STRATASCAN

Geophysical Survey Report

Cadeby Quarry, Leicestershire

for

University of Leicester Archaeological Services

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LIST OF FIGURES

1 SUMMARY OF RESULTS

A detailed magnetic survey was carried out over approximately 24ha within three separate parcels of land to the east of Cadeby in Leicestershire. Within Area 1, immediately east of the village of Cadeby, are several positive linear and rectilinear anomalies that may be responses to the fill of magnetically enhanced material within cut features of an archaeological origin. There is also evidence within Area 1 and possibly Area 3 of former ridge and furrow agricultural systems. Buried pipelines, dumped material and ferrous objects in Area 2 may have obscured more subtle responses in magnetic 'noise'. The low magnitude of many of the anomalies has made confident interpretation difficult and may partly be related to the magnetic characteristics of the soils in this area.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by University of Leicester Archaeological Services (ULAS) to undertake a geophysical survey of an area outlined for development as a quarry. This survey forms part of an archaeological investigation by ULAS in order to determine if archaeological features are present within the site prior to development.

2.2 Site location

The site is located between Cadeby and Newbold Vernon in Leicestershire and is approximately centred on OS ref. SK 438 025.

2.3 Description of site

The survey area is approximately 24ha of generally flat agricultural land within three separate areas. Area 1 is immediately east of the village of Cadeby and comprises 6 predominantly pasture fields totalling approximately 14ha in area. Area 2 is located to the northeast of Brascote House and covers an area of approximately 1.4ha. Area 3 is located immediately north of Brascote Lane and consists of a parcel of land approximately 8ha in area.

2.4 Geology and soils

The underlying geology is Triassic mudstone including "Keuper Marl" with overlying deposits of glacial sands and gravels (British Geological Survey South Sheet, Fourth Edition Solid, 2001; First Edition Quaternary, 1977). The overlying soils are known as Arrow soils which are gleyic brown earths. These consist of deep permeable coarse loamy soils affected by groundwater (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 Site history and archaeological potential

No specific details were available to Stratascan.

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 over 15 days from the 7th to the 25th of February 2005. Weather conditions during the survey were cold and snowy.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information for each area in Figures 3, 20 and 26. 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 giving a strong response to deep 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 601-2 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 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 trace plots have been clipped at ±100nT for clarity of display and to reveal any anomalies of a low magnitude that may have been obscured.

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 (e.g. Figure 4) and trace plots (e.g. Figures 5 and 6), together with a greyscale plot of the processed data (e.g. Figure 7). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (e.g. Figure 8).

4 RESULTS

The detailed magnetic survey located a number of geophysical anomalies within each of the survey areas. These anomalies can be generally classified as positive linear anomalies of a possible archaeological origin, positive and negative linear anomalies of an uncertain origin, discrete positive area anomalies of an uncertain origin, positive and negative linear anomalies with an agricultural origin, strong dipolar linear anomalies relating to buried services or cables, areas of magnetic debris and disturbance and strong dipolar anomalies relating to ferrous objects within the topsoil.

The results of each survey area will be discussed separately below with reference to anomaly codes (1 to 43) seen within the abstraction and interpretation plots. Due to the large size of Area 1, it has been divided into Area 1nw, Area 1sw and Area 1ne in order to display the site at an appropriate scale. As well as individual plots of these sections at a scale of 1:1000, the whole of Area 1 has been plotted at a scale of 1:2500 (Figure 19) in order to view the abstracted anomalies within context.

Area 1nw (centred on SK 4275 0243) (Figures 2-8)

Several low magnitude linear and possible rectilinear anomalies (1) are located close to the south-eastern edge of Area 1nw. These anomalies are generally less than 1nT in magnitude indicating that they may be a response to weakly enhanced material within the fill of cut features such as a ditches. A continuation of similar features can be seen

extending to the southeast into the adjacent field (see Area 1sw below and Figures 13 and 19). These linear anomalies are generally oriented northwest to southeast and northeast to southwest and are parallel with the field boundaries.

In the centre of the survey area are two parallel positive linear anomalies (2) between 21m and 25m in length and distanced approximately 8m apart. It is difficult to be certain of the origin of these anomalies. It is possible that they have been formed by agricultural activity although it should be considered that they may be an extension of anomalies (1).

Situated close to anomalies (1) are several areas of magnetic debris (3). It is possible that this is a response to thermoremnant material with a moderately strong magnitude such as brick/tile although it is difficult to determine if this is a spread of material associated with (1) or if it relates to modern dumped material.

In the north of the site are several areas of magnetic debris (4) and areas of magnetic disturbance (5). It is likely that these are associated with areas of dumped thermoremnant and ferrous material.

In the north are a series of parallel positive linear anomalies (6) oriented west-south-west to east-north-east. These low magnitude linear anomalies are generally between 6 and 7m apart and are characteristic responses to a ploughed out ridge and furrow agricultural system. These anomalies are parallel to the northern, southern and dividing field boundaries suggesting that these boundaries may be at least contemporary with the ridge and furrow.

Area 1sw (centred on SK 4286 0222) (Figures 9-13)

In the north of this subsection of Area 1 a series of positive linear and possible rectilinear and curvilinear anomalies can be seen (7). They have a similar form and magnitude as anomalies (1) seen to the northwest in Area 1nw and are likely to be a continuation of them. It is possible that these anomalies relate to the fill of cut features with an anthropogenic origin and archaeology should be considered.

