SHARP

SEDGEFORD HISTORICAL AND ARCHAEOLOGICAL RESEARCH PROJECT

Registered Charity No: 1064553

# ARCHAEOLOGICAL EVALUATION REPORT: 14th October 2021
# FLUXGATE GRADIOMETER SURVEY
# Church of St Peter and St Paul, Mautby, NORFOLK
# TG 48069 12380
# Elevation 14m ODN[1]

# ENF152064


**Report Prepared for SHARP by:**

**Melinda Barham and David Wood**


[1] Ordnance Datum Newlyn (ODN) vertical coordinate system

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Note
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## LIST OF FIGURES:



## APPENDICES



Note – This report has been produced in colour and it is recommended that any further copies are also produced in colour.

## 1.0 INTRODUCTION

1.1 The Sedgeford Historical and Archaeological Research Project was founded in 1996. It is a long-term, multi-period, multi-disciplinary research project based at Sedgeford, Norfolk, set up to investigate the entire range of human settlement and land-use in the village of Sedgeford.

**1.2** At the request of Peter Stibbons, on the behalf of the Paston Heritage Society (www.thisispaston.co.uk/), the non-invasive archaeology team were asked to undertake a geophysics survey at Mautby Church. This report is a magnetometry survey of the area and a discussion of its findings.

**1.3** The site works, and reporting, conform to current UK national and European guidelines, as set out in the Institute for Field Archaeologists Standards and guidance for archaeological evaluations and Historic England Geophysical Survey in Archaeological Field Evaluations.

## 2.0 SITE LOCATION

**2.1** The parish of Mautby is comprised of a largely rural area along the north bank of the River Bure. It includes the hamlets of Mautby. Runham and Thrigby. It is located approximately 10km north west of Great Yarmouth and 30km east of Norwich.


**FIGURE 1 – LOCATION OF MAUTBY**


**FIGURE 2 – LOCATION OF SURVEY**

**2.2** The land that is the subject of this survey is that directly to the north and south of the Church.

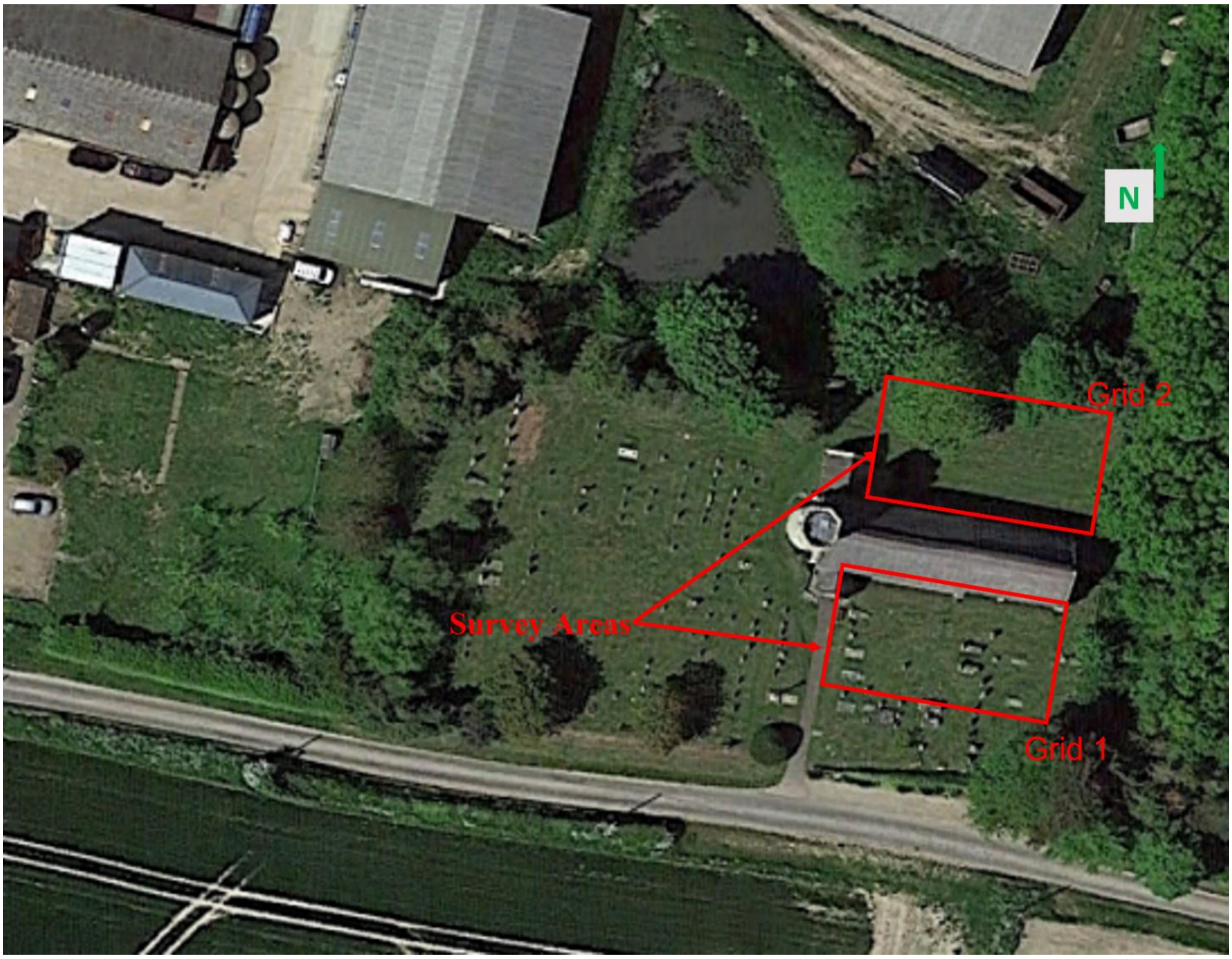


**FIGURE 3 – LAYOUT OF GRIDS**

## 3.0 HISTORICAL AND ARCHAEOLOGICAL BACKGROUND

**3.1** The Church of St Peter and St Paul is mentioned in the Domesday book, as a village with a mill and 7 salt works, which suggests that at that time the sea reached further inland than it does today. The building itself is mainly dated 1200 – 1275.

