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Geophysics

Bossington, Hampshire
Report on Geophysical Survey, February 2015

Neil Linford, Paul Linford and Andrew Payne

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SUMMARY
Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted over the Mesolithic settlement at Bossington, Hampshire, to support the assessment of archives from the excavations conducted by John Evans at the site. The vehicle towed caesium magnetometer survey (9.5ha) shows modern interference from ferrous pipes and track ways across the site, together with a more indistinct geomorphological response along the edge of the raised gravel terrace. Some concentrations of ferrous litter may help identify the location of the original excavation sites. GPR survey (5.3ha) was targeted mainly on the gravel terrace and also detected the modern pipelines, tracks and a network of field drainage on the lower ground. A complex geomorphological response has also been revealed, although it is difficult to offer a more significant interpretation.

CONTRIBUTORS
The geophysical fieldwork was conducted by Neil Linford, Paul Linford and Andrew Payne.

ACKNOWLEDGEMENTS
The authors are grateful to the Bossington Estate for allowing access to the site for the survey to be conducted.

ARCHIVE LOCATION
Fort Cumberland, Portsmouth.

DATE OF SURVEY
The fieldwork was conducted between 23rd to 27th February 2015 and the report completed on 28th February 2018. The cover image shows the vehicle towed caesium magnetometer being prepared for data acquisition with the raised gravel terrace in the background.

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INTRODUCTION

Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted over the Mesolithic settlement site excavated by the late Professor John Evans between 1989 and 1996, at Bossington, near Horsebridge, Hampshire (NHRE Event 1606483). Unfortunately, the excavations were not written up before Professor Evans died and until recently no further assessment of the archive or the current state of preservation at the site had been undertaken. The current geophysical survey was requested in support of a Historic England funded project to assess the documentary, lithic, and faunal archives from the excavations (Pope *et al.* 2014, RASMIS 7028).

The aim of the geophysical survey was to map the distribution of periglacial structures across the site and to attempt to accurately locate the previous excavation trenches. These excavations revealed an assemblage of flintwork and faunal material which determined the presence of an extensive, well-preserved Mesolithic site, covering at least 2ha and set on a gravel terrace immediately adjacent to the flood plain of the river Test. Mesolithic artefacts and early Holocene fauna were concentrated within a depression some 7m across, originally interpreted as a periglacial pingo on the gravel terrace, but possibly of human construction due to the association with stakeholes indicative of structures and rich palaeoenvironmental evidence.

The site, known as Rusham's or Heike's Field, is located in the Test valley and the geology consists of a raised valley gravel terrace to the east, with alluvium deposited over Cretaceous Upper Chalk on the flood plain towards the river to the west (Geological Survey of Great Britain 1949). The local soils are of the 1024c Adventurers' 3 Association consisting of deep peat soils with associated extremely calcareous mineral soils and high groundwater levels (Soil Survey of England and Wales 1983). The ground surface consisted of grass and marginal vegetation on the floodplain with extensive surface waterlogging and heavily saturated soils. Weather conditions during the survey were predominantly wet and windy with some dryer intervals.

METHOD

Magnetometer survey

Magnetometer data were collected along the instrument swaths shown on Figure 1 using an array of six Geometrics G862 caesium vapour sensors mounted on a non-magnetic sledge (Linford *et al.* 2015). The sledge was towed behind a low-impact All-Terrain Vehicle (ATV) which housed the power supply and data logging electronics. Five sensors were mounted 0.5m apart in a linear array transverse to the direction of travel and, vertically, ~0.25m above the ground surface. The sixth was fixed 1.0m directly above the centre of this array to act as a gradient sensor. The sensors were sampled at a rate of 25Hz resulting in an along-line sample density of ~0.15m given typical ATV travel speeds of 3.5-4.0m/s. As the five non-gradient sensors were 0.5m apart, successive survey swaths were separated by approximately 2.5m to maintain a consistent traverse separation of 0.5m. Navigation and positional control were achieved using a Trimble R8 Global Navigation Satellite System (GNSS) receiver mounted on the sensor platform 1.65m in front of the central sensor and a second R8 base station receiver established using the Ordnance Survey VRS Now correction service. Sensor output and survey location were continuously monitored during acquisition to ensure data quality and minimise the risk of gaps in the coverage.

After data collection the corresponding readings from the gradient sensor were subtracted from the measurements made by the other five magnetometers to remove any transient magnetic field effects caused by the towing ATV or other nearby vehicles. The median value of each instrument traverse was then adjusted to zero by subtracting a running median value calculated over a 50m 1D window (see for instance Mauring *et al.* 2002). This operation corrects for biases added to the measurements owing to the diurnal variation of the Earth's magnetic field and any slight directional sensitivity of the sensors. A linear greyscale image of the combined magnetic data is shown superimposed over the base Ordnance Survey (OS) mapping in Figure 3 and minimally processed versions of the range truncated data ($\pm$60nT/m) are shown as a trace plot and greyscale image in Figures 6 and 7. A greyscale image of the local topography recorded by the GNSS receiver mounted on the magnetometer sledge is shown in Figure 5.

Ground Penetrating Radar survey

A 3d-Radar MkIV GeoScope Continuous Wave Step Frequency (CWSF) Ground Penetrating Radar (GPR) system was used to conduct the survey collecting data with a multi-element DXG1820 vehicle towed, ground coupled antenna array (Linford et al. 2010). A roving Trimble R8 Global Navigation Satellite System

(GNSS) receiver, together with a second R8 base station receiver established using the Ordnance Survey VRS Now correction service, was mounted on the GPR antenna array to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 2. Data were acquired at a 0.075m x 0.075m sample interval across a continuous wave stepped frequency range from 60MHz to 2.99GHz in 4MHz increments using a dwell time of 3ms. A single antenna element was monitored continuously to ensure data quality during acquisition together with automated processing software to produce real time amplitude time slice representations of the data as each successive instrument swath was recorded in the field (Linford 2013).

