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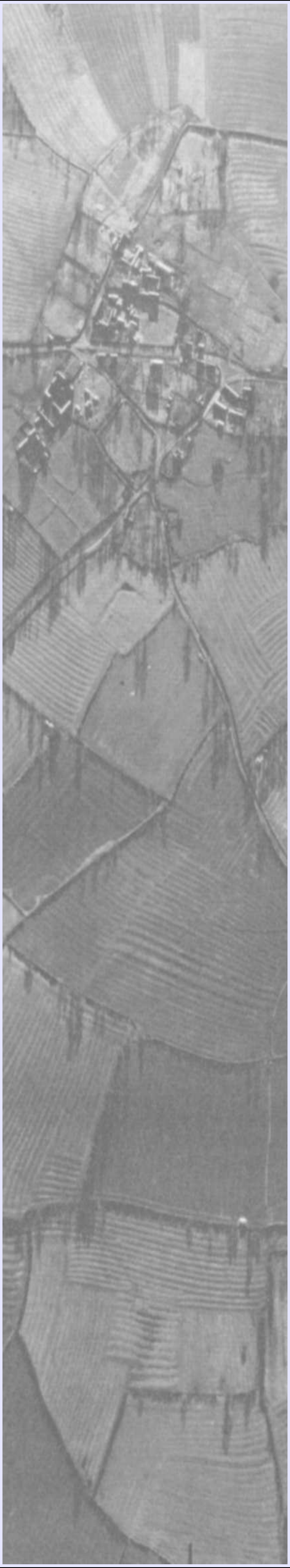

Castle Pulverbatch
Motte and Bailey
Shropshire

EARTH RESISTANCE & MAGNETOMETER SURVEY REPORT

for

Stiperstones and Corndon Hill Country Landscape Partnership Scheme

Kerry Donaldson & David Sabin

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ARCHAEOLOGICAL SURVEYS LTD

Castle Pulverbatch
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Earth Resistance & Magnetometer Survey Report

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Fieldwork by David Sabin & Kerry Donaldson
Report by Kerry Donaldson BSc (Hons) and David Sabin BSc (Hons) MCIfA

Survey date – 1st April 2017
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SUMMARY

A geophysical survey, comprising earth resistance measurement (resistivity) and magnetometry, was carried out at Castle Pulverbatch Motte and Bailey in Shropshire by Archaeological Surveys Ltd. The work was undertaken for the Stiperstones and Corndon Hill Country Landscape Partnership Scheme with funding from the Castle Studies Trust in order to support the understanding of the character and extent of the archaeological features within the site. The survey was carried out over all accessible areas within the inner and outer baileys under a Section 42 licence from Historic England. The results of the earth resistance survey reveal a number of high resistance responses within the inner bailey that appear consistent with features of archaeological potential. These include a number of high resistance linear, rectilinear and a curvilinear response that may relate to structural remains. The magnetometer survey revealed a broad, ditch-like feature along the eastern side of the inner bailey, with discrete positive responses possibly indicating pit-like features or an association with burning. One discrete anomaly corresponds with the interior of the high resistance curvilinear response and together they may indicate a circular structure, such as a well. Within the outer bailey there are a large number of high resistance linear, rectilinear, discrete and amorphous anomalies, with the general trend parallel with the responses located within the inner bailey and also the bailey banks and ditches. The morphology of the high resistance anomalies is not well defined, but it is also possible that these relate to features with archaeological potential. The magnetometer results show a number of broad, parallel, positive and negative anomalies, some of which correspond to high resistance anomalies. It is possible that some relate to internal trackways extending northwards from an entrance within the southern bank.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by the Stiperstones and Corndon Hill Country Landscape Partnership Scheme to undertake a resistivity and magnetometry survey of Castle Pulverbatch Motte and Bailey in Shropshire. The Stiperstones and Corndon Hill Country Landscape Partnership Scheme have applied to the Castle Studies Trust for funding the geophysical survey. The work is being carried out in support of the 'Helping Hillforts and Earthwork Castles' strand of the Stiperstones and Corndon Hill Country Landscape Partnership Scheme.

1.1.2 The site is a Scheduled Monument: *Castle Pulverbatch motte and bailey castle with outer bailey 100m NNW of Brook Cottage* (List Entry No. 1012860). In order to carry out the geophysical survey within the scheduled area, a licence, under Section 42 of the 1979 Ancient Monuments and Archaeological Areas Act (as amended by the National Heritage Act 1983), was issued by Alison MacDonald, Assistant Inspector of Ancient Monuments for Historic England, prior to commencing the fieldwork. The survey was carried out by lead surveyor David Sabin and Kerry Donaldson from Archaeological Surveys Ltd, with support from Giles Carey from the Shropshire Historic Environment Team.

1.1.3 The geophysical survey aims to provide information in order to better understand the character and extent of the archaeological features within the site. Recent vegetation clearance by The Friends of Castle Pulverbatch, under a Section 17 management agreement licence from Historic England, has opened up areas of the motte and bailey castle making it more accessible for the geophysical survey. The coverage within the scheduled area was approximately 0.3ha in total (see Fig 1).

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use earth resistance survey (resistivity) and magnetometry to meet the aims set out above. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 *The survey and report generally follow the recommendations set out by: English Heritage (2008) Geophysical survey in archaeological field evaluation;* European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site lies within the parish of Church Pulverbatch approximately 13km south west of Shrewsbury. The motte and bailey site is located at the south western end of Castle Pulverbatch village. It is centred on Ordnance Survey National Grid Reference (OS NGR) SJ 42237 02202 see Figs 01 and 02.

1.3.2 The site is defined by well preserved earthworks that include banks, ditches and a motte. The earthworks represent an inner bailey to the north east of the motte with an outer bailey forming the western side of the site. It is situated on a knoll of high ground with extensive views over lower ground to the north east and east.

1.3.3 The geophysical survey covers approximately 0.3ha within the accessible areas of the outer and inner baileys. The motte itself was not surveyed using the earth resistance meter as the only safely accessible zone on the summit consists of compacted stone and gravel that could not be penetrated adequately by the instrument probes; however, the summit was surveyed with the magnetometer.

1.3.4 Ground cover consisted mainly of short grass although a small car park is located in the north western part of the site and this had been recently made up with grit and gravel. A few small thorn bushes are located within the site with some tree stumps and evidence of recent clearance around the periphery. There is a bench within the inner bailey.

1.3.5 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry and resistivity data. However, resistivity was not possible on the summit of the motte or the car park due to the compacted nature of the surface and presence of stone or gravel. Weather conditions during the survey were variable and generally overcast with periods of rain in the early part of the day and later in the afternoon. The weather conditions were considered unlikely to have influenced the survey results.

Plate 1: Motte and outer bailey looking south

1.4 Site history and archaeological potential

1.4.1 A desk-based study has been compiled for the site, as well as three others, under the Heritage Lottery Funded Stiperstones and Corndon Hill Country Landscape Partnership Scheme (Hannaford & Silvester, 2015). Castle Pulverbatch is recognised as being one of the finest examples of a motte and bailey castle in Shropshire. The first documented mention of the castle is in 1153, although it may have been constructed before by Roger Venator who held the manor in 1086. It was deserted by 1202 with no further evidence for development or use after that date. The motte has a diameter at the base of 35m and is up to 8m high, and it is possible that a timber tower may have stood on the motte. There are local traditions of stonework surviving on the summit, but although there are no traces today on the motte or elsewhere within the site, there is, however, potential for such buried structural remains to exist.

1.4.2 During the course of the survey observations of soil within the ditch between the motte and inner bailey suggested that there may have been some dumping within the 19th and early 20th centuries. A slight holloway or track was noted at the southern end of the site. Hollows within the earthworks along the southern side of the inner bailey are purported to relate to military activity in WWII (Giles Carey pers. comm.).

1.5 Geology and soils

1.5.1 The underlying geology is interbedded siltstone and limestone from the Pre-Cambrian Bridges Formation, formed into river terrace deposits approximately 542 to 635 million years ago in the Ediacaran Period (BGS, 2017).

1.5.2 The overlying soil across the survey area is from the Withnell 2 association and is a typical brown podzolic soil. It consists of a well drained, loamy soil over rock (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced variable results as at times it can be difficult to distinguish natural features within the shallow geology from those with an anthropogenic origin. The underlying geology and soils are, however, considered acceptable for magnetic survey. Resistivity may respond to natural variations in the depth of soil and make-up of the solid geology.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response. Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance.

