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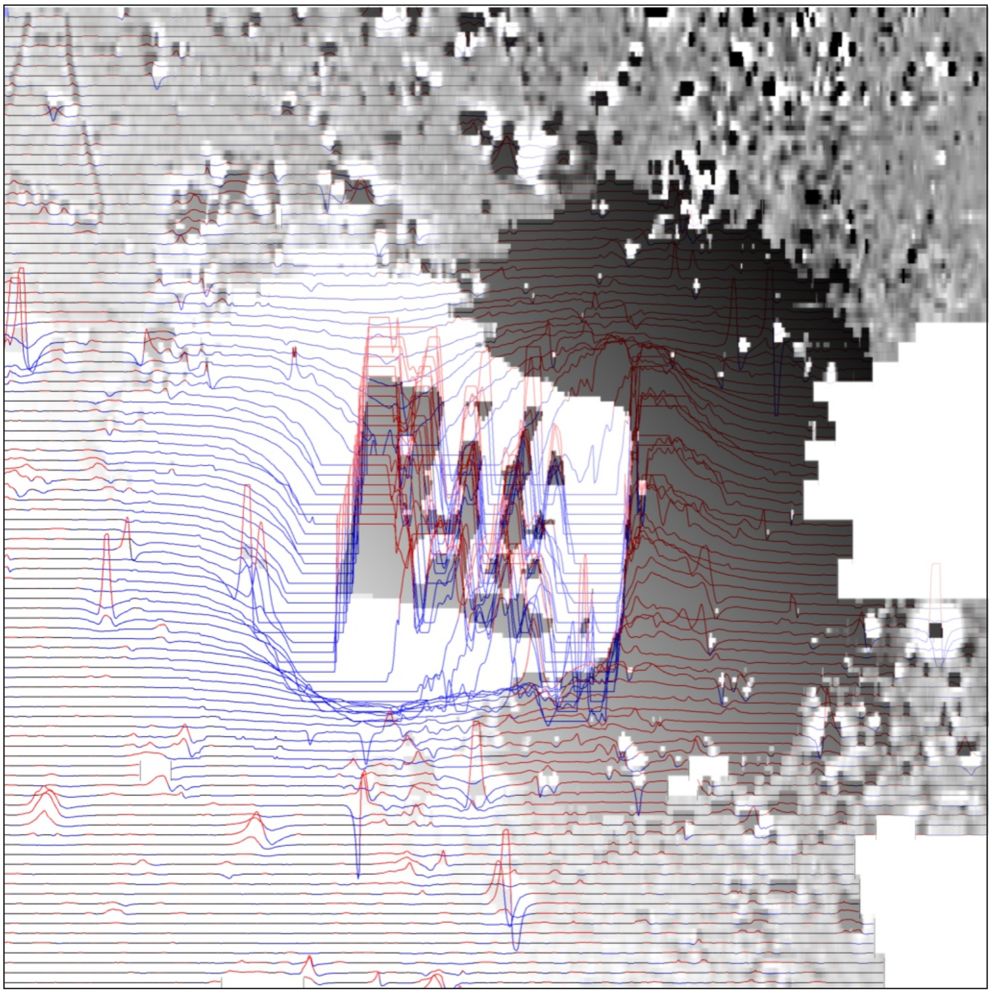
Ashley Walk Ministry of Home Security Target New Forest, Hampshire

Geophysical Survey Report



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Ashley Walk Ministry of Home Security Target
New Forest, Hampshire

Geophysical Survey Report

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Summary

A geophysical survey was conducted over land within the New Forest and former Ashley Walk bombing range over a buried concrete target some 5.15km east of Fordingbridge, Hampshire. The project was commissioned by the New Forest National Park Authority with the aim of establishing the extent, structure, character and state of preservation of a Ministry of Home Security (MoHS) bombing target. This survey forms part of the New Forest National Park Authority's project named "New Forest Remembers: Untold Stories of WW2" that aims to identify all WW2 remains in the area and make them accessible and understandable to the public.

The site comprises an area of rough pasture within the New Forest National Park, located between Fordingbridge to the west and Fritham to the East. The site occupies the crest of a ridge with stream valleys either side. The site had been cleared of the densest vegetation prior to the survey. Four geophysical survey techniques were used on this site including gradiometer, earth resistance, Earth Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) and all four techniques fell within a 2ha area around the buried structure.

The four surveys revealed various elements of the bombing target with ERT and gradiometer data proving the most useful by detecting internal divisions as well as observing patterns of damage. In addition to detecting the concrete structure other features relating to the bombing range like a line target and cable was detected close by.

The ERT data revealed patterns of damage across the slab as well as picking out the end supporting walls underneath the slab although little detail could be discerned below a depth of 3m. The gradiometer data was useful in identifying the positions of the internal supporting walls. Together these two survey techniques revealed most of the main structural elements of the concrete structure.

The earth resistance and GPR surveys by contrast revealed very little of the structure and damage to it. This is considered likely to be the result of poor signal penetration through the structure, probably as a consequence of the construction techniques.

The geophysical survey was undertaken in two main phases from 11th November 2013 to 7th February 2014.

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The detailed gradiometer survey was commissioned by the New Forest National Park Authority. The assistance of James Brown is gratefully acknowledged in this regard. The advice of Neil Linford of English Heritage is also greatly appreciated.

The fieldwork was directed by Rachel Chester and Laura Andrews, assisted by Alistair Black, Clara Dickinson, Rachel Williams and Jennifer Smith. Ross Lefort and Ben Urmston processed and interpreted the geophysical data. This report was written by Ross Lefort, with contributions by Ben Urmston. The geophysical work was quality controlled by Dr. Paul Baggaley. Illustrations were prepared by Ross Lefort, Richard Milwain and Karen Nichols. The project was managed on behalf of Wessex Archaeology by Dr. Paul Baggaley.

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1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by the New Forest National Park Authority (NFNPA) to carry out a geophysical survey of land on the former bombing range at Ashley Walk in the New Forest National Park, Hampshire (**Figure 1**), hereafter "the Site" (centred on NGR 420030, 114125). The survey forms part of an ongoing programme of archaeological works being undertaken to assess the condition of a reinforced concrete structure at the Site that is buried under an earth mound.

1.1.2 The aim of the geophysical survey was to establish the extent and character of the concrete structure as well as seeing if internal divisions could be detected through geophysical survey. This survey forms part of the NFNPA's project named "New Forest Remembers: Untold Stories of WW2" that aims to identify all WW2 remains in the area and make them accessible and understandable to the public.

1.1.3 A Method Statement was prepared by Wessex Archaeology that outlines the proposed methodology (WA 2013). A two phase approach was adopted to establish the most suitable methodology to apply to the mound. The first phase (Phase 1) involved collecting test Earth Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) transects along with earth resistance (twin-probe) and detailed gradiometer survey across and around the mound. Following on from this phase 30 transects of ERT data and a gridded GPR survey of the top of the mound was carried out as part of Phase 2. Further details of the instrumentation, sampling strategy and processing used are outlined below.

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

1.2 Site Location and Topography

1.2.1 The survey area comprises part scrub land within the New Forest National Park located between Fordingbridge, some 5.15km to the west, and Fritham that is located some 4km to the east (**Figure 1**). The earth mound that is roughly circular in plan (**Plate 1**) is located to the south of the Pitts Wood Inclosure, less than 50m from a track running through the area. The Site served as a practice bombing range during the Second World War.

1.2.2 The Site occupies the high ground on a ridge aligned roughly southwest to northeast, flanked by a number of stream valleys that form an undulating landscape. Two watercourses named Ditchend Brook (to the northwest) and Latchmore Brook (to the south) are visible running past the Site with smaller unnamed tributaries running close by. The land around the mound lies at a height just over 105m above Ordnance Datum (aOD); the highest ground lies further northeast at Coopers Hill (over 110m aOD). The survey extents are limited to a roughly 2ha square area surrounding the mound.

1.3 Soils and Geology

1.3.1 The soils underlying the Site are likely to be stagnogley-podzols of the 643c (Bolderwood) association. Typical stagnogley soils of the 711g (Wickham 3) association are recorded on the lower lying land a short distance from the Site (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

1.3.2 The bedrock geology under the Site is recorded as sedimentary deposits dating to the Palaeogene period with Selsey sand formation (sand silt and clay) recorded under the mound with sedimentary Poole formation (sand, silt and clay) recorded on lower ground close by (BGS).

1.3.3 The superficial deposits recorded on Site date to the Quaternary period and include river terrace deposits (sand and gravel) under the mound and alluvial and head deposits in the lower river valleys close to the site (BGS).

1.4 Archaeological and Historical Background

1.4.1 The following information is summarized from the Heritage Gateway website (www.heritagegateway.org.uk) and the online database for Hampshire HER (http://historicenvironment.hants.gov.uk/AHBSearch.aspx). A search was performed for all heritage assets within 1km of the Site.

1.4.2 Prehistoric records include flint scatters, burnt mounds and barrows such as Ashley Cross Hill barrow (EH222827). The Roman records in the area seem to feature mainly kiln sites such as the five kilns found within the Pitts Wood Inclosure (EH661532). The post-Roman and early medieval remains include a possible deserted medieval village named Slacham that was destroyed to create the New Forest (EH222812). The remains recorded after this date relate to the management of the New Forest. There are several undated earthworks recorded in the area.

1.4.3 The Ashley Walk bombing range was created in 1940 with a 3,800 acre (1,540 ha) area being fenced in (Hants 36791). Numerous practice targets were built within this range including observation shelters (Hants 60388 & 60389), a line target (Hants 60387), a firing range (Hants 59497), a dummy airfield (Hants 60390) and fragmentation targets (Hants 60395). Many targets were destroyed following the end of the war but some remain including the concrete structure surveyed for this project. This structure is recorded as a replica German submarine pen in the Hampshire HER (Hants 60392) but the Ministry of Home Security (MoHS) documents do not support this and instead seem to suggest this was built as an aid to study bomb shelter design for civilian air raid defence (MoHS 1943a & 1943b).

1.5 Design, Construction Methods and Materials

1.5.1 Details of the construction methods and materials used are outlined in a report produced by Research and Experiments Department of the MoHS (*ibid* 1943a), summarised below. The plans and design of the target are shown in **Plate 3**.

1.5.2 The structure was made from reinforced concrete and consisted of a slab sat on five supporting walls. The slab measured 79ft x 70ft with a thickness of 6ft. The reinforcing steel mesh used amounted to 1% of the total volume and this was concentrated in three layers. The first layer was 2in from the top surface using 8% of the steel mesh, the second was set 2ft 6in below the surface using 24.5% of the mesh and the third was set at least 2in from the bottom using 67.5% of the mesh. The mesh was overlapped by an assumed 10% and soft wire ties were used to bind the mesh where necessary (MoHS 1943a: 1-2). Evidence of this upper layer of mesh was seen on Site as exposed bars (Plate 2).

1.5.3 The five supporting walls consisted of two thick end walls 3ft 3in wide and three internal walls 1ft 6in wide. All five walls ran across the entire width of the slab for a length of 70ft with a height of 6ft and had two layers of reinforcing mesh close to the wall faces. The clear spans between the walls that formed the base measured 18ft, 16ft, 14ft and 20ft and the ceilings of these spans (base of the slab) were lined with $^{3}/_{16}$in mild steel plates. The majority of the plates measured 20ft x 5ft and were attached to the concrete slab using ¼in diameter 2ft long mild steel hangers that were welded to the plate and hung from ¼in diameter bars that run longitudinally through the slab above the bottom layer of steel mesh. The gaps between these plates were covered with 3½in wide cover strips (MoHS 1943a: 1-2).

1.5.4 The cement used was normal Portland cement and was produced to a particular specification using set quantities of sand, crushed gravel of three sizes. The construction time was around five and a half months and vibrators were used to consolidate the concrete with a maximum of 100 cubic yards of concrete poured for the roof slab every day (MoHS 1943a: 2).

1.6 Bombing Trials

1.6.1 A number of trials were designed involving the dropping of live and inert bombs on the structure and positioning live bombs side-on and "nose-on" close to various parts of the structure and detonating them remotely. These trials were designed to assess the effect of impact and explosions targeted at specific parts of the structure in order to improve the design of future bomb-resisting structures (MoHS 1943a: 1-7).

1.6.2 Construction of the target finished in September 1941 and following this date several attempts were made to hit it from a height of 12,000ft; a successful hit was not achieved until May 1943. In total five dropped bombs hit the target with a further three detonated from the ground. The positions of the eight hits are mapped on **Plate 3** and the summary of the resulting damage of each bomb is given in **Table 1** below.

Bomb Number	Bomb Type	Method of Deployment	Area of the Structure Hit	Depth of Crater	Damage and Mesh Layers Exposed
1	Live British 500lb G.P. Mark IV	Air drop	Top of slab	18in	1 (Upper slab)
2	Inert British 500lb S.A.P. Mark V	Air drop	Top of slab	20½in	1 (Upper slab)
3	Inert British 500lb S.A.P. Mark V	Air drop	Corner of slab	2ft 6in	2 (Upper and middle slab)
4	Live German 250kg S.C.	Static detonation	Set in the crater of bomb 2	No change	Wider area of the upper layer exposed along with cracks to the west
5	Live German 50kg S.C.	Static detonation	Northern support wall	9in	Partial exposure of both layers of mesh in wall
6	Live German 500kg S.C.	Static detonation	Top of slab (undamaged)	2ft 1in	Concrete shattered to bottom level possibly exposing all three layers
7	Live British 4000lb M.C.	Air drop	Southern support wall	10ft	Both mesh layers in wall exposed, cracks in the slab partially exposed all three slab layers
8	Live British 4000lb M.C.	Air drop	West side of the target	14ft	Damage mainly to the floor slab

Table 1: Summary of bomb damage from the trials (MoHS 1943a & 1943b)

1.6.3 The results of the bombing trials revealed a number of ways in which the design and construction of bomb-resisting structures can be improved to make them stronger and more cost-effective (MoHS 1943a: 7-9). After the end of the war the structure was deemed impractical to demolish and was instead covered with earth.