Several positive linear anomalies (8 and 9) can be seen in the west of the area. These anomalies are of a very low magnitude and although of uncertain origin, archaeology cannot be ruled out.

Close to the south eastern corner of the survey area is an area of magnetic debris (10) which obscures an elliptical positive linear anomaly (11) with a magnitude of between 5 and 35nT (see raw data in Figure 9). Although the magnetic debris is generally of a similar magnitude there are two very strong dipolar anomalies of at least 3000nT which indicates ferrous objects are associated with the debris and that a modern origin is likely.

A series of parallel positive linear anomalies (12) oriented approximately northeast to southwest and spaced 7m apart can be seen within this area. It is likely that these parallel anomalies are also responses to the fill of former furrows of a ridge and furrow agricultural system.

In the west a positive linear anomaly (13) extends from beyond the limits of the survey area towards an electricity pole. It is likely that this is a response to a cut or buried feature such as a pipe or cable associated with the electricity pole.

Areas of magnetic disturbance (14) and strong discrete dipolar anomalies (15) are responses to ferrous material used in adjacent fence-lines and modern ferrous objects within the site.

Area 1ne (centred on SK 4297 0247) (Figures 14-18)

In the centre of the site and generally oriented northwest to southeast are several positive linear anomalies (16). These anomalies converge towards the gateway in the south eastern boundary and are associated with a track way. Positive linear anomalies (17) adjacent to them may also be agricultural marks or possibly be associated with the track way.

There area several other sets of linear anomalies caused by agricultural activity within this site. In the western corner several positive linear anomalies are oriented almost north – south (18), while to the southeast of (18) the linear anomalies are oriented approximately west-north-west to east-south-east (19). In the east of the site they are oriented northwest to southeast (20) and crossed orthogonally by (21). It is likely that these anomalies have all been caused by past agricultural activity ranging from ridge and furrow (18) to modern ploughing (21).

Between and parallel to (17 and 20) is a negative linear anomaly (22). The form and magnitude of this anomaly indicates that it is a response to material that is less magnetically enhanced than the surrounding topsoil, and although such a response may suggest a former land boundary it is possible that this anomaly is a response to a modern feature such as a pipeline.

A low magnitude possible curvilinear anomaly (23) is located in the eastern part of this survey area and is of uncertain origin.

Several areas of magnetic debris (24) and magnetic disturbance (25) are situated across the site and are likely to be responses to dumped thermoremnant and ferrous material or areas of burning. Two strong dipolar linear anomalies (26) can be seen in the north of this section and relate to modern pipelines. Strong dipolar anomalies (27) are responses to ferrous objects and material within the site.

Area 2 (centred on SK 4422 0224) (Figures 20-25)

In the northwest of the survey area are several low magnitude positive linear anomalies (28). It is difficult to accurately determine the origin of these anomalies or if they relate to cut features.

In the eastern part of the site is a positive linear anomaly (29) that appears to lead to towards a strong dipolar linear anomaly (30) and it is possible that it is associated with it. Anomaly (30) extends across the survey area and is joined within the centre of the

site by a second strong linear anomaly. These very strong dipolar anomalies are responses to buried services.

Within the survey area are widespread areas of magnetic debris (31) which are likely to be responses to dumped or demolished thermoremnant material of modern origin. Areas of strong magnetic disturbance (32) are responses to ferrous material and objects within the site.

Area 3 (centred on SK 4458 0277) (Figures 26-31)

A series of positive linear anomalies (33) are located in the central south of the survey area. It is difficult to confidently interpret the origin of these anomalies due to the very low magnitude of the response. Other positive linear anomalies (34 and 35) can also be seen in the survey area and are also of uncertain origin. It is possible that these anomalies are of a geological/pedological origin, although archaeology cannot be ruled out.

Two discrete positive area anomalies (36 and 37) have a response of between 3 and 9nT, although there is an associated negative return which may suggest some ferrous content to them and it is possible that they are modern in origin.

There are several series of positive linear anomalies that have been caused by agricultural activity. Anomalies (38 and 39) are oriented parallel to the north western and south western field boundaries respectively. In the west of the site anomalies (40) are oriented generally north-north-east to south-south-west and may relate to former ridge and furrow. A series of parallel negative linear anomalies (41) are spaced approximately 23m apart and may relate to agricultural activity or land drainage. One negative linear anomaly (42) in the northeast may also be associated with agricultural activity.

There are several strong discrete dipolar anomalies (43 which are caused by ferrous objects within the topsoil.

5 CONCLUSION

The detailed magnetic survey located a number of geophysical anomalies within the survey areas. Although the location of several pipelines was indicated by very strong dipolar linear responses, the general magnitude of the majority of other linear anomalies was very low. Within Area 1 to the east of Cadeby, a series of positive linear, rectilinear and possible curvilinear anomalies may be responses to the fill of cut features with an archaeological origin. There are also positive linear responses that indicate the former ridge and furrow agricultural regime. In Area 2 close to Brascote House, the origin of a small number of positive linear responses could not be determined and widespread areas of magnetic debris and disturbance may have destroyed or obscured lower magnitude responses. Within Area 3 the very low magnitude of the responses have made confident interpretation of several positive linear anomalies difficult. Several phases of agricultural marks can be seen in the results, possibly including former ridge and furrow.

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.