NAA

GEOPHYSICAL SURVEY

FIELD 3730

TENDLEY QUARRY

CUMBRIA

prepared for

Tendley Quarries Ltd

NAA 21/2

January 2021

Northern
Archaeological
Associates

01833 690800
info@naaheritage.com
www.naaheritage.com
Marwood House
Harmire Enterprise Park
Barnard Castle
Co. Durham
DL12 8BN

QUALITY ASSURANCE		
Project Number	2021	
Report Number	21-2	
Manager	Alice James	
Edit	Matthew Town and Helen Devonshire	
Authorised	Alice James	
Draft 1		22/01/21

Author Alice James
Illustrations Alice James and Dawn Knowles

Client Tendley Quarry
Location Tendley Quarry, Brigham, Cumbria, CA13 0SE
Planning authority Cumbria
Grid Ref NY 08369 29322
OASIS Ref northern1-413227 (1)
Date of Fieldwork 6th to 8th January 2021

FIELD 3730, TENDLEY QUARRY, CUMBRIA
GEOPHYSICAL SURVEY REPORT

TABLE OF CONTENTS

Disclaimer

The results of geophysical survey may not reveal all potential archaeology and do not provide a comprehensive map of the sub-surface, but only responses relative to the environment. Geological, agricultural and modern responses may mask archaeological features. Short-lived features may not give strong responses. Only clear features have been interpreted and discussed in this report.

FIELD 3730, TENDLEY QUARRY, CUMBRIA
GEOPHYSICAL SURVEY REPORT

Summary

Northern Archaeological Associates (NAA) was commissioned by Tendley Quarries Ltd to undertake a geophysical survey of land to the north-west of the existing workings at Tendley Quarry (Field 3730), Brigham, Cumbria, CA13 0SE, in advance of a proposed quarry extension (NGR: NY 08369 29322). The work was required to assess the archaeological potential of the site and help inform subsequent archaeological mitigation, if needed.

The survey area was located within an agricultural landscape with its occupied origins in at least the medieval period, if not before, and historic maps record mineral exploitation within the post-medieval period, with an abundance of lime kilns to the east and west of Hotchberry Brow. Generally, the archaeological record in the direct vicinity of Tendley Quarry is fairly sparse. Archaeological investigations between 2019 and 2020 in the field directly to the east of the current study area recorded a Bronze Age funerary site. On Tendley Hill, in 2019 a mound was recorded as a possible round barrow, and medieval burials had been discovered there during early 19th-century quarrying. Otherwise, archaeological investigations undertaken as part of former extensions to west and south of Tendley Quarry have revealed very few notable archaeological features.

The geophysical survey targeted approximately 6.5ha of agricultural land and was carried out between 6th and 8th January 2021. The results of the survey identified ridge and furrow and former field boundaries confirming that the site is likely to have been in continual agricultural use since at least the medieval period. One sub-circular anomaly was identified but consisted of weak increases in magnetic value and so it is unknown if it denotes an infilled feature or is geological in nature. Otherwise, anomalies were considered to be modern or geological in origin including several bipolar anomalies likely to relate to ferrous objects in the topsoil, and broad linear anomalies considered to be indicative of buried pedological changes in the substrata.

1.0 INTRODUCTION

1.1 Northern Archaeological Associates (NAA) was commissioned by Tendley Quarries Ltd to undertake a geophysical survey of land to the north-west of the existing workings at Tendley Quarry (Field 3730), Brigham, Cumbria, CA13 0SE, in advance of a proposed quarry extension (NGR: NY 08369 29322). The work was required to assess the archaeological potential of the site and help inform subsequent archaeological mitigation, if required. The geophysical survey targeted approximately 6.5ha of agricultural land and was carried out between 6th and 8th January 2021.

1.2 This report details the setting (location, topography, geology) of Field 3730 and archaeological background of the scheme and gives the methodology used for the geophysical survey. The interpretation of the geophysical survey is achieved through the analysis of identified anomalies and was aided by a rapid examination of supporting information. The results of the geophysical survey are discussed below, and the interpretations are supported by appropriate illustrations. Where feasible, a detailed synopsis of anomalies is provided and, if possible, the features that the anomalies are likely to relate to are suggested.

2.0 LOCATION, GEOLOGY AND TOPOGRAPHY

Location

2.1 The survey areas lay directly to the north-west of Tendley Quarry, which is approximately 1km to the south of Brigham village and 0.75km to the north-east of Eaglesfield. In total, four fields of pasture (totalling c.6.5ha) to the north of the quarry was targeted by geophysical survey (Fig. 2). The site was bounded to the south by an unnamed road leading to the north of the quarry, and bounded to the north by agricultural land.