2 METHODOLOGY

2.1 Introduction

2.1.1 The detailed magnetometer survey was conducted using a Bartington Grad601-2 dual fluxgate gradiometer system. The earth resistance survey was carried out using a Geoscan RM15 system. The ERT survey was conducted using a Campus Tigre system and the GPR survey was carried out using the Radarteam Cobra system. The four surveys were conducted in accordance with English Heritage guidelines (2008).

2.1.2 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team in two main phases. Phase 1 ran from 11th November to 22nd November 2013 and Phase 2 ran from 20th January to 7th February 2014. A site meeting was conducted between Wessex Archaeology, the New Forest National Park Authority (NFNPA) and English Heritage between Phase 1 and 2 to decide on the most suitable methodology for Phase 2. Phase 1 involved the collection of gradiometer and earth resistance data along with test transects of ERT and GPR data and Phase 2 involved the collection of gridded ERT and GPR data based on the positive results from the test transects. Field conditions at the time of the survey were fairly good, with the central portion of the Site area having been cleared of the densest vegetation prior to the survey. However, the seasonally waterlogged nature of the Site resulted in numerous shallow pools forming and, along with sparse scrub, made certain parts of the Site unsurveyable at different times.

2.2 Method

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

2.2.2 The magnetometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between sensors. Data were collected at 0.25m intervals along transects spaced 1m apart with an effective sensitivity of 0.03nT, in accordance with EH guidelines (2008). Data were collected in the zigzag method using the 100nT and 1000nT ranges.

2.2.3 Data from the gradiometer survey was subject to minimal data correction processes. These comprise a Zero Mean Traverse (ZMT) function (±25nT thresholds) applied to correct for any variation between the two Bartington sensors used, the deslope function to account for flaws in the ZMT function and a de-step function to account for variations in traverse position due to varying ground cover and topography. These three steps were applied to all survey areas, with no interpolation applied.

2.2.4 The earth resistance survey was undertaken using a Geoscan Research RM15 instrument in parallel twin (4 probe) configuration using the MPX15 multiplexer; each of the mobile probes were spaced 0.5m apart, with the centres of the two twin probe arrays spaced 1m apart. Data were collected at 1m intervals along transects spaced 1m apart with an effective sensitivity of 0.1 ohms (Ω), in accordance with EH guidelines (2008). Data were collected in the zigzag method.

2.2.5 Data from the survey were subject to minimal data correction processes. These comprise despiking to remove erroneous readings resulting from poor contact resistance and grid matching to correct for systematic offsets resulting from sequential movements of the remote probes. This minimally processed dataset was then high-pass filtered (10x10 uniform) to emphasise smaller, more rapidly varying anomalies and to remove broad changes within the data typically associated with geological changes. A low-pass filter

(2x2 Gaussian) was also applied to the minimally processed data to remove high frequency small scale data. Both datasets were interpolated in X and Y directions to improve the appearance of the final images, although the original datasets and intermediate stages of processing can be made available.

2.2.6 The Phase 1 ERT data were acquired using a Campus Tigre system using 128 electrodes arranged at a spacing of 1m and the Phase 2 data were collected using 64 electrodes at a spacing of 1.5m. All electrode positions were surveyed using the GPS system. The system was controlled via a laptop running ImagerPro 2006 which automatically selects the electrodes required for each reading. The system used all the available electrodes at ever increasing electrode spacings to acquire a complete data set. The Wenner alpha array was selected as it is robust, generates a stronger signal compared to other arrays and has good vertical sensitivity.

2.2.7 The data was processed as individual sections using Res2Dinv software to provide a two-dimensional inversion of the data incorporating the topography recorded along the electrode arrays. As the values obtained from the concrete structure contrast sharply with the surrounding background values the decision was taken to apply robust inversion constraints for the Phase 2 data to minimise the smearing of the edges. The data inversion constraint applied was 0.060 and the value used for the model inversion constraints was 0.005. Standard settings were used to process the Phase 1 test transect.

2.2.8 The 2D data including topography were also combined into a 3D format and were processed using the Res3Dinv software. Although it is better to collect a 3D data set using a purpose-built system and more appropriate array it is possible to combine and apply inversion to all 2D profiles at the same time to get a better result. The 3D data was set to the software's default settings. The only changes applied were the enabling of automatic smoothing of the model resistivity and an approximate inverse starting model was used; these changes were necessary as the maximum measured value was more than 100 times the minimum value.

2.2.9 The Ground Penetrating Radar (GPR) survey was conducted using a Radarteam Cobra instrument with dual central frequencies of 300MHz and 500MHz. Data were collected at 0.02m intervals along orthogonal profiles spaced 0.5m apart to allow for better detection of anomalies parallel with either survey orientation. The data interpreted and presented in this report were from the 300MHz channel.

2.2.10 Data from the GPR survey were subject to standard processing, including gain and wobble correction, before being sliced and regridded to produce 3D timeslices of the dataset. These are effectively horizontal groupings of data of equal depth, as determined by the two way travel time and the effective velocity of the radar pulse through the ground.

2.2.11 The approximate depth conversion is shown in Table 2 below, assuming the velocity of the GPR pulse through the ground is c. 0.025m/ns. It is possible to determine more precisely the average velocity of the GPR pulse through the ground if excavated features at a known depth can be identified in the data. Analysis of the GPR profiles did not reveal sufficient individual hyperbolae to produce a reliable velocity profile; very few hyperbolae were encountered in over 80 profiles and the majority of the values returned clustered around 0.025m/ns.

2.2.12 The Relative Dielectric Permittivity (RDP) of the bulk structure can be calculated using $K = \left(\frac{V_c}{V_r}\right)^2$, where K is the RDP, V_c speed of light in a vacuum and V_r the GPR pulse velocity. A value of 0.025m/ns equates to an RDP of c. 140, which is rather high; various sources indicate that a value of around 6 to 12 would be more typical.

2.2.13 It is therefore considered likely that the lack of suitable hyperbolae or definite correlation between GPR reflections & known horizons has skewed the velocity estimation downwards. However, the two-way travel times are still accurate.

Timeslice	Start (ns)	End (ns)	Start (m)	End (m)	Average (m)
1	0.00	11.81	0.00	0.15	0.07
2	4.95	16.76	0.06	0.21	0.14
3	9.90	21.71	0.12	0.27	0.20
4	14.85	26.66	0.19	0.33	0.26
5	19.80	31.61	0.25	0.40	0.32
6	24.75	36.56	0.31	0.46	0.38
7	29.70	41.51	0.37	0.52	0.45
8	34.65	46.46	0.43	0.58	0.51
9	39.60	51.41	0.50	0.64	0.57
10	44.55	56.36	0.56	0.70	0.63
11	49.50	61.31	0.62	0.77	0.69
12	54.45	66.26	0.68	0.83	0.75
13	59.40	71.21	0.74	0.89	0.82
14	64.35	76.16	0.80	0.95	0.88
15	69.30	81.11	0.87	1.01	0.94
16	74.25	86.06	0.93	1.08	1.00
17	79.20	91.01	0.99	1.14	1.06
18	84.15	95.96	1.05	1.20	1.13
19	89.10	100.91	1.11	1.26	1.19
20	94.05	105.86	1.18	1.32	1.25
21	99.00	110.81	1.24	1.39	1.31
22	103.95	115.76	1.30	1.45	1.37
23	108.90	120.71	1.36	1.51	1.44
24	113.85	125.66	1.42	1.57	1.50
25	118.80	130.61	1.49	1.63	1.56

Table 2: GPR timeslice information, assuming v=0.025m/ns

2.2.14 Further details of the geophysical and survey equipment, methods and processing are described in **Appendices 1** to **5**.

3 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

3.1 Introduction

3.1.1 The four geophysical survey techniques used detected various elements of the concrete bombing target with gradiometer and ERT survey proving the most successful in identifying internal features and patterns of damage. Other features nearby of probable and possible archaeological interest have been identified including the line target observed previously from LiDAR data. Results are presented as a series of greyscale, colour scale and XY plots along with archaeological interpretations, at a scale of 1:1000 (**Figures 2** to **13**).

3.1.2 The gradiometer data are displayed at ranges of -6nT (white) to +9nT (black) and -500nT and +500nT for the greyscale images and ranges of ±25nT at 25nT per cm, ±50nT at 100nT per cm and ±750nT at 1000nT per cm for the XY trace plots. The earth resistance data are displayed from +175Ω to +375Ω for the minimally processed and low pass filtered data and -40Ω to +60Ω for the high pass filtered data.

3.1.3 The vertical ERT sections are displayed using a colour scale at a range of 0Ω·m (Blue) to 1280Ω·m (Purple). The horizontal pseudo-slices are displayed with values set on a logarithmic scale with values ranging from 0.51Ω·m to over 3000Ω·m.

3.1.4 The GPR data are displayed as a series of timeslices and interpretations, with selected radargrams demonstrating data quality. Timeslices are shown as amplitude plots, from Low (blue) to High (red). Radargrams are shown as greyscale plots, from Low Amplitude (white) to High Amplitude (black).

3.1.5 The interpretation of the datasets highlights the presence of potential archaeological anomalies, modern features and weak linear trends (**Figures 4**, **6**, **10** and **12**). Full definitions of the interpretation terms used in this report are provided in **Appendix 5**.

3.1.6 Numerous ferrous anomalies are visible throughout the gradiometer survey dataset. Some are presumed to be modern in provenance but most of them are likely to relate to this areas use as a bombing range.

3.2 Phase 1: Gradiometer Survey Results and Interpretation

3.2.1 The area of the concrete structure is dominated by a broad ferrous response (**4000**) which was to be expected given the amount of steel mesh used in the structure's construction. For this reason this area was subject to an additional gradiometer survey at a range of ±1000nT to see if this would reveal any more detail within the ferrous anomaly.

3.2.2 This data reveals that within the wider bipolar anomaly of the reinforced structure are a series of narrow bipolar anomalies running roughly east west across the structure around **4000**. These linear anomalies correspond closely to the positions of the 1ft 6in internal supporting walls under the slab and the layers of reinforcement within these walls are most likely to be the cause of these strong responses. The end walls appear to be less visible but these may be masked by the stronger responses at the north and south ends that are generated by the three layers of mesh contained within the slab above.

3.2.3 Further away from the concrete structures are a couple of curvilinear responses thought to relate to some form of cable at **4001** and **4002**; their form in the XY trace plots appears to support this interpretation. These possible cables do not appear to be connected to anything that would suggest they are modern services. Given that some of the detonations at this target were carried out "electrically" there is a possibility that they relate to testing at the Site. They have been termed possible archaeology to reflect the uncertainty in their interpretation and their possible relation to the tests carried out at the structure.

3.2.4 There is a line of strong positive anomalies north of **4003** that appears to join up with the possible cable at **4002**. This line differs from the cable as it is not a continuous linear positive anomaly but is interrupted along its length. It is unclear whether this line of responses is related to the possible cable but they have been interpreted as possible archaeology.

3.2.5 There are three sub-oval positive anomalies at **4004** to **4006**; all three have strong magnetic values over +10nT but all three also have curved profiles in the XY trace plots. It is not clear whether these anomalies represent pits or deeply buried ferrous objects and all three anomalies have been interpreted as increased magnetic response to reflect this uncertainty. The remaining broad spreads interpreted as increased magnetic response such as the example around **4007** are very different in form to those discussed above and represent concentrated areas of numerous small ferrous/ceramic responses rather than single features.

3.2.6 There are numerous weak trends running through the data such as those around **4008**; these trends are aligned parallel and may either represent agricultural features such as ploughing scars or may be scars from the movement of earth on site during the construction and covering of the target. There are curvilinear trends running across the data; it is less clear what these anomalies may relate to.

3.2.7 The remaining anomalies are small sub-oval and sub-circular in shape with positive magnetic values. These anomalies may represent either geological or archaeological features and some could even represent data spikes and unusual ferrous responses. As there is no significant patterning in their spatial distribution it is not possible to interpret these as anything more than possible archaeology.

3.3 Phase 1: Earth Resistance Survey Results and Interpretation

3.3.1 The earth resistance survey revealed very little of the concrete structure with only low resistance values obtained from the exposed edges of the concrete slab around **5000**. The values around here were low and this may have been caused by exposed steel reinforcement close the edges. These low areas have been interpreted as archaeology. Nothing was detected relating to the supporting walls and no significant variation was observed across the top of the slab that could be linked to bomb damage.

3.3.2 There are low resistance values near the base of the slope at **5001** and **5002**; these anomalies are considered to be caused by the change in topography rather than the presence of an archaeological feature. The reason why low values occur near the base of slope is that the current density at the change in relief is less as there is a greater volume of soil at this point for the current to spread into.

3.3.3 A linear low resistance anomaly was detected at **5003** and **5004** and corresponds to a line target that was previously detected from LiDAR data. This target was marked out using chalk and this may explain the lower resistance values as the chalk may have held a higher amount of water than the surrounding soil. The best defined areas are classed as archaeology and the intermittent areas have been classed as probable and possible archaeology.

3.3.4 There are a few weak linear trends scattered throughout the data such as the example at **5005**. It is unclear what these anomalies may relate to as some may prove to be agricultural whereas others may be archaeological.

3.3.5 There are high and low resistance anomalies spread throughout the data such as **5006** and **5007**. These anomalies are considered to be of uncertain origin as most do not correlate with observed crater locations.

