STRATASCAN

Geophysical Survey Report

EASTERN LEIGHTON LINSLADE

for

ALBION ARCHAEOLOGY

APRIL 2008

J2426

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REGISTERED IFA ORGANISATION

Document Title:	**Geophysical Survey Report** **Eastern Leighton Linslade**
Client:	**Albion Archaeology**
Stratascan Job No:	**J2426**
Techniques:	**Detailed magnetic survey (gradiometry)**
National Grid Ref:	**SP 942 258**

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1 SUMMARY OF RESULTS

This detailed geophysical survey undertaken over 240 hectares of agricultural land near Leighton Buzzard, Bedfordshire has located a number of features of an archaeological origin. Three enclosures, possibly of Iron Age or Romano-British origin, have been identified in the central regions of Archaeological Zone 2 and a large circular feature is evident in Zone 6. Other anomalies of a possible archaeological origin such as cut features and former earthworks have been identified across the survey area with concentrations correlating with the zones designated by Albion Archaeology as having moderate potential.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area of land identified for a review of the green belt around Leighton Linslade. This survey forms part of an archaeological investigation being undertaken by Albion Archaeology.

2.2 Site location

The site is located east of Leighton Buzzard centred on OS ref. SP 942 258.

2.3 Description of site

The survey area consists of 240ha of agricultural land used as both pasture and arable. Two areas of relatively higher ground can be noted within the site; one in Zone 2 and the other in Zone 6.

2.4 Geology and soils

The underlying geology is Upper Greensand, Gault and Chalk (British Geological Survey South Sheet, Fourth Edition Solid, 2001).

The overlying soils are known as Evesham 3 which are typical calcareous pelosol soils. These consist of slowly permeable calcareous clayey and fine loamy over clayey soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 Site history and archaeological potential

The desk based assessment compiled by Joe Abrams of Albion Archaeology suggests that there is potential for archaeological remains

within the data dating from prehistory through to the post medieval period; particularly in areas of high ground and close to rivers or brooks.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological significance in order that they may be assessed prior to development.

2.7 Survey methods

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out between December 2007 and April 2008. Weather conditions during the survey were varied.

3.2 Grid locations

The location of the survey grids can be seen on Figure 2. The referencing and alignment of grids was achieved using a Leica DGPS Smart Rover.

A DGPS (differential Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. Calculations to correct for these errors are performed at an accurately located base station. The base station then transmits the corrections which are received by DGPS consoles giving centimetre accuracy.

3.3 Survey equipment

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and

ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

3.4.2 Depth of scan and resolution

The Grad 601 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an optimum methodology for the task balancing cost and time with resolution.

3.4.3 Data capture

The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Processing is performed using specialist software known as *Geoplot 3.* This can emphasise various aspects contained within the data but which are often not easily seen

in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all processed gradiometer data used in this report:

1. *Despike* (useful for display and allows further processing functions to be carried out more effectively by removing extreme data values)

   Geoplot parameters:
   X radius = 1, y radius = 1, threshold = 3 std. dev.
   Spike replacement = mean

2. *Zero mean grid* (sets the background mean of each grid to zero and is useful for removing grid edge discontinuities)

   Geoplot parameters:
   Threshold = 0.25 std. dev.

3. *Zero mean traverse* (sets the background mean of each traverse within a grid to zero and is useful for removing striping effects)

   Geoplot parameters:
   Least mean square fit = off

In addition a de-stagger has been carried out on a number of grids to further enhance the data

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data both as greyscale (Figures 2-7), together with a greyscale plot of the processed data (Figures 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34 and 36). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figures 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35 and 37).

4 RESULTS

4.1 Archaeological Zone 1

This zone consists of Field 1. No access was available for geophysical survey in Archaeological Zone 1.

4.2 Archaeological Zone 2

Archaeological Zone 2 consists of Fields 2,3,4,5 and 64. Ground conditions related to quarry activity resulted in Field 2 not being surveyed.