2.1.2 The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m.

2.1.3 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.4 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.5 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.6 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The earth resistance survey was carried out using Geoscan Research Ltd RM85 resistance meter using a mobile parallel twin probe array with a 0.5m electrode separation. Data were recorded at 0.5m intervals along traverses separated by 0.5m within 10m grids with a zig-zag progression. The instrument was set to filter stray earth currents which can cause errors within the resistance measurements.

2.2.2 The earth resistance survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GPS. The GPS is used in conjunction with Leica's SmartNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.2.3 It was considered prudent to use a small 10m grid for the resistivity in order to maintain good positional control as the site contains many undulations associated with the earthworks. However, this greatly increased the setting out and survey time compared to larger grids. The magnetometry survey was carried out to supplement the resistivity and time constraints and poor weather conditions resulted in a modification to the methodology, and the magnetometer survey was carried out at 0.5m traverses rather than at 0.25m as stated in the WSI. It should be noted that standard archaeological prospection in the UK uses a 1m traverse separation.

2.2.4 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20 Hz. The gradiometers have a range of recording data between 0.1nT and

10,000nT. It is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

2.2.5 Data are collected along a series of parallel survey transects wherever possible. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses.

2.3 Data processing and presentation

2.3.1 Data logged by the resistance meter are downloaded and processed within Geoplot and TerraSurveyor software respectively. Raw data are analysed and displayed within the report as well as processed data. The following processing has been carried out on data in this survey:

- raw earth resistance data are shown with absolute readings of between -9Ω and 204.7Ω for Area 1 but for display have been clipped at 3SD for Area 2 showing data effectively at between 47Ω and 204.7Ω ,

- processed data have been clipped at 2SD resulting in 28Ω and 183.44Ω for Area 1 75.91Ω and 190.04Ω for Area 2 to enhance any possible archaeological anomalies.

2.3.2 Additional processing including despike and high/low pass filtering was tested but not considered informative. Minimum processing is a requirement of Historic England guidelines.

2.3.3 Graphic raster images in Tagged Image Format (.TIF) are initially prepared in TerraSurveyor for the display of the resistivity data. Regardless of survey orientation, data captured along each traverse are displayed and processed by TerraSurveyor from left to right. Prior to displaying against base mapping, raster graphics require a rotation of 90° anticlock wise to restore north to the top of the image upon insertion into CAD.

2.3.4 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. The software effectively allocates a geographic position for each data point and can compensate for fixed offsets present within the FGM650 sensors. The offsets are positive or negative values present on all fluxgate gradiometer sensors. Some systems use manual or electronic balancing to effectively zero the sensors; however, this is a short term measure that is prone to drift through temperature changes and vibration and can easily be incorrectly set due to localised magnetic fields. The FGM650 sensors are very accurately aligned to the vertical magnetic gradient and are highly stable showing negligible drift on long traverses. The offset values are removed using TerraSurveyor software.

2.3.5 Magnetometer survey tracks are analysed and georeferenced raw data (UTM

Z30N) are then exported in ASCII format for further analysis and display within TerraSurveyor. The removal of offset values (compensation) of the sensors is also carried out in TerraSurveyor using a zero median traverse function. Data are then considered to be minimally processed. Note: without the zero median traverse function it is not possible to create a meaningful data plot as all sensors have a different offset value. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.6 The minimally processed magnetometer data are collected between limits of ±10000nT and clipped for display at ±15nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track.

2.3.7 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on processing.

2.3.8 A greyscale image of the magnetometer data as a TIF file was produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot. With regard to the Sensys MXPDA, minimally processed data are considered by the manufacturer to be data that are compensated by SENSYS MAGNETO DLMGPS software, see 2.3.1 and 2.3.2. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to very high density of data collection.

2.3.9 The raster images are combined with base mapping using ProgeCAD Professional 2016, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.10 The geophysical data are also represented as greyscale images and abstracted anomalies overlain on a 3D surface model with digital aerial photography captured by Adam Stanford of Aerial Cam. The surface model was derived from Environment Agency LiDAR data interpolated and processed using Surfer software. Both geophysical and airphoto data are georeferenced allowing the production of accurate overlays that can be interrogated by the software and used to produced oblique views of the site.

2.3.11 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.12 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.13 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results - resistivity

3.1.1 The earth resistance survey was carried out over approximately 0.3ha within two survey areas. Area 1 is within the outer bailey and Area 2 within the inner bailey.

3.1.2 Resistance anomalies located can be generally classified as high and low resistance anomalies of archaeological origin, high and low resistance anomalies of uncertain origin and low resistance linear anomalies of a modern origin. Anomalies located within each survey area have been numbered and will be outlined in 3.4 below with subsequent discussion in Section 4.

3.2 Statement of data quality and other factors influencing the results - resistivity

3.2.1 Data are considered representative of the resistive anomalies present within the site. There are no significant defects within the dataset.

3.2.2 Generally the data demonstrate useful resistive contrast and numerous high and low resistance anomalies are present. The data spread are wide ranging demonstrating significant variability in the soil resistance across the site. It is possible that recent use of the site has produced anomalies in places.

3.3 Data interpretation - resistivity

3.3.1 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the earth resistance survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics within the survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with archaeological potential AS-ABST RES HIGH LINEAR ARCHAEOLOGY AS-ABST RES HIGH AREA ARCHAEOLOGY BANK AS-ABST RES LOW AREA ARCHAEOLOGY DITCH AS-ABST RES LOW AREA ARCHAEOLOGY BANK	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as enclosures, structures, ring ditches, etc.. High resistance may indicate structural material (e.g. stone); low resistance may relate to the moisture retentive fill of cut features.
Anomalies with an uncertain origin AS-ABST RES HIGH LINEAR UNCERTAIN AS-ABST RES HIGH AREA UNCERTAIN AS-ABST RES LOW AREA UNCERTAIN AS-ABST RES HIGH DISCRETE UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. High resistance anomalies are indicative of comparatively low moisture and may indicate stone, compacted soil, changes in drainage, etc. Low resistance anomalies are indicative of comparatively high moisture and may relate to the fill of cut features, organic material within the soil, damp areas etc..
Anomalies with a modern origin AS-ABST LOW RES PATH	Anomalies relating to existing paths and tracks can be high or low resistance anomalies and relate to visible or mapped paths.

Table 1: List and description of resistivity interpretation categories

3.4 List of anomalies – resistivity

Area centred on OS NGR 342237 302202, see Figs 03 - 05.

Anomalies of archaeological potential

(1) - Within the inner bailey (Area 2) are a number of high resistance linear responses. They are parallel with the bailey banks to the north and west and are likely to relate to structural remains. A curvilinear high resistance response can also be seen, and this type of anomaly could indicate a circular structure, possibly the walls surrounding well.

(2) - Two parallel high resistance linear anomalies also appear to relate to structural remains but they are not parallel with the bailey banks or the other high resistance responses (1).

(3) - Areas of high resistance relate to material within the bailey banks.

(4) - Areas of high resistance are partly associated with a bank of the inner bailey but also partly include the edges of a circular depression purported to be constructed during the WWII.

(5, 6 & 7) - A low resistance response (5) relates to moisture retentive material within the bank, as it extends north eastwards the response is high resistance (6). The adjacent ditch (7) can also be seen as a low resistance response.

Anomalies of uncertain origin

(8) - Located within the the outer bailey are a number of high resistance linear, rectilinear, discrete and amorphous anomalies. Although their layout is not well defined, the linear and rectilinear morphology indicates that they relate to potential structural remains. They also have a similar north north east to south south west and east south east to west north west orientation as anomalies (1) seen within the inner bailey to the north east.

(9) - A zone of low resistance is located at the northern edge of the site within a shallow depression on a slightly raised area immediately north of the original outer bailey bank. This bank has been subject to erosion and truncation by the access route to the car-park. The response indicates moisture retentive material.

(10) - Several high resistance spikes at the southern end of the site appear aligned at regular intervals. This type of response is usually associated with poor contact due to shallow material of high resistance and is often of modern origin. However, the spikes may represent discrete features associated with a former fence or track.

Anomalies with a modern origin

(11) - Several low resistance linear anomalies relate to modern informal paths within the inner and outer baileys.

3.5 General assessment of survey results - magnetometry

3.5.1 The detailed magnetic survey was carried out over approximately 0.3ha.

3.5.2 Magnetic anomalies located can be generally classified as positive and negative linear anomalies of an archaeological origin, positive and negative anomalies of an uncertain origin, areas of magnetic debris and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within the survey area have been numbered and are described in 3.8 below with subsequent discussion in Section 4.

3.6 Statement of data quality and other factors influencing the results - magnetometry

3.6.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.

3.6.2 Zones of magnetic debris were located by the survey. Although it is likely that these relate to relatively modern dumping, early industrial activity may produce an identical magnetic response.