Geology and soils

2.2 The majority of the solid geology consists of Hensingham Grit sandstone with no recorded superficial deposits. In the south-west and east of the site, the geology is recorded as Carboniferous Limestone overlain by Devensian Diamicton till (BGS 2021). The soils are mapped as being of the Malham 1 Association, consisting primarily of well-drained soils in silty aeolian drift, intermixed in places with bare limestone pavement or crags (Soil Survey of England and Wales 1983; Jarvis *et al*. 1984, 234–5).

Topography

2.3 The natural topography across the site slopes upwards to the north. The highest level is in the north-west of the site and is recorded at 102m above Ordnance Datum (aOD); the south-east of the site forms the lowest section at 97m aOD.

3.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

Previous archaeological investigations

3.1 A number of archaeological works have been carried out by various companies prior to previous quarry extensions at Tendley Quarry:

- Headland Archaeology: a rapid archaeological desk-based assessment (Conolly and Carter 2001) and trial trenching (Dutton 2003);
- West Yorkshire Archaeological Services (WYAS): geophysical surveys (Webb 2003; Gidman and Webb 2007; Watson 2008);
    - Oxford Archaeology North: trial trenching (Lee and Vannan 2008);
    - North Pennines Archaeology: trial trenching (Jackson 2009; Haigh 2011);
    - GSB Prospection: geophysical survey (GSB 2014);
    - Northern Archaeological Associates: trial trenching (NAA 2014); geophysical survey (NAA 2017); trial trenching (NAA 2018a); excavation (NAA 2018b); geophysical survey (NAA 2019); and excavation (NAA 2020).

3.2 No significant archaeological remains were revealed during the surveys undertaken between 2001 and 2014. The geophysical survey undertaken in 2017 in an area at the north-western side of the quarry identified several linear anomalies that could have been indicative of archaeological features. Trial trenching and a subsequent small excavation carried out by NAA recorded small linear gullies and pits containing charcoal, burnt stones and fired clay (NAA 2018b). Artefacts were limited to a whetstone and a probable hammerstone, neither of which were diagnostic. Although these features were undated, the pits were of a character suggestive of prehistoric settlement in the vicinity.

3.3 In 2019, a further prehistoric site was identified in the immediate vicinity of the quarry, during a geophysical survey and subsequent archaeological evaluation, directly to the east of the current proposed development area (PDA). The site, an Early Bronze Age funerary monument, was excavated in January 2020. Excavations

recorded a penannular gully c.25m in diameter with an entrance to the south-east, thought to be the remains of a barrow. The gully enclosed four pits, a posthole, and an inhumation with an associated Early Bronze Age Food Vessel (NAA 2019; NAA 2020).

Historical background

3.4 The route of a Roman road running between Ravenglass and Papcastle is reputed to pass close to Tendley Hill (Margary 1973, 389–95). Historic accounts suggest parts of this road were uncovered during quarrying activity, though no other finds or sites dating to this period have been revealed in the vicinity.

3.5 A cist burial of probable early medieval date was found at Eaglesfield, which is located c.1.5m to the south-east of the PDA (Wilson 1978). Closer to the current site, a number of burials are reported to have been found during quarrying on Tendley Hill, and one discovered in 1814 was accompanied by a 10th-century sword, a 'pike' (possibly a spear) and a brooch (*ibid.*, 48; Edwards 1992, 48). The 1867 Ordnance Survey (OS) map notes 'Human remains have been found here' on Tendley Hill at the eastern side of Hotchberry Brow. There is believed to be some correlation between early medieval burials and historic boundaries, and the presence of the boundary between Dean and Brigham parishes, skirting Tendley Hill, may suggest that it was an early cemetery.

3.6 Little is known about medieval activity in the direct hinterland of the site. Geophysical survey undertaken in numerous fields surrounding the quarry has recorded extensive ridge and furrow. This suggests that the area had been agricultural land in the wider hinterland of Cockermouth since at least the medieval period. Historic maps from the mid-19th century show much of the area surrounding Tendley Quarry forming strip fields and show the changes in land management.

3.7 During the post-medieval period, Tendley Hill was subjected to extensive limestone quarrying. Several quarries and lime kilns are recorded on 19th-century mapping and are shown to have grown in size between the 1867 and 1890 Ordnance Survey maps.

4.0 AIMS AND OBJECTIVES

4.1 The aim of the geophysical survey was to map and record potential buried features located within the PDA. Through detailed analysis of the results of the geophysical survey, NAA aimed to provide a detailed interpretation that assessed the

archaeological potential of the site and will inform future archaeological mitigation strategies.