Post-acquisition processing involved conversion of the raw data to time-domain profiles (through a time window of 0 to 75ns), adjustment of time-zero to coincide with the true ground surface, background and noise removal, and the application of a suitable gain function to enhance late arrivals. Representative profiles from the GPR survey are shown on Figure 8. To aid visualisation amplitude time slices were created from the entire data set by averaging data within successive 2.5ns (two-way travel time) windows (e.g. Linford 2004). An average sub-surface velocity of 0.077m/ns was assumed following constant velocity tests on the data, and was used as the velocity field for the time to estimated depth conversion. Each of the resulting time slices therefore represents the variation of reflection strength through successive ~0.1m intervals from the ground surface, shown as individual greyscale images in Figures 9 and 10. A greyscale image of the time slice from between 17.5 and 20.0ns (0.7-0.8m) is also shown superimposed over the base Ordnance Survey (OS) mapping in Figure 4.Further details of both the frequency and time domain algorithms developed for processing this data can be found in Sala and Linford (2012).

Due to the size of the resultant data set a semi-automated algorithm has been employed to extract the vector outline of significant anomalies shown on Figure 12. The algorithm uses edge detection to identify bound regions followed by a morphological classification based on the size and shape of the extracted anomalies. For example, the location of possible pits is made by selecting small, sub circular anomalies from the data set (Linford and Linford 2017).

RESULTS

Magnetometer survey

A graphical summary of significant magnetic anomalies [**m1-16**] discussed in the following text superimposed on base OS map data is provided in Figure 11.

Two pipelines appear as intense anomalies [**m1**] and [**m2**] together with a less pronounced linear response [**m3**] to the causeway running across the floodplain, further ferrous disturbance also occurs to the east of the survey area along the route of the disused railway line from Southampton to Andover. Both [**m2**] and [**m3**] are also partially expressed in the local topography that shows the raised gravel terrace and traces of possible ridge and furrow to the north, abutting [**m3**] suggesting the causeway may have originated as a former ploughing headland (Figure 5). A linear depression visible in the local topography to the south west of the survey area may indicate a possible palaeochannel, running approximately parallel to the current main channel of the Test, corresponding to an indistinct magnetic response.

A linear band of intermittent anomalies [**m4**], with a magnitude between 0.9-3.0nT/m, follows the edge of the raised gravel terrace, possibly either a geomorphological response or, perhaps more tentatively, some form of archaeological activity along the wetland edge bordering the floodplain. Broader areas of disturbance [**m5**] and [**m6**] extend to the NE and SW from [**m4**], and there is a suggestion that [**m4**] continues to the south, but the response is less clear here [**m7**] due to the intense ferrous response crossing the pipeline [**m2**] and the modern field boundary.

An intense response [**m8**] is found where the causeway [**m3**] crosses [**m4**] to meet the edge of the gravel terrace and may represent either the location of the excavation or an area of burning associated with occupation activity, although a modern origin seems most likely. A cluster of smaller scale disturbance [**m9-13**] to the SE may also represent previous archaeological interventions, such as the test pits known to have been dug in this area, with one response at [**m13**] found within the pingo surface depression together with a surrounding scatter of ferrous detritus. No similar responses are found on the gravel terrace, suggesting this may well represent evidence for the location of the original excavations.

Concentrations of discrete strongly positive anomalies at [**m14**] and [**m15**] on the floodplain could, perhaps, represent either natural geomorphological responses or burnt material, although these appear to be associated with a degree of, presumably modern, ferrous detritus. A tentative rectilinear arrangement of weak parallel negative linear anomalies [**m16**] may relate to local undulations in the surface topography to the south of the gravel terrace or ground disturbance from the construction of either the pipeline or the railway.

Ground Penetrating Radar survey

A graphical summary of the significant GPR anomalies, [**gpr1-10**] discussed in the following text, superimposed on the base OS map data, is provided in Figure 12.

Despite the saturated soil conditions significant reflections have been recorded to approximately 50ns before the signal begins to become attenuated. The very near surface data shows the location of paths and the raised causeway crossing the site [**gpr1**], together with an extensive distribution of animal burrows [**gpr2**] between approximately 2.5 and 10.0ns (0.1 to 0.4m). The two pipe lines are also replicated at [**gpr3**] and [**gpr4**], with both the easement and underlying pipe showing at [**gpr3**] corresponding to the topographic and magnetic anomaly [**m2**]. Anomaly [**gpr4**] is only partially described in the data (cf [**m1**]) as it appears to run beneath uneven ground to the edge of the footpath across the site which hampered data collection, although the response to the pipe is evident between 40 and 42.5ns (1.6 to 1.7m) and in the individual profiles (Figure 8). Some local disturbance has also been encountered close to the GNSS base station radio modem, to the north east of the survey area, most evident in the deeper data.

A pattern of field drains [**gpr5**] are found to the north of the survey area between 5.0 and 25.0ns (0.1 to 1.0m). These do not appear to be either ceramic or ferrous drains as there are no corresponding magnetic anomalies, although this area is heavily disturbed by the ferrous pipe [**m1**] which is seen to cut through [**gpr5**]. The data between approximately 7.5 and 25.0ns (0.3 to 1.0m) contain some more amorphous areas of high amplitude response, possibly associated with heavily waterlogged soil in the lower lying parts of the site associated with the field drains [**gpr5**] and also, perhaps, anomalies due to the underlying gravel [**gpr6**]. This geomorphological response in part follows the edge of the raised terrace, although similar anomalies are also found on the lower lying ground, for example at [**gpr7**], where they appear to be associated with a high density of animal burrows in the near surface data.