3.7 Data interpretation - magnetometry

3.7.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading CAD layer names and plot colour	**Description and origin of anomalies**
Anomalies of archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY AS-ABST MAG POS DISCRETE ARCHAEOLOGY AS-ABST MAG POS ARCHAEOLOGY AS-ABST MAG NEG LINEAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc. Negative responses relate to material with low magnetic susceptibility such as stone or subsoil, indicating structural remains or banks/earthworks.
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS UNCERTAIN AS-ABST MAG NEG UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

Table 2: List and description of interpretation categories

3.8 List of anomalies – magnetometry

Area centred on OS NGR 342237 302202, see Figs 06 & 07.

Anomalies of archaeological potential

(12) - A discrete positive response corresponds to the centre of the high resistance curvilinear feature and the negative linear responses on the eastern and northern sides to the surrounding high resistance anomalies. The positive magnetic response indicates magnetically enhanced material either within a pit-like feature or possible association with burnt material.

(13) - A short positive linear anomaly and a discrete response are parallel with but situated in between two high resistance linear anomalies (2). The response indicates magnetically enhanced material, possibly within cut features.

(14) - A broad, positive linear anomaly extends along the eastern edge of the inner bailey bank. This type of response indicates magnetically enhanced material usually within the fill of a cut feature.

(15) - The summit of the motte has a magnetically enhanced response of archaeological potential although more modern activity, such as burning, could be responsible. Within the outer bailey patches of magnetically enhanced material are associated with the banks.

Anomalies with an uncertain origin

(16) - At the western edge of the outer bailey are a number of negative linear anomalies. One is parallel with and situated just to the north of high resistance linear anomalies (8). Others are more random and do not appear to correspond to any resistance responses.

(17 & 18) - A broad negative linear response (17) with flanking positive responses appears as a possible continuation of a trackway that extends from an entrance in the southern bank. It is parallel with other broad positive linear responses (18). There are other parallel positive linear anomalies to the south and discrete positive anomalies with a stronger response indicating pit-like anomalies or areas of burning within and adjacent to them.

Anomalies associated with magnetic debris

(19) - Much of the site contains numerous discrete dipolar anomalies with zones of magnetic debris on the banks within the site. They relate to ferrous and other magnetically thermoremnant material, which has been dumped and/or burnt on site. Although it is likely that the majority of the material is of relatively recent origin, ancient industrial processes could potentially cause similar anomalies.

4 DISCUSSION

4.1.1 The geophysical survey has located a number of high resistance linear anomalies including a circular feature within the inner bailey (1). The centre of this circular feature corresponds to a positive magnetic anomaly (12) which relates to magnetically enhanced material. It is possible that the circular feature relates to a structure such as a well. Other high resistance linear anomalies located within the inner bailey are generally parallel with the surrounding banks; however, two high resistance anomalies (2), flanking positive responses (13), have a different orientation but also indicate possible structural remains. The magnetometer survey also revealed a broad linear ditch on the internal side of the eastern bank (14).

4.1.2 Within the outer bailey a number of high resistance linear, discrete and amorphous responses (8) were located. These were generally parallel with the linear responses within the inner bailey and oriented north east to south west. Although they lack a coherent morphology, they may relate to further structural remains within the outer bailey, although there has been other activity such as dumping within the site over a long period, so a more recent origin is possible. Also within the outer bailey, the magnetometer survey located a number of parallel positive and negative anomalies, visible as broad bands (17 & 18). Although natural features, such as bands in the underlying geology could produce such a response, the anomalies appear to have been truncated by negative linear anomalies (16). Such responses could also indicate ridge and furrow, but they do not seem to correspond to features visible on the surface, possibly a continuation of a trackway extending northwards from the southern edge of the outer bailey. There is some correlation with several high resistance responses.

5 CONCLUSION

5.1.1 The geophysical survey comprised resistivity and magnetometry within the site. The results of the resistivity demonstrate the presence of a number of high resistance linear and a curvilinear responses within the inner bailey that may indicate former structural remains. The magnetometry results within the inner bailey indicate the presence of a number of discrete positive responses relating to pits or areas of burning, with one corresponding to the centre of the high resistance curvilinear response. A broad positive linear anomaly, indicating a possible former ditch-like feature, has also been located at the eastern edge of the inner bailey.

5.1.2 Within the outer bailey, several anomalies relate to the extant bailey banks and inner ditch, with a low resistance response to the bank indicating moisture retentive material. Within the flat area of the outer bailey a large number of high resistance linear, discrete and amorphous responses have been located, with the orientation generally parallel with those within the inner bailey. Their morphology is poorly defined; however, the responses could indicate further structural remains within the outer bailey. The magnetometer survey located a number of broad, parallel, positive and negative anomalies, with several corresponding high resistance responses.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – basic principles of earth resistance survey (resistivity)

Earth resistance survey, commonly known as resistivity, relies on the variability of conduction of current through soil and the subsurface matrix. The variability relates to the distribution of moisture within different materials so that porous features, such as foundations, produce a relatively high resistance response and more moisture retentive soil, such as found within the fill of a former ditch, produces a low resistance measurement. The technique is, therefore, influenced by climatic factors although the success of a survey can be difficult to predict based on these alone. Soil type, ground use, vegetative cover and the nature of buried features and subsoil are all factors that will influence the outcome of a survey.

The technique involves inputting a small electrical current into the ground and measuring subtle variations to the current at regular intervals across an area. The current input and measurement requires a series of probes to be inserted into the ground and the configuration of these can influence the resolution of resistive anomalies and the depth of response. Research has demonstrated that the twin electrode configuration is one of the most useful for archaeological prospection. It requires a mobile frame with two electrodes separated usually by 0.5m and a pair of remote probes linked to the logging instrument using a long cable.

Cart-based systems are also regularly used in archaeological prospection, and generally these require four spiked wheels to inject current into the ground and take measurements. The four wheels act as a square array which can be electronically switched to change the orientation of measurement and current input. Two or three readings are rapidly logged at each recording station and these are referred to as alpha, beta and gamma. The gamma is often not recorded as this represents the difference between the alpha and beta configurations and can be derived during data processing. The alpha and beta datasets often demonstrate subtle differences that relate to the orientation of subsurface features and both are analysed as part of the abstraction and interpretation process. Advantages of cart systems are speed and resolution and they do not require a trailing cable; however, ground conditions are more critical and problems can be encountered with ground cover and in areas that are excessively damp or dry.

When using the twin probe configuration a useful reading interval for archaeological prospection across an area is 1m. Data are logged at 1m centres along traverses separated by 1m. Where areas contain known archaeological features 0.5m x 0.5m or 1m x 0.5 readings are considered more informative. Data collected by cart-based systems is typically at 0.25m centres along traverses separated by 1m.

Appendix C – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Edge Match

Calculates the mean of the 2 lines (rows or columns) of data either side of the edge to match. It then subtracts the difference between the means from all datapoints in the selected area.

High Pass Filter

Removes low frequency anomalies within the data that are not considered to be archaeologically significant and may be natural in origin. A window passes over the data, the mean of all the data within the window is subtracted from the centre value. The size of the window is adjusted as is the weighting which may be uniform or Gaussian.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

Despike

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold.

Appendix D – survey and data information

Area 1 raw resistance data

Filename: J708-res-Area1.xcp
Description: Imported as Composite from GeoPlot
Instrument Type: Resist. (RM85P)
Units: ohm
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Northwest corner: 342190 302249.75
Dimensions
Composite Size (readings): 180 x 180
Survey Size (meters): 90 m x 90 m
Grid Size: 10 m x 10 m
X Interval: 0.5 m
Y Interval: 0.5 m
Stats
Max: 204.70
Min: -9.00
Std Dev: 38.86
Mean: 105.72
Median: 101.30
Composite Area: 0.81 ha
Surveyed Area: 0.2697 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 1
1 Base Layer

Area 1 processed resistance data

Filename: J708-res-Area1-proc.xcp
Stats
Max: 183.44
Min: 28.00
Std Dev: 37.19
Mean: 105.01
Median: 101.30
Composite Area: 0.81 ha
Surveyed Area: 0.2697 ha
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Area 2 raw resistance data

Filename: J708-res-Area2.xcp
Description: Imported as Composite from GeoPlot
Instrument Type: Resist. (RM85P)
Units: ohm
Collection Method: Zig-zag
Sensors: 4
Dummy Value: 2047.5
Northwest corner: 342260 302229.75
Dimensions
Composite Size (readings): 80 x 60
Survey Size (meters): 40 m x 30 m
Grid Size: 10 m x 10 m
X Interval: 0.5 m
Y Interval: 0.5 m
4 Clip from -15.00 to 15.00 nT