3.3.6 There are wide spreads of slight high resistance readings with the largest located around **5008**. These areas are considered to be geological given their broad spreads, weak values and diffuse irregular form in plan.

3.4 Phase 1: Earth Resistance Tomography and Ground Penetrating Radar Pilot Survey

3.4.1 Test transects of ERT and GPR data was collected across the mound to see if these techniques were worth pursuing through to Phase 2 (**Figure 7**).

3.4.2 A test transect of ERT was collected using 128 electrodes at a separation of 1m using the Wenner alpha array. The data was inverted using the standard settings of Res2Dinv. The results showed the concrete structure as a low resistivity anomaly with some high resistance regions suggesting some possible internal structure. The data collection was limited by the speed the Tigre to log readings which limited the depth of the test transect to 14 levels that day. As a result of this preliminary test it was decided to carry out a gridded ERT survey covering the entire mound with 30 transects of ERT data spaced 2m apart. Each transect was set to use 64 electrodes spaced 1.5m apart using the Wenner alpha array.

3.4.3 The test GPR transect revealed a number of reflections on the top of the mound that looked like they might show some structure or patterns of damage. Based on this assessment it was decided to carry out a gridded GPR survey on the top of the mound only as part of Phase 2 of the survey.

3.5 Phase 2: Earth Resistivity Tomography Survey Results and Interpretation

3.5.1 The 2D and 3D inversion results seem to show that fine detail is only visible in the top three metres (**Figures 8** to **10**). This top three metres seems to show patterns in resistivity that corresponds closely with the patterns of damage recorded in the MoHS documents. Below this shallow depth the structure is visible as a uniform spread of low resistivity values barely over 0.2Ω·m. The loss in resolution with depth is possibly a combination of the electrode separations at these depths, the array used and the construction materials used. The data was processed using a number of variations of the inversion settings, none of which helped to resolve internal details.

3.5.2 The least-squares inversion process used appears to smooth out small scale detail. No way was found to prevent this loss of small scale detail that included weak vertical linear anomalies observed in the same position in adjacent traverses. This smoothing of weak variations in the measured values could have resulted in the inability to detect internal walls.

3.5.3 The linear target observed in the earth resistance data is also visible in the ERT pseudo-slices as an area of low resistivity at **5009** and **5010**. The slab shows as a low resistivity anomaly that is slightly smaller than the actual concrete feature. This low rectangular area is flanked by two linear high resistivity features at **5011** and **5012**; these anomalies may possibly relate to the 3ft 3in end walls here but may also be topographic effects and have been classed as possible archaeology to reflect this uncertainty.

3.5.4 Although it was not possible to detect all supporting walls it seems as though the data collected nearest the surface reveals a variation in resistivity across the slab that broadly correlates with the recorded bomb damage. The 3D inversion pseudo-slices show that the open east and west sides of the structure have lower resistivity values with a broader area of low values along the western side that may correspond to the greater amount of bomb damage sustained on this side. In contrast the northern and southern edges have higher resistivity values that are likely to have been created by the 3ft 3in end walls underneath.

3.5.5 There is a high resistance region around **5013** that lies in the area recorded as sustaining the least damage. At the narrow electrode separations at these depths it would be expected that the intact section of concrete here would give higher resistivity values whereas the bomb damaged regions where steel mesh has been exposed and the concrete has been shattered would be lower. Where bomb damage has been extensive such as at the sites of bombs 6 and 7 where the mesh was not only exposed but has been severed in many places the values may be slightly higher as this loose mesh was removed to allow measurements of the bomb damage to be taken.

3.5.6 Overall it seems the shallow ERT results closely correspond to the recorded areas of bomb damage detailed in the MoHS reports (1943a and 1943b).

3.6 Phase 2: Ground Penetrating Radar Survey Results and Interpretation

3.6.1 Slice 3 (9.90 ns to 21.71 ns; c. 0.2m below surface): Little coherency can be seen within the GPR datasets in general and Timeslice 3 illustrates high amplitude responses throughout, e.g. **3000**. In places, trends appear to define varying amplitudes of response (**3001**) and localised regions of lower response can be seen around the periphery, particularly at **3002**.

3.6.2 Slice 5 (19.8 ns to 31.61 ns; c. 0.32m below surface): The typical background response is relatively low, with a marked curving region of higher response **3003** towards the southeast. A spur extends towards **3004** to the northwest, where a cluster of anomalies of somewhat elevated response are visible in a rough sub-circular arrangement; there is no direct indication that they are related however. A series of low amplitude anomalies **3005** can be seen along the extent of survey, although the origin of these is unclear.

3.6.3 Slice 8 (34.65 ns to 46.46 ns; c. 0.51m below surface): Within this timeslice, the central portion of the dataset is of generally high response, e.g. **3006**, and it is possible to see some trends within the elevated background. Towards the south, the responses become more rectilinear in form (**3007**) and it is possible that this relates to extant structural elements within the mound. Low amplitude anomalies can be seen encircling the central region, although it is considered more likely that these are a product of the contrast within the responses, rather than being associated with physical changes.

3.6.4 Slice 15 (69.30 ns to 81.11 ns; c. 0.94m below surface): A sinuous network of regions of high response can be seen throughout this timeslice, with more obvious areas of high amplitude, e.g. **3008**. However, comparison with Slice 3 shows that several of the groups of anomalies correspond directly with near-surface responses, e.g. **3009**, **3010** and **3011**. It is considered likely that ringing within the profile dominates the dataset at this depth, resulting in a much lower confidence that any of the anomalies identified relate to physical structure.

4 CONCLUSION

4.1.1 The four geophysical survey techniques have all identified some element of the concrete structure although it is clear the gradiometer and ERT data revealed the greatest level of detail relating to the structure of the target and patterns of damage sustained during the bombing trials.

4.1.2 The gradiometer data revealed the locations of the internal supporting walls along with parts of the end walls. It was thought the horizontal steel plates lining the clear spans might give a bigger response than the walls but it is possible that the two layers of mesh in each wall creates a bigger anomaly as they are aligned vertically. The two end walls appear to be hidden by the strong effect generated at either end of the reinforced concrete slab above. Overall the gradiometer data has been successful in revealing internal features.

4.1.3 It emerged that the ±1000nT range used for the gradiometer survey was not sufficient to identify the full range of values for the concrete structure. It may be beneficial to use a system with a wider range for future surveys but a comparison between the ±100nT and the ±1000nT range data shows there was little difference in what could be seen and use of a wider range may not result in the detection of greater structural detail.

4.1.4 The earth resistance data revealed the edge of the concrete target but very little of the structure's internal layout or the level of damage sustained to the structure. It is possible that using a wider electrode separation might give better results but this technique does not seem suited to investigate such a deep structure as the twin-probe array is better suited to the detection of shallow deposits.

4.1.5 The ERT data revealed patterns of damage and responses possibly corresponding to the thicker end walls of the target. The level of detail detected drops off at greater depth which is perhaps due to a number of factors including the array chosen, the electrode separation and the construction materials used. Despite these minor problems the ERT data from near the surface revealed some variations in the slab that appears to relate to the bomb damage recorded in the MoHS documents (MoHS 1943a and 1943b).

4.1.6 The Wenner alpha array used for the survey gives good signal strength and vertical resolution but does not give the best horizontal resolution and this resolution drops off further as the electrode separation increases. This may partially explain why internal features were not detected at greater depths but the large amount of reinforcing steel used in the construction of the structure is clearly a significant factor also. Steel has low resistivity values and therefore high conductivity values and exposed sections of steel reinforcement would carry a current very well. As the array is widened a greater volume of soil is sampled and this would include a greater amount of exposed steel; as the current passing through the ground will find the path of lowest resistance the values will inevitably fall. This may explain why a high resistance void was not detected under the slab as was expected because the conductive steel mesh surrounding the void effectively masks it.

4.1.7 The processing of the ERT data revealed that small scale detail can be lost during the inversion process no matter what parameters are applied. This was the case with a couple of transects where the inversion resulted in the loss of a clear vertical linear anomaly observed in the measured apparent resistivity pseudo-section. It may be worth looking into other inversion methods aside from the least-squares method to see if better results can be obtained.

4.1.8 The results of the GPR data were of limited use. The preliminary survey identified problems with data collection in the field, with low scrubby vegetation and standing water presenting particular challenges; whilst data were acquired along two long traverses, it was not practicable to undertake further such long lines, given the limited amount of clearance that it was possible to undertake over the mound. The second phase of survey was confined to a rectangular area over the top of the mound.

4.1.9 Analysis of the data indicate strong variability throughout the timeslices; comparison with the radargrams shows a strong change in the data at c. 75 ns, where clear horizontal banding visible, persisting to c. 120 ns with instrumental noise seen within the lowest parts of the dataset.

4.1.10 The strong undulating reflector seen in all radargrams at between 30 ns to 40 ns is likely to be associated with the construction of the upper slab. Reinforcing mesh was documented to have been installed 2”, 30” and 70” below the top of the slab (0.05m, 0.76m and 1.78m respectively); given the earth currently covering the slab, it is likely that this anomaly relates to the interface between concrete and soil. It is interesting that there do not appear to be any hyperbolae associated with the mesh; typically steel reinforcing bars or rods produce measurable responses and it is possible that this indicates the largely degraded condition of the internal components following the decommissioning of the structure.

4.1.11 The lack of penetration through the concrete slab is likely to be associated with the effect of the reinforcing mesh and the leaching of ionic material into the rest of the structure. Photographs from inside the mound show the mesh rusted where exposed and it is likely that the overall conductivity of the concrete has been increased through the permeation of water through the structure. It would be interesting to explore whether this was a limitation of the specific GPR equipment used or whether this effect persists with dedicated, single frequency antennae.

4.1.12 It can be difficult to exactly match a geophysical anomaly to a particular structural feature but in this case the anomalies observed closely match the MoHS records of layout and damage. It may be possible to use a similar methodology to correlate other similar bombing targets to their respective research reports in cases where the records exist but cannot be linked to a target on the ground as detailed coordinates of its location are not given in the report. Provided the structures and patterns of damage are significantly unique from one another then geophysics may be helpful in identification. It should be noted that while certain techniques performed poorly or well at this Site it is not assured that they will work the same way at other sites. The size of the target and its construction methods (ascertained through a site visit) will be the bigger determining factor in the possible failure or success of a technique.

4.1.13 It should be noted that some features may produce responses that are below the detection threshold of the survey equipment used. It may therefore be the case that more archaeological features may be encountered than have been identified through geophysical survey.

5 REFERENCES

5.1 Bibliography

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5.2 Cartographic Sources

British Geological Survey (BGS) http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Soil Survey of England and Wales, 1983. Sheet 6, Soils of South East England. Ordnance Survey, Southampton.

5.3 HER Records

Hants 36791 – Ashley Walk bombing range

Hants 59497 – WWII military firing range, Ashley Walk

Hants 60387 – Line target, Ashley Walk

Hants 60388 – Observation and camera shelters, Ashley Walk

Hants 60389 – Observation and camera shelters, Ashley Walk

Hants 60390 – Dummy airfield, Ashley Walk

Hants 60392 – Sub pens, Ashley Walk

Hants 60395 – Fragmentation targets, Ashley Walk

5.4 English Heritage PastScape Records

EH222812 – Deserted settlement (Slacham/Sloden), Ashley Walk

EH222827 – Ashley Cross Hill barrow

EH661532 – Roman kilns, Pitts Wood Inclosure

APPENDIX 1: GRADIOMETER SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

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

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

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

Post-Processing

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

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

Typical data and image processing steps may include:

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

Typical displays of the data used during processing and analysis:

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

APPENDIX 2: EARTH RESISTANCE SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The earth resistance data for this project was acquired using a Geoscan Research RM15 system in the twin probe configuration. Probes are arranged at fixed separations on a horizontal bar, with the RM15 controller and MPX15 multiplexer held on a frame above the bar. The multiplexer allows a range of different measurements to be taken at each survey station, depending on the requirements of the survey. Common configurations include arrays of expanding width and arrays arranged side-by-side. The twin probe array comprises a pair of remote probes set at a location outside the survey area, connected to the controller by electrical cable, and one or more pairs of mobile probes.

Readings are taken by injecting an electrical current into the ground and measuring the resistance of the ground within the path the current takes. The electrical resistance of the earth is dependent partly upon the chemical and geological composition of the soils but also largely upon the soil moisture content; for instance wet, briny environments will typically exhibit low electrical resistance, whereas dry sands will exhibit high resistance. Where ditches and pits are present, soil moisture content is likely to be higher within their fills, hence their appearance as low resistance anomalies. Walls, porous fills and voids are likely to be better drained than the surrounding material and are therefore generally high resistance anomalies.

The separation of the mobile probes is chosen depending upon the likely depth of investigation, with wider separations allowing the current to travel deeper into the ground at the expense of horizontal resolution. A separation of 0.5m is a common compromise, allowing good horizontal resolution whilst allowing depth penetration of approximately 0.7m, depending upon ground conditions.

Typical earth resistance surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 1m intervals along traverses spaced 1m apart. These strategies give 400 or 900 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.25m intervals along traverses spaced up to 0.25m apart, although the increase in sample density is directly proportional to the time taken to complete the survey.

Post-Processing

The earth resistance data collected during the detail survey are downloaded from the Geoscan Research RM15 system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

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

Typical data and image processing steps may include:

- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data);
- Grid Match – Each time the remote probes are moved, e.g. between grids or on different days, systematic offsets will be introduced through the change in resistance at the new location. Whilst efforts are made to minimise this in the field, small mismatches can be corrected by setting the statistical mean of any given grid to that of one of its neighbours.