Photo: Field 3- looking south

The processed data and interpretations for this zone can be seen in Figures 8-11.

The data collected in Archaeological Zone 2 is dominated by the presence of agricultural marks. However a number of anomalies of a possible archaeological origin have been identified. Positive linear and area anomalies indicating the presence of cut features such as ditches can be noted in all the fields in this particular zone. Three rectilinear enclosures are evident within Zone 2; one in Field 5 and two in Field 64. These enclosures consist of mostly positive anomalies; however a number of negative anomalies may indicate the presence of banks as well as ditches. A large concentration of positive area anomalies can be noted in the western limits of Field 4. These anomalies indicate the presence of cut features of a possible archaeological origin.

Discrete positive anomalies are evident across Zone 2. These anomalies have been interpreted as pits of a possible archaeological origin. A particular concentration of these anomalies can be noted in the northern limits of Field 64.

Magnetic disturbance can be seen throughout Zone 2. In many cases this disturbance is related to the presence of metallic perimeter fences or a close proximity of the gradiometer to a metallic object. However, large swathes of magnetic variation noted in Fields 5 and 64 may be related to magnetic debris or changes in geology or pedology.

4.3 Archaeological Zone 3

Archaeological Zone 3 includes Fields 6, 7, 8 and 9. The data collected in this zone is dominated by the presence of agricultural marks, land drains and magnetic disturbance. However a number of anomalies of a possible archaeological origin are evident.

Photo: Field 8- looking south east

The processed data and interpretations for this zone can be seen in Figures 12-15.

Positive linear anomalies indicating cut features such as pits and ditches are evident in Fields 6, 7 and 9. The majority of these anomalies in this zone can be noted in Field 6. Two curvilinear positive anomalies can be identified in the south eastern limits of Field 7.

A number of discrete positive anomalies indicating the presence of pits of a possible archaeological origin can be seen spread across Field 9.

The magnetic disturbance present in Field 8 is likely to be related to the landscaping activity that has taken place. The disturbance evident along the western boundary of Field 9 is related to the industrial estate located in this area.

4.4 Archaeological Zone 4

Archaeological Zone 4 comprises of Fields 10-16 and 61-63. There was no access to Fields 14, 61, 62 and 63 for geophysical survey.

Photo: Field 10- looking west

The processed data and interpretations for this zone can be seen in Figures 14-16.

A number of positive linear and area anomalies are present within this zone. These anomalies indicate the presence of cut features such as pits and ditches and may be of an archaeological origin. Positive anomalies are evident in each of the fields in this zone with the exception of Field 10. A number of curvilinear anomalies can be noted in the north eastern limits of Field 11 and a concentration of positive area anomalies can be seen in the data collected in Field 15. These anomalies in Field 15 have associated negative responses which may suggest the presence of some form of bank and ditch arrangement.

A positive linear anomaly representing a possible former field boundary can be noted in the southern region of Field 13. Other anomalies of an agricultural origin in Zone 4 include ridge and furrow and land drains.

Magnetic disturbance can be noted within this zone. In many cases it is related to perimeter fences and metallic objects. Discrete areas of disturbance are sometimes related to the presence of telegraph poles or pylons that exist in this survey area.

4.5 Archaeological Zone 5

Photo: Field 23- looking north east

Archaeological Zone 5 consists of Fields 17-24. The majority of anomalies identified in this area are related to agricultural activity such as ridge and furrow, plough marks and land drains. A number of anomalies of a possible archaeological origin have been identified in many of the survey areas.

The processed data and interpretations for this zone can be seen in Figures 18-23.

Positive linear and area anomalies are evident in each of the fields in this zone. These anomalies indicate the presence of cut features of a possible archaeological origin such as pits or ditches. Particular concentrations of these anomalies can be noted in Fields 18 and 21 which may suggest centres of activity in these areas.

Negative linear and area anomalies indicating possible former earthworks or banks can be noted in Fields 17, 21, 22 and 24.