A narrow linear anomaly [**gpr8**] runs approximately parallel to the raised track way across the site, but is not expressed in the magnetic data (cf [**m3**]). Whilst [**gpr8**] could potentially be a path or even part of the field drainage system it might also represent a ditch or excavation trench terminating at the approximate edge of the raised gravel terrace. Other high amplitude rectilinear anomalies [**gpr9**] are found on the track, in close proximity to the intense magnetic responses at [**m8**] and, again, these might indicate areas associated with previous archaeological intervention at the site. There is no particular evidence for the location of the pingo in the radar data, however a group of discrete anomalies [**gpr10**] are found between 12.5 and 20.0ns (0.5 to 0.8m) in the centre of the surface depression identified from the topographic data close to [**m13**] and could, possibly, indicate the location of test pits excavated here.

CONCLUSIONS

Despite challenging field conditions, including heavily waterlogged soils, both the magnetic and GPR surveys produced successful results over the raised gravel terrace and large proportion of the lower lying ground towards the river. The data from both techniques was, to a certain extent, influenced by modern interference from two pipelines and the raised causeway crossing the site, together with a response to the underlying geomorphology. It has proved difficult to confidently interpret any anomalies of archaeological origin at the site, although it is possible that some of the geomorphological structures identified by the survey may provide a focus for occupation activity. Some possible locations for the previous archaeological intervention at the site have also been indicated, particularly within the centre of a surface depression visible in the topographic data which is thought to be the pingo investigated by the excavation.

LIST OF ENCLOSED FIGURES

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Figure 1

BOSSINGTON, HAMPSHIRE
Location of caesium magnetometer instrument swaths, February 2015

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Location of GPR instrument swaths, February 2015

Figure 2

0 90m
1:1750

2015-02-24-042 Location of selected GPR profiles shown on Figure 8

GPR survey swaths

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Location of caesium magnetometer survey, February 2015

Figure 3

0 90m

1:1750

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Figure 4

BOSSINGTON, HAMPSHIRE
GPR amplitude time slice between 17.5 and 20.0ns (0.7 to 0.8m), February 2015

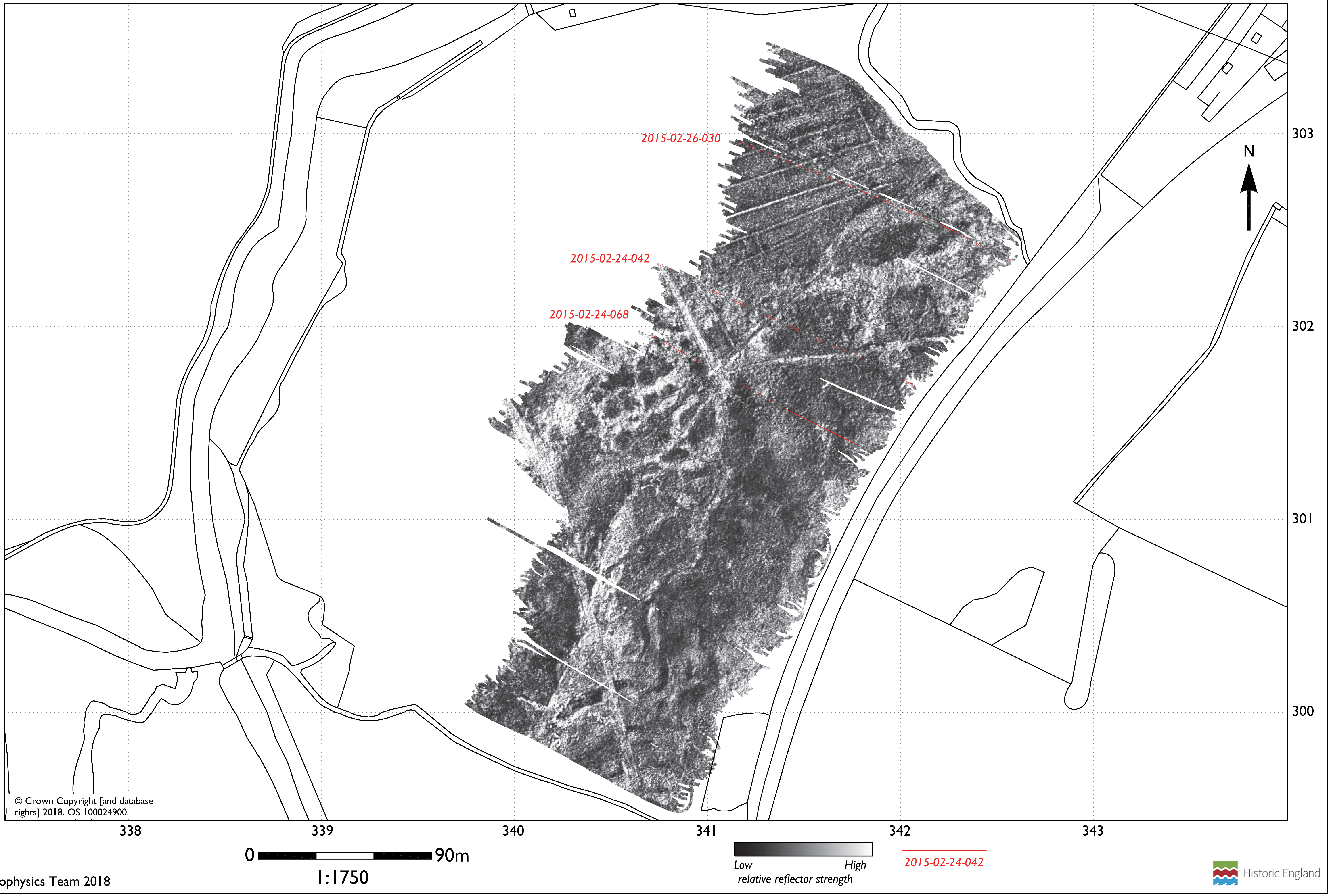

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Figure 5

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Local topography, February 2015