Typical displays of the data used during processing and analysis:

- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 3: ERT SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The Earth Resistivity Tomography (ERT) data was acquired using a Campus Tigre system that gives the option of collecting data using 32, 64, 96 and 128 electrodes. The system uses four of these electrodes at a time to measure one reading and by varying the position and separation of the four electrodes used the position along transect and the depth of the reading can be controlled. A laptop running the ImagerPro 2006 software is used to log the readings of all available configurations of the electrodes used according to the parameters selected by the user.

Readings are taken by passing an electrical current through the ground and measuring the resistivity of the ground within the path the current takes. The electrical resistivity of the earth is dependent partly upon the chemical and geological composition of the soils and the geometry of the electrode array used but also largely upon the soil moisture content. Wet, briny environments will typically exhibit low electrical resistivity, whereas dry sands will exhibit high resistivity. Very low resistivity values can also be obtained where a large conductive structure such as a steel pipe or a reinforced concrete structure is present.

Typical ERT surveys consist of the collection of a series of linear transects with electrodes spaced at regular intervals along the line. The type of array, the number of electrodes used and the separation between them dictates the maximum depth of investigation of the survey. The particular array used is determined by the particular application and requirements of the site. If transects are collected on a regular grid the individual 2D transects can be combined and processed to give a 3D output although it is recommended that 3D ERT data is collected from a grid of electrodes using appropriate equipment rather than collecting individual 2D transects.

A number of standard arrays are available for use in an ERT survey and these include Wenner alpha, Wenner beta, Wenner gamma, dipole-dipole, Wenner-Schlumberger, pole-pole and pole-dipole. The array selection is important as the array chosen can dictate the form of the anomaly in the data, signal strength, the depth of investigation, horizontal data coverage and the sensitivity of the array to vertical and horizontal changes in the subsurface resistivity. For full 3D surveys the use of either the pole-pole, pole-dipole or dipole-dipole arrays is recommended as other arrays have poorer data coverage near the edges of the survey grid. It should be noted that it is possible to use other arrays for 3D surveys.

The Wenner alpha array is most commonly used by Wessex Archaeology as it is a robust array that is sensitive to vertical changes in the subsurface resistivity and has the highest signal strength compared to the other main arrays. The one drawback to this array that it is less sensitive to horizontal changes and this sensitivity drops as the electrode separation is increased.

Post-Processing

The ERT data collected during the survey are downloaded from the ERT system using ImagerPro 2006 and are processed and analysed using commercial software (Res2Dinv and Res3Dinv). This software allows for the inversion of the collected 2D transects in isolation and the inversion of several 2D transects collected in a regular grid at the same time. The software uses the least-squares and smoothness-constrained least-squared inversion methods and the parameters of the particular inversion can be altered to better suit the data being processed and can also incorporate topographic data during the inversion process. The inversion process creates a model and calculates the resistivity values that would be recorded over it from this model. By comparing the model data with the field data an error value can be calculated and the software goes through a number of iterations to minimise this error by altering the pseudo-section.

Typical inversion parameters that may be altered include:

- Robust inversion – This option is typically used where sharp boundaries exist between subsurface bodies that would be smeared by the standard least-squares inversion method. The robust model constrain inversion method minimises the absolute changes in the resistivity values producing models with sharp interfaces;
- Smoothing of model resistivity values – This is used for particularly noisy data sets where the smoothness constraint used in the standard least-squares inversion method is not sufficient on its own.

Typical displays of the data used during processing and analysis:

- 3D Output – Outputs of 3D models generated in the Rockworks software package;
- 2D Vertical Pseudo-Section – Presents each ERT transect in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. Topography data can displayed along with the inverted data. The varying resistivity is expressed using a colour scale;
- 2D Horizontal Pseudo-Slice – Presents the data as a series of successive plan views of the variation in resistivity from the surface to the deepest inversion layer. The variation in resistivity is represented using a colour scale.

APPENDIX 4: GPR SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The ground penetrating radar (GPR) data were collected using a cart-based dual-frequency GPR system (Radarteam Cobra); this system can collect frequencies ranging from 100MHz to 900MHz. This configuration consists of the antenna sat in between the four wheels of the cart, one of which has an odometer attached to measure distance travelled. The combined viewer and data logger unit is affixed to the top of the handle.

The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivity (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration c. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

The GPR beam is conical in shape and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

The vertical resolution is similarly dependent upon the central frequency; for the 300MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

GPR data for detailed surveys are collected along traverses of varying length separated by 0.5m with cross lines collected running perpendicular to these traverses at wider separations. The data sampling resolution is governed by the data logger and a minimum separation of 0.05m between traces is collected for all surveys.

Post-Processing

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

Typical data and image processing steps may include:

- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background. A wobble correction is also applied during this step;
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.

Typical displays of the data used during processing and analysis:

- Timeslice – Presents the data as a series of successive plan views of the variation of reflector energy from the surface to the deepest recorded response. The variation in amplitude is represented using a colour scale with red indicating high amplitude and blue indicating low amplitude responses;
- Radargram – Presents each radar profile in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. The amplitude variation is expressed using a greyscale.

APPENDIX 5: GEOPHYSICAL INTERPRETATION

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

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

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

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

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

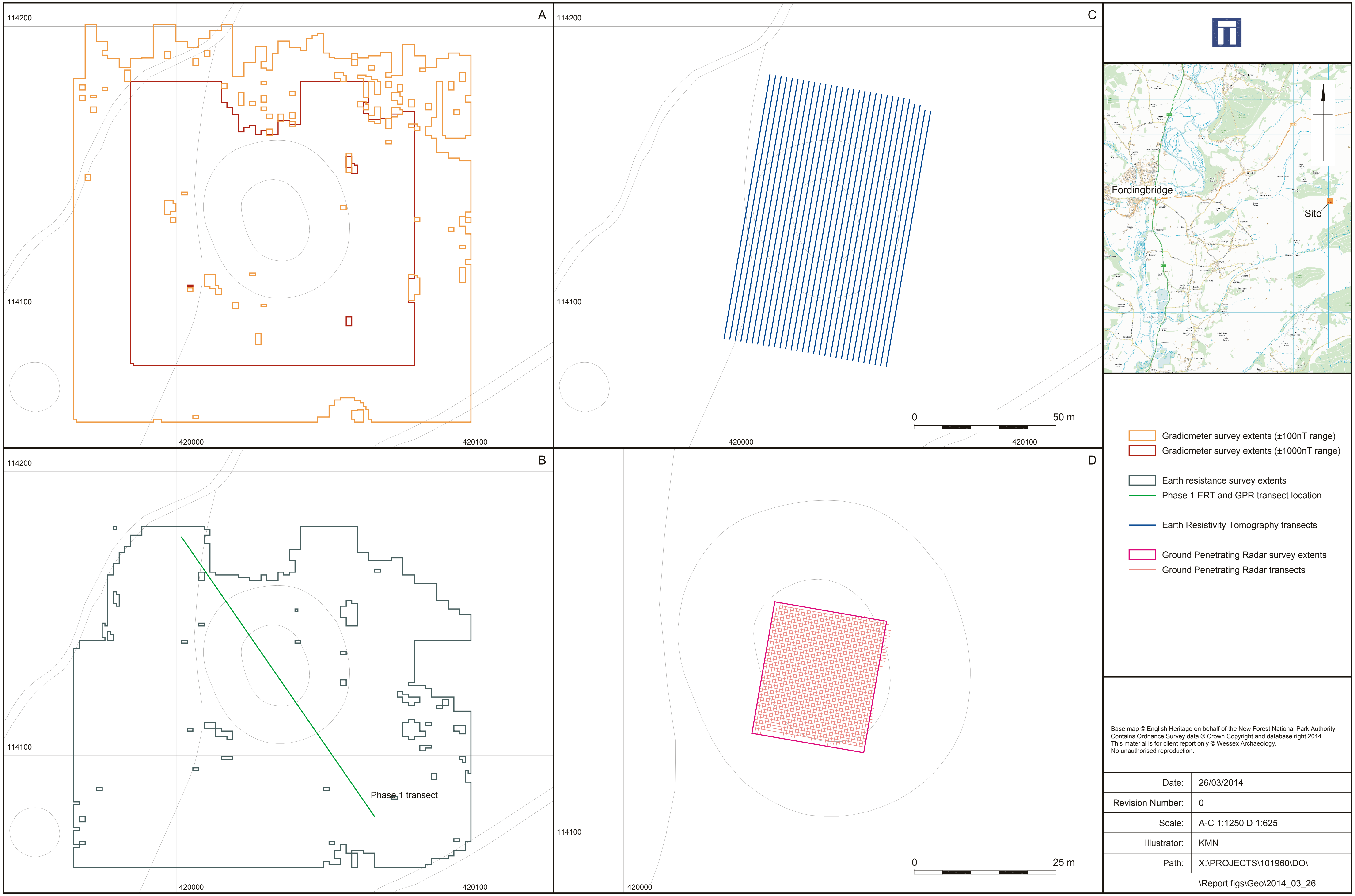
The agricultural category is for clear features that are likely to relate to recent farming activity:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping;
- Agricultural ditches – used for ditch sections that are aligned parallel to existing boundaries and former field boundaries that are not considered to be of archaeological significance;
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow;
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries;
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses. These drains can also be defined as ditches where a clear herringbone pattern can be discerned.

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

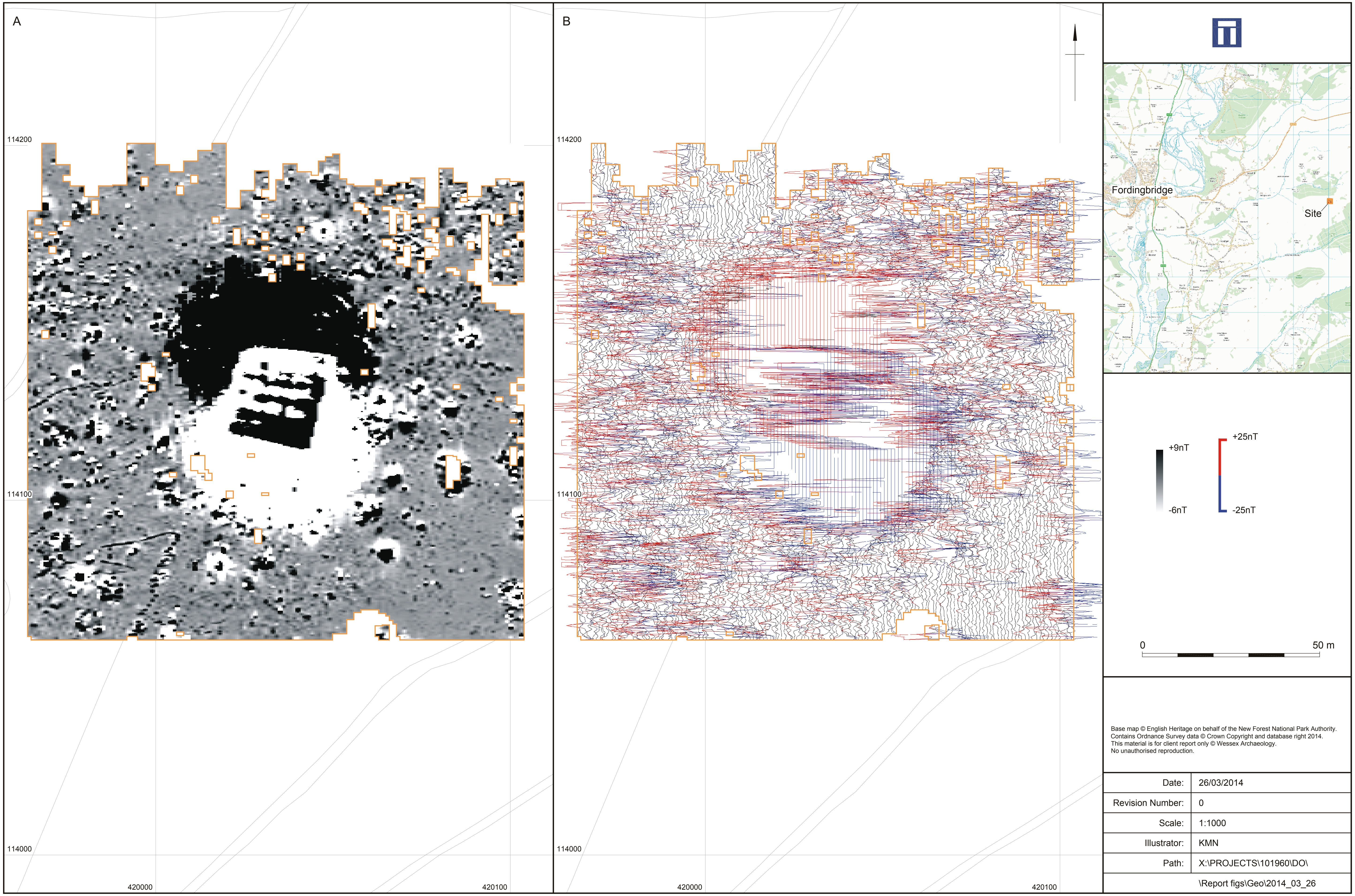
- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential;
- Trend – used for low amplitude or indistinct linear anomalies;
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They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

Apart from the categories particular to gradiometer data (Ferrous and Increased magnetic response) all categories listed above are utilised where relevant for the interpretation of earth resistance and Ground Penetrating Radar (GPR) data. Uncertain categories such as high or low amplitude response and high or low resistance anomaly may be added but these are purely geophysical interpretations describing the anomaly, they make no comment on their archaeological significance.