Discrete positive anomalies representing pits of a possible archaeological origin can be identified across this zone. A particular concentration of these anomalies can be noted in the south western corner of Field 17.

Linear magnetic disturbance can be seen running through Fields 17, 18 and 19. This disturbance is related to overhead cables. Discrete areas of disturbance punctuate this linear arrangement and are related to telegraph poles. Other magnetic variations have been caused by ground disturbance and the presence of metallic objects. A modern pipe or cable can be seen running approximately north-south through Field 19.

4.6 Archaeological Zone 6

Photo: Field 26- looking east

Archaeological Zone 6 includes Fields 26-35, 44-48, 50-60, 67 and 69-72. No access was available for Fields 37, 47, 57, 58, 60 and 67.

The data collected in this zone is dominated by agricultural activity and magnetic disturbance. However a number of features of a possible archaeological origin have been identified.

The processed data and interpretations for this zone can be seen in Figures 24-33 and 36-37.

Positive linear and area anomalies indicating cut features of a possible archaeological origin are present in many of the fields in this zone. Particular concentrations can be seen in Fields 26, 50, 52, 53, 54, 55, 56, 69 and 71.

A large concentric ring of interrupted ditches is evident in Field 55. This feature is around 65m in diameter and may be of a prehistoric origin. A number of other positive linear and area anomalies can be noted in close proximity to this feature; a set of large parallel ditches are located immediately to its south west for example. The adjoining fields to the east and south also contain anomalies related to cut features. Further investigation is required in order to ascertain the origin of these features and to discern as to whether they are contemporary with each other.

Two large ditches form an L shaped feature in Field 71. The longest of these cut features measures approximately 90m in length and 5m in width. It is possible that the quarrying activity that has taken place immediately to the south has destroyed the southern end of this feature.

A linear positive trend can be noted in the central region of Field 52. This feature has been interpreted as a cut feature of a possible archaeological origin. However, the anomaly is of a relatively low magnitude and as a result it is possible that it is of a geological or pedological origin. A negative trend is also present in association with the positive anomaly which may suggest some form of bank and ditch arrangement.

Large swathes of discrete positive anomalies can be seen in Fields 34, 52, 55, 59 and 72. These anomalies are characteristic of pit like features. However, the large number of these anomalies may suggest that they relate to land clearance; the removal of trees for example. Other discrete positive anomalies can be seen throughout Zone 6. These anomalies have been interpreted as pits of a possible archaeological origin.

Five very large circular bipolar anomalies are evident in Zone 6. Two are located in Field 46, two in Field 50 and one in Field 69. These anomalies consist of a high magnitude positive anomaly surrounded by a large negative response which increases in magnitude towards the positive centre. These anomalies are characteristic of the type of response expected from an event such as a meteor strike. Further investigation is needed to gain a true understanding of the origin of these features as the large size and magnitude of these anomalies would suggest that they are not man-made ferrous objects.

Magnetic disturbance is evident in many of the fields in this zone. This disturbance is particularly prevalent in Fields 29, 44 and 48. A pipe with associated disturbance runs around the western and northern perimeters of Fields 26, 32 and 33. Another pipe can be seen coming from the covered reservoir off Shenleyhill Road through Fields 53, 50 and 52. Magnetic disturbance related to metallic objects, ground disturbance and pipes may mask any subtle archaeological features that may be present in these areas.

4.7 Archaeological Zone 7

Archaeological Zone 7 comprises of Fields 36, 38-42 and 49. No access for geophysical survey was available for this zone.

4.8 Archaeological Zone 8

Archaeological Zone 8 consists of Field 43. A number of linear arrangements of positive and negative linear anomalies have been identified in this area. The positive anomalies indicate the presence of cut features such as ditches whereas the negative anomalies suggest the presence of former earthworks or possible buried masonry. This may indicate that some from of structure or structures were present in this area, possibly relating to the nearby farm.