**3.2** In 1199, the Lordship passed from the Earl of Norfolk to the de Mauteby family, who held it until the reign of James 1. One of the de Mauteby's was Margaret, she was born and lived at Mautby Hall, a building that is no longer present. Marrying John Paston in 1440, she put Mautby on the map by writing many letters to her husband and sons. Known collectively as the Paston Letters and are a fine example of the earliest examples of English letter writing. Lodged in the British Museum, they detail life during the Wars of the Roses. Indeed, two of her sons defended Caister Castle, which had been bequeathed to the family by Sir John Falstaff, Margaret's Uncle.

**3.3** When Margaret died in 1484, she was buried at Mautby in the South Aisle. Her will states*,"... my body to be beried in the ele of the cherch of Mauteby byfore the ymage of Our Lady there, jn which ele reste the bodies of diuers of my anceteres. who sowles God assoile*."[2] That section of the church has since been demolished and there is no marked grave for Margaret. The Paston Heritage Society are seeking to locate her final resting place.

**3.4** In 2015 a small extension was constructed to the northwest for kitchen and toilet facilities. During excavations for this work, a total of 34 graves were exposed and it was necessary to excavate and rebury 20 individual inhumations. They were relocated to an area along the northern boundary of the church.

## 4.0 METHODOLOGY FOR THE SURVEY

**4.1** A Level II magnetometer survey (Gaffney and Gater 1993) using a fluxgate gradiometer was used.

**4.2** See Appendix 3 for 'Magnetometry Theory and Principle of Operation'

**4.3** Magnetometry of Grid 1 was repeated in accordance with current guidelines and recommendations for conduct of surveys (Historic England). The Grid was laid out using Magnetic North and the Zig Zag survey commenced on North, moving Eastwards. An additional survey of Grid 1 was carried out using a Zig Zag survey commenced on East moving Northwards. Although this repeat procedure is 'non-standard', it was decided that the limited and busy space around the gravestones would benefit from a second Grid 1 survey using a different direction of travel.

**4.4** The Data was downloaded from the Bartington 601-2 and accessed using the TerraSurveyor Lite 3.0.29.3 Software programme

## 5.0 RESULTS

**5.1** The following Figures show the results of the magnetometry survey. The Base Layer is shown in order to show the degree to which subsequent data manipulation can enhance the clarity of the features located by the Fluxgate Magnetometer. The Metadata is attached at Appendix 1.

[2] Rosenthal J.T. (2010) Family Wills: Margaret Paston and the Rest. In: Margaret Paston's Piety. The New Middle Ages. Palgrave Macmillan