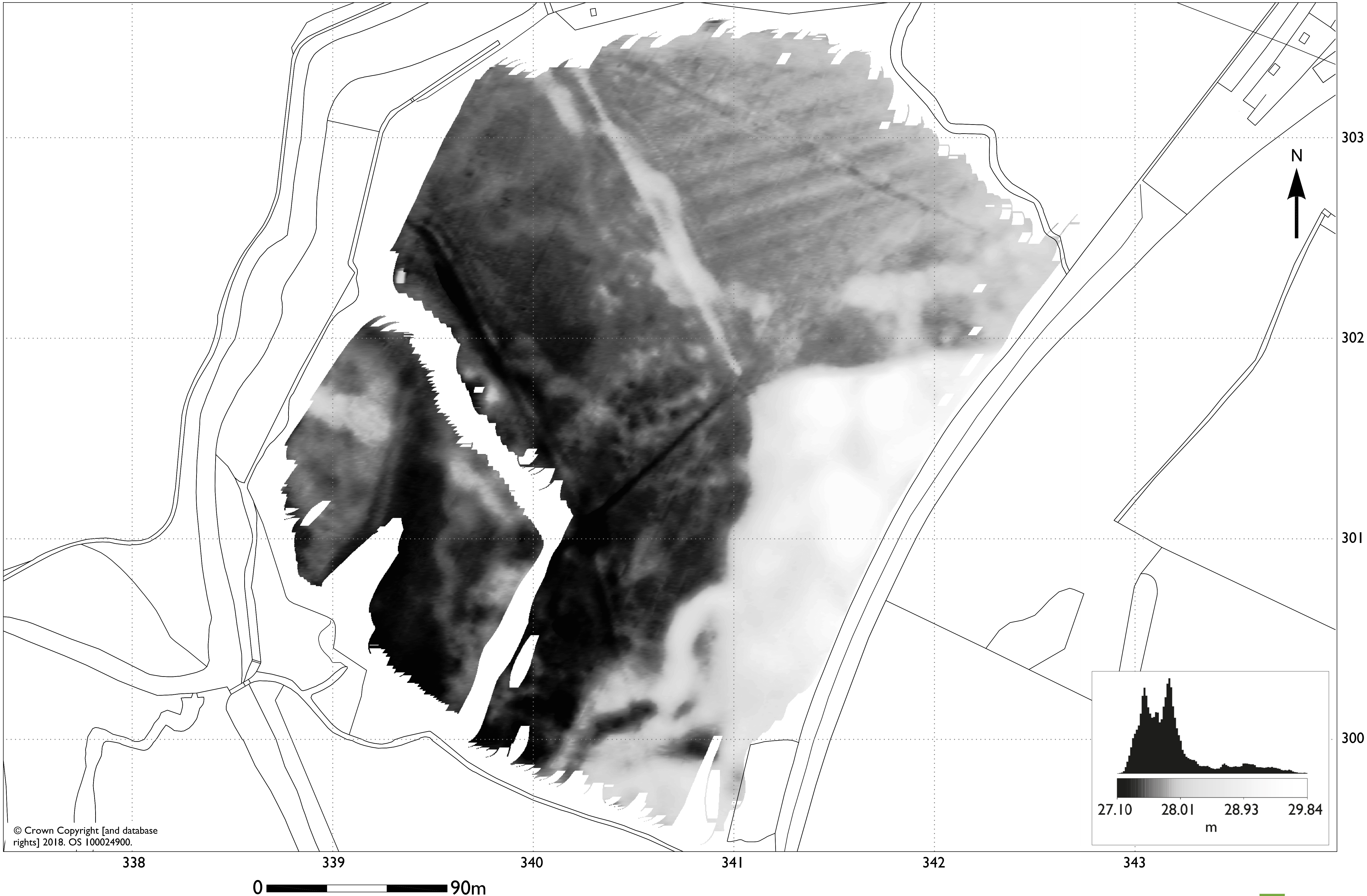

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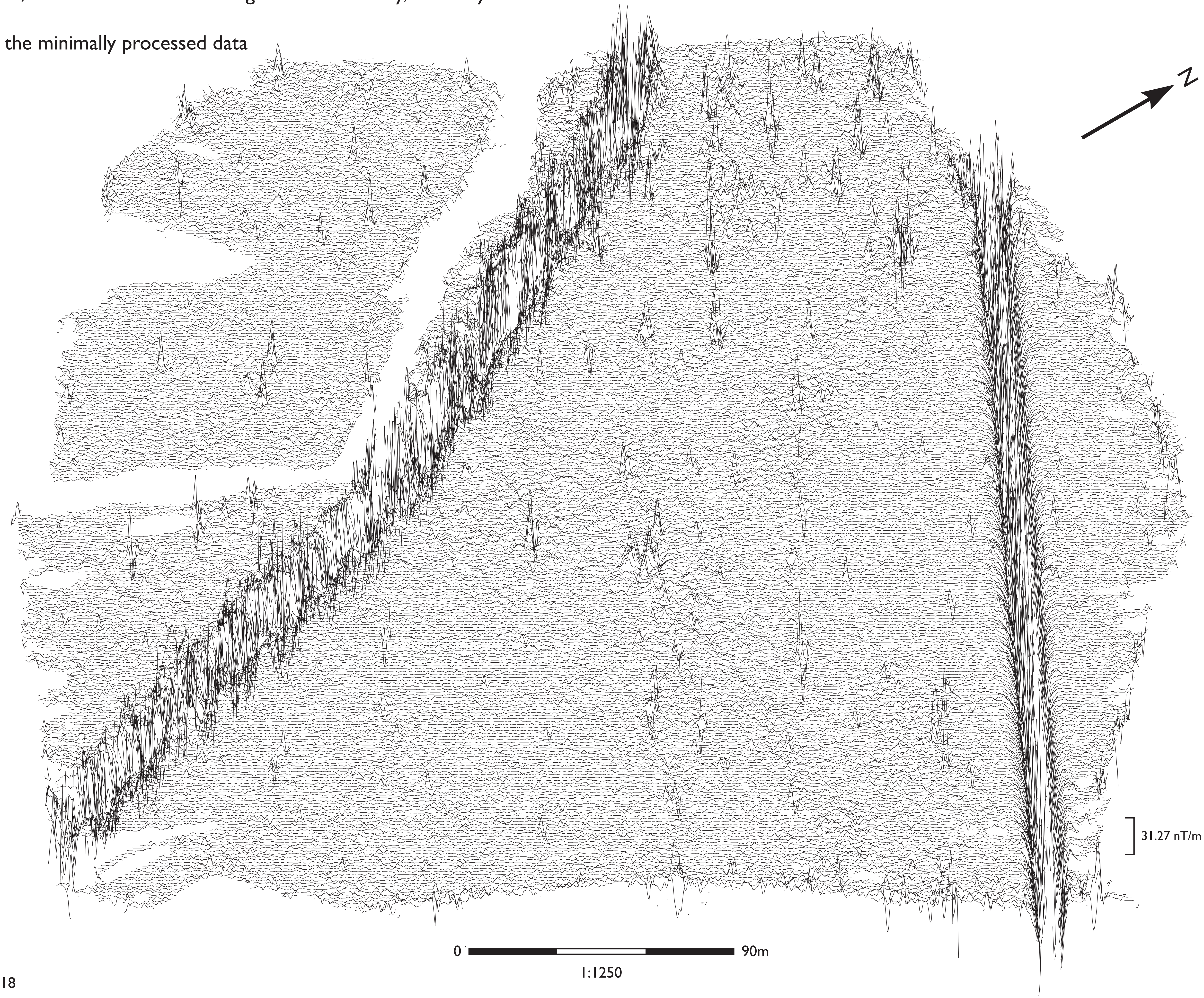
Figure 6

BOSSINGTON, HAMPSHIRE Caesium magnetometer survey, February 2015

