Land at Common Road, Harthill, South Yorkshire

Detailed Gradiometer Survey Report

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	E	*AJS*	*PAB*		13/04/2017
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File:					

* I = Internal Draft; E = External Draft; F = Final

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Summary

A detailed gradiometer survey was conducted over land at Common Road, Harthill, South Yorkshire (centred on NGR 450578, 380477). The project was commissioned by ERM on behalf of INEOS with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of a planning application for the development of the site as a shale gas extraction point.

The site comprises a portion of a single arable field located north of Common Road, Harthill, covering an area of 1.9 ha. The geophysical survey was undertaken on 22nd March 2017 and has demonstrated the presence of a number of anomalies of possible archaeological origin across the survey area.

The survey has revealed a substantial number of ditch-like features that together may form a network of Iron Age or Romano-British enclosures. However, the anomalies are consistent with geological responses found on a similar dolostone geology at Clowne (Wessex Archaeology 2013) making a definite conclusion as to the origin difficult. A circular anomaly has been identified in the north-west of the site, and may be evidence of earlier Bronze Age activity; a round barrow or small enclosure. However, this could also be caused by natural features in the dolostone bedrock. It is not possible to accurately determine the nature of the anomalies from the geophysical data alone, and further investigation would be required to provide clarity.

Additionally, this archaeological investigation has detected parallel trend anomalies consistent with modern ploughing.

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Acknowledgements

Wessex Archaeology would like to thank ERM for commissioning the geophysical survey on behalf of INEOS. The assistance of Michael Tomiak of ERM is gratefully acknowledged in this regard.

The fieldwork was undertaken by Christ Hirst and Matt Tooke. Alexander Schmidt processed and interpreted the geophysical data and wrote the report. The geophysical work was quality controlled by Tom Richardson and Paul Baggaley. Illustrations were prepared by Richard Milwain. The project was managed on behalf of Wessex Archaeology by Lucy Learmonth.

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1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by ERM on behalf of INEOS to carry out a geophysical survey at Common Road, Harthill, South Yorkshire (hereafter "the Site") centred on NGR 450578, 380477 (**Figure 1**). The survey forms part of an ongoing programme of archaeological works being undertaken in support of a planning application for the development of the Site as a shale gas extraction point.

1.1.2 This report presents a brief description of the methodology followed by the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 The Site

1.2.1 The Site is located in South Yorkshire, 1.2 km east of the village of Harthill and 7.8 km west of Worksop.

1.2.2 The detailed gradiometer survey consists of 1.9 ha of agricultural land, currently utilised for winter wheat crop. The Site is bounded by open agricultural land to the north and west, a small parcel of woodland to the east, with a hedgerow and Common Road to the south.

1.2.3 The Site is on a gentle incline, sloping from 138 m above Ordnance Datum (aOD) at the southern edge to approximately 136 m aOD at the northern edge.

1.2.4 No overhead cables traverse the Site.

1.2.5 The underlying bedrock geology throughout the Site is mapped as Dolostone of the Cadeby (Magnesian limestone) formation with no superficial deposits recorded (BGS 2017).

1.2.6 The soils underlying the Site are likely to consist of typical brown calcareous earths of the 511a (Aberford) association (SSEW SE Sheet 1 1980). Soils derived from such geological parent material have been shown to produce contrasts acceptable for the detection of archaeological remains through gradiometer survey.

2 ARCHAEOLOGICAL BACKGROUND

2.1.1 The following background details of relevant sites within 1km of the Site in order to inform the geophysical interpretation. This information has been compiled from data from the Heritage Gateway (accessed 2017).

2.1.2 There are no designated heritage assets, such as Scheduled Monuments, within the boundary of the proposed survey. Several find spots have been identified within the wider study area. A late Mesolithic to early Neolithic flint blade was recovered close to Loscar Farm. The potential for buried archaeological remains pertaining to this period is thought to be low.

2.1.3 Cropmarks to the south of the site are suggestive of a possible squared enclosure and field system. Are thought to potentially be later prehistoric to Romano-British in origin. The potential for buried archaeological remains of this period is thought to be low to moderate.

2.1.4 There are no Grade I, II or II* Listed buildings within the wider study area of the Site. Spot finds to the south at Loscar Farm revealed medieval and post-medieval pottery. It is thought any archaeological remains are likely to be agricultural in origin and the potential is low to moderate.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team on the 22nd March 2017. Field conditions at the time of the survey were good throughout the period of survey. An overall coverage of 2.0 ha was achieved, with any extra area covered to ensure maximum coverage across open boundaries.