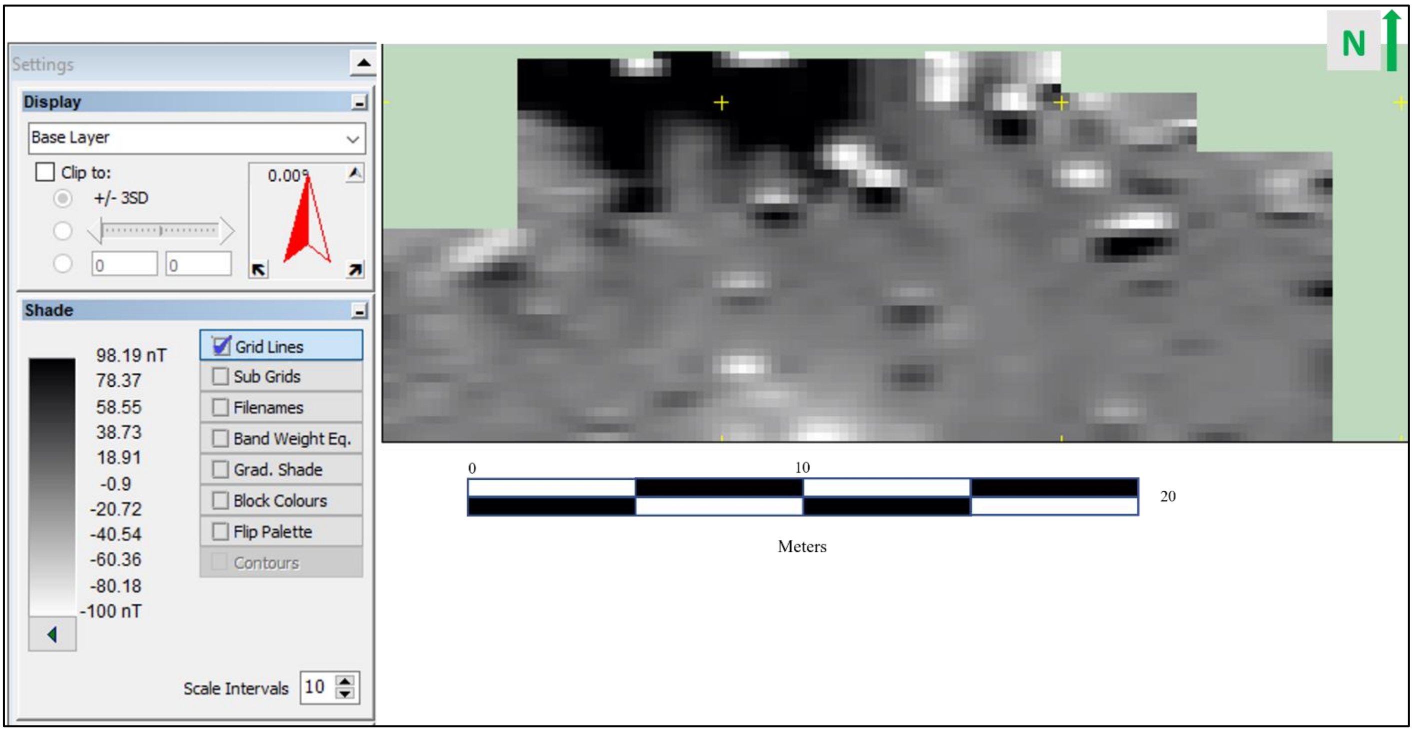


**FIGURE 4 – GRID 1 N/S ZIG ZAG BASE LAYER DATA (before software manipulation)**

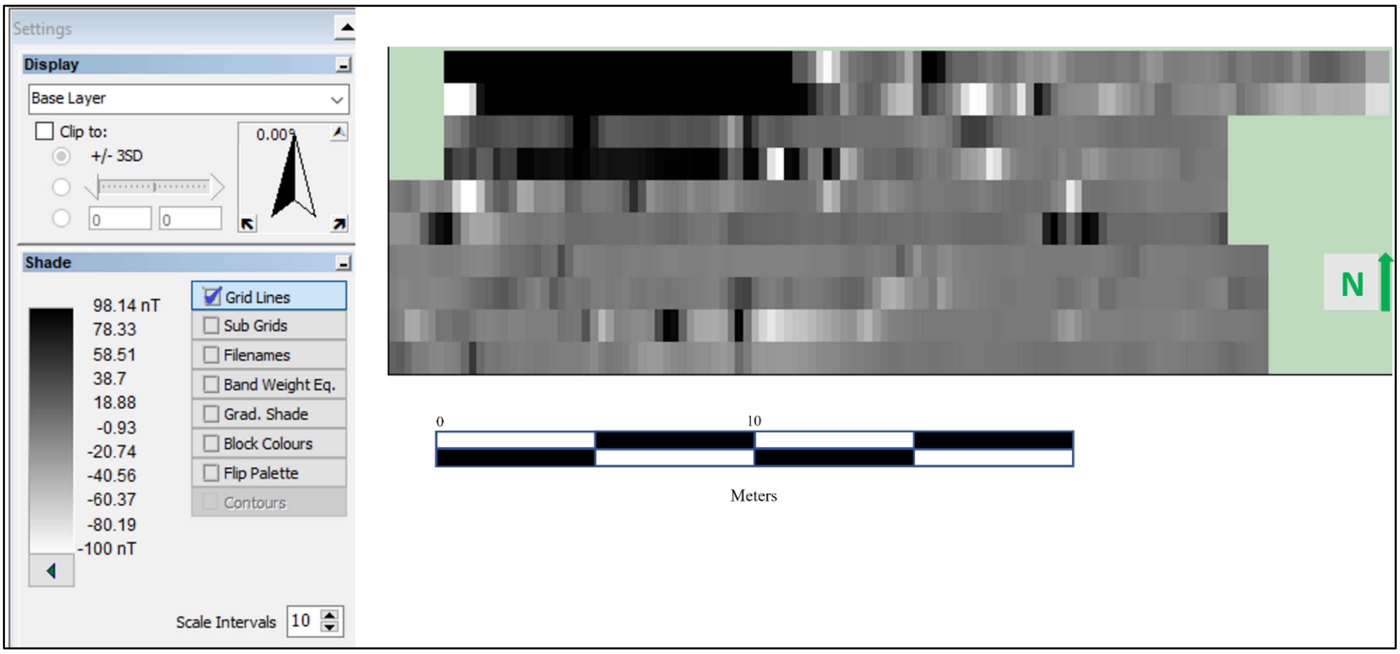


**FIGURE 5 – GRID 1 E/W ZIG ZAG BASE LAYER DATA (before software manipulation)**

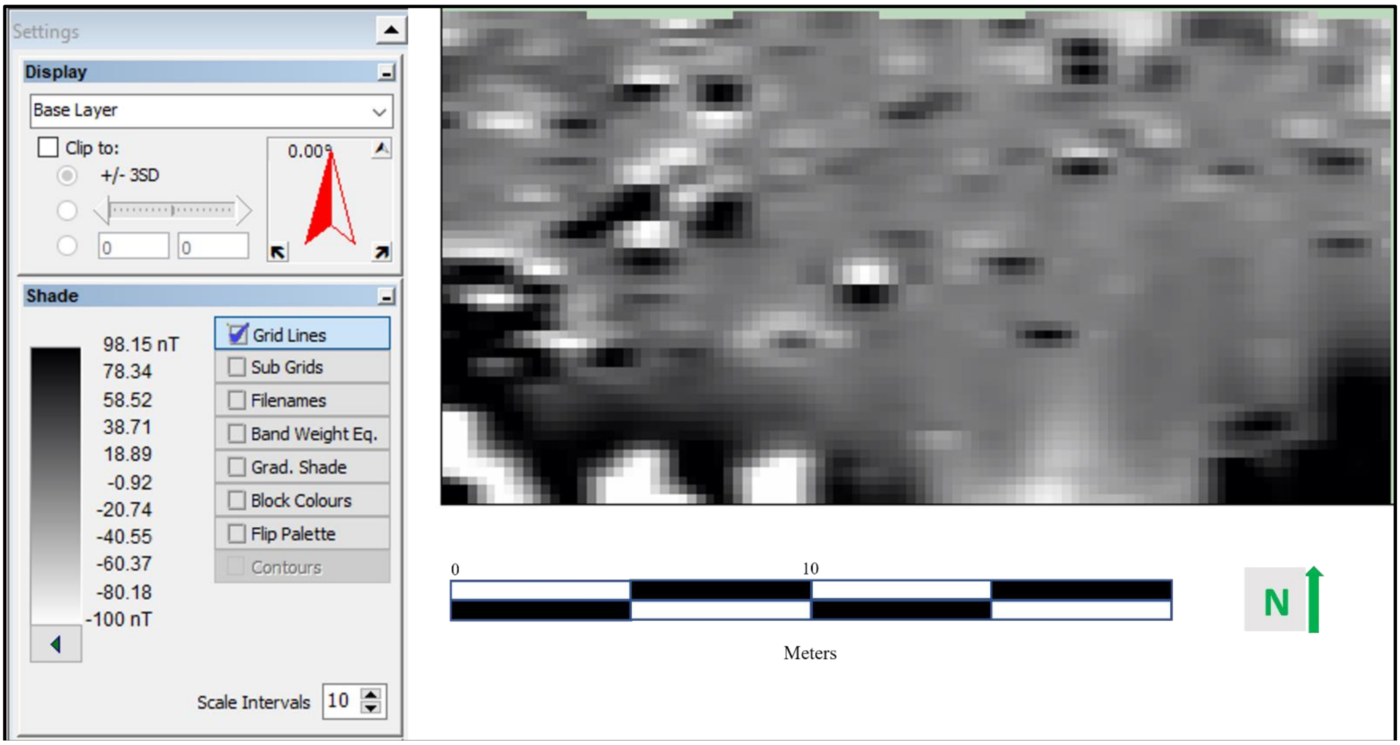


**FIGURE 6 – GRID 2 N/S ZIG ZAG BASE LAYER DATA (before software manipulation)**

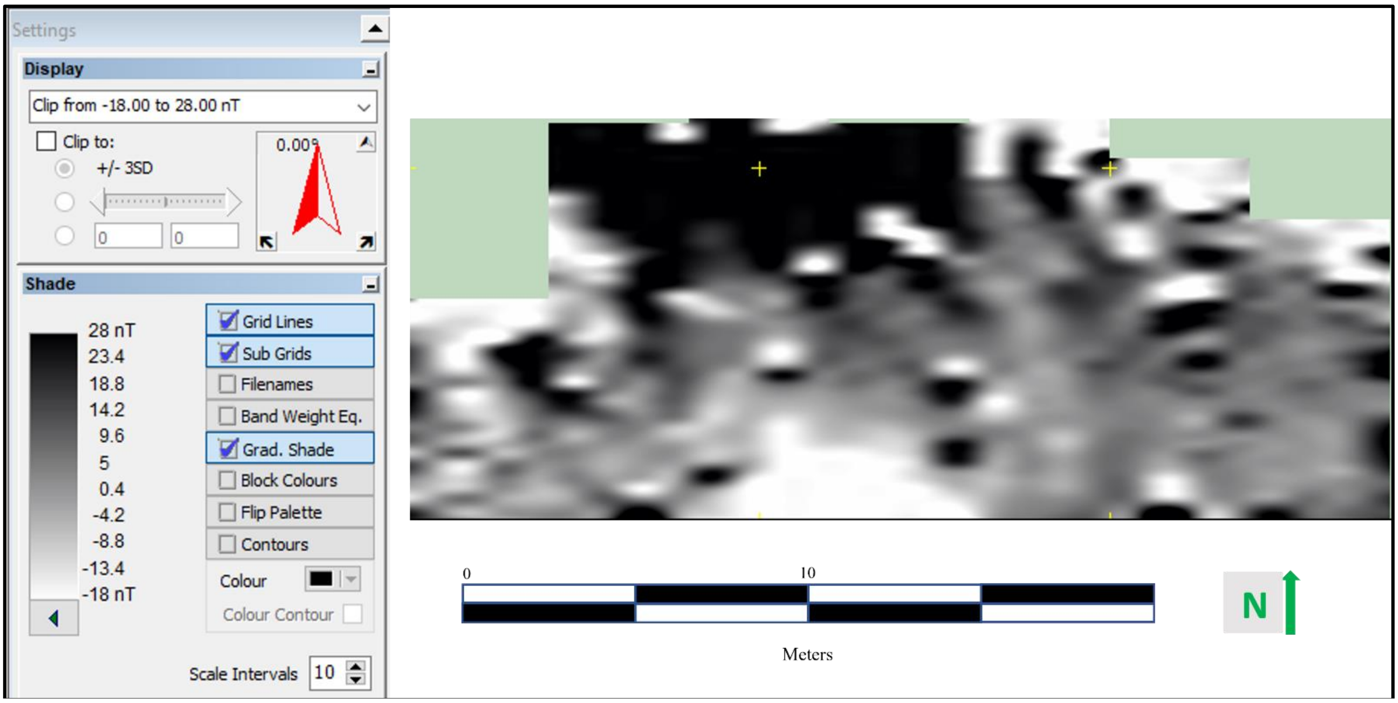