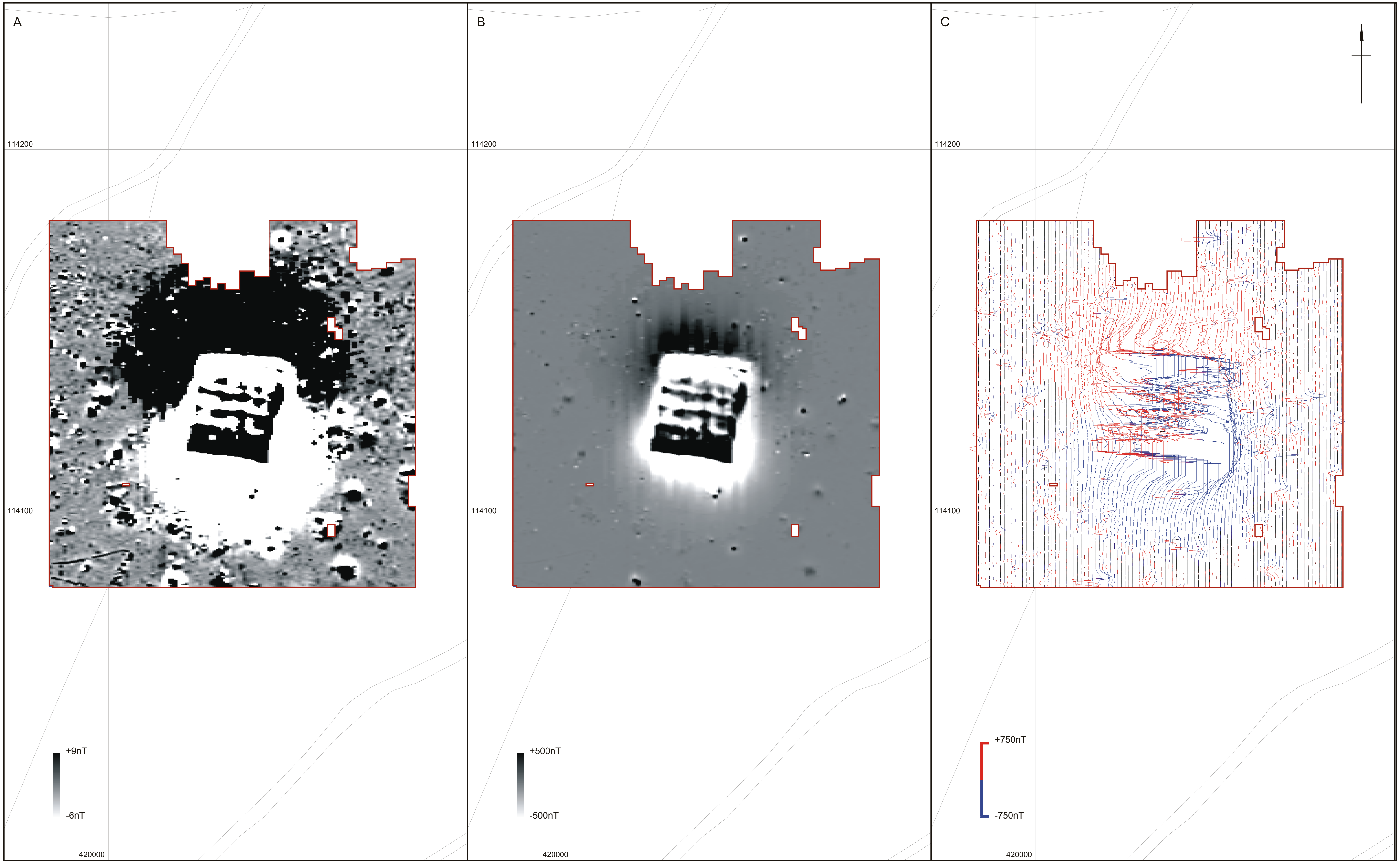
Site location map and survey extents

Figure 1



Narrow range gradiometer data (±100nT), greyscale and XY trace plot

Figure 2



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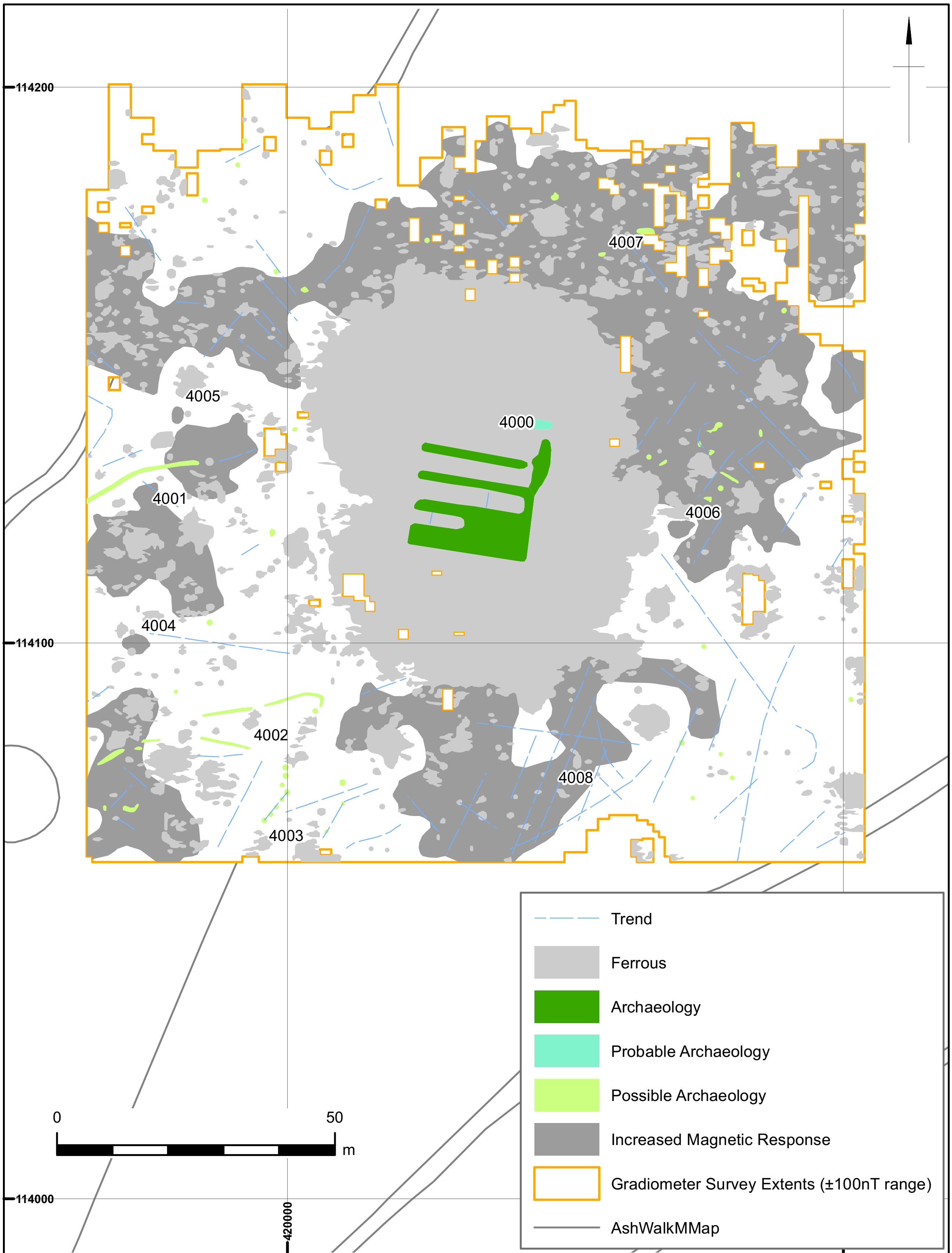
Wide range gradiometer data (±1000nT), greyscales and XY trace plot

Figure 3



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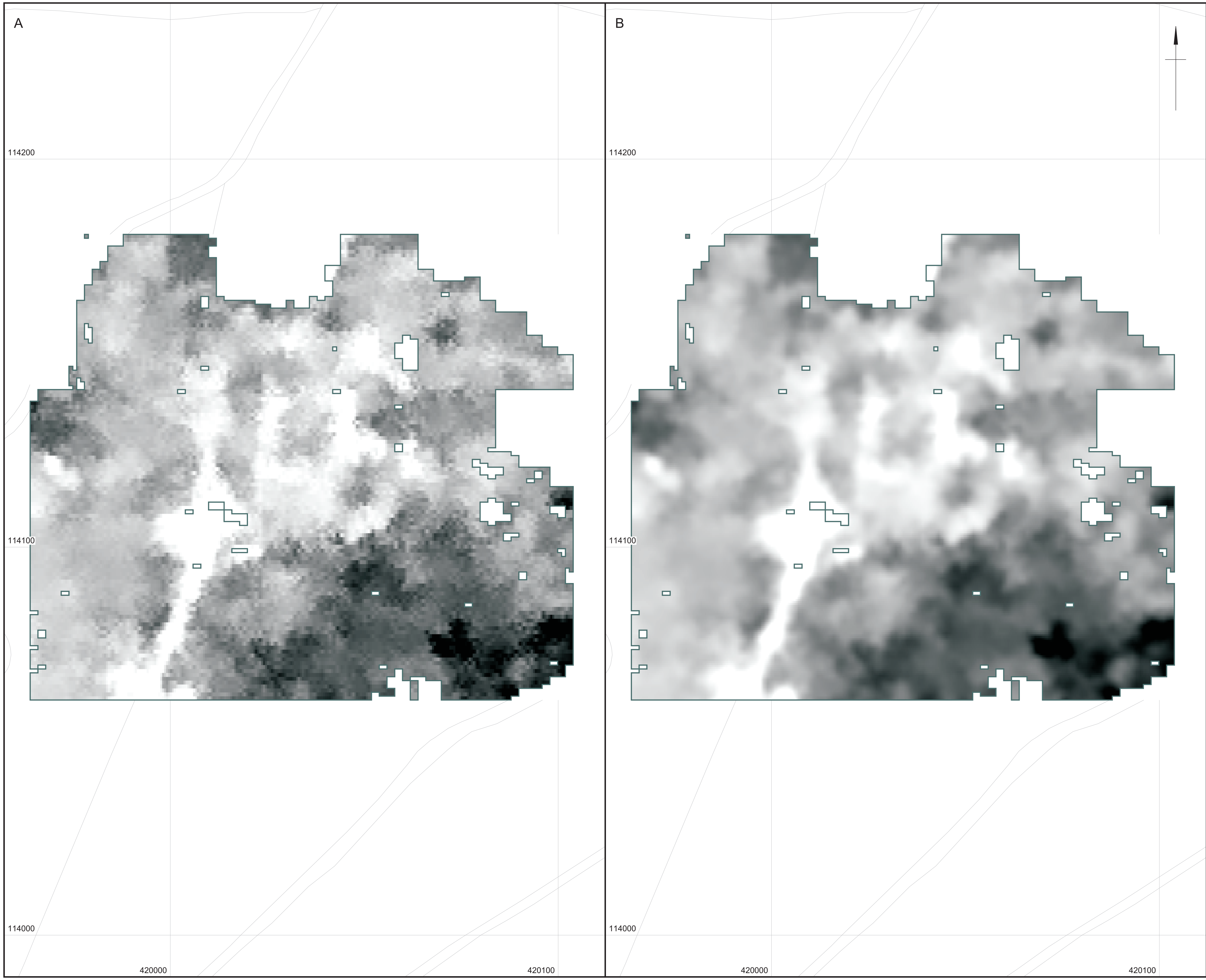
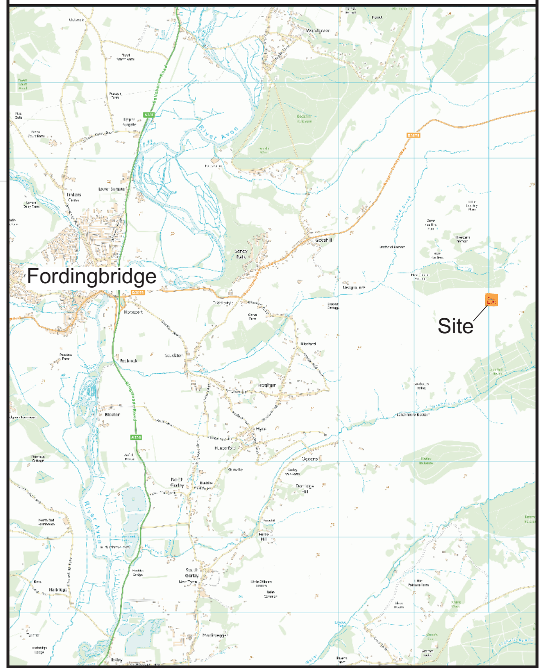
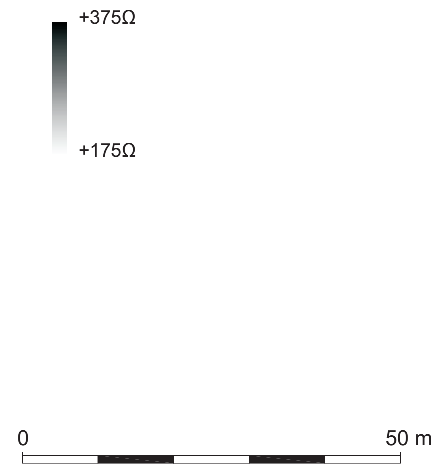
Gradiometer survey interpretation