4.2 The objectives of the survey were to:

- undertake a geophysical survey across areas deemed suitable for data collection;
- attempt to identify and record any sub-surface remains within the survey boundary;
- characterise the nature of identified anomalies and, where possible, suggest the nature of feature to which they potentially relate;
- assess the archaeological significance of identified anomalies;
- identify possible concentrations of past activity in order to inform the requirement for any further archaeological investigation at the site; and
- produce a detailed report that includes illustrated results of the geophysical survey.

5.0 METHODOLOGY

5.1 The geophysical survey was undertaken as a gradiometer survey using the Bartington Grad601-2 dual magnetic gradiometer system with data logger. The readings were recorded at a resolution of 0.01nT, and data was collected with a traverse interval of 1m and a sample interval of 0.25m. All recorded survey data were collected with reference to a site survey grid comprising individual 30m x 30m squares. The grid was established using Real Time Kinematic (RTK) differential GPS equipment and marked out using non-metallic survey markers. All grid nodes were set out with a positional accuracy of at least 0.1m as per existing guidelines (CIfA 2014; Schmidt *et al.* 2015) and could be relocated on the ground by a third party. The base lines used to create the survey grids are shown on Figure 2 and further details are available in Appendix A.

5.2 The processing was undertaken using Geoplot 3.0 software and consisted of standard processing procedures. Details of processing steps applied to collected data are given in Appendix B.

5.3 On the greyscale plot (Fig. 3 and Fig. 4), positive readings are shown as increasingly darker areas and negative readings are shown as increasingly lighter areas.

5.4 Interpretation of identified anomalies is generally achieved through analysis of anomaly patterning and increases in magnetic response, and is often aided through examining supporting information (including but not limited to historic maps, LiDAR survey data, aerial photographs, as well as geophysical survey data and excavation

results in the direct hinterland of the scheme). The interpreted data uses colour coding to highlight specific readings in the survey area (see Fig. 5).

Surface conditions and other mitigating factors

5.5 At the time of the survey, the site contained sheep, and the ground was obscured by snow. Ground conditions were variable, with several areas containing deep hoofprints resulting in uneven footing and discrete areas not being suitable for survey. Field boundaries comprised hedgerows and metal fencing, and there were occasional areas of high vegetation along field edges.

5.6 Due to poor ground conditions, it was not possible to survey a grid in Area 4.

5.7 Attempts were made to avoid areas affected by above-ground features that were likely to have a high magnetic susceptibility, such as metal fencing, to minimise the potential for their magnetic responses to impinge on the survey results and mask potential buried features.

6.0 GEOPHYSICAL SURVEY RESULTS

6.1 Several of the field boundaries present on the 1867 Ordnance Survey map appear in the geophysical survey results in Areas 1, 3 and 4. A tentative interpretation has been applied where isolated linear anomalies associated with field boundaries are composed of very weak increases in magnetic value in Area 1.

6.2 A sub-circular anomaly was identified in Area 4 (Fig. 5 **A**). It is unclear if this anomaly denotes an infilled feature or is caused by geological or pedological changes in the substrata.

6.3 A weak and diffuse trend was identified in Area 3 (Fig. 5 **B**). B appears to be the continuation of a field boundary and stream directly to the east of the survey area and so is likely to denote an infilled stream or boundary ditch.

6.4 Broadly spaced ridge and furrow occurs on an east–west orientation in Areas 2, 3 and 4. Several diffuse linear anomalies composed of weak increases in magnetic response were identified. Although tentative, it is plausible that these anomalies relate to modern farming practices.

6.5 Dipolar anomalies are generally likely to relate to ferrous or modern objects buried in the topsoil. Consequently, these anomalies are largely considered to be of a modern nature and so have not been depicted on interpretation plots.

6.6 Several isolated bipolar responses have been identified which are likely to be caused by highly magnetic material, such as ferrous objects in the topsoil of the site.

6.7 Areas of increased magnetic response have been used to highlight concentrations of dipolar anomalies. Generally, these are considered likely to be caused by modern magnetic debris in the topsoil or near the surface of the site.

6.8 Several responses have been identified in Area 1 and 2 that have a relatively broad form and correspond with the natural topography within the PDA. Although tentative, it is plausible that these anomalies relate to pedological changes within the substrata.

7.0 CONCLUSIONS

7.1 NAA was commissioned to undertake a geophysical (gradiometer survey) to the north-west of the current workings at Tendley Quarry to assess the archaeological potential of four fields in advance of an extension of the quarry.

7.2 Ridge and furrow is clearly visible in the east of the survey area suggesting that the PDA was agricultural land since at least the medieval period. Several linear anomlies correspond with the location of field boundaries present on 19th-century historic maps, and a trend identified in the survey could plausibly be indicative of an infilled stream.

7.3 A sub-circular anomaly was identified in the east of the survey area that lacked the required increase in magnetic value and patterning for conclusive interpretation. Consequently, it is unknown if this anomaly denotes an infilled feature or is present as a result of geological, or pedological changes in the substrata.