**FIGURE 7 – GRID 1 N/S ZIG ZAG Clipped -18 to +28nT and greyscale**

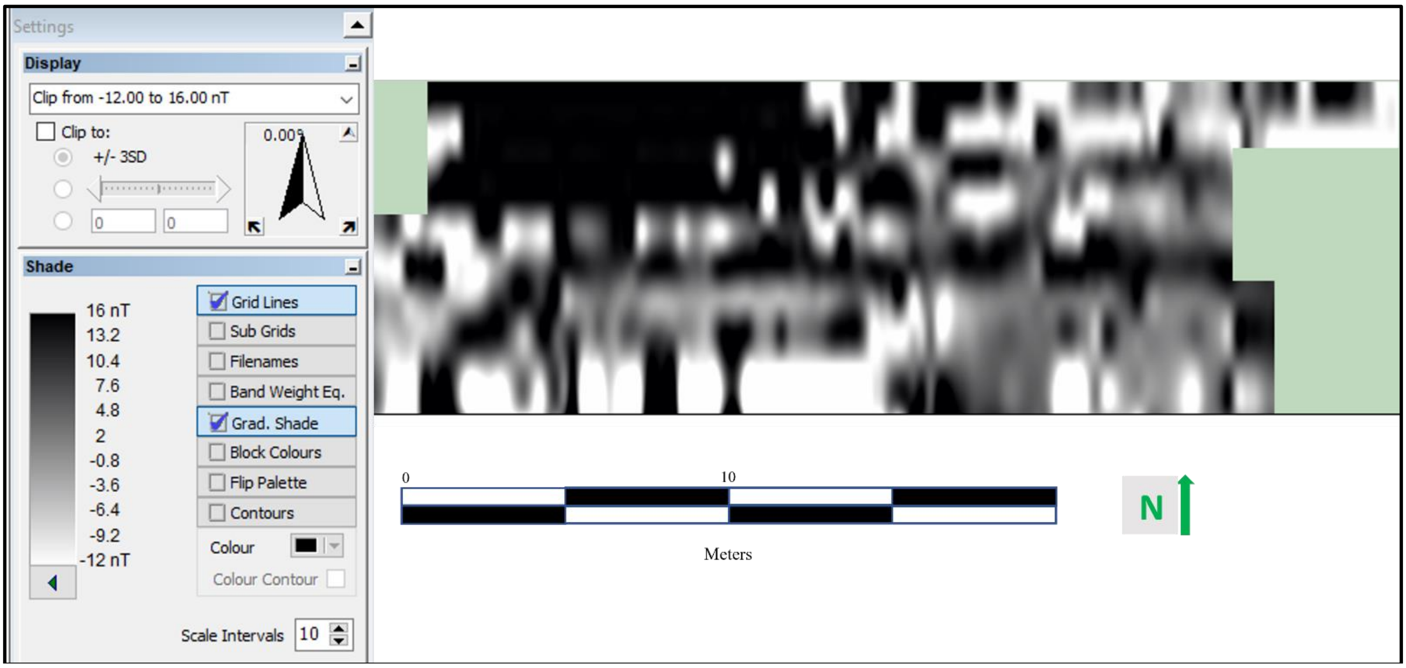


**FIGURE 8 – GRID 1 E/W ZIG ZAG Clipped -12 to +16nT and greyscale**

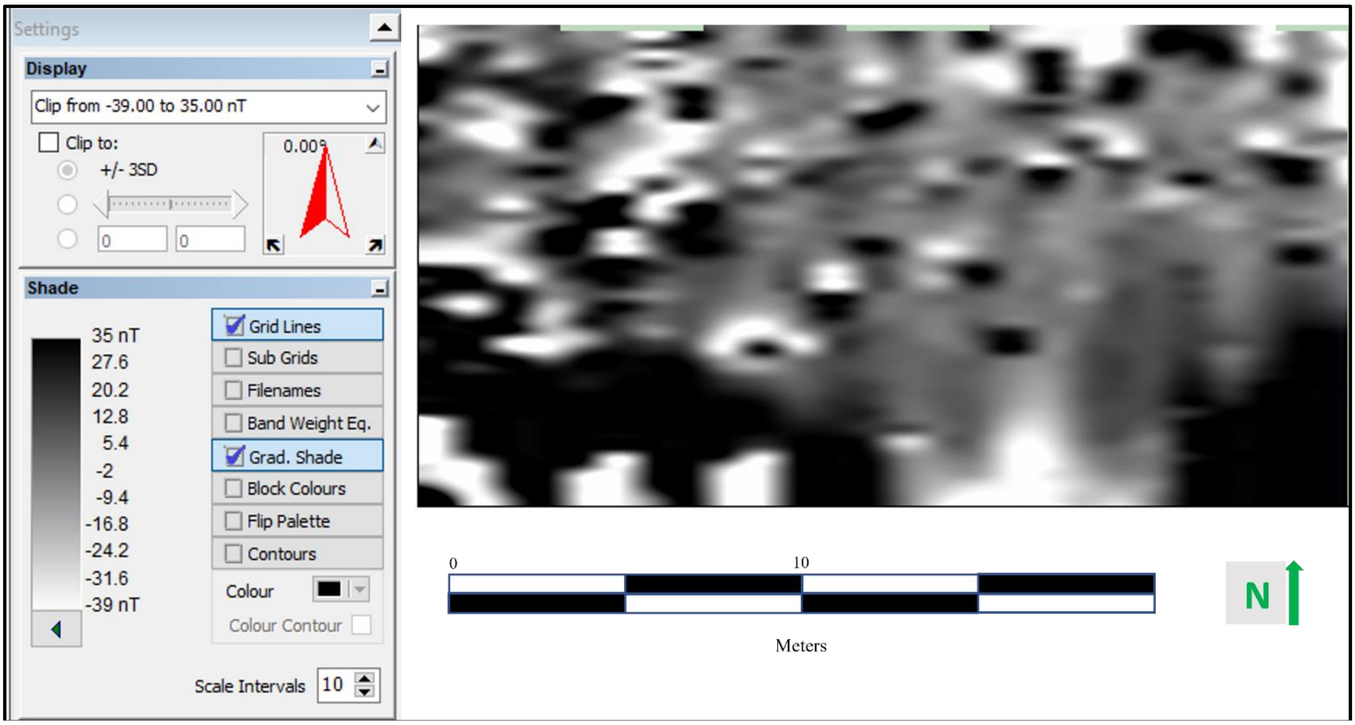


**FIGURE 9 – GRID 2 N/S ZIG ZAG Clipped -39 to +35nT and greyscale**

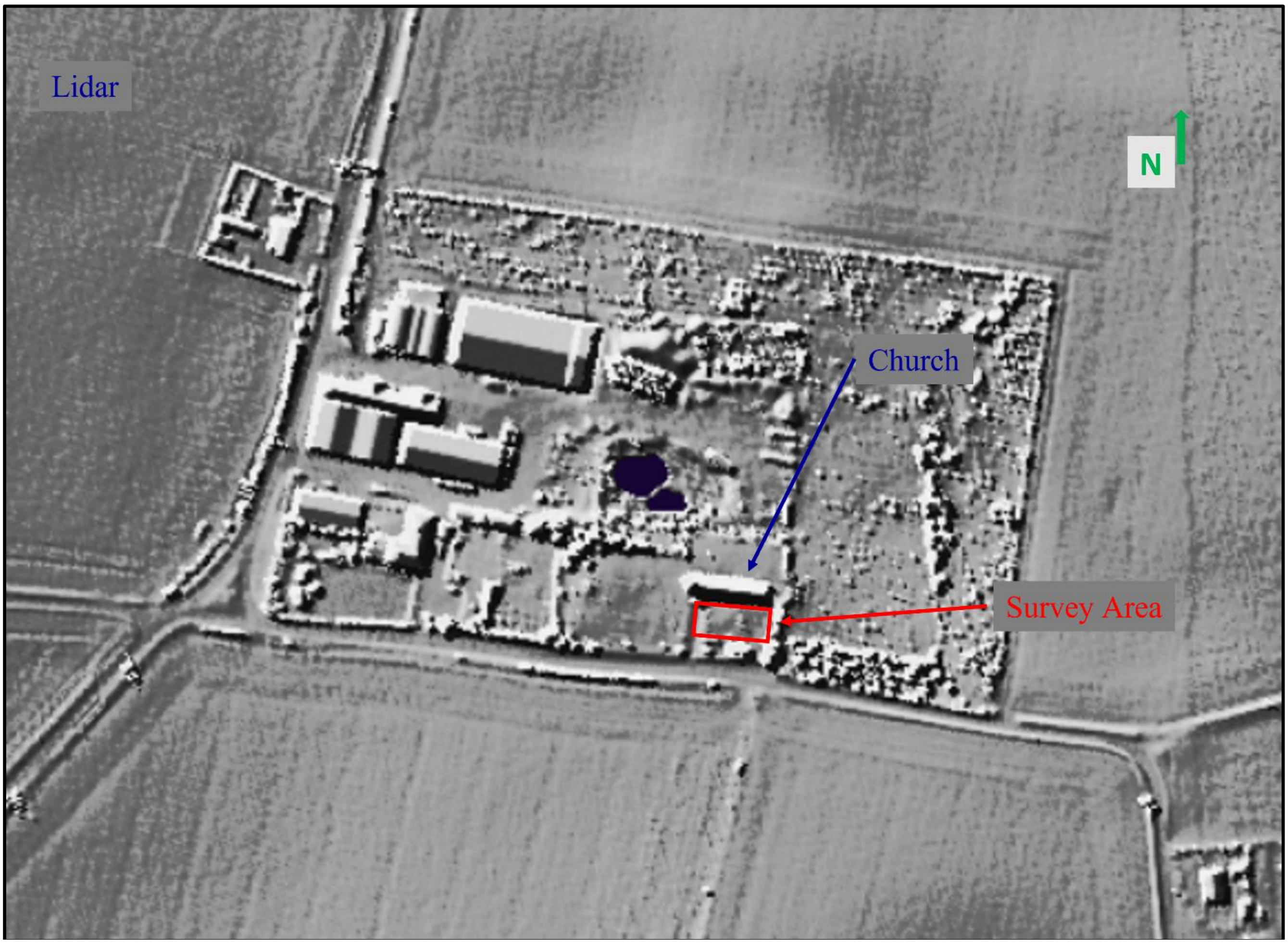


**FIGURE 10 – Lidar picture of Survey area**

**5.2** Currently the only Lidar data available is the 1m DTM, however, this does not detract from the overal picture of the location of the church on higher ground next to depression in the ground filled with water, likely to be an Ognip[3] (highlighted in Dark Blue 50m northwest of the church).