Figure 4







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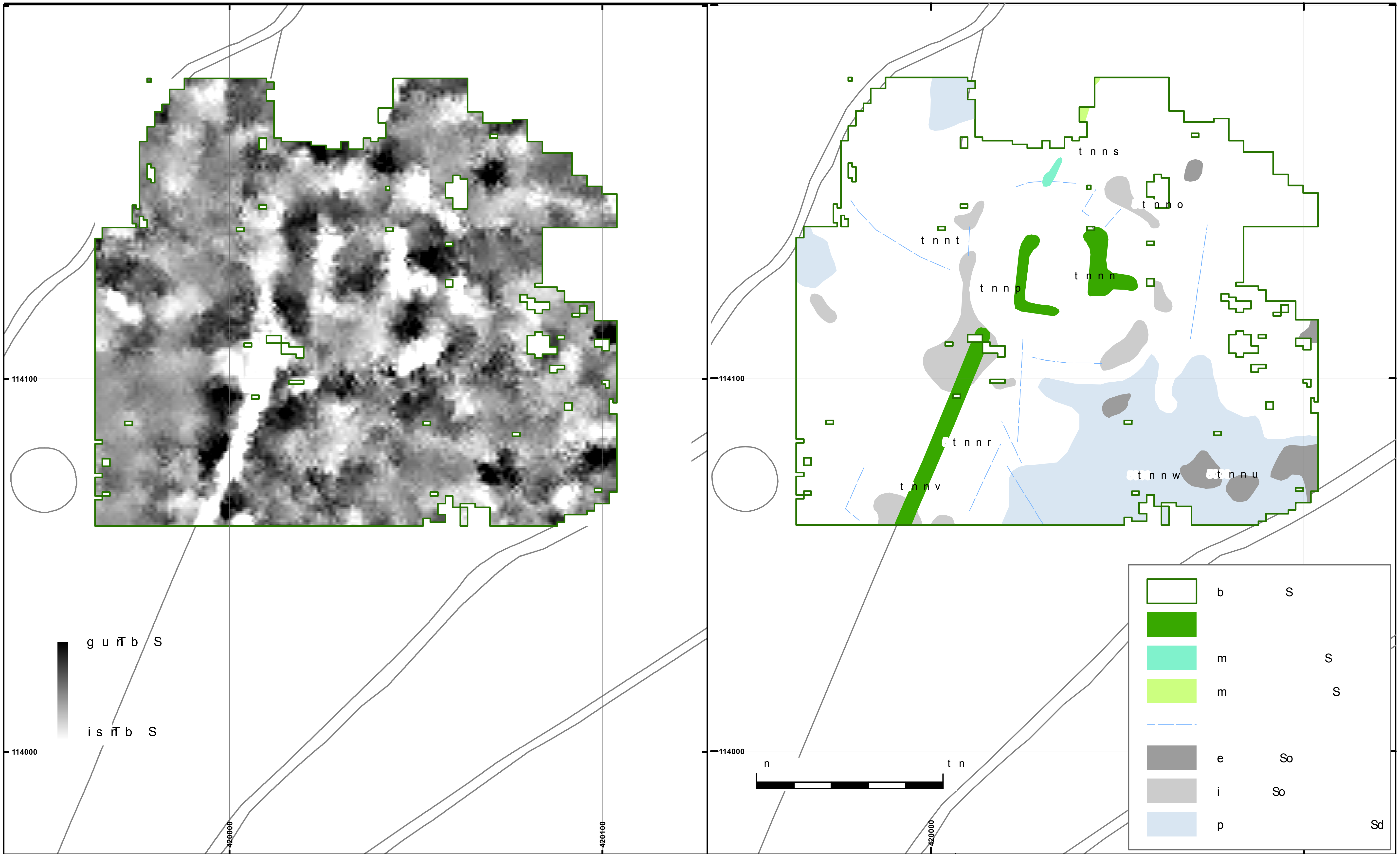
Minimally processed and low-pass filtered earth resistance greyscales

Figure 5



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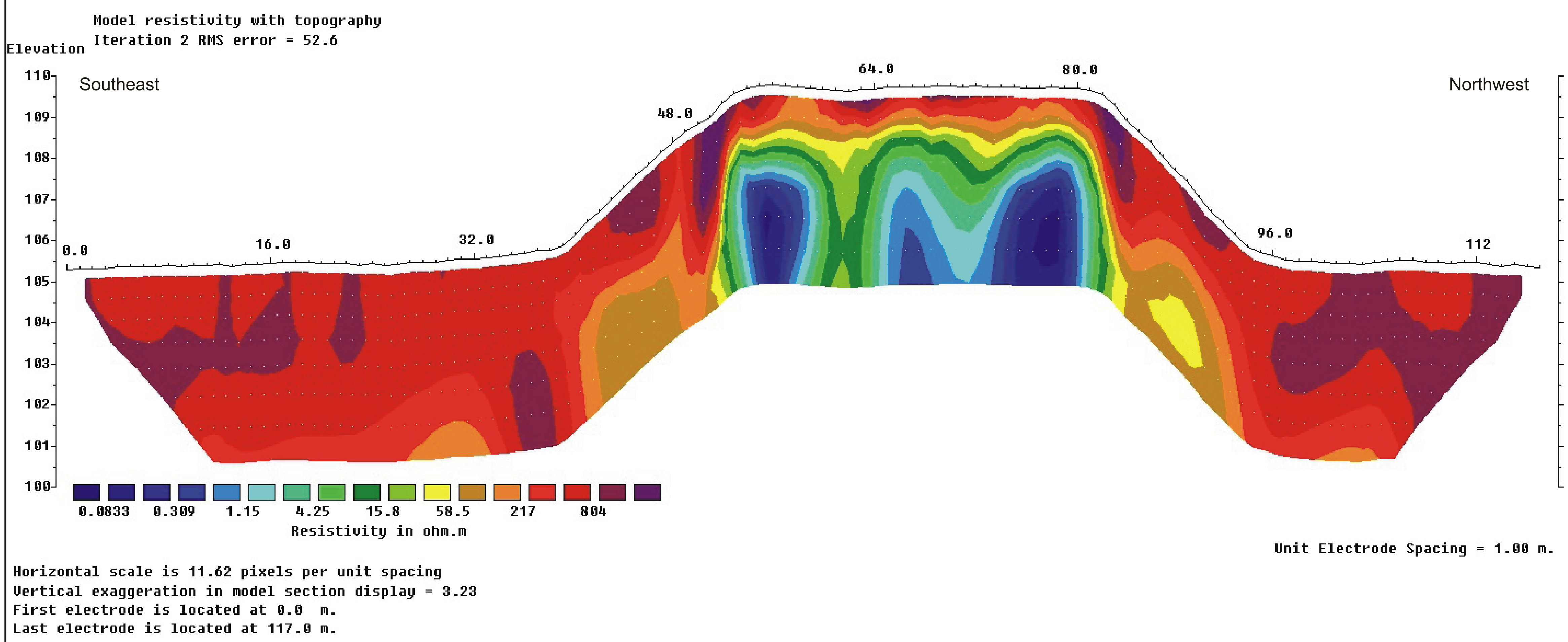
A



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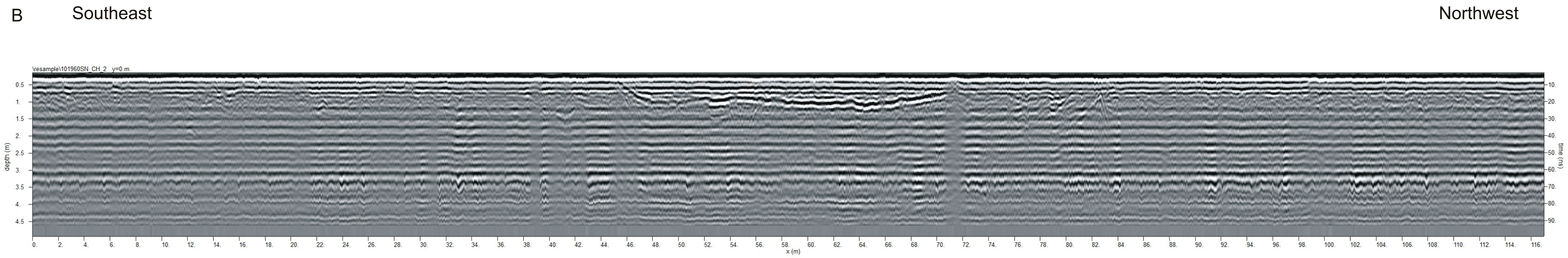

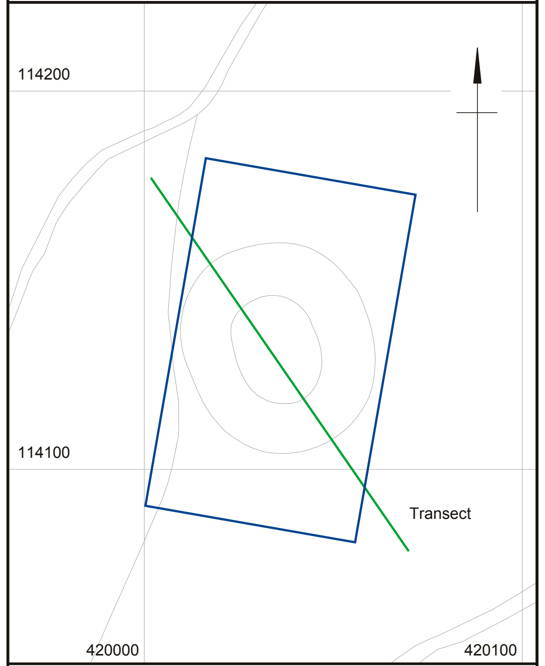

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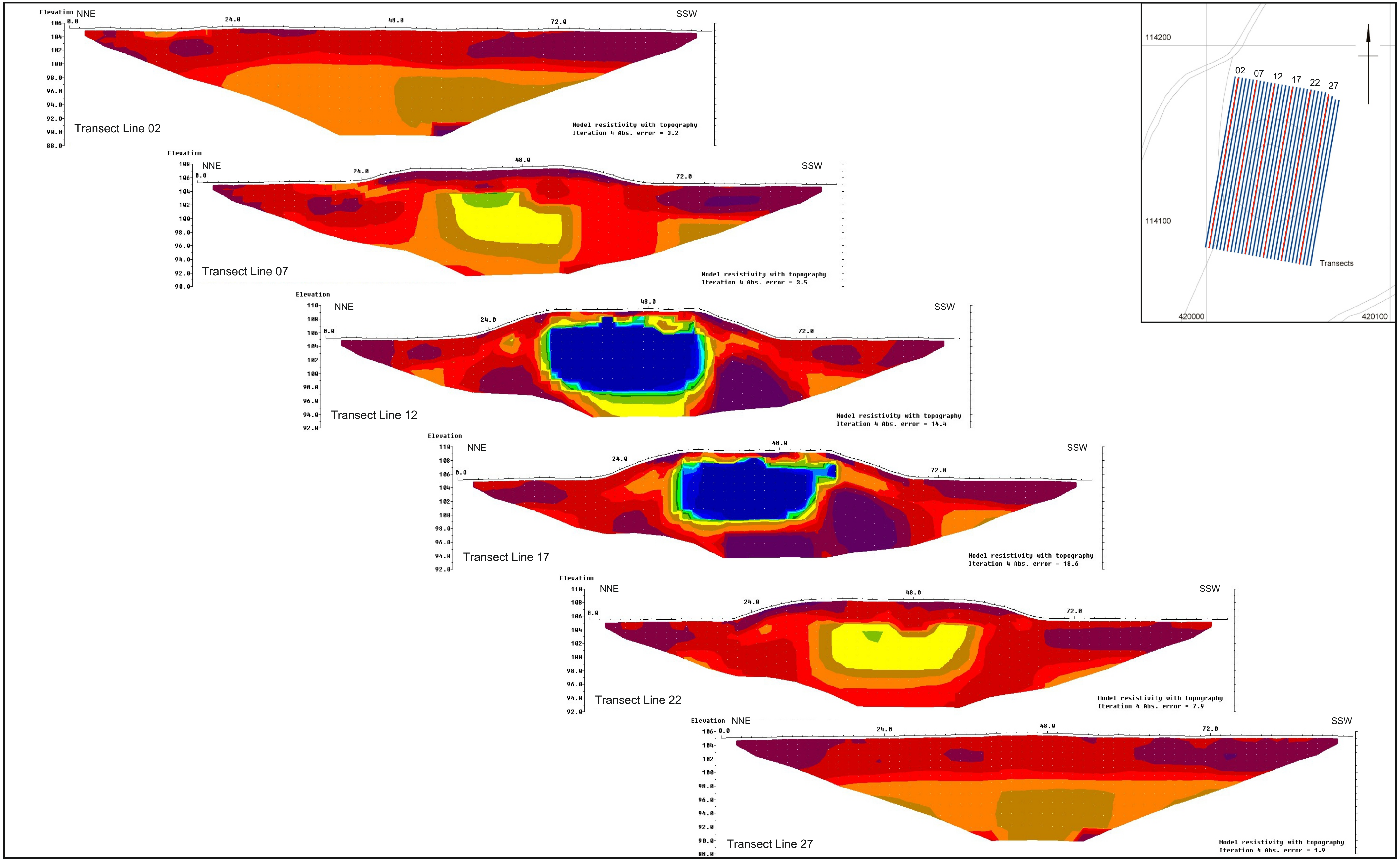
Phase 1 Earth Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) profiles

Figure 7



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Horizontal scale is 21.50 pixels per unit spacing
Vertical exaggeration in model section display = 1.00
First electrode is located at 0.0 m.
Last electrode is located at 94.5 m.

0.00 2.00 4.00 6.00 10.0 40.0 160 640
Resistivity in ohm.m

Unit Electrode Spacing = 1.50 m.