3.2 Aims and objectives

3.2.1 The aims of the survey comprise the following:

- to conduct a detailed survey covering as much of the specified area as possible, allowing for artificial obstructions;
- to clarify the presence/absence and extent of any buried archaeological remains within the site;
- to determine the general nature of the remains present.

3.3 Fieldwork methodology

3.3.1 Individual survey grid nodes were established at 30 m x 30 m intervals using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02 m and therefore exceeds Historic England recommendations (2008).

3.3.2 The detailed gradiometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1 m between sensors. Data were collected at 0.25 m intervals along transects spaced 1 m apart with an effective sensitivity of 0.03 nT, in accordance with Historic England guidelines (English Heritage 2008). Data were collected in the zigzag method.

3.4 Data processing (Gradiometer)

3.4.1 Data from the survey was subject to minimal data correction processes. These comprise a zero mean traverse function (±5 nT thresholds) applied to correct for any variation between the two Bartington sensors used, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These two steps were applied throughout the survey area, with no interpolation applied.

3.4.2 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 The detailed gradiometer survey has identified several anomalies of possible archaeological origin, as well as a large amount of parallel trend anomalies. Results are presented as a series of greyscale plots, XY plots and archaeological interpretations at a scale of 1:1500 (**Figures 2** to **4**). The data are displayed at -2 nT (white) to +3 nT (black) for the greyscale image and ±25 nT at 25 nT per cm for the XY trace plots.

4.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ferrous/burnt or fired objects, and magnetic trends (**Figure 4**). Full definitions of the interpretation terms used in this report are provided in Appendix 2.

4.1.3 Numerous ferrous anomalies are visible throughout the dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

4.1.4 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that more archaeological features may be present than have been identified through geophysical survey.

4.1.5 Gradiometer survey may not detect all services present on Site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on Site.

4.2 Gradiometer survey results and interpretation

4.2.1 The survey has revealed numerous intersecting, linear and recti-linear anomalies that may form a network of enclosures consistent with a pre-historic pattern of land division where ditches were used to separate parcels of land. However, these anomalies have been interpreted as possible archaeology due to the nature of the underlying dolostone geology. Similar patterns of anomalies have been identified at Clowne over the same geology (Wessex Archaeology 2013). Trenching of these anomalies found them to be the result of natural fissures. The anomalies are described and discussed below.

4.2.2 In the south-western portion of the survey, a cluster of positive (-10 - +14 nT) recti-linear anomalies has been identified covering an area approximately 80 m x 75 m on a north-west to south-east alignment (**4000**). A larger recti-linear anomaly measuring approximately 26 m x 29 m has been identified at the north of this group. Within this feature several weaker (+/-2 nT), fragmented linear anomalies have been identified; however, their origin is not clear. If these anomalies are archaeological then it is likely that they represent pitting activity or internal divisions within a larger enclosure. A similar rectilinear anomaly lies immediately to the west. This is a larger feature, measuring 42 m north-west to south-east. However, it is not possible to identify the western extent, as it appears to extend outside the survey area.

4.2.3 To the south of the two larger features, several smaller (11 m x 12 m) recti-linear anomalies have been identified. These anomalies continue south-east forming a ‘ladder’ shape that appears to have a gap at the southern extent, possibly relating to an entranceway. These smaller enclosures may form part of the wider network continuing to the west outside the survey area. The anomalies together may form a larger enclosure with internal and external divisions however they may also be the result of natural fissures in the underlying geology.

4.2.4 To the north and south of the data set two moderate magnitude (8 – 14 nT) positive linear anomalies (**4001** and **4002**) have been identified on a south-west to north-east alignment. Both anomalies appear fragmented with respective lengths of 50 m and 56 m. **4002** appears to interconnect with anomalies to south at the south-western extent at **4000**, while the extent of **4001** is unclear as it continues outside of the dataset. It is possible the anomaly may continue and form an intersection with a linear anomaly protruding to the north-west from the group of anomalies at **4004**.

4.2.5 In the centre of the dataset a cluster of amorphous anomalies has been identified (**4003**). These anomalies present as a very similar magnitude (-10 - +11 nT) to the surrounding enclosure-like anomalies. However, no clear discernible pattern or orientation can be identified. These anomalies have therefore also been interpreted as possible archaeology. They may be evidence of settlement activity within the surrounding enclosures, or be natural fissures.