Stats
Max: 204.70
Min: -204.70
Std Dev: 28.53
Mean: 132.98
Median: 127.60
Composite Area: 0.12 ha
Surveyed Area: 0.05675 ha
Processes: 2
1 Base Layer
2 Image clip at 3SD

Area 2 processed resistance data

Filename: J708-res-Area2-proc.xcp
Stats
Max: 190.04
Min: 75.91
Std Dev: 26.08
Mean: 132.46
Median: 127.60
Composite Area: 0.12 ha
Surveyed Area: 0.05675 ha
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Magnetometry minimally processed data

Filename: J708-mag-proc.xcp
Description: Imported as Composite from: J708-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 342195.029533158, 302252.495716982 m
Southeast corner: 342286.229533158, 302163.245716982 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 114700

Dimensions
Composite Size (readings): 608 x 595
Survey Size (meters): 91.2 m x 89.3 m
Grid Size: 91.2 m x 89.3 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 16.58
Min: -16.50
Std Dev: 5.73
Mean: 0.21
Median: -0.01
Composite Area: 0.81396 ha
Surveyed Area: 0.33615 ha
Processes: 1
1 Base Layer
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:

Appendix E – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A printed copy and PDF copy will be supplied to the Shropshire Historic Environment Record. Copies of the report will also be sent to the Historic England West Midlands team in Birmingham and to Paul Linford, Geophysics Team Leader at Fort Cumberland. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Geophysical data - path: J708 Castle Pulverbatch\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
Res\comps\J708-res-Area1.xcp Res\comps\J708-res-Area2.xcp	TerraSurveyor 3.0.23.0	Composite data file	02/04/17	D.J.Sabin
Res\comps\J708-res-Area1-proc.xcp Res\comps\J708-res-Area2-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file	17/05/17	D.J.Sabin
Mag\pulver1\MX\.dgb, .disp,.prm	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	01/04/17	D.J.Sabin
Mag\pulver1\MX\J708-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey area in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	02/04/17	D.J.Sabin
Mag\comps\J708-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	02/04/17	D.J.Sabin
Mag\comps\J708-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±15nT).	02/04/17	D.J.Sabin
Graphic data - path: J708 Castle Pulverbatch Data				
Res\graphics\J708-res-Area1-raw.tif Res\graphics\J708-res-Area2-raw.tif	TerraSurveyor 3.0.23.0	TIF file showing a raw greyscale plot clipped to 3SD	02/04/17	D.J.Sabin
Res\graphics\J708-res-Area1-proc.tif Res\graphics\J708-res-Area2-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a processed greyscale plot, high pass filtered and clipped to 3SD	16/05/17	D.J.Sabin
Mag\graphics\J708-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±15nT.	02/04/17	D.J.Sabin
Mag\graphics\J708-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	02/04/17	D.J.Sabin
CAD data - path: J708 Castle Pulverbatch\CAD				
J708 version 2.dwg	ProgeCAD 2014	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	25/04/17	K.T.Donaldson
Text data - path: J708 Castle Pulverbatch\Documentation				
J708 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	10/05/17	K.T.Donaldson

Appendix F – copyright and intellectual property

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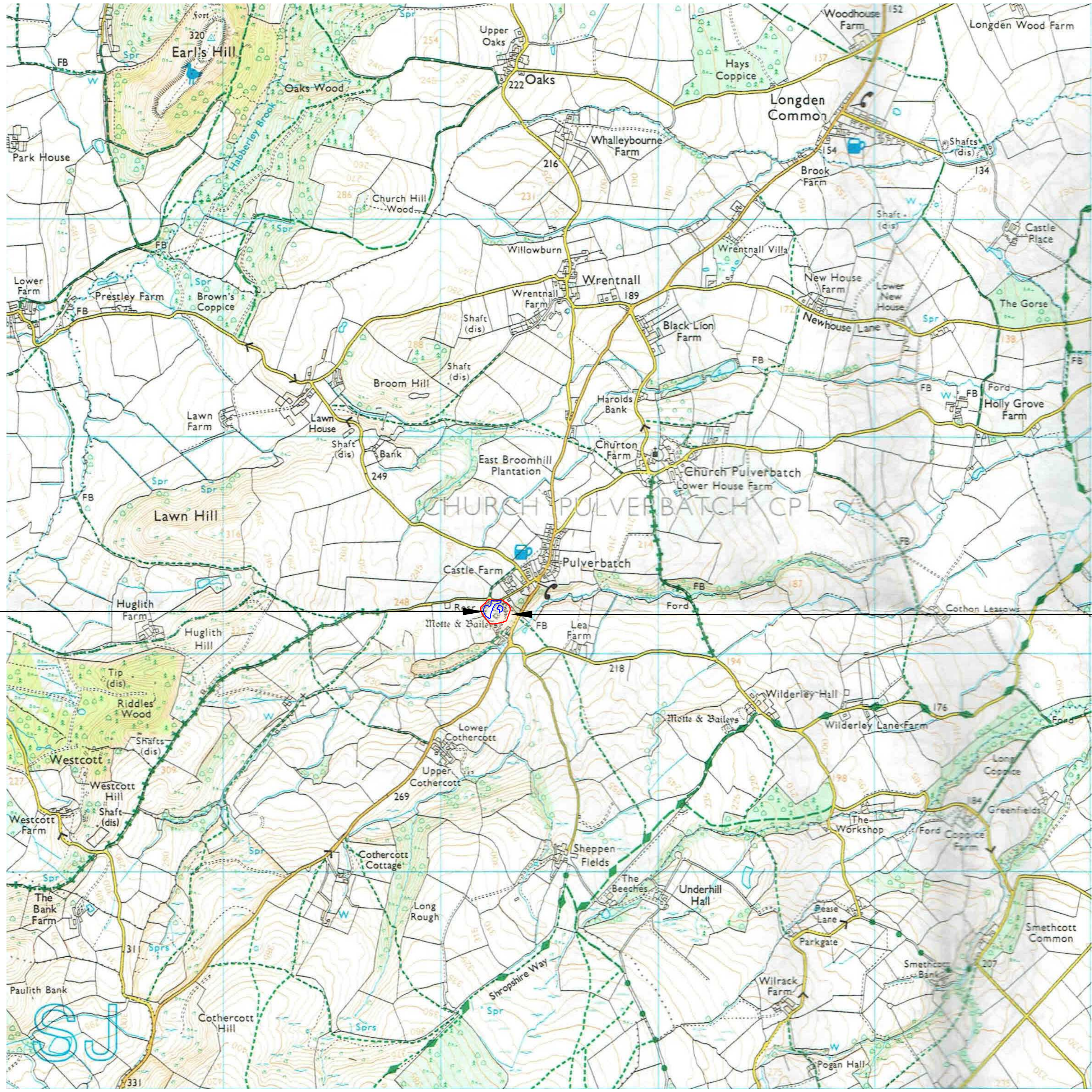

Survey location

Scheduled monument boundary

N

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Castle Pulverbatch
Motte and Bailey
Shropshire

Map of survey area

Reproduced from OS Explorer map no.241 1:25 000 by permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office.

