A lack of magnetic contrast could indicate either that the topsoil/subsoil is not susceptible to magnetic enhancement by anthropogenic activity or that the features have been truncated by ploughing so that the actual volume of magnetically enhanced material within the feature is very small. Given the extremely strong responses from some of the other anomalies it is likely that truncation by ploughing is the more likely explanation. A case in point is the linear anomaly, **A**, which 'disappears' 35m from the north-eastern corner of Block A. However, the aerial photographic evidence suggests it continues uninterrupted north-eastwards into the field north of the road accessing the farm. Nevertheless, it has not been detected in either Blocks J or K, through which it should pass even allowing for any slight error in the rectification of the aerial photographs.

4.5 It can be seen that the two parts of the site containing the greatest number of magnetic anomalies are those encompassed by Blocks A and B. The data from Block A is much 'smoother' than that in Block B (or any of the other blocks) as can be seen by comparing the X-Y trace plots in Appendix 3. This primarily reflects the ease with which the survey was carried out in the field with the root crop as opposed to the muddy re-seeded fields in which Block B and the remaining blocks were surveyed. The net result is that the data has been much easier to interpret in this part of the site.

4.6 Although there is no coherent morphology to the anomalies in Block A two spinal linear anomalies, **A** and **B**, around which the remaining anomalies appear to be aligned, have been identified. These anomalies are indicative of infilled ditch features. The much stronger magnetic response from Anomaly B probably reflects a larger proportion of burnt or fired material within the fill. The differing alignments of these two anomalies possibly suggests more than one phase of occupation. Enclosed by these two curvi-linear ditches are two small D-shaped anomalies thought to be enclosures as well as many isolated responses indicative of pits, post-holes or small areas of burning. Other much broader responses, such as those identified as Anomaly **E**, could indicate a burnt clay surface.

4.7 In Block B the background noise makes definitive interpretation difficult and it is expected that there will be more features, especially discrete features such as pits, than have been interpreted. As in Block A the anomalies are arranged around a central linear ditch type anomaly, **I**, with other linear ditch type anomalies sub-dividing this area. There are a greater number of isolated responses here than in Block A and it is significant that a scatter of Roman pot sherds, recovered during field walking, was focussed in this small area. Because of the perturbed background it is impossible to state whether any of the isolated responses could be caused by a kiln, or whether the pot scatter is simply indicative of normal domestic occupation. The absence of any wasters in the finds collected during the field walking suggests that this area was probably a focus of domestic rather than industrial activity.

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 excavation.

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Alistair Webb

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Appendices

Appendix 1 Gradiometer Survey: technical information and methods
Appendix 2 Geophysical Archive
Appendix 3 Gradiometer Data Plots (1:500) & Interpretation and Crop Mark Plot (1:2500)

Appendix 1

Gradiometer Survey: technical information and methods

1. Technical Information

1.1 Iron makes up about 6% of the Earth's crust and is mostly dispersed through soils, clays and rocks as chemical compounds. These compounds have a weak, measurable, magnetic response which is termed its magnetic susceptibility. 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 topsoils, subsoils and rocks into which these features have been cut, which cause the most recognisable responses. This is primarily because there is a tendency for the more magnetic compounds to concentrate in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features, such as ditches, that were cut into the subsoil and/or bedrock, and which have subsequently silted up or have been backfilled with topsoil, will 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 a plastic service pipe, which intrudes into the topsoil will tend to 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 areas of burning.

1.4 High, sharp, responses are usually due to iron objects ('spikes) in the topsoil. These produce a rapid change from a positive to a negative readings.

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

Iron Spikes (Dipolar Anomalies)
These responses are referred to as dipolar and are caused by buried or surface iron objects. Little emphasis is usually given to such responses as iron objects of recent origin are common on agricultural sites. Occasionally 'spikes' can indicate human activity such as smithing by detecting hammerscale. However, without supporting evidence, or a significant cluster or distribution of 'spikes', it is virtually impossible to interpret archaeological significance from these type of responses.

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 feature. They are often associated with burnt material, such as industrial waste or other strongly magnetised material. It is not always easy to determine their date or origin without supporting information.

Positive, linear anomalies
The strength of these responses varies depending on the underlying geology. They are commonly caused by ancient ditches or more recent agricultural features.

Isolated positive responses
These usually exhibit a magnitude of between 2nT and 300nT and, depending on their response, can be due to pits, ovens or kilns. They can also be due to natural features on certain geologies. It can, therefore, be very difficult to establish an anthropogenic origin without an intrusive means of examining the features.

Negative linear anomalies
These are normally very faint and are commonly caused by features or objects, such as plastic water pipes, which are less magnetic than the surrounding soils and geology. They too can be caused by natural features on some geologies.

2. Field Methodology

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 identify visually anomalous responses 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. 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 a detailed survey although this can be extremely difficult.

2.2 The second method is referred to as *detailed survey* and employs the use of a sample trigger to take readings automatically 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.

2.3 During this survey Geoscan FM36 fluxgate gradiometers with ST1 sample triggers were used to take readings at 0.5m intervals on zig-zag traverses 1m apart within 20m by 20m grids. Eight hundred readings were taken in each grid.

2.4 The survey areas were set out using the 100m Ordnance Survey grid established by the Bedfordshire County Archaeology Service prior to survey.

No responsibility is accepted for any errors in the set-out of this grid.

3. Data Processing and Presentation

3.1 The two display options used in this report are X-Y trace plots and dot density images. The former option shows the 'raw' data with no processing, other than grid biasing whilst in the latter the data has been processed to remove spurious errors caused by instrument drift and inconsistencies in survey technique caused by poor field conditions.

3.2 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 15nT. 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 process and present the X-Y trace plots.

3.2 In-house software (Geocon 9) was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid. Contors was used to produce the dot density image in which maximum and minimum cut-off limits are chosen. Data values above or below the selected limits are displayed as white or black respectively whilst values between the two limits will have a specified number of dots dependent on the relative position between the limits.

Appendix 2

Geophysical Archive

The geophysical archive comprises:-

- archive disks containing the raw data, survey tie-in information and grid location information, the report text (Word 6), and compressed CorelDraw/AutoCAD files of the illustrations

- a full copy of the report

- A1 paste-ups of the gradiometer data

At present these are all held by Archaeological Services (WYAS).

Appendix 3

Gradiometer Data Plots (1:500)
&
Interpretation and Crop Mark Plot (1:2500)