Photo: Field 43- looking west

The processed data and interpretations for this zone can be seen in Figures 30-31.

Discrete positive anomalies indicating the presence of pits of a possible archaeological origin can also be noted within this area.

Magnetic disturbance is evident around the perimeter of Field 43 and is likely to be related to a metallic fence.

4.9 Archaeological Zone 9

The processed data and interpretations for this zone can be seen in Figures 34-35.

Archaeological Zone 9 is made up of Field 65. This field contains an amount of magnetic disturbance along its northern edge. This disturbance is likely to have been caused by the construction of the A6 highway.

Positive linear and area anomalies can be noted within this area. These anomalies indicate the presence of cut features such as ditches of a possible archaeological origin. Discrete positive anomalies interpreted as pits are also evident within this zone.

5 CONCLUSION

The geophysical survey undertaken over 240ha of agricultural land at Eastern Leighton Linslade has located a number of anomalies of possible archaeological origin. The most common features that have been identified are positive linear anomalies representing agricultural activity. Almost every field within the survey area has produced evidence of plough marks or medieval ridge and furrow. A complex system of ridge and furrow can be seen in Field 33. This agricultural activity spreads from the south of the survey area in Field 4 to the northern limits of Fields 71 and 72. This correlates well with Albion's desk based assessment which states that "…the most likely archaeological remains to occur within the PDA are those of field systems" (Abrams, J 2008). In reference to possible settlement activity in Fields 71 and 72 the DBA suggests that "It is likely that these remains would comprise fields associated with the settlement, rather than the remains of domestic or industrial activity" (Abrams, J 2008).

A number of archaeological features have been identified within the survey area. A rectilinear enclosure was identified early on in the survey in the southern limits of Field 5. This enclosure consists of a number of positive linear anomalies indicating cut features and a series of negative anomalies suggesting the presence of former earthworks or banks. A roughly square shaped feature can also be noted to the north of this enclosure.

A further two enclosures can be noted in the south eastern limits of the adjacent field, Field 64. One of these enclosures is orientated roughly north west to south east and is rectangular in shape. The other is more oblong in shape and is positioned perpendicular to the first. Both of these enclosures have internal cut features. The oblong feature seems to cut the rectangular enclosure which may suggest that it is of a later date. However, further investigation would be required in order to ascertain an accurate dating sequence of these two enclosures and that of the enclosure in Field 5.

A large concentric set of circular ditches has been identified in Zone 6's Field 55. This feature measures approximately 65m in diameter. A number of cut features of possible archaeological origin are in close proximity to the circle including a set of large parallel ditches and a number of curvilinear features.

The putative site of Clipstone's medieval chapel is thought to be located in the south western corner of Field 20 in Archaeological Zone 5. The gradiometer data showed no evidence of any structural remains in this area or in its immediate proximity. A close centred resistance survey may have more success in locating the chapel if it is in this area.

Areas of swathes of discrete positive anomalies have been identified in Fields 8, 34, 55, 59 and 72. These anomalies are characteristic of pits of a possible archaeological origin. However, the large number of them may suggest that they are related to land clearance or landscaping activity.

The five large bipolar anomalies that have been interpreted as relating to meteor strikes located in Archaeological Zone 6 require further investigation as this interpretation is not certain.

The desk based assessment suggests that "…high ground occupied by land parcels 4, 5 and 64 in the south and 47, 52, 53, 54, 55, 58, 59 and 60 in the north, may have some potential to preserve remains of prehistoric date." It is interesting to note that the aforementioned enclosures and the circular feature occur in the high ground represented by these fields.

Prior to the geophysical survey taking place the survey area was divided into areas of low potential, moderate potential and no potential based on the results of the desk based assessment. The zones that were designated as being of moderate potential included Zones 2, 5 and 6. This correlates well with the results of the geophysical survey as these were the areas in which the majority of anomalies with archaeological potential were located.

6 REFERENCES

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid)*. British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern England*.