Survey location

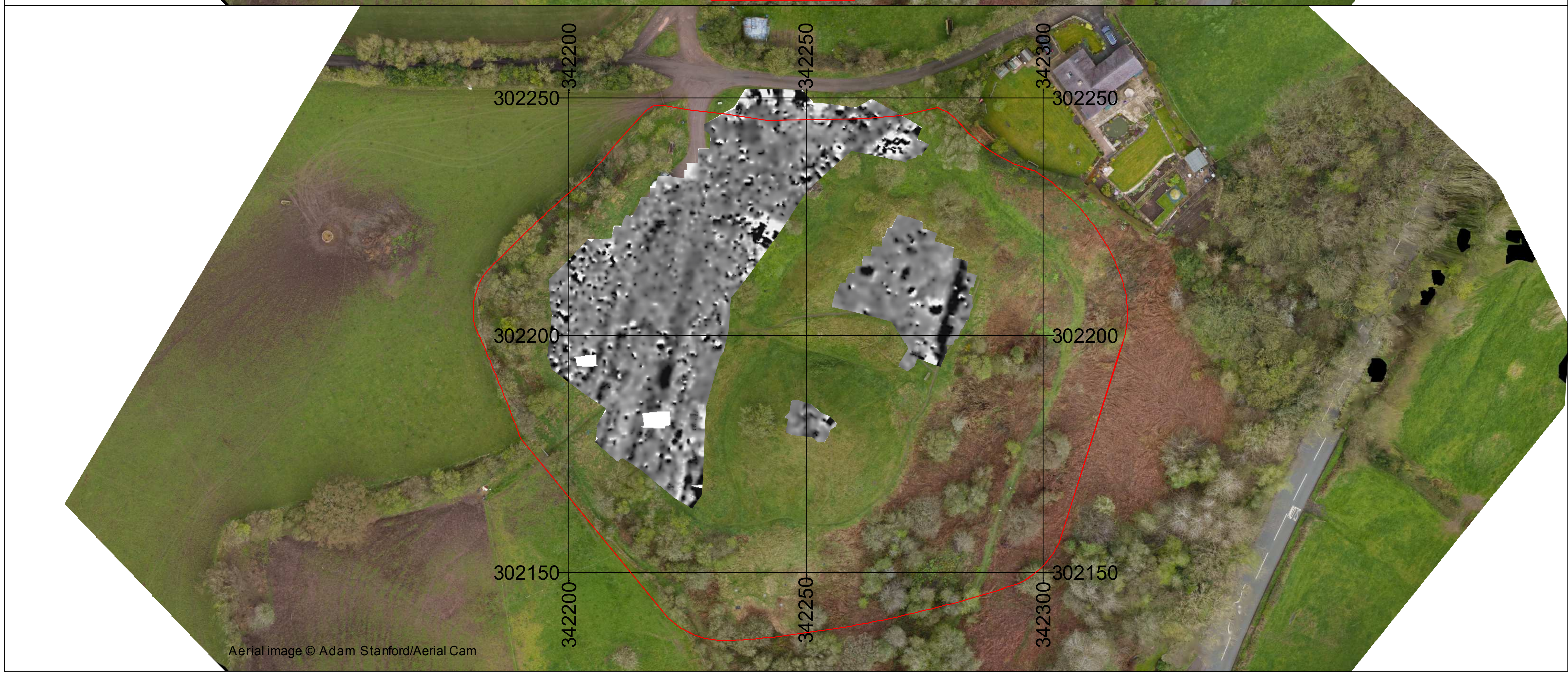
Site centred on OS NGR
SJ 42237 02202

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



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Referencing information

Resistivity survey grid size = 10m

Survey start and traverse direction

1 Grid reference number and filename

Survey carried out at 0.5m centres along 0.5m traverses. Survey start on baseline therefore readings shown 0.25cm either side of baseline

Grid coordinates based on Ordnance Survey OSGB36 datum. Grids set out using RTK GPS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Magnetometry referencing grid to OSGB36 datum at 50m intervals

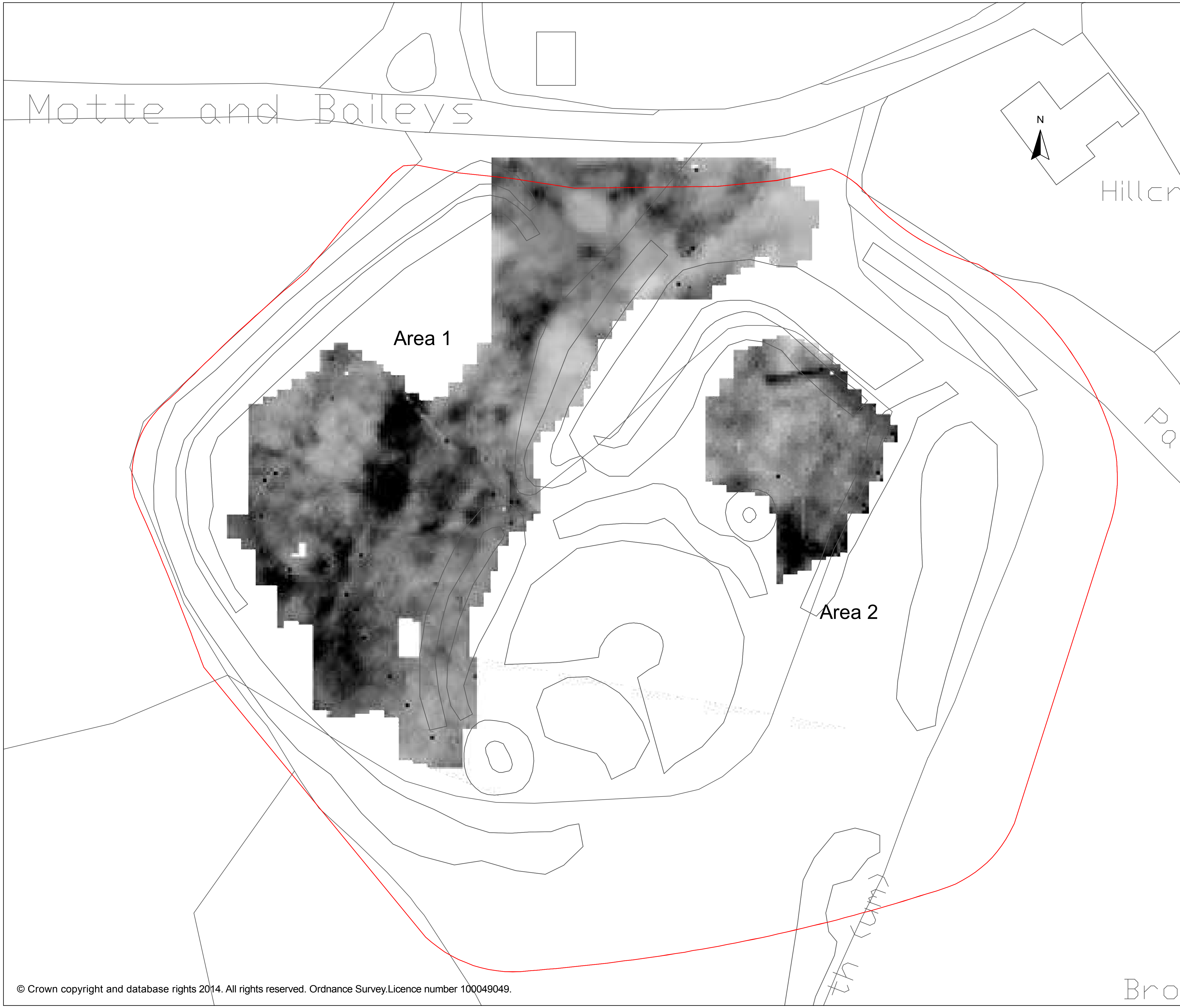
Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 02



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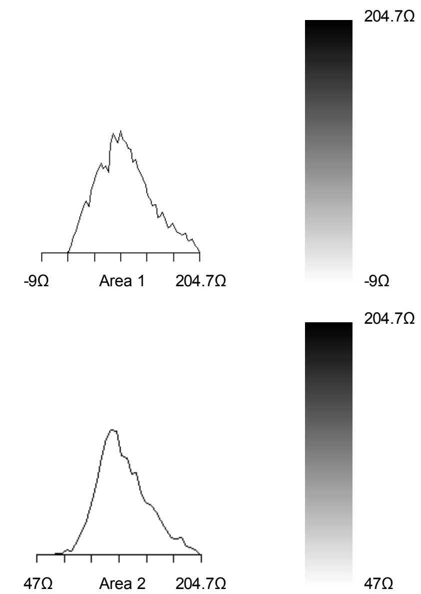
Greyscale plot of raw resistance data



SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 03

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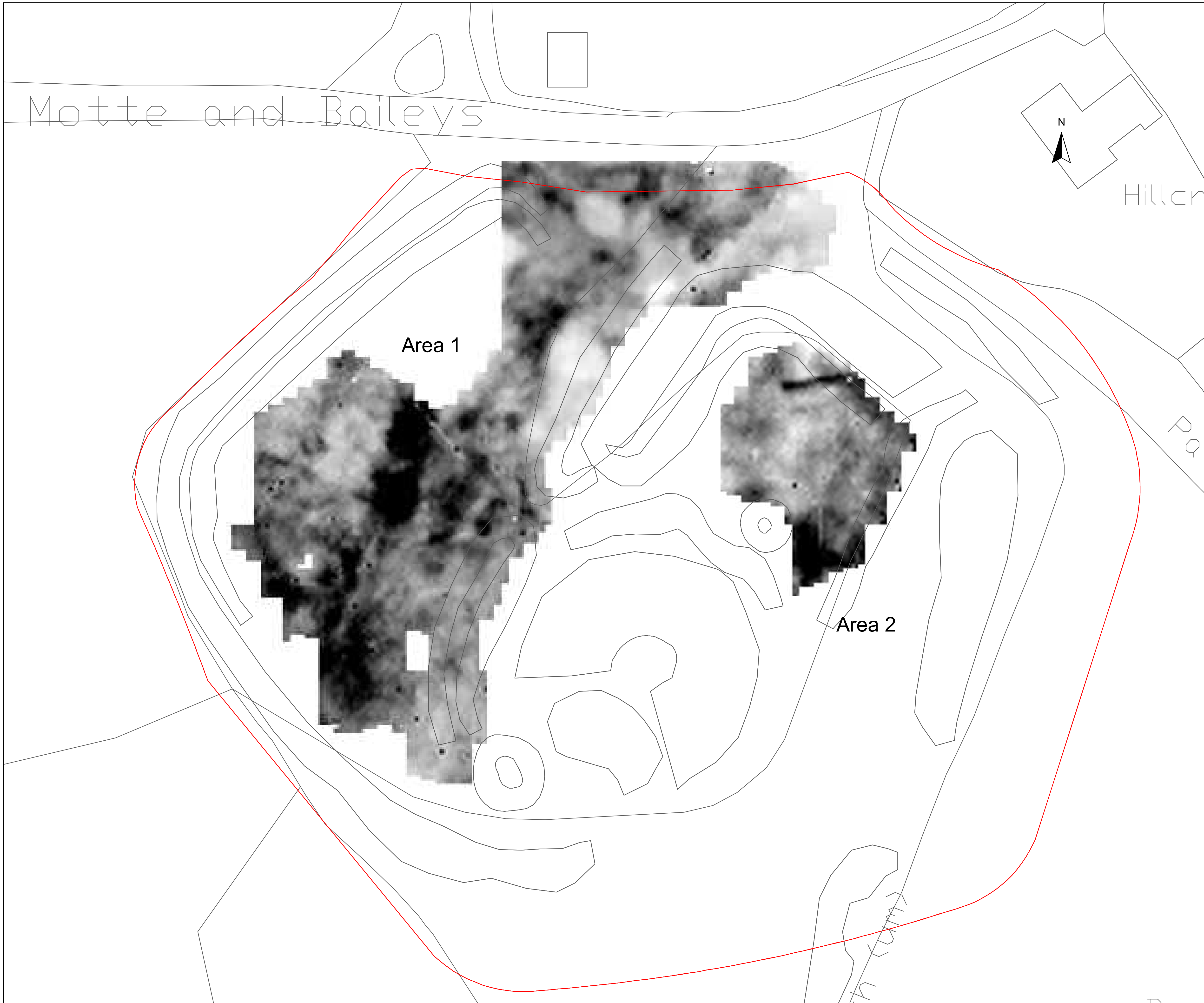
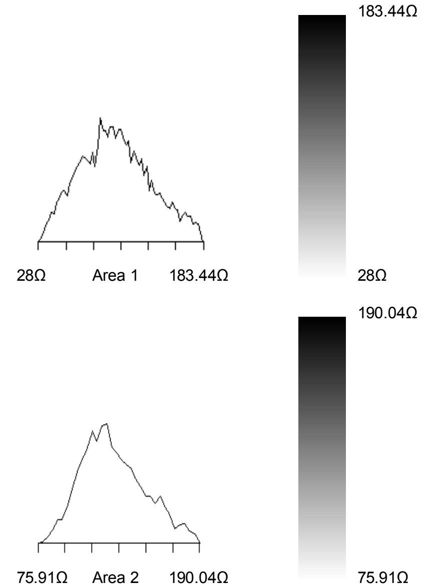
Greyscale plot of processed resistance data





SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 04

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Abstraction and interpretation of resistance anomalies

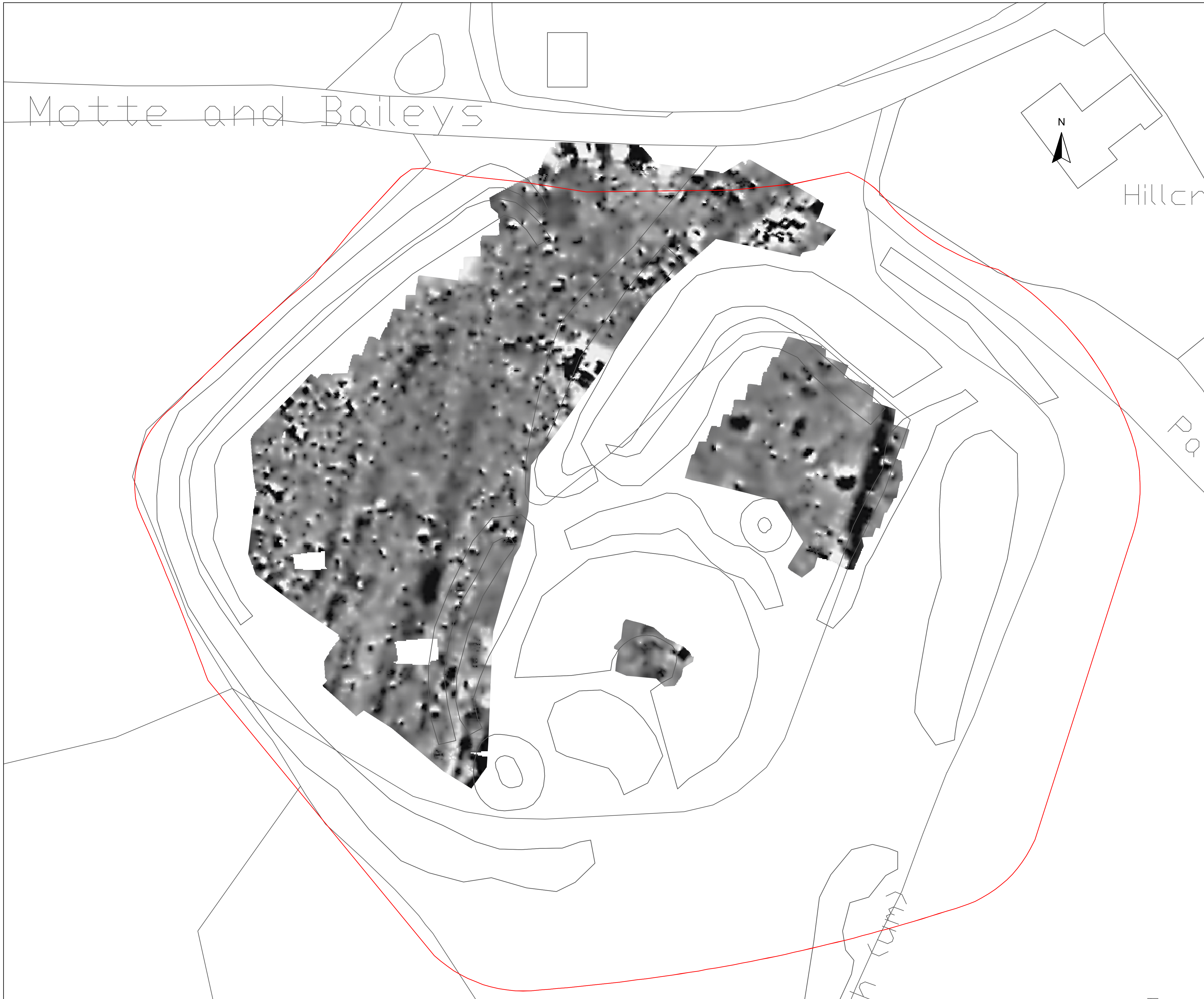
- High resistance linear anomaly - possible structural remains
- High resistance linear anomaly - of uncertain origin
- Area of high resistance - bank
- Low resistance response - bank
- Area of low resistance - ditch
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Discrete high resistance response - of uncertain origin
- Low resistance linear anomaly - modern informal footpath

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 05



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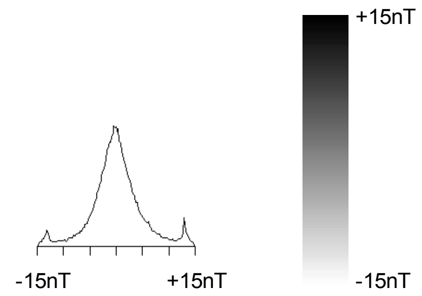
Greyscale plot of minimally processed magnetometer data