7.4 The remainder of the results of the survey were largely considered to be of a modern or geological nature.

8.0 STORAGE AND CURATION

8.1 The records of the geophysical survey are currently held by NAA. All material will be appropriately packaged for long-term storage in accordance with national guidelines (CIfA 2014; Schmidt *et al*. 2015). An online OASIS form will be completed within

three months of the completion of the project. This will include submission of a PDF version of the final report to the Archaeology Data Service via the OASIS form.

REFERENCES

Aspinal, A., Gaffney., C. and Schmidt, A. (2008) *Magnetometry for Archaeologists*. Plymouth: Altamira Press.

Bartington Instruments Ltd (n.d.) *Grad601 Single Axis Magnetic Field Gradiometer system*. Oxford: Bartington Instruments Ltd.

Bewley, R. H. (1994) *Prehistoric and Romano-British Settlement in the Solway Plain, Cumbria*. Oxbow Monograph 36. Oxford: Oxbow Books.

Bradbury, J. B. (1996) *Bradbury's History of Cockermouth*. Cockermouth: R. Byers.

British Geological Survey (BGS) (2021) Geology of Britain Viewer. [Online] Available at: https://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html (accessed on 13/01/2021).

Chartered Institute for Archaeology (CIfA) (2014) *Standard and Guidance for Archaeological Geophysical Survey*. Reading: Chartered Institute for Archaeologists.

Conolly, R. and Carter, S. (2001) *Tendley Quarry, Brigham, Cumbria: An Archaeological Assessment of a Proposed Extension to the Quarry*. Unpublished Headland Archaeology Ltd report.

Dutton, A. (2003) *Archaeological Evaluation at Tendley Quarry, Cockermouth, Cumbria*. Unpublished Headland Archaeology Ltd report.

Edwards, B. J. N. (1992) 'The Vikings in North West England: the archaeological evidence,' in Graham-Campbell, J. (ed.) *Viking Treasure from the North West. The Cuerdale Hoard in Context*. National Museums and Galleries on Merseyside Occasional Paper 5, 43–62.

Gaffney, C. and Gater, J. (2003) *Revealing the Buried Past*. Stroud: Tempus Publishing.

Gidman, J. and Webb, A. (2007) *North-Western Extension to Tendley Quarry, Brigham, Cumbria*. Unpublished Archaeological Services WYAS Report 1725.

GSB Prospection (GSB) (2014) *Tendley Quarry, Brigham, Cumbria: Geophysical Survey Report*. Unpublished GSB Prospection report.

Haigh, M. (2011) *Tendley Quarry, Brigham, Cumbria: Archaeological Evaluation Report*. Unpublished Northern Pennines Archaeology Report 1504/11.

Jackson, D. (2009) *Report on an Archaeological Field Evaluation at Tendley Quarry, Brigham, Cumbria*. Unpublished North Pennines Archaeology Ltd Report 877/09.

Jarvis, R. A., Bendelow, V. C., Bradley, R. I., Carroll, D. M., Furness, R. R., Kilgour, I. N. L. and King, S. J. (1984) *Soils and their use in Northern England*. Soil Survey of England and Wales Bulletin No. 10. Harpenden: Rothamsted Experimental Station.

Lee, R. and Vannan, A. (2008) *Tendley Quarry Extension, Brigham, Cockermouth, Cumbria: Archaeological Evaluation*. Unpublished Oxford Archaeology North Report 2007–8/798.

Margary, I. D. (1973) *Roman Roads in Britain*. London: John Baker.

NAA (2014) *Tendley Quarry, Brigham, Cumbria: Evaluation Report*. Unpublished Northern Archaeological Associates Ltd Report No. 14/86.

NAA (2017) *Tendley Quarry, Brigham, Cumbria: Geophysical Survey Report*. Unpublished Northern Archaeological Associates Ltd Report 17/31.

NAA (2018a) *Tendley Quarry, Brigham, Cumbria: Archaeological Evaluation*. Unpublished Northern Archaeological Associates Ltd Report No. 18/36.

NAA (2018b) *Tendley Quarry, Brigham, Cumbria: Archaeological Excavation Report*. Unpublished Northern Archaeological Associates Ltd Report No. 18/71.

NAA (2019) *Land to the North of Tendley Quarry, Cumbria: Geophysical Survey*. Unpublished Northern Archaeological Associates Ltd Report No. 19/107.

NAA (2020) *Land to the North of Tendley Quarry, Cumbria: Post-Excavation Assessment Report*. Unpublished Northern Archaeological Associates Ltd Report No. 20/112.

National Library of Scotland (2020) Explore Georeferenced Maps. [Online] Available at: https://maps.nls.uk/view/102340848 (accessed on 13/01/2021).