APPENDIX A – Basic principles of magnetic survey

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremnant* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremnance is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremnant archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

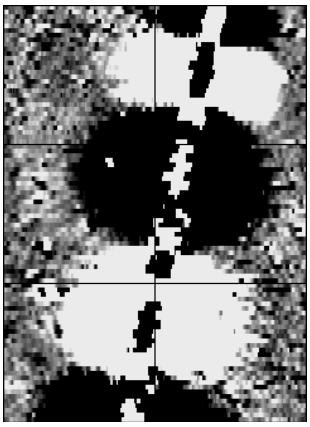
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically either 0.5 or 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

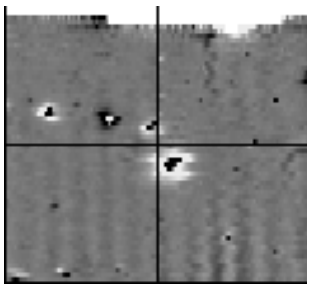
APPENDIX B – Glossary of magnetic anomalies

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

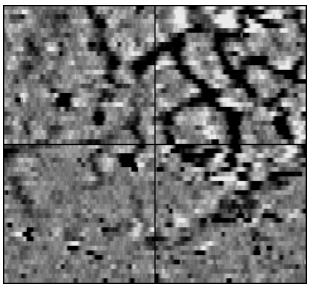


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

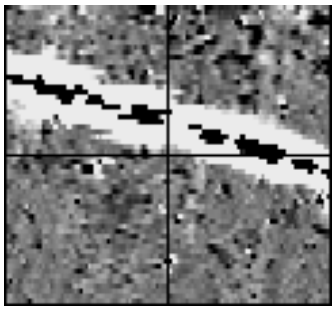
See bipolar and dipolar.

Positive linear



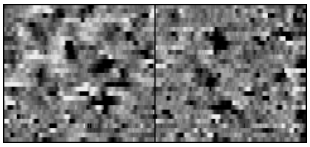
A linear response which is entirely positive in polarity. These are usually related to infilled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



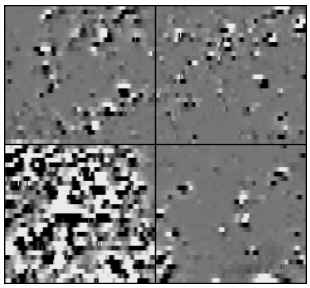
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



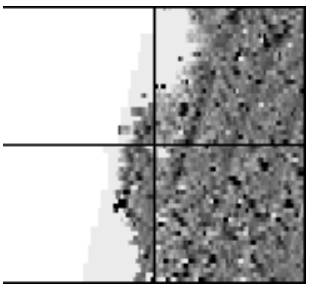
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by infilled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



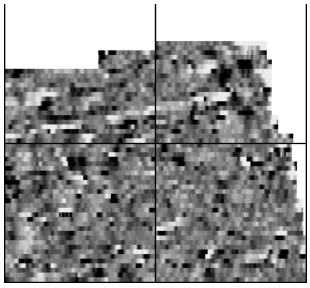
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly (+/-250nT) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremnant material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

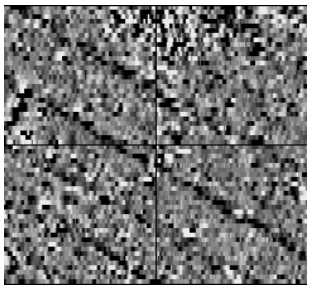


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing, clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

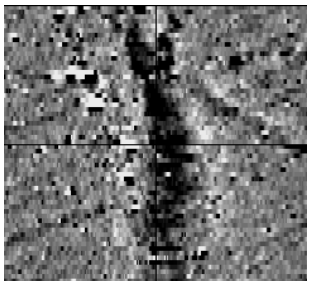
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a $10m^2$ area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Trace plots are used to show the amplitude of response.

Thermoremnant response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred insitu (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.