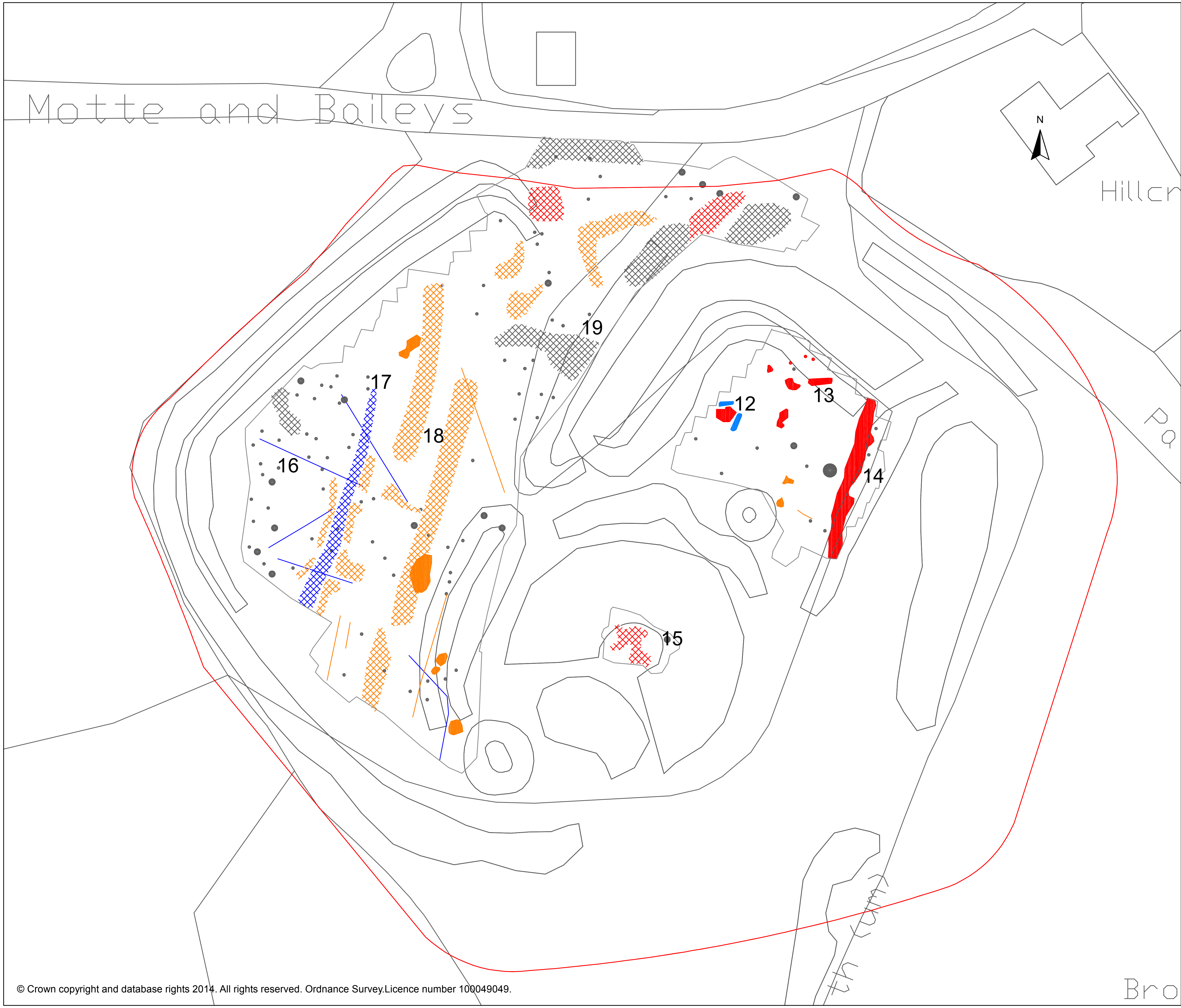


SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 06



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Abstraction and interpretation of magnetic anomalies

Positive linear anomaly - cut feature of archaeological potential

Positive linear anomaly - possible ditch-like feature

Negative linear anomaly - material of low magnetic susceptibility

Discrete positive response - cut feature of archaeological potential

Discrete positive response - possible pit-like feature

Positive anomaly - magnetically enhanced material of archaeological potential

Positive anomaly - magnetically enhanced material of uncertain origin

Negative anomaly - material of low magnetic susceptibility

Magnetic debris - spread of magnetically thermoremnant/ferrous material

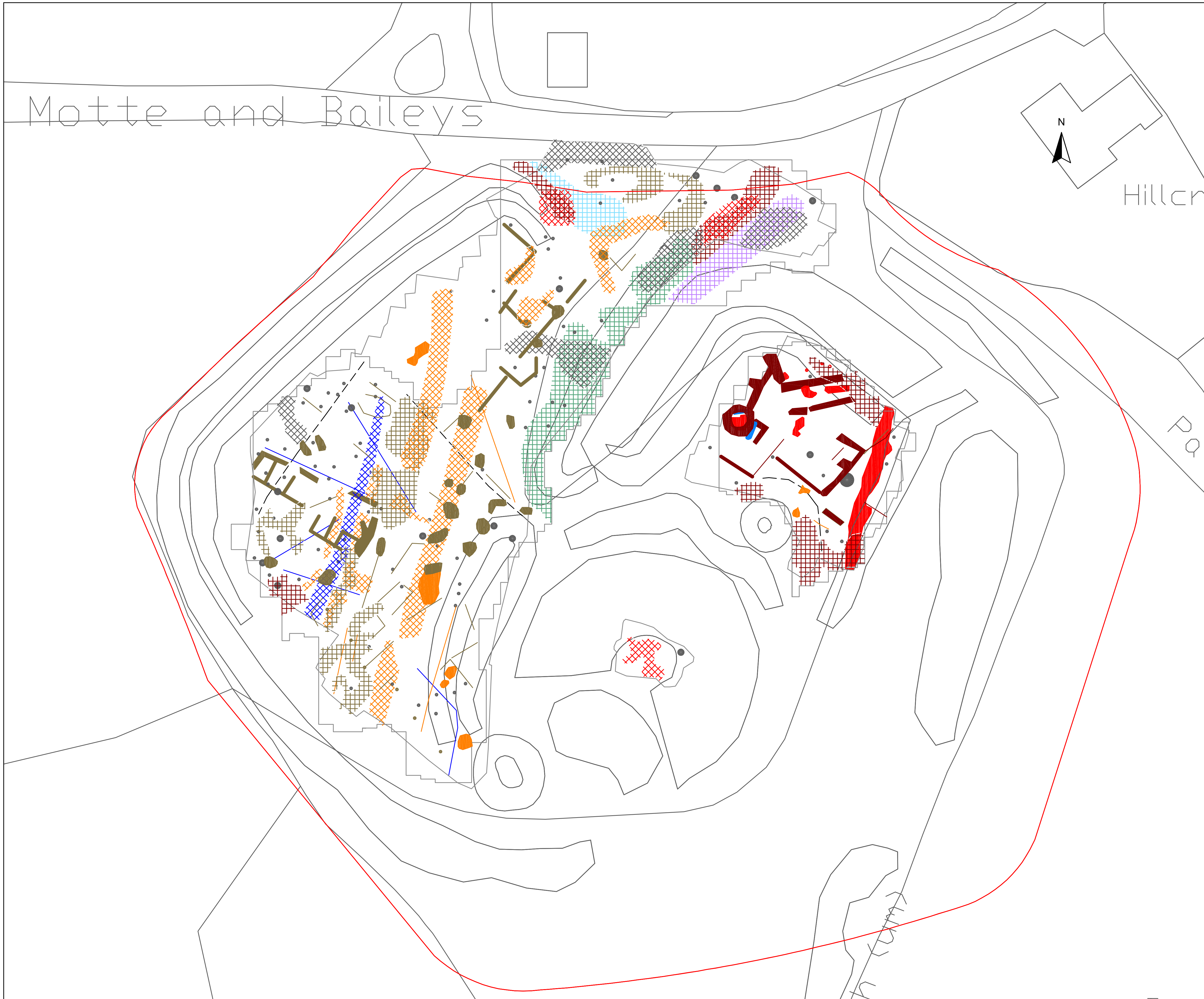
Strong dipolar anomaly - ferrous object

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 07



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Abstraction and interpretation of resistance & magnetic anomalies