Trace plot of the minimally processed data



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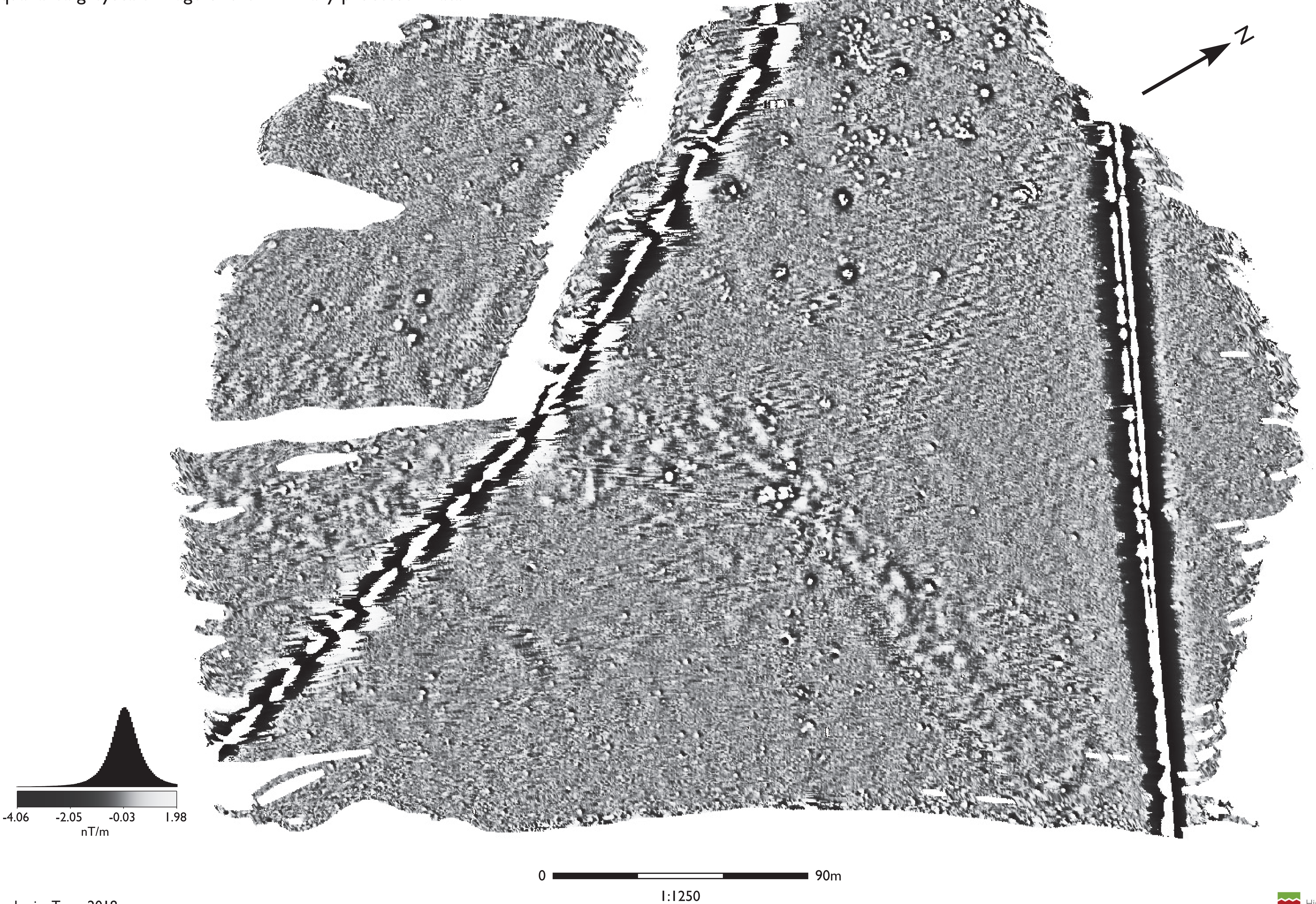
BOSSINGTON, HAMPSHIRE Caesium magnetometer survey, February 2015