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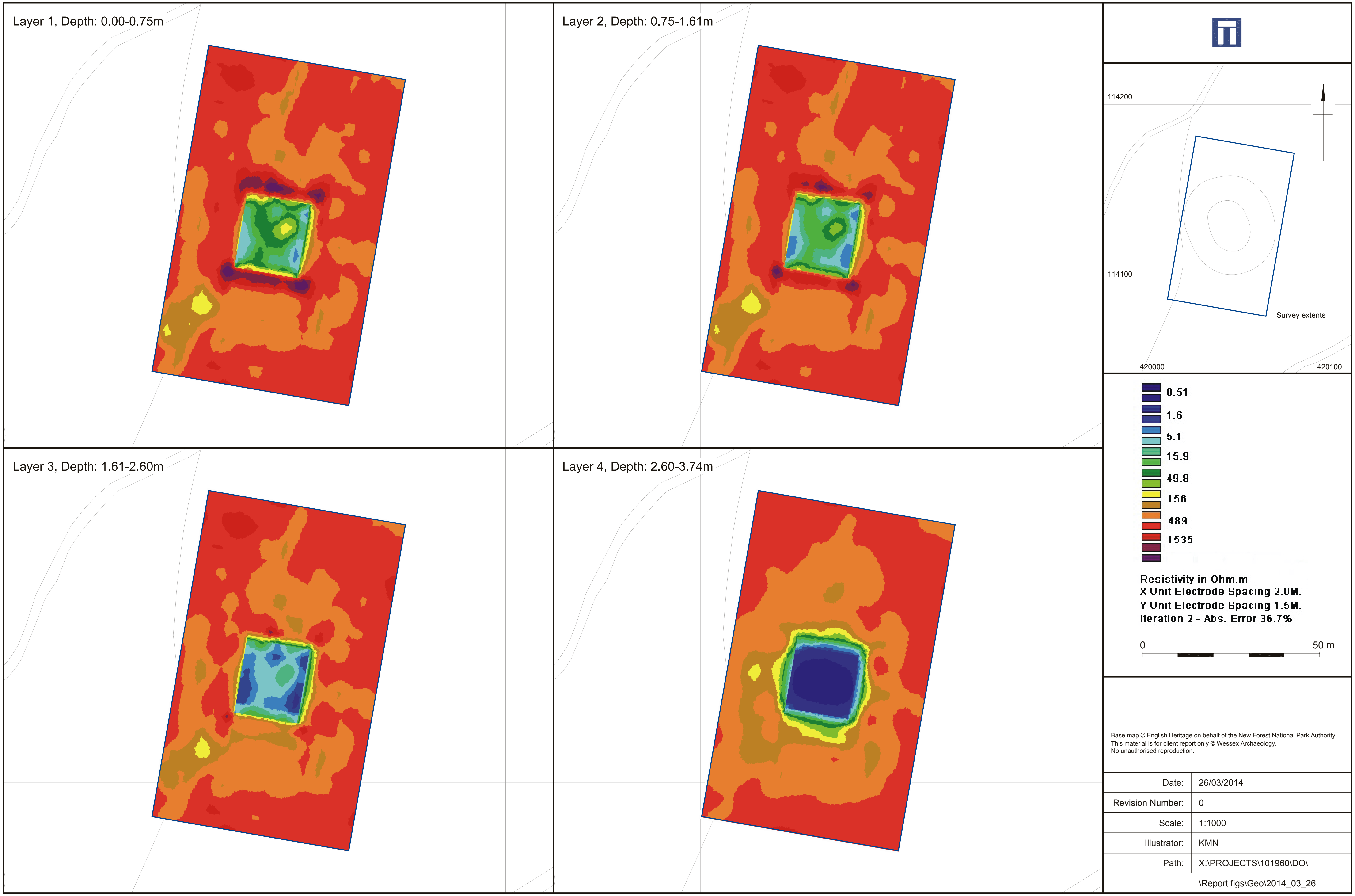
Selected 2D Earth Resistivity Tomography (ERT) transects

Figure 8



Earth Resistivity Tomography (ERT) pseudo-slices

Figure 9

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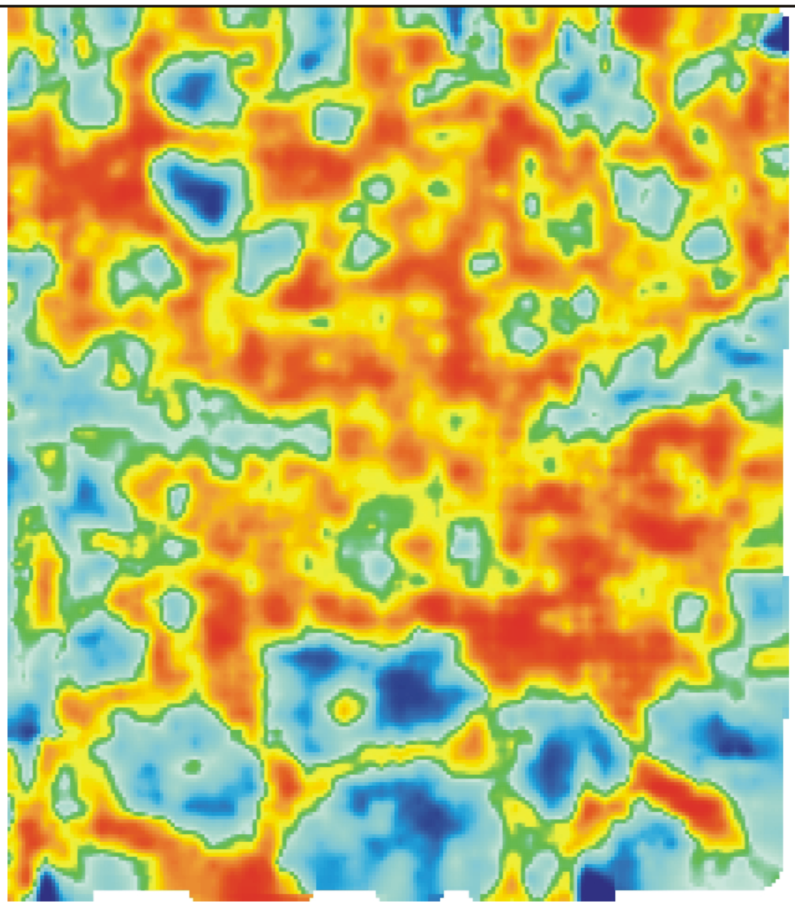
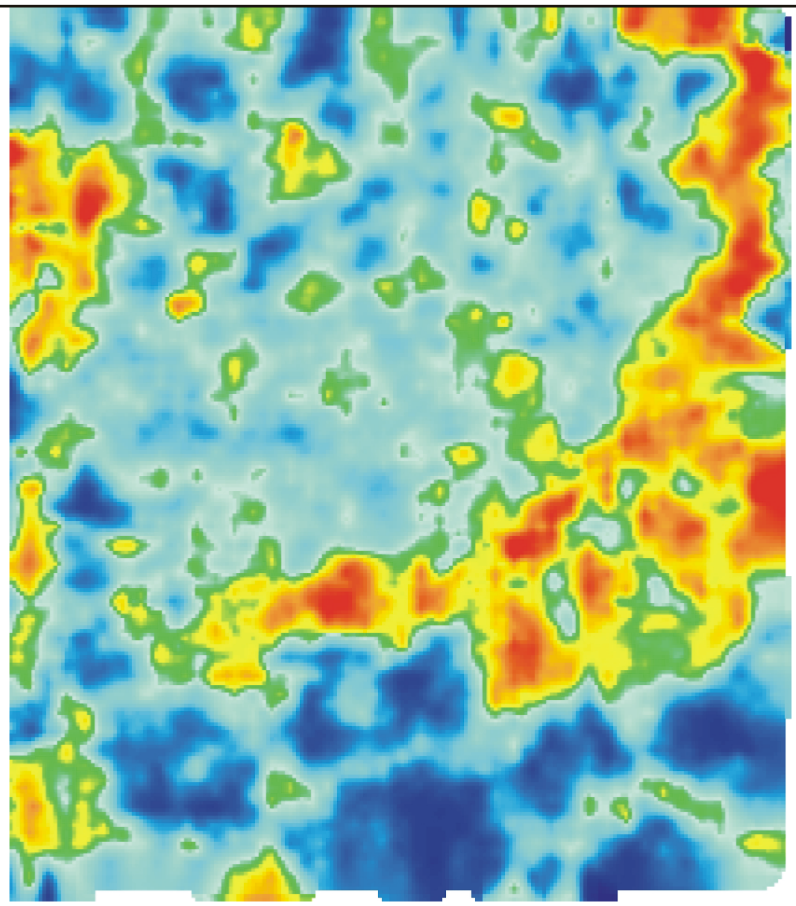
Earth Resistivity Tomography (ERT) interpretation

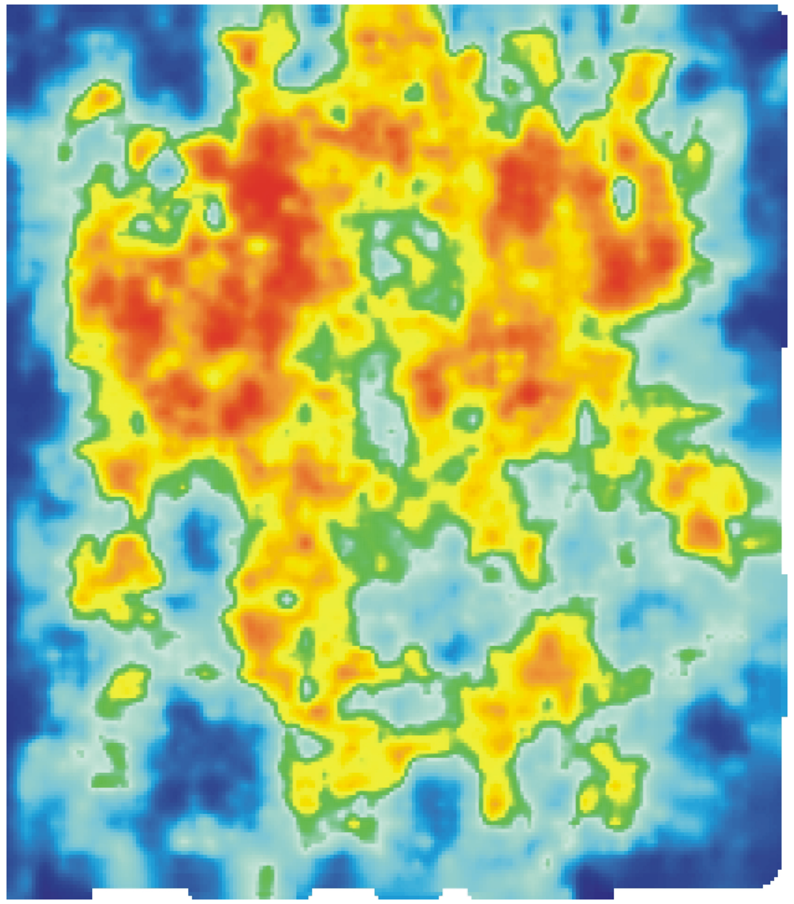
Figure 10



Timeslice 3



Timeslice 5



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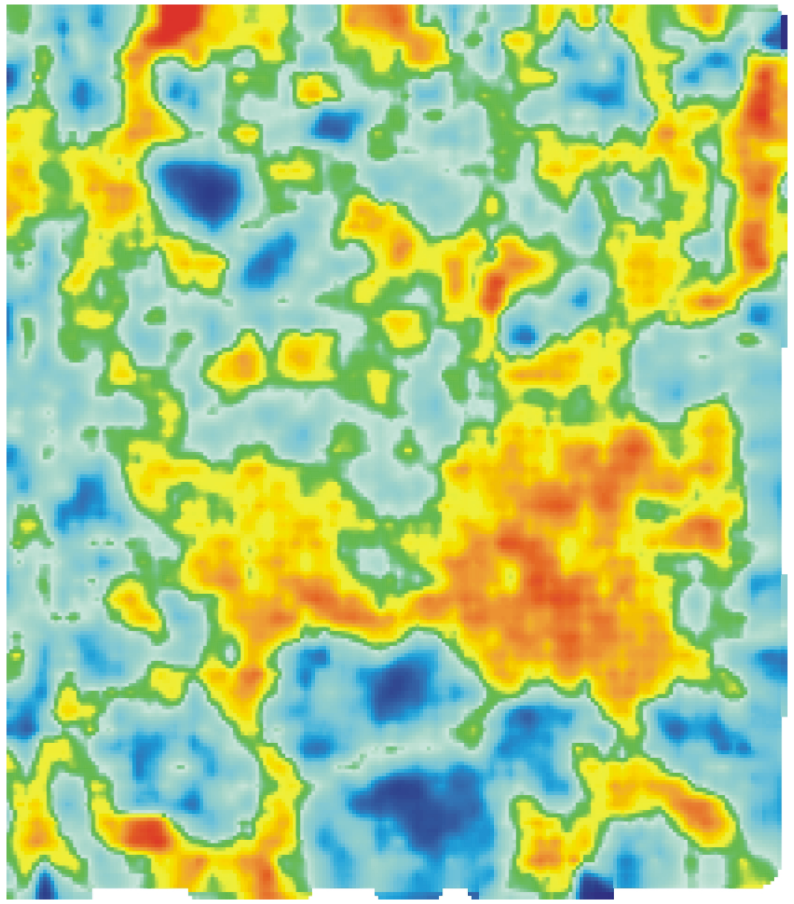