4.2.6 To the north-east of **4003** a second, more defined pattern of anomalies forms another network of interlinking linear and recti-linear anomalies (**4004**). Three or possibly four 'ladder' shaped anomalies measuring approximately 11 m x 12 m and appearing on a north-west to south-east alignment have been identified. Connected to the east, three more undefined recti-linear anomalies have been identified. These anomalies have been noted on a slightly different alignment (east – west) but appear to intersect with the more 'ladder' shaped anomalies on the eastern side. The anomalies together may form a network of smaller divisions or enclosures; however, they may also be the result of natural fissures in the underlying geology.

4.2.7 To the south of **4004** a group of larger, more fragmented recti-linear anomalies have been identified (**4005**). These anomalies measure approximately 30 m x 28 m and fall on the same alignment as the 'ladder' shaped anomalies at **4004**, but form a more regular pattern of squares. These anomalies may also form larger enclosures interlinked with smaller enclosures to the north-west, however may also be natural in origin.

4.2.8 A low magnitude, positive (+2 - +4 nT), curvi-linear anomaly has been identified in the north of the survey area (**4006**). This is indicative of a former ditch feature, however its position at the periphery of the survey area makes accurate interpretation difficult. It is possible that this is evidence of a small enclosure or other archaeological settlement activity. However, it could equally relate to natural feature in the dolostone bedrock.

4.2.9 A clearer circular/curvi-linear anomaly has been identified in the north-west of the dataset (**4007**). This is indicative of a ring ditch, with an internal diameter of approximately 12 m. It is possible that this relates to a Bronze Age barrow or a small circular enclosure feature. However, given the similar magnetic strength (8 – 12 nT) to the surrounding features that may be fissures in the dolostone bedrock, a natural origin cannot be discounted.

4.2.10 Closely spaced (1.5 – 2 m) parallel linear anomalies have been identified across the Site on an east – west orientation. These are indicative of modern agricultural activity, such as ploughing.

5 DISCUSSION

5.1.1 The detailed gradiometer survey has been successful in detecting anomalies of possible archaeological interest throughout the dataset. These anomalies have the expected pattern and form of a network of Iron Age/Romano British enclosures. However, similar anomalies have been identified over a similar geology at a site in Clowne (Wessex Archaeology 2013), and were found to be natural depressions and fissures by trenching. This makes confident interpretation of the anomalies difficult, and it is entirely plausible there could be a mixture of both natural and archaeological features within the dataset. Distinction between natural and archaeological anomalies is not possible from the geophysical data alone; further investigations would be required to clarify this.

5.1.2 The circular anomaly (**4007**) in the north-west of the Site has a clearly different form to the rest of the rectilinear anomalies across the area. This may suggest it is of a different origin, and therefore more likely to be archaeological. It is possible that it relates to a Bronze Age round barrow or other small circular enclosure. However, it has similar magnetic properties, meaning a natural origin cannot be discounted.

5.1.3 In addition to the above, anomalies interpreted as evidence of agricultural activity have also been identified. These are apparent as parallel linear trend anomalies throughout the dataset on an east – west alignment, and are likely related to modern ploughing.

5.2 Recommendations

5.2.1 Following the results of the geophysical survey, it is considered that further archaeological investigations could be required by the Local Planning Authority. It is recommended that these works could take the form of archaeological trial trenching in the first instance. Should this be the case, the anomalies identified as archaeology and probable archaeology are tested.

5.2.2 Additionally, further data should be collected via trial trenching from the areas identified as superficial archaeology / potential spreads to ensure that these responses are not masking weaker and potentially archaeological responses. Trenches should also be planned to investigate areas where no anomalies of potential archaeological interest have been identified within the Site.

6 REFERENCES

6.1 Bibliography

English Heritage 2008 *Geophysical Survey in Archaeological Field Evaluation. Research and Professional Service Guideline No 1.* Swindon (2nd Edition)

Wessex Archaeology 2013 *Mansfield Road, Clowne, Derbyshire Detailed Gradiometer Survey Report*

6.2 Cartographic and documentary sources

Ordnance Survey 1983 *Soil Survey of England and Wales Sheet 3, Soils of Midland and Western England.* Southampton.

6.3 Online resources

British Geological Survey Geology of Britain Viewer (accessed April 2017)
http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Heritage Gateway (accessed April 2017)
http://www.heritagegateway.org.uk/gateway/

7 APPENDICES

7.1 Appendix 1: Survey Equipment and Data Processing

Survey methods and equipment

The magnetic data for this project will be acquired using a non-magnetic cart fitted with 4x Bartington Grad-01-1000L magnetic gradiometers. The instrument has four sensor assemblies fixed horizontally 1 m apart allowing four traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03 nT over a ±100 nT range, and measurements from each sensor are logged at a rate of 6 hz (intervals of sub 0.25 m). All of the data are stored on a Leica Viva CS35 tablet controller using the data acquisition program MLGrad 601. This also collects readings streamed by a Leica GS14 GNSS receiver, which is fixed to the cart at a measured distance from the sensors.