Figure 7

Equal area greyscale image of the minimally processed data



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Topographically corrected GPR profiles, February 2015

Figure 8

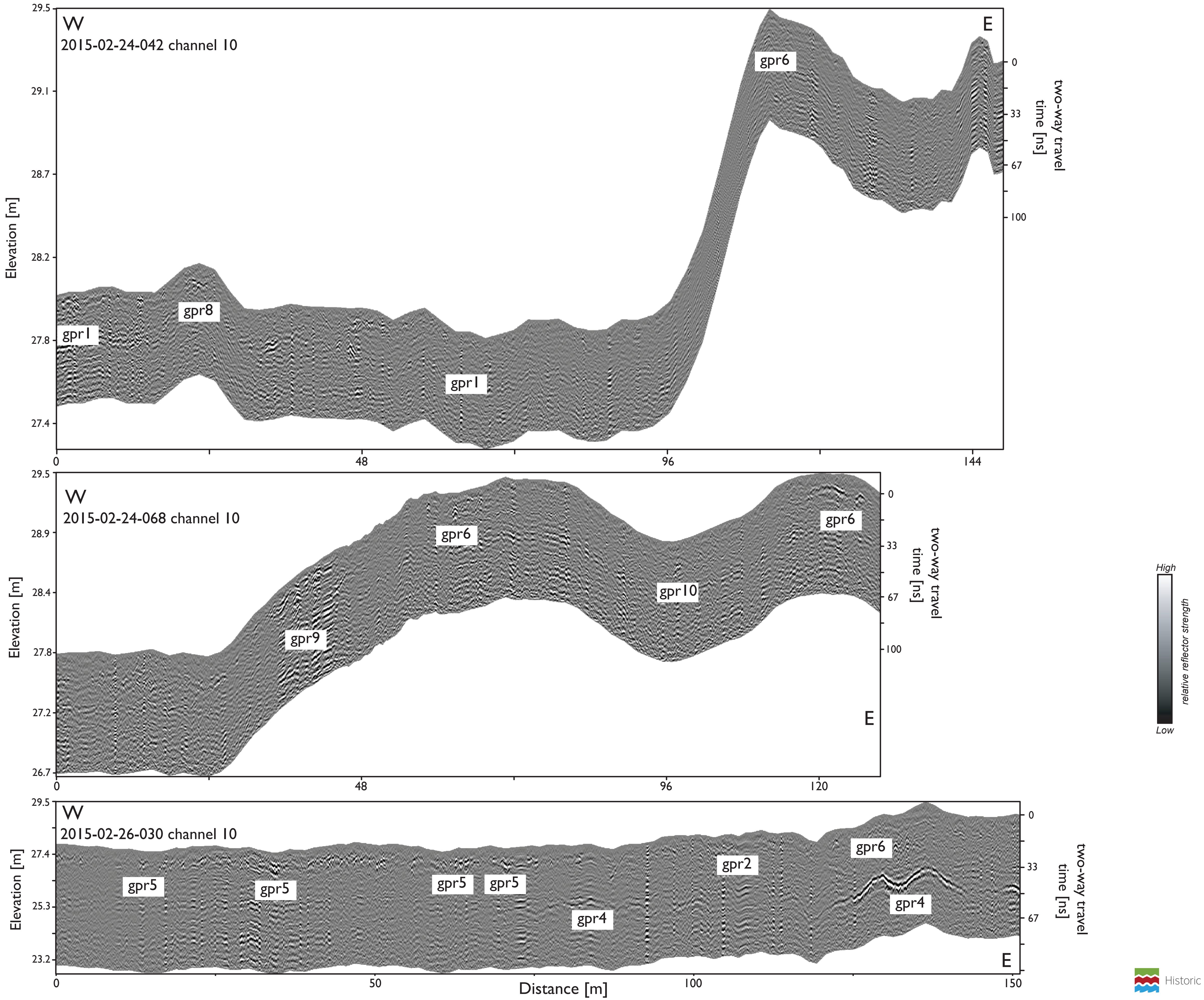

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Figure 9