Timeslice 15

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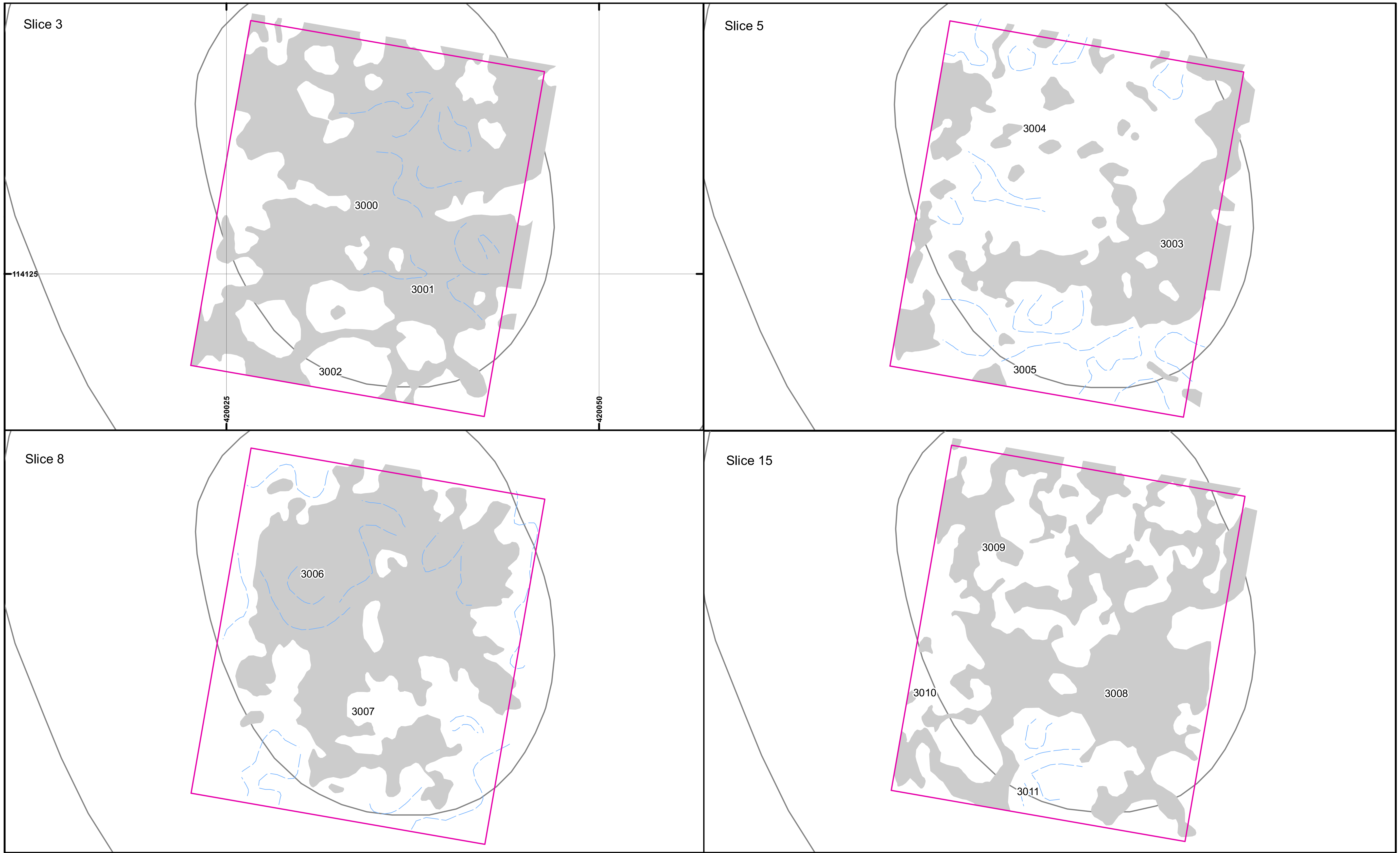
Ground Penetrating Radar: Selected Timeslices

Figure 11



0 10 m

GPRextents

Trend

High Amplitude Response

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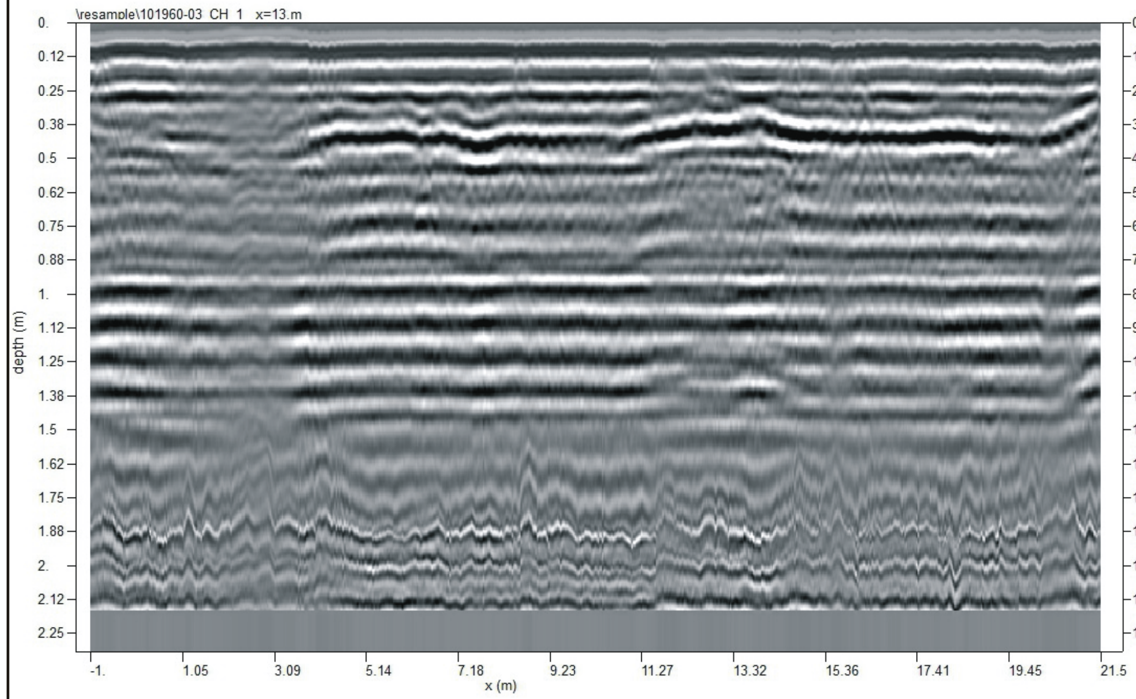
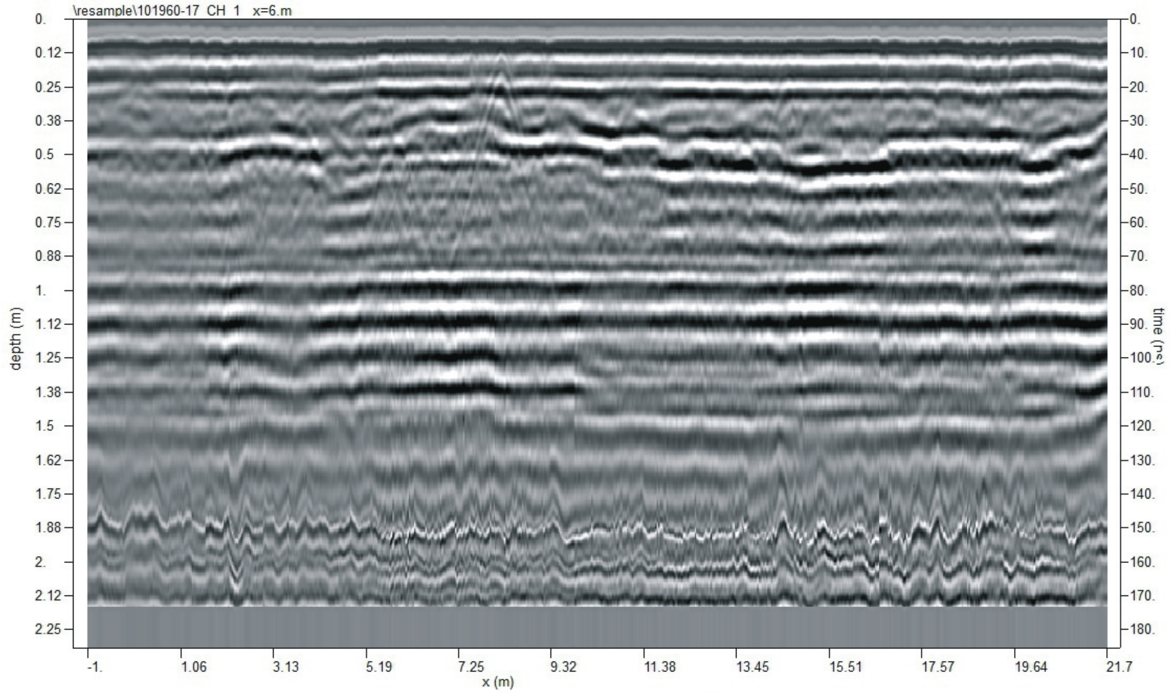
Ground Penetrating Radar: Selected Interpretations

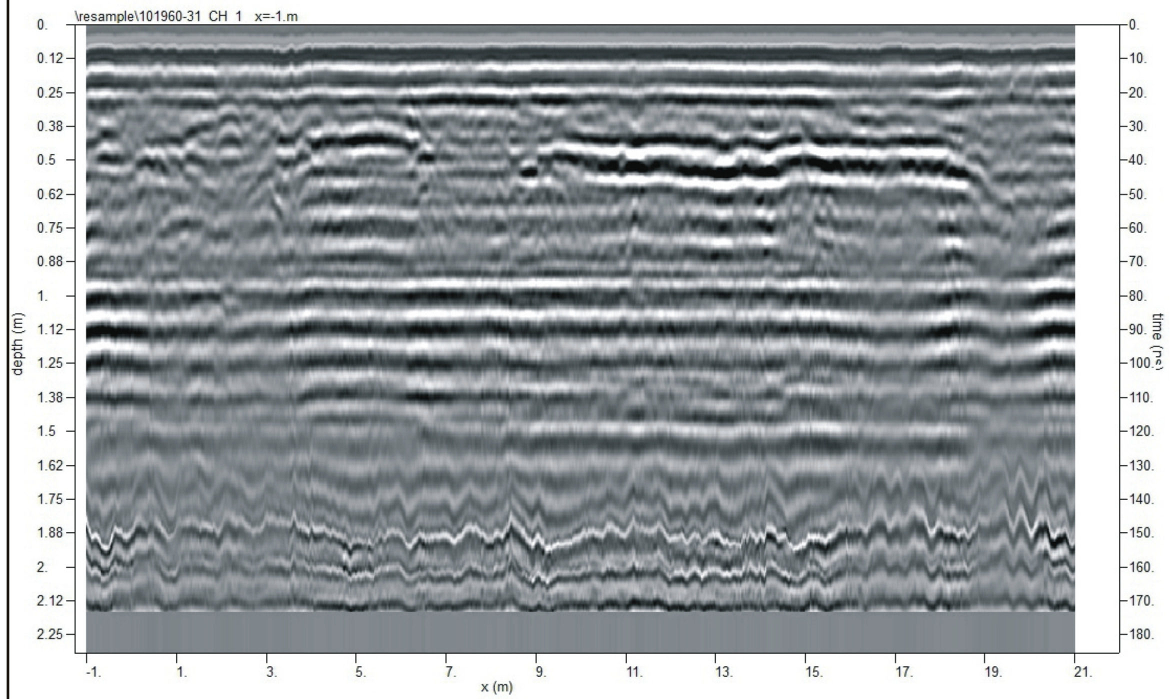
Figure 12



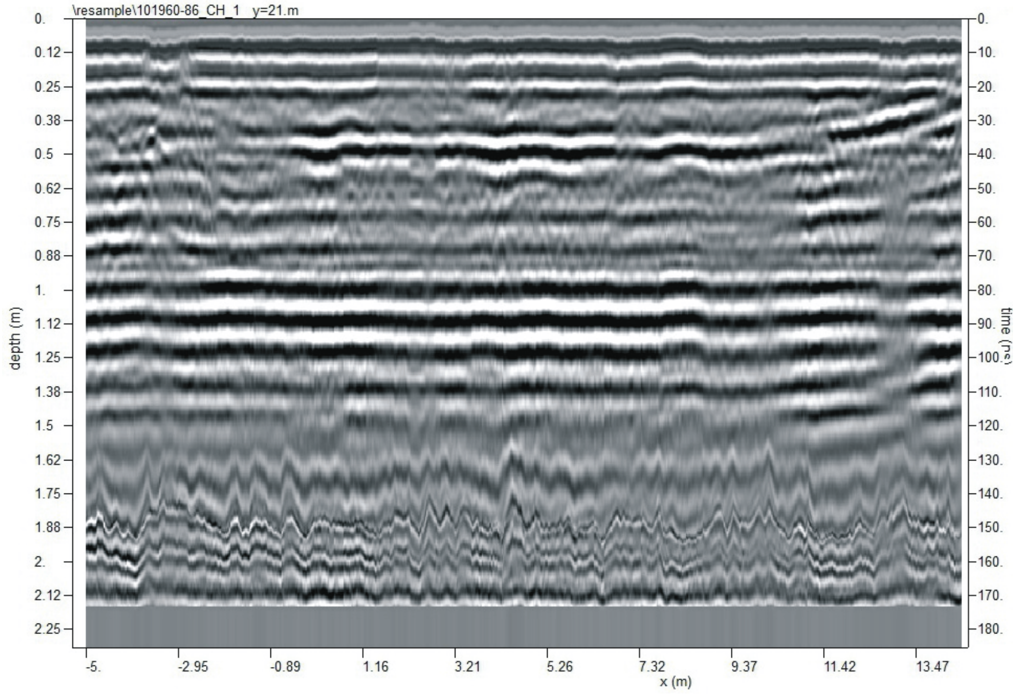
Profile 3



Profile 17



Profile 31



Profile 86

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Ground Penetrating Radar: Selected Radargrams

Figure 13

salisbury rochester sheffield edinburgh

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