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J. (2015) *EAC Guidelines for the Use of Geophysics in Archaeology*. EAC Guidelines 2. Belgium: Europae Archaeologiae Consilium.

Soil Survey of England and Wales (1983) *Soils of England and Wales 1:250 000 Map Sheet 1: Northern England*. Southampton: Ordnance Survey.

Watson, E. (2008) *Proposed Southern Extension to Tendley Quarry, Brigham, Cumbria*. Unpublished Archaeological Services WYAS Report 1851.

Webb, A. (2003) *Land at Tendley Quarry, near Cockermouth, Cumbria*. Unpublished Archaeological Services WYAS Report 1119.

Wilson, P. A. (1978) Eaglesfield: the name, the place, the burials. *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* **78**, 47–54.

Cartographic sources

Ordnance Survey (1867) Six-inch Cumberland Sheet LIV (Surveyed 1864).

Ordnance Survey (1900) Cumberland LIV.NW (includes: Brigham; Broughton; Broughton Moor; Camerton; Great Clifton; Greysouthen; Little Clifton. (Revised 1898 to 1899).

APPENDIX A
TECHNICAL INFORMATION

GRADIOMETER SURVEY

Magnetic surveys measure distortions in the earth's magnetic field caused by small magnetic fields associated with buried features (Gaffney and Gater 2003, 36) that have either remnant or induced magnetic properties (Aspinal *et al*. 2008, 21–26). Human activity and inhabitation often alter the magnetic properties of materials (Aspinal *et al*. 2008, 21) resulting in the ability for numerous archaeological features to be detected through magnetic surveys. Intensive burning or heating can result in materials attaining a thermoremanent magnetisation; examples of which include kilns, ovens, hearths and brick structures (*ibid*., 27; Gaffney and Gater 2003, 37). When topsoil that is rich with iron oxides fills a man-made depression in the subsoil, it creates an infilled feature, such as a pit or ditch, with a higher magnetic susceptibility compared to the surrounding soil (Aspinal *et al*. 2008, 37–41; Gaffney and Gater 2003, 22–26). Magnetic surveys can also detect features with a lower magnetically susceptibility than the surrounding soil, an example of which is a stone wall.

LIMITATIONS

Poor results can be due to several factors including short-lived archaeological occupation/use or sites with minimal cut or built features. Results can also be limited in areas with soils that are naturally deficient in iron compounds or in areas with soils overlying naturally magnetic geology, which will produce strong responses masking archaeological features.

Overlying layers, such as demolition rubble or layers of made ground, can hide any earlier archaeological features. The presence of above-ground structures and underground services containing ferrous material can distort or mask nearby features.

Particularly uneven or steep ground can increase the processing required, or distort results beyond the capabilities of processing. It is also possible in areas containing dramatic topographical changes that natural weathering, such as hillwash, often in combination with intensive modern ploughing, will reduced the topsoil on slopes and towards the peaks of hills, and possibly destroy or truncate potential archaeological features. Conversely, features at the bottom of slopes may be covered by a greater layer of topsoil and so if buried features are present, they appear faint within the results, if at all.

Over processing of data can also obscure or remove features, especially if they are on the same orientation as the direction of data collection. Consequently, where possible, attempts are made to ensure data is not collected on the same orientation as known potential features and that data quality is sufficient to minimise the required data processing.

INSTRUMENTATION

The data was collected using handheld Bartington Grad 601-2 fluxgate gradiometers. The Bartington 601-2 is a single-axis, vertical component fluxgate gradiometer comprising a data logger battery cassette and two sensors. The sensors are Grad-01-1000L cylindrical gradiometer sensors mounted on a rigid carrying frame; each sensor contains two fluxgate magnetometers with 1m vertical separation.

The difference in the magnetic field between the two fluxgates in each sensor is measured in nanoTesla (nT). NAA gradiometer data is recorded with a range of ±100nT, which equates to a resolution of 0.01nT. It should be noted that the actual resolution is limited to 0.03nT as a consequence of internal instrumental noise (Bartington Instruments n.d., 23).

The gradiometer records two lines of data on each traverse, the grids are walked in a zigzag pattern amounting to 15 traverses. The gradiometers are calibrated at the start of every day and recalibrated whenever necessary.

SURVEY DETAILS

Table A1: survey summary.

Item	Survey
Grid size	30m x 30m
Traverse interval	1m
Reading interval	0.25m
Direction of 1st traverse	N
Number of grids	120
Area covered	6.5ha

Table A2: baseline co-ordinates.

Item	Survey
gpA	308253.8612 529416.1169
gpB	308283.8612 529416.1169

Table A3: site information and conditions.