GPR amplitude time slices between 0.0 - 25.0ns (0.0 - 1.0m), February 2015

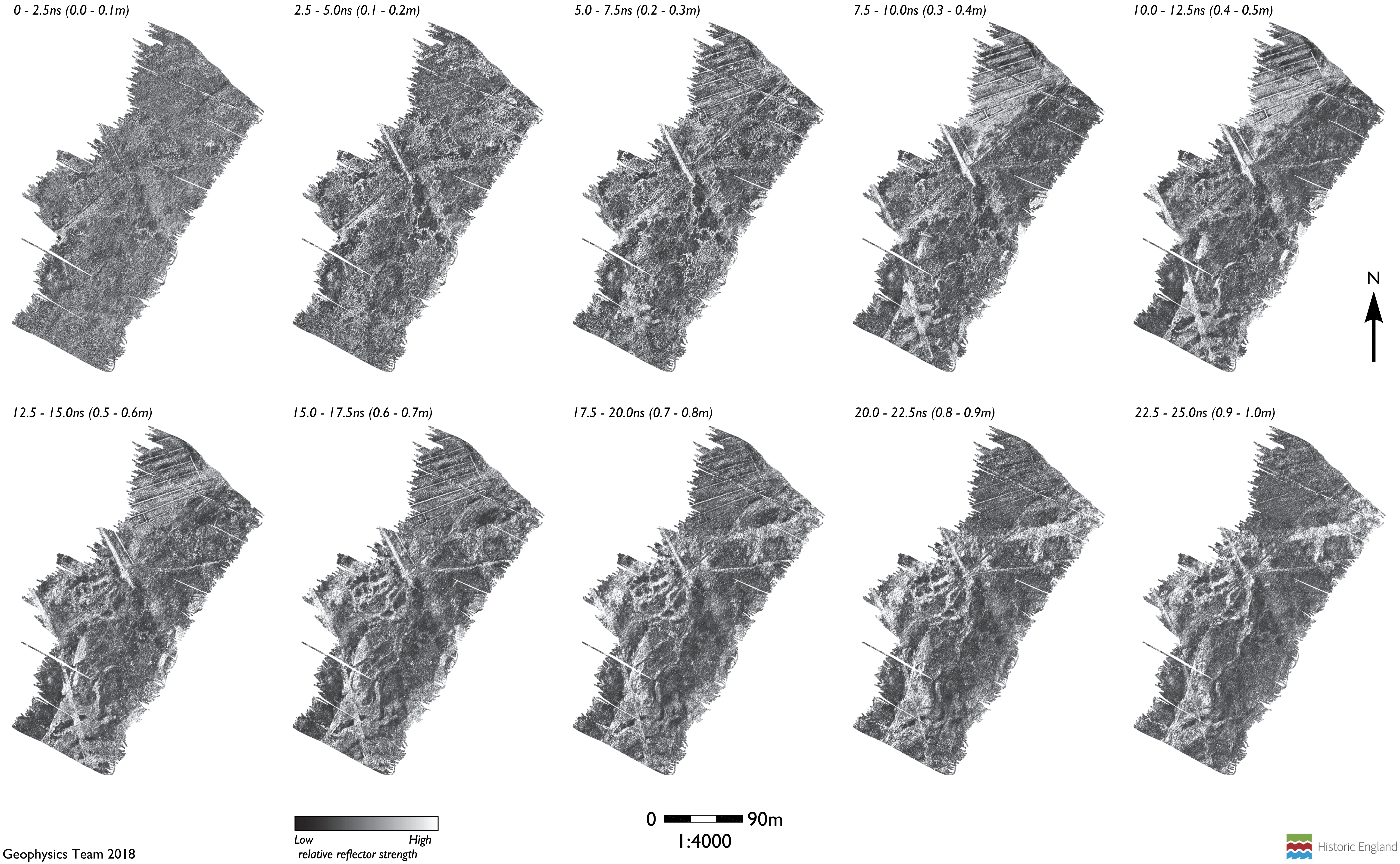

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Figure 10

GPR amplitude time slices between 25.0 - 50.0ns (1.0 - 2.0m), February 2015

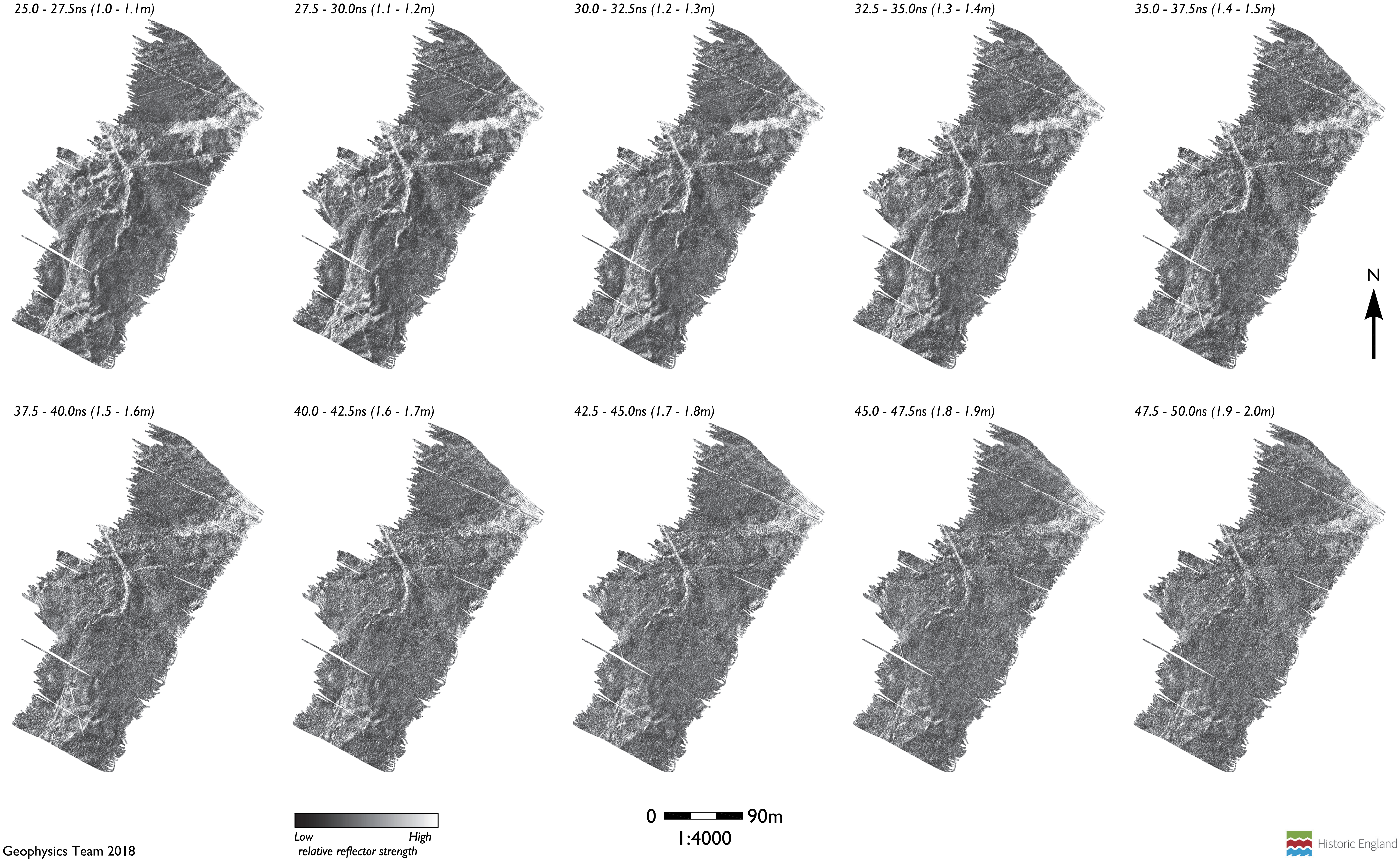