The use of the non-magnetic cart has several advantages over the use of the Bartington Grad 601-2 fluxgate gradiometer instrument. Perhaps chief amongst these is that it has a higher sample rate resulting in higher resolution dataset. The addition of the GPS receiver also negates the need to establish a survey grid prior to the survey and therefore increases efficiency. Mounting the instrument on the cart also reduces the occurrence of operator error caused by inconsistent walking speeds and variation in traverse position due to varying ground cover and topography.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. When not using the handheld Bartington 601-2 dual magnetic gradiometer, both types depend upon the establishment of an accurate 20 m or 30 m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02 m in real-time and therefore exceed the level of accuracy recommended by Historic England (English Heritage 2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25 m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20 m x 20 m or 30 m x 30 m grids, and data are collected at 0.25 m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20 m or 30 m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125 m intervals along traverses spaced up to 0.25 m apart, resulting in a maximum of 28800 readings per 30 m grid, exceeding that recommended by Historic England (English Heritage 2008) for characterisation surveys.

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps for the non-magnetic cart fitted system may include:

- Smooth – Applying a smooth function removes any small scale spiking or 'fuzziness', generally caused by internal system noise. This effectively 'destripes' the data and reduces the appearance of dominant anomalous readings.
- Spline interpolation – Gridding the data with splines allows the application of minimum and maximum data values and reduces oscillations for potential fields such as gravity or magnetic.

Typical data and image processing steps for the dual magnetic gradiometer system may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by
- directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

7.2 Appendix 2: Geophysical Interpretation

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative or broad bipolar (positive and negative) anomalies.

7.3 Appendix 3: OASIS form

Project Details:

Project name	Land at Common Road, Harthill, South Yorkshire				
Type of project	Detailed gradiometer survey				
Project description	A detailed gradiometer survey was conducted over land at Common Road, Harthill, South Yorkshire (centred on NGR 450578, 380477). The project was commissioned by ERM on behalf of INEOS with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of a planning application for the development of the site as a shale gas extraction point. The site comprises a portion of a single arable field located north of Common Road, Harthill, covering an area of 1.9 ha. The geophysical survey was undertaken on 22nd March 2017 and has demonstrated the presence of a number of anomalies of possible archaeological origin across the survey area. The survey has revealed a substantial number of ditch-like features that together may form a network of Iron Age or Romano-British enclosures. However, the anomalies are consistent with geological responses found on a similar dolostone geology at Clowne (Wessex Archaeology 2013) making a definite conclusion as to the origin difficult. A circular anomaly has been identified in the north-west of the site, and may be evidence of earlier Bronze Age activity; a round barrow or small enclosure. However, this could also be caused by natural features in the dolostone bedrock. It is not possible to accurately determine the nature of the anomalies from the geophysical data alone, and further investigation would be required to provide clarity. Additionally, this archaeological investigation has detected parallel trend anomalies consistent with modern ploughing.					
Project dates		**Start:** 22-03-2017		**End:** 22-03-2017	
Previous work		Not known			
Future work		Not known			
Project Code:	116430	**HER event no.**	N/A	**OASIS form ID:**	wessexar1-282648
		NMR no.	N/A		
		SM no.	N/A		
Planning Application Ref.					
Site Status		None,			
Land use		Cultivated Land 2- Operations to a depth less than 0.25m			
Monument type		N/A	**Period**	N/A	

Project Location:

Site Address	Common Road, Harthill, South Yorkshire			**Postcode**	S26 7ZD
County	Yorkshire	**District**	Rotherham	**Parish**	Harthill with Woodall CP
Study Area	1.9 ha	**Height OD**	136 – 138 m aOD	**NGR**	450578, 380477

Project Creators:

Name of Organisation	Wessex Archaeology		
Project brief originator	ERM	**Project design originator**	Wessex Archaeology
Project Manager	Lucy Learmonth	**Project Supervisor**	
Sponsor or funding body	ERM	**Type of Sponsor**	Developer

Project Archive and Bibliography:

Physical archive	N/A	**Digital Archive**	Geophysics, survey and report	**Paper Archive**	N/A
Report title	Land at Common Road, Harthill, South Yorkshire			**Date**	April 2017
Author	Wessex Archaeology	**Description**	Unpublished report	**Report ref.**	116430.01