STRATASCAN

Geophysical Survey Report

Halfkey Road, Malvern

for

Mr Gilbert Brooke

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J 2029

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National Grid Ref:	**SO 7713 4872**

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1 SUMMARY OF RESULTS

A detailed magnetic survey was carried out over 1.6ha of land at Halfkey Road, Malvern, Worcestershire.

The results have shown a section of medieval ridge and furrow ploughing in the centre of the survey area. This seems to cut through anomalies which are typical of burnt features, suggesting they pre date the ploughing marks. Other anomalies have been identified with unclear origins. Further investigation may be required to clarify their source, and to confirm the nature of the possible burnt features.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Mr Gilbert Brooke to undertake a geophysical survey of an area outlined for residential development.

2.2 Site location

The site is located off Halfkey Road Malvern, Worcestershire at OS ref. SO 7713 4872.

2.3 Description of site

The survey area is approximately 1.6ha of grass covered land.

2.4 Geology and soils

The underlying geology is part of the Mercia Mudstone Group from the Triassic Period (British Geological Survey Mid Wales & Marches, 1990) .The overlying soils are of the Brockhurst series. These consist of medium loamy or medium silty drift over reddish-clayey material passing to clay or mudstone (Soil Survey of England and Wales, Soils of Worcester and Malverns District, Sheet 150, 1985).

2.5 Site history and archaeological potential

The survey area lies within a region of a nationally important Roman ceramic industry (Worcestershire Historic Environment & Archaeology Service Planning Advisory Section, n.d). It is possible the area may contain kilns and other features associated with this industry.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological origin 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 on 14 June 2005.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site.

3.3 Survey equipment

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each sensor has a 1m separation between the sensing elements increasing the sensitivity to small changes in the Earths magnetic field.

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 Grad601-2 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 0.25m centres provides an appropriate methodology 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 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 = on

Trace plots have been adjusted prior to display in order to remove artefacts of the data collection process.

3.5.2 Presentation of results and interpretation

The presentation of the data for each site involves a print-out of the raw data as greyscale (Figure 3) and adjusted trace plots (Figure 4 and 5), together with a greyscale plot of the processed data (Figure 6). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 7).

4 RESULTS

The gradiometer survey has identified geophysical anomalies which can be broadly classified as:

- Linear anomalies probably caused as a result of agricultural ploughing.
- Weak positive linear anomalies of uncertain origin – possibly archaeological.
- Weak areas of positive response with associated negative halos.
- Stronger areas of positive response with associated negative halos which may represent burnt features.
- Areas of magnetic disturbance probably of modern origin.

Across the centre of the site is a series of parallel linear anomalies separated by approximately 5m-10m. This is likely to be the effect of medieval ridge and furrow ploughing. Cutting through these possible agricultural marks on the north eastern edge of the survey area are three discrete positive anomalies each surrounded with a negative halo. These have a relatively weak magnetic enhancement (less than 10 nT) leaving their origin ambiguous. While they are not strong enough to represent ferrous debris or kilns they are too strong to be caused by infilled pits. They are likely to post date the ploughing marks as they appear cut through the plough marks.

Within the centre and towards the west of the survey area are five stronger areas of positive enhancement with surrounding negative halos. Each has a diameter of around 5m. With magnetic readings ranging up to 100nT this is the typical type of anomaly expected from burnt features. Two of these anomalies, within the plough marks, appear to be elongate in line with the plough marks. This suggests they have been spread by the medieval ploughing and may pre date it.

The eastern side of the survey area contains several weak positive curvilinear anomalies. It is unclear what their cause is. It is possible they represent natural variations within the soil, although cut features of an archaeological origin can not be ruled out.

5 CONCLUSION

The geophysical survey has identified features which probably represent medieval ridge and furrow ploughing. Several strong responses appear to pre date the ploughing which may relate to burnt features. Given the site history it is possible these have a Roman origin. Similar weaker responses have also been seen in the data. The origin of these is unclear, but they appear to post date the ploughing. Curvilinear anomalies in the east of the area may have an archaeological origin, although this is unclear and further investigation is needed to determine their nature.

REFERENCES

British Geological Survey, 1990. *Mid Wales & Marches.* British Geological Society.

Soil Survey of England and Wales, 1985. *Soil Survey of England and Wales, Soils of Worcester and Malverns District, Sheet 150.*

Worcestershire Historic Environment & Archaeology Service Planning Advisory Section, n.d. *Requirements for an Archaeological Evaluation at Land off Halfkey Road Malvern, Worcestershire*.

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.