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Figure 11

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Graphical summary of significant magnetic anomalies, February 2015

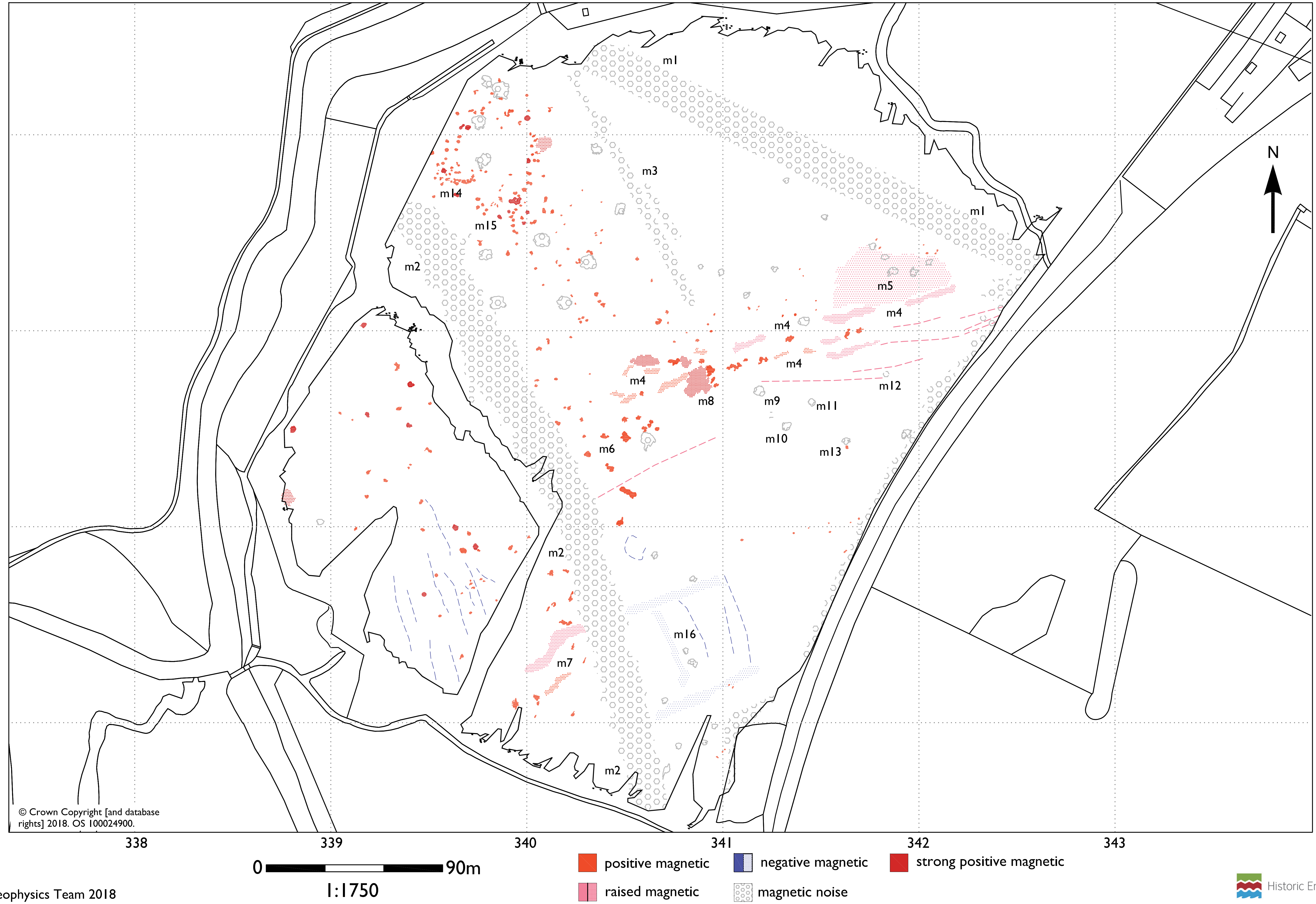

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