## 6.0 INTERPRETATION

**6.1** There are numerous polar and di-polar responses scattered throughout the survey area. Many of them likely to be ferrous objects within the soil. There are also many linear and curvilinear anomalies which are difficult to interpret without further investigation. However, it is possible to eliminate the possibility of a Lead Coffin in the vicinity of the South Aisle as has been suggested from historical records (See para 3.3 above). In addition, the probable location of the South Aisle floor or foundation can be seen in the positive responses shown in the Figure below.

[3] There have been many explanations of how these depressions came to exist (from marl pits to WW2 bombs dropped on the landscape), however, the most compelling explanation is that they are pingos, which are formed during the Ice Age. The water in the artesian wells below the Norfolk Chalk was forced upwards by the weight of the ice above it. This pushed the ground up, fracturing the chalk geology and making an expanding ice core. When the ice sheet retreated the pingo collapsed (becoming an ognip). The ground beneath the ognip was still fractured and artesian water flowed, as a result of its own hydraulic pressure – resulting in a spring.


**FIGURE 11 – Initial Interpretation of Grid 1 Anomalies**

**6.2** Several unidentified anomalies are highlighted within Grid 1, many of which are likely to be grave cuts. The large negative response in the central / south of the grid may be associated with a large metal object centred to the south of the surveyed area. This is the type of response that would be associated with a large metal object such as the lead coffin. The negative responses close to the church wall are likely 'shadow' responses from the flint and mortar walls overspilling into the fluxgate gradiometer sensors. The 'dog bowl' was left in place as a means of assurance of the sensors accuracy and as a confidence feature during interpretation of the nearby anomalies.

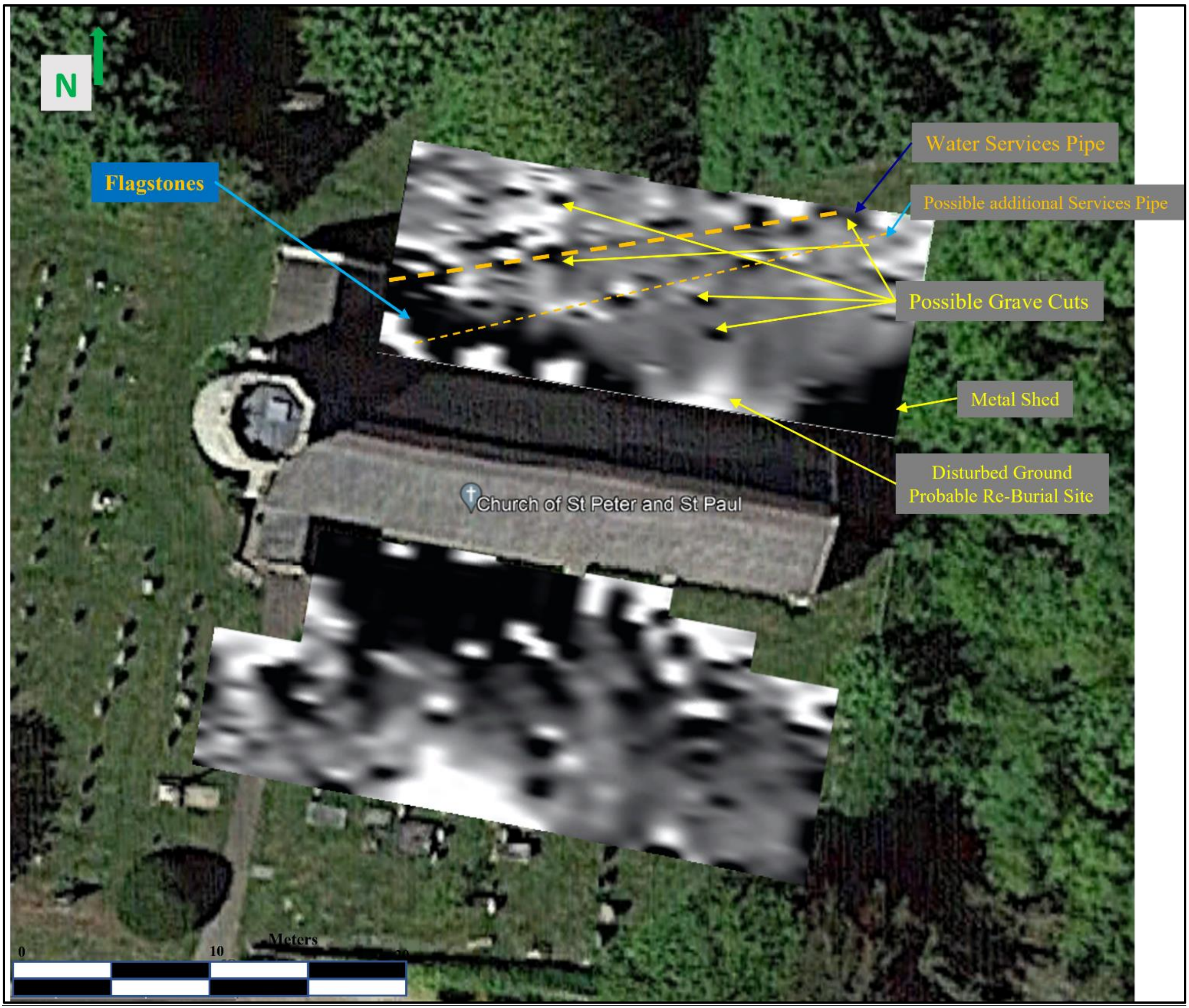


**FIGURE 12 – Initial Interpretation of Grid 2 Anomalies**

**6.3** Two utilities (Cable or Pipeline) Bi-Polar response is located at the Northeast Corner of the survey area towards the kitchen extension on the northwest corner of the church. These features are buried in trenches and relatively modern. The northern of the two utilities is a water pipe. The area od disturbed ground is probably the re-burial site of the human remains excavated during the works to build the kitchen. The flagstone patio is clearly shown in the corner between the kitchen and the main church.