Item	Detail
Geology	Hensingham Grit sandstone and Carboniferous Limestone
Superficial deposits	Devensian Till
Soils	Malham 1 Association
Topography	Highest: 102m aOD Lowest: 97m aOD
Land use	Agricultural - pasture
Weather conditions prior to and during survey	Overcast – snow showers

APPENDIX B

DATA PROCESSING INFORMATION

Gradiometer survey data is downloaded using the Bartington Grad 601 software and the processing was undertaken using Geoplot 3.0 software.

Table B1: commonly applied techniques.

Process	Effect
Zero mean traverse	Removes stripping that can occur as a consequence of using multisensor arrays or a 'zigzag' data collection method by setting the mean reading for each traverse to zero.
Destagger	Removes stagger in the data introduced through inconsistent data collection pace and often exacerbated through the 'zigzag' methodology.
Clip	Clips data above or below a set value to enhance potential weaker anomalies.
Despike	Removes random spikes or high readings to reduce the appearance of dominant readings, often created by modern ferrous objects that can distort the results.
Low pass filter	Removes low-frequency waves or broad anomalies such as those caused by strong or large gradual variations in the soil's magnetic susceptibility often caused by geological or natural changes in the substrata.
Interpolation	Used to smooth or reduce the blocky appearance of data by improving the spatial density and increase the quantity of data points in the Y direction.

Table B2: processing steps.

Minimal Processing	Increased Processing
• Zero mean traverse • Destagger: *Area 1* - All grids: 2 - 32: -2 *Area 2* - All grids: 2 - 16: 1 *Area 3* - All grids: 2 *Area 4* - All grids: 2 - 19: -1 - 25 and 28: 1	• Low Pass Filter • Interpolate Y, Expand - Linear, x2

APPENDIX C

DATA VISUALISATION INFORMATION

FIGURES

The data were used to produce a series of images to demonstrate the results of surveys, which are detailed below:

- Greyscale/Colourscale Plot – This visualised the results as a shaded drawing with highest readings showing as black, running through different shades to lowest showing as white.
- XY-trace Plot – This creates a line drawing showing the peaks and troughs of the readings as vertical offset from a centreline.
- Interpreted Plot – Through detailed analysis, anomalies have been interpreted and possible features identified. Interpretation drawings are used to show potential features and in particular to reinforce and clarify the written interpretation of the data. Anomalies have been characterised using the terminology detailed in the following section, and have been assigned colour coding outlined in keys found on the relevant figures associated with this report.

MAGNETIC ANOMALIES AND TERMINOLOGY

Table C1: lexicon of terminology.

Terminology	Description
Anomaly	Any outstanding high or low readings forming a particular shape or covering a specific area within the survey results.
Feature	A man-made or naturally created object or material that has been detected through investigation works and has sufficient characteristics or supporting evidence for positive identification.
Magnetic susceptibility	The ability of a buried feature to be magnetically induced when a magnetic field is applied.
Magnetic response	The strength of the changes in magnetic values caused by a buried feature with either a greater or lesser ability to be magnetised compared with the soil around it. Anomalies are considered to have either strong/weak or positive/negative responses. The strength of magnetic response (along with patterning) can be essential in determining the nature of an anomaly, but it should be noted that the size or strength of the magnetic response does not correlate with the size of the buried feature.
Patterning of an anomaly	The shape or form of an individual anomaly.
Thermoremanence	The affect caused when a material has been magnetically altered through a process of heating. Thermoremanent magnetisation occurs when an object or material is heated passed the Curie Point and acquires a permanent magnetisation that is associated with the magnetic field that they cooled within (Gaffney and Gater 2003, 37).

Different anomalies can represent different features created by human, agricultural or modern activity, or natural pedological or geological changes in the substrata.

Anomalies interpreted with a 'greater' categorisation are considered more likely to be of the interpreted characterisation; whereas a more tentative interpretation is applied to those with a 'lesser' categorisation as a consequence of weaker increases in magnetic response or the anomaly's incomplete patterning or irregular form.

The strength and size of anomalies can vary depending on the magnetic properties of the feature, the magnetic susceptibility of the soil, the depth to which the feature is buried, and the state of preservation.

Table C2: characterisation of anomalies.