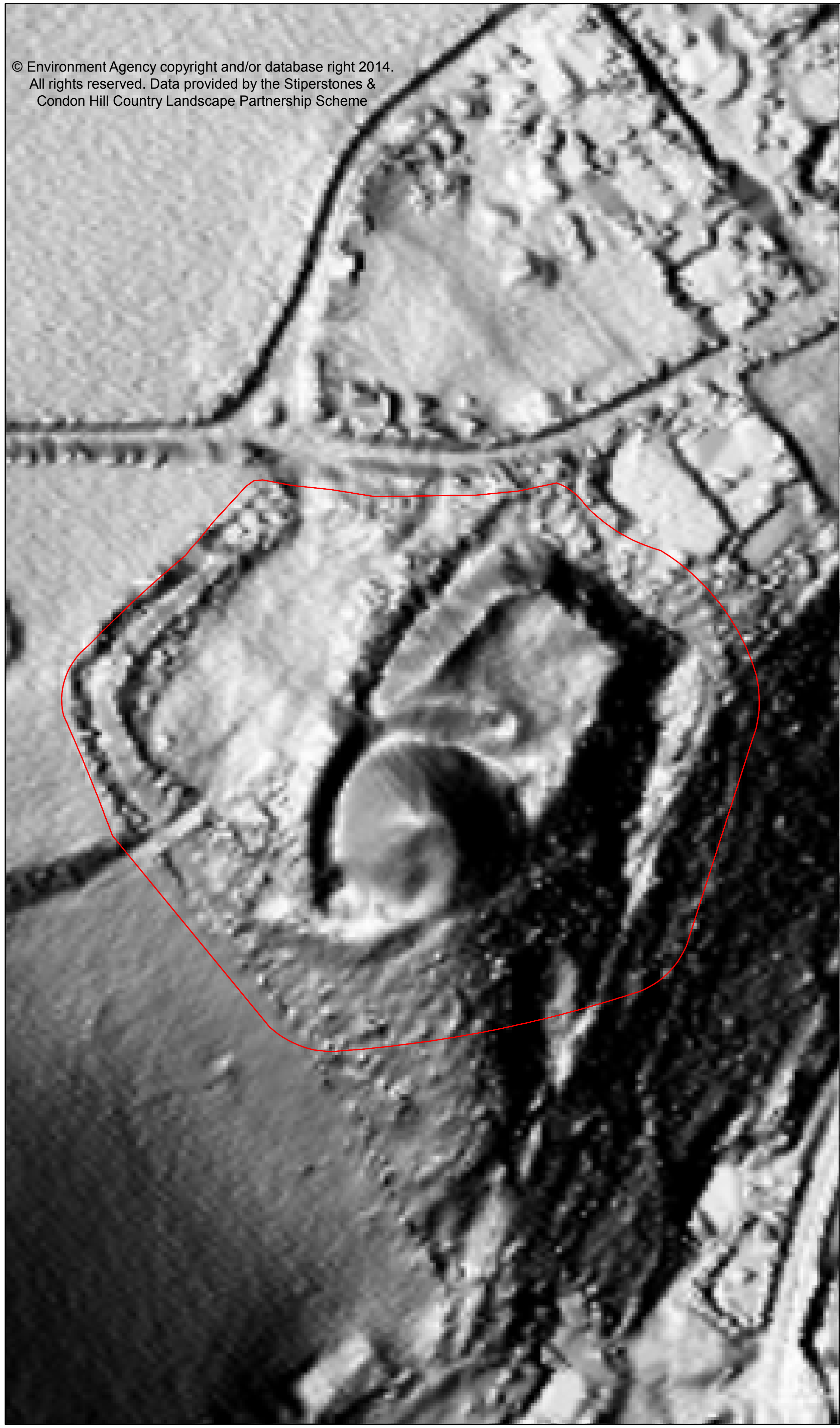
- High resistance linear anomaly - possible structural remains
- High resistance linear anomaly - of uncertain origin
- Area of high resistance - bank
- Low resistance response - bank
- Area of low resistance - ditch
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Discrete high resistance response - of uncertain origin
- Low resistance linear anomaly - modern informal footpath
- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material of archaeological potential
- Positive anomaly - magnetically enhanced material of uncertain origin
- Negative anomaly - material of low magnetic susceptibility
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Strong dipolar anomaly - ferrous object

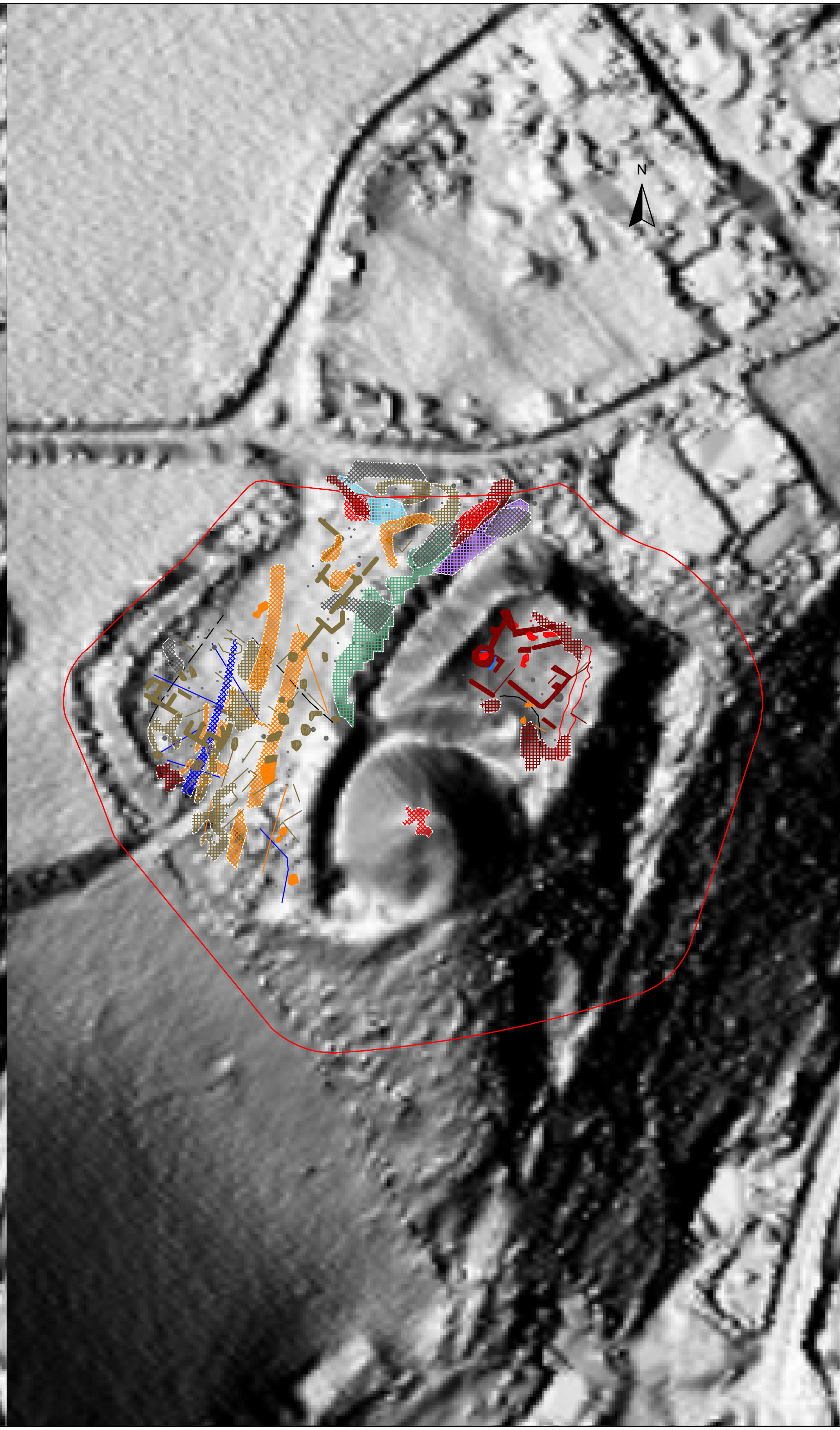
SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

FIG 08





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Geophysical Survey Castle Pulverbatch Motte and Bailey Shropshire

Digital Surface Model & abstraction & interpretation of resistance & magnetic anomalies

- High resistance linear anomaly - possible structural remains
- High resistance linear anomaly - of uncertain origin
- Area of high resistance - bank
- Low resistance response - bank
- Area of low resistance - ditch
- Area of high resistance - of uncertain origin
- Area of low resistance - of uncertain origin
- Discrete high resistance response - of uncertain origin
- Low resistance linear anomaly - modern informal footpath
- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - cut feature of archaeological potential
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material of archaeological potential
- Positive anomaly - magnetically enhanced material of uncertain origin
- Negative anomaly - material of low magnetic susceptibility
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 09

Surface overlay of aerial image over LiDAR DSM with resistivity greyscale

Surface overlay of aerial image over LiDAR DSM with magnetometry greyscale

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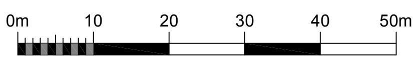
Resitivity & magnetometry greyscales with aerial image surface overlay

SCALE 1:1000



SCALE TRUE AT A3

FIG 10