**6.4** The metal shed in the southeast corner of Grid 2 is clearly visible and there are several anomalies that appear to be grave cuts.

## 7.0 <u>CONCLUSIONS</u>

**7.1** Magnetometry proved not to be the correct non-invasive methodology for surveying the area. However, it has added clarity to the picture surrounding the church. A more accurate 3D picture would be achieved by conducting a Ground Penetrating Radar survey. It was not possible to identify any lead coffins in the original south aisle area. However, there may be such an object associated with the large negative anomaly along the central southern edge of Grid 1.

## 8.0 RECOMMENDATIONS

**8.1** Further investigation to ascertain the cause of the magnetic anomalies would be required, including invasive investigation for dating.

## 9.0 EFFECTIVENESS OF METHODOLOGY

**9.1** Although magnetic surveying is usually the preferred method for the majority of surveying (David, 1995) there are well documented limitations of the survey technique. The use of Ground Penetrating Radar would be a more effective choice of survey technique when looking for graves, or depths of specific features / anomalies. The use of Resistance Surveying, particularly 3D Resistance Surveying over most of the intense areas of activity, and also over the tentative magnetic anomalies identified by the magnetic survey may possibly help to define the anomalies and possibly provide further information on their origin. However, the presence/absence and date of these anomalies can only be confirmed by intrusive means resulting in feature identification and classification.

## 10.0 ARCHIVING

**10.1** SHARP maintains an in-house digital archive, which is supplemented by back-up of data in 3 locations. This date is stored as collected measurements, baseline data, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of this report.

## 11 ACKNOWLEDGEMENTS

**11.1** The Authors would like to acknowledge the support of the Diocese of Norwich, the Rector Rev. Susan Hemsley Halls and Paston Heritage Society for their permission to survey the area and providing refreshments and facilities.

## 12.0 REFERENCES


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A guide to coordinate systems in Great Britain D00659 v2.3 Mar 2015 © Crown copyright

Ordnance Survey Map (Norfolk) 1: 25,000 OS Online Mapping Service

**APPENDIX 1– Magnetometry metadata**

| | |
|---|---|
| SITE | |
| Name: | Mautby |
| Location: | Norfolk |
| MapRef: | |
| Comments: | 40x40m |
| | Churchyard |
| | |
| COMPOSITE | |
| Path: | E:\Desktop\Mautby\comps' |
| Filename: | Grid 1 base layer.xcp |
| Description: | |
| Instrument Type: | Bartington (Gradiometer] |
| Units: | nT |
| Direction of 1st Traverse: | 0 deg |
| Collection Method: | ZigZag |
| Sensors: | 2 @ 1 m spacing. |
| Dummy Value: | 2047.5 |
| | |
| Dimensions | |
| Survey Size (meters): | 40 m x 40 m |
| X&Y Interval: | 0.25 m |
| | |
| Stats | |
| Max: | 98.19 |
| Min: | -100.00 |
| Std Dev: | 36.42 |
| Mean: | 10.65 |
| Median: | 5.35 |
| Composite Area: | 0.16 ha |
| Surveyed Area: | 0.0282 ha |
| | |
| PROGRAM | |
| Name: | TerraSurveyor |
| Version: | 3.0.34.10 |

**APPENDIX 2 –**

**Photo 1 – south of the Church – area of Grid 1**

**Photo 2 – south of the Church – area of Grid 1**

**Photo 3 – south of the Church – taken from the tower**

**Photo 4 – north of the Church – area of grid 2 - taken from the tower.**

**APPENDIX 3 - Magnetometry Theory and Principle of Operation**

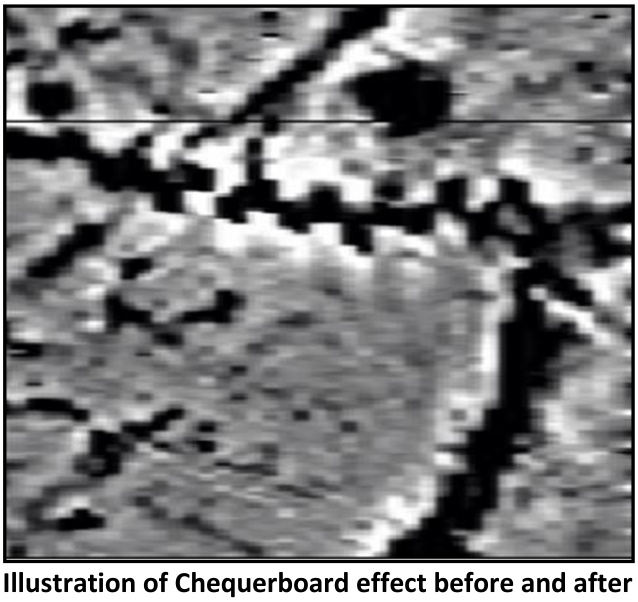
The survey was carried out using a Bartington Grad 601-2 Dual Fluxgate Gradiometer with an onboard automatic DL601 data logger. The data was then processed using Terra Surveyor Lite to fine-tune the readings. This instrument is a highly stable magnetometer which utilises two vertically aligned fluxgates, one positioned 1m above the other. This arrangement is then duplicated and separated by 1m cross bar. The 1m vertical spacing of the fluxgate provides for deeper anomaly detection capabilities than the older 0.5m versions. The dual arrangement allows for rapid assessment of the archaeological potential of the site. Data storage from the two fluxgate pairs is automatically combined into one file and stored using the onboard data logger.

The data from the DL601 is uploaded to a laptop computer and processed using Terra Surveyor Lite, which is used to fine-tune and focus the readings to give a much clearer image. Base Layer data is stored and remains separated from the manipulated data to ensure that survey data is not lost and can be used by a larger number of software packages at a future date. The resulting data set plots are presented with positive nT mapped as black and negative nT mapped as white. The data has been corrected and processed using numerous filters. Each figure shown has the parameters noted to show what has been done to the raw data to achieve the resolution shown.

A 'de-spike' / 'clipped' process is used to remove spurious or extreme high intensity anomalies or datapoint values, often caused by ferrous objects, which may affect subsequent filter use, data enhancement and interpretation.

The de-stripe process is used to equalise underlying differences between grids. The differences are most often caused by directional effects inherent in magnetic surveying instruments, instrument drift, instrument orientation (such as off-axis surveying or heading errors) and delays between surveying adjacent grids. The de-stripe process is used with care as it can sometimes have an adverse effect on linear features that run parallel to the orientation of the process.

The de-stagger process compensates for data collection errors by the operator. Such errors can be caused by unsuitable or uneven surface conditions, such as ploughed sites and a windy hillside, where the operator can start the recoding of traverses a few centimetres too early or late – chequerboard anomaly effect.



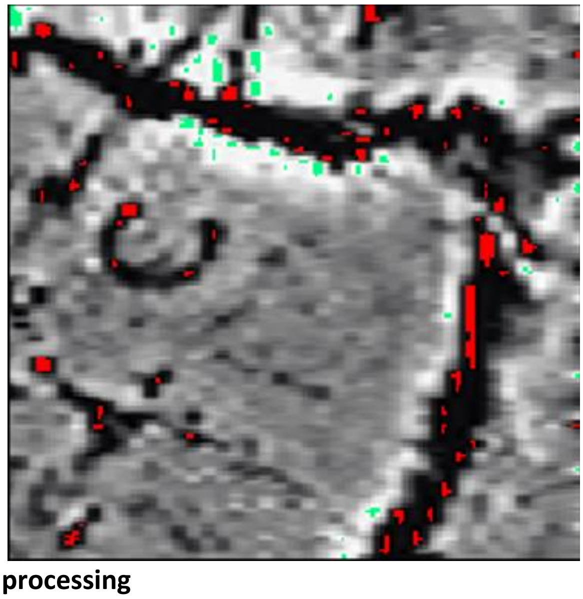


**Illustration of Chequerboard effect before and after processing**

Plots of the data are presented in processed linear greyscale (with de-stripping (or ZMT – zero mean transverse) and de-spiking applied and interpolated), in trace plot form and as a separate simplified graphic summary showing the main magnetic anomalies detected.

Detailed magnetic surveys 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. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas(nT) in an overall field strength of over 48,000 (nT), can be accurately detected.

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

Thermoremanence 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. Thermoremanent archaeological features can include hearths and kilns; 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 nonmagnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

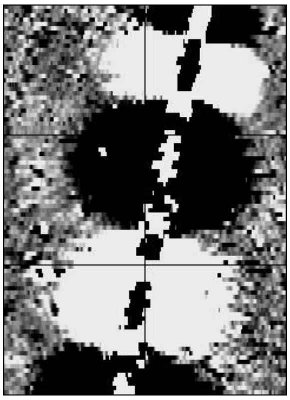
Heat, followed by cooling induces magnetism in any iron oxide present in soils and clays. The magnetisation derives from the earth's magnetic field in its direction at the time of the last cooling (in most cases this happened billions of years ago when the Earth cooled, but it can also be associated with volcanic action, lightning or intense heat from a kiln or ovens).

A 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. The recorded amount of magnetic flux depends on the material’s magnetic susceptibility to induced magnetism; the more susceptible it is equals more thermoremnant magnetisation present. This gives a strong magnetic signal for furnaces, kilns and ovens and burnt structures, appearing as a dense dark area on the plot. In the case of pits and ditches, the accumulated fill has subtly different magnetic properties from that of the background, resulting from disturbance and increased moisture and humic material in the fill. This difference in the magnetic signal is detected and recorded by the instrument.

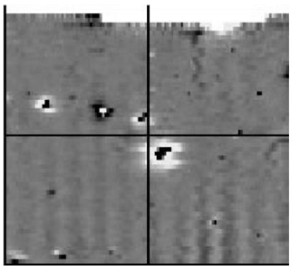
The following anomaly types may be present within the data:

**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**

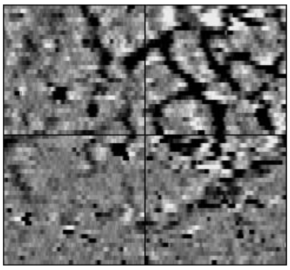


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very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

**Positive anomaly with associated negative response**

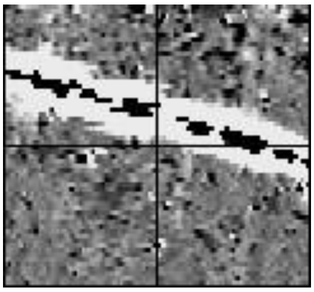
See bipolar and dipolar.

**Positive linear**



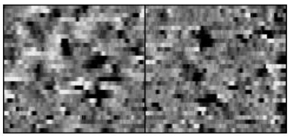
A linear response which is entirely positive in polarity. These are usually related to infilled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity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

**Positive linear anomaly with associated negative response**



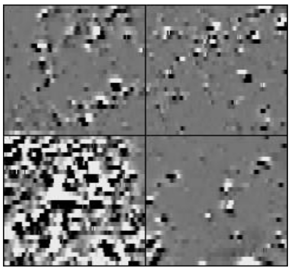
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field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

**Positive point/area**



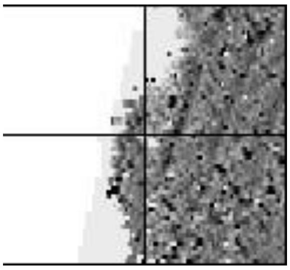
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by infilled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally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

**Magnetic debris**



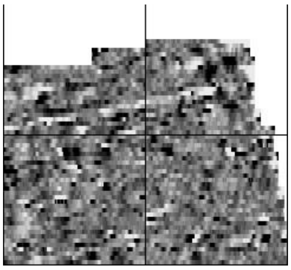
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low (+/-3nT) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly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

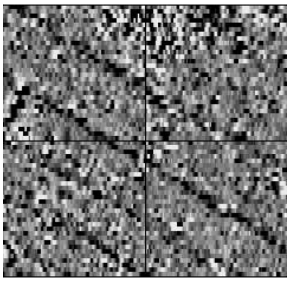


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background topsoil is built up. See also ploughing activity.

**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).

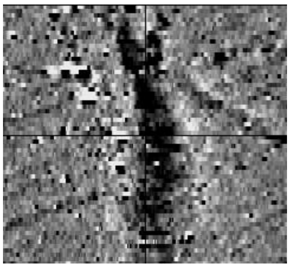
**Strength of response**

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 10$m^2$ 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.

**Thermoremanent 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.