Characterisation	Description
Archaeology	
Bipolar anomaly (quarrying)	Anomalies often composed of a bipolar response that is indicative of quarrying.
Positive anomaly (unknown origin)	Linear anomalies with a positive or negative magnetic response, and composed of a patterning or shape that could be suggestive of a buried infilled feature, but lacks the strength or patterning to be conclusively interpreted.
Agriculture	
Field boundary	Isolated linear anomalies that are likely to be indicative of former land divisions. A more conclusive interpretation is given to linear anomalies that correspond with the location of field boundaries recorded on historic maps, aerial photos or LiDAR coverage of the site.
Ridge and furrow	Broadly spaced linear anomalies that are likely to be indicative of earlier forms of agriculture, such as ridge and furrow. These often correspond with the location of earthworks visible on the ground or identified on aerial photos or LiDAR survey coverage.
Agriculture?	Weak, irregularly spaced or isolated linear anomalies that relate to agricultural activity, but the agricultural process they are caused by is unknown.
Modern	
Bipolar response (modern)	Positive anomalies with associated negative 'halo' (bipolar) denote features with a strong magnetic response that are likely to be of a modern origin. Isolated bipolar responses of a modern nature are likely to relate to buried ferrous material or objects, such as metallic agricultural debris. If a trend is noted in the alignment or spacing of isolated bipolar responses, it is possible that they are indicative of ferrous fittings or connectors used on non-magnetic buried utilities. Linear bipolar anomalies are likely to be indicative of modern services.
Dipolar response	Dipolar anomalies relate to individual spikes within the data and tend to be caused by ferrous objects. These responses have been shown only when located near to archaeological features. When the site is located in a mining landscape it is possible that identified dipolar anomalies relate to mining activity and are indicative of further pits or mine shafts.
Area of increased magnetic response	Areas of increased magnetic response denote areas of disturbance containing a high concentration of dipolar and/or bipolar responses. These are generally considered to be caused by modern debris in the topsoil,

Characterisation	Description
	although it is possible that the disturbance is in part also caused by isolated archaeological material or geological or pedological changes in the substrata.

APPENDIX D

OASIS FORM

OASIS DATA COLLECTION FORM: England

OASIS ID: northern1-413227

Project details

Project name	Field 3730, Tendley Quarry, Cumbria
Short description of the project	Geophysical Survey
Project dates	Start: 06-01-2021 End: 08-01-2021
Previous/future work	Yes / Not known
Type of project	Field evaluation
Site status	None
Current Land use	Grassland Heathland 4 - Regularly improved
Monument type	NONE None
Significant Finds	NONE None
Methods & techniques	"Geophysical Survey"
Development type	Mineral extraction (e.g. sand, gravel, stone, coal, ore, etc.)
Prompt	Direction from Local Planning Authority - PPS
Prompt	Pre-planning scoping
Position in the planning process	Pre-application
Solid geology (other)	Hensingham Grit sandstone and Carboniferous Limestone
Drift geology (other)	Devensian Till
Techniques	Magnetometry

Project location

Country	England
Site location	CUMBRIA ALLERDALE BRIGHAM Field 3730, Tendley Quarry, Cumbria
Postcode	CA13 0SE
Study area	6.5 Hectares
Site coordinates	NY 08369 29322 54.650543467615 -3.420308462663 54 39 01 N 003 25 13 W Point
Height OD / Depth	Min: 97m Max: 102m

Project creators

Name of Organisation	Northern Archaeological Associates
Project brief originator	Tendley Quarries Ltd
Project design originator	Northern Archaeological Associates
Project director/manager	Alice James
Project supervisor	Aidan Pratt

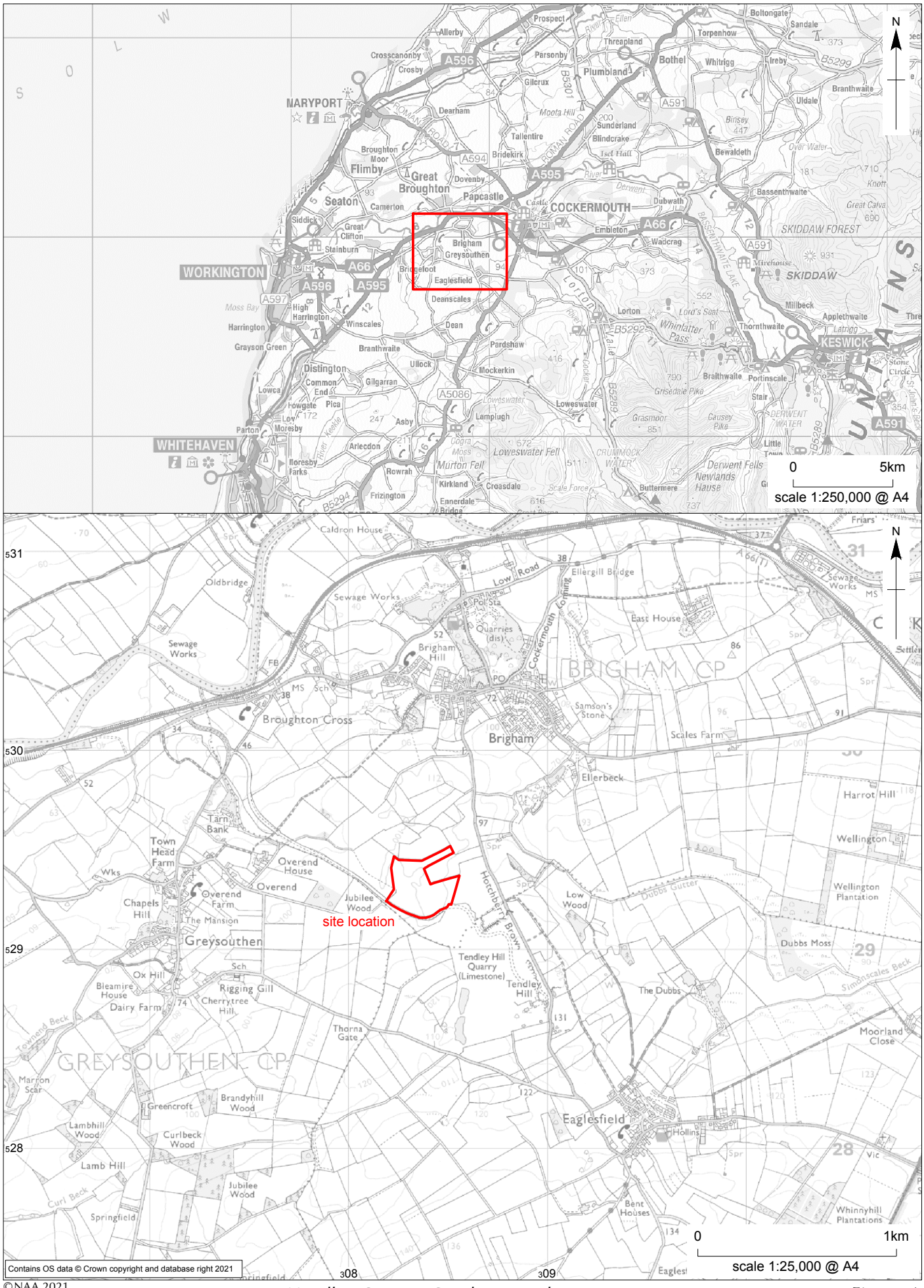
Project archives

Physical Archive Exists?	No
Digital Archive recipient	Northern Archaeological Associates
Digital Contents	"none"
Digital Media available	"Geophysics"
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Field 3730, Tendley Quarry, Cumbria: Geophysical Survey
Author(s)/Editor(s)	James, A
Other bibliographic details	21-2
Date	2021
Issuer or publisher	NAA
Place of issue or publication	Barnard Castle
Description	Blue Spine

Entered by	Alice (aj@naaheritage.com)
Entered on	22 January 2021



Tendley Quarry, Cumbria: site location *Figure 1*

NAA
HERITAGE & ARCHAEOLOGY

KEY
geophysical survey baseline
geophysical survey grid
geophysical survey area
proposed development area

N

0 100 m
scale 1:2000 @ A3

Area 1
Area 2
Area 3
Area 4
gpA
gpB
Issues
90.9m
94.2m
BM 102.70m
Lime Kiln (Dis)

Field 3730, Tendley Quarry, Cumbria: geophysical survey areas

Figure 2

NAA
HERITAGE & ARCHAEOLOGY

0 100 m
scale 1:2000 @ A3

N

5nT
-4nT
Pallette:grey55.ptt

Area 1
Area 2
Area 3
Area 4

Issues
94.2m
90.9m
94.2m
BM 102.70m
Lime Kiln
(Dis)

Field 3730, Tendley Quarry, Cumbria: unprocessed greyscale plot of gradiometer survey results

Figure 3

NAA
HERITAGE & ARCHAEOLOGY

0 100 m
scale 1:2000 @ A3

N

4nT
-3nT
Pallette:grey55.ptt

Area 1
Area 2
Area 3
Area 4

Issues
94.2m
90.9m
94.2m
BM 102.70m
Lime Kiln
(Dis)

Field 3730, Tendley Quarry, Cumbria: processed greyscale plot of gradiometer survey results

Figure 4

NAA
HERITAGE & ARCHAEOLOGY

KEY

- positive anomaly (unknown origin)
- field boundary
- field boundary?
- ridge and furrow
- agriculture?
- bipolar response (modern)
- area of increased magnetic response
- area of disturbance (geology?)
- edge of geophysical survey
- proposed development area

0 100 m

scale 1:2000 @ A3

N

Area 1

Area 2

Area 3

Area 4

A

B

Issues

HEFCHBERRY ROAD

90.9m

94.2m

BM 102.70m

Lime Kiln (Dis)

Field 3730, Tendley Quarry, Cumbria: interpretation of gradiometer survey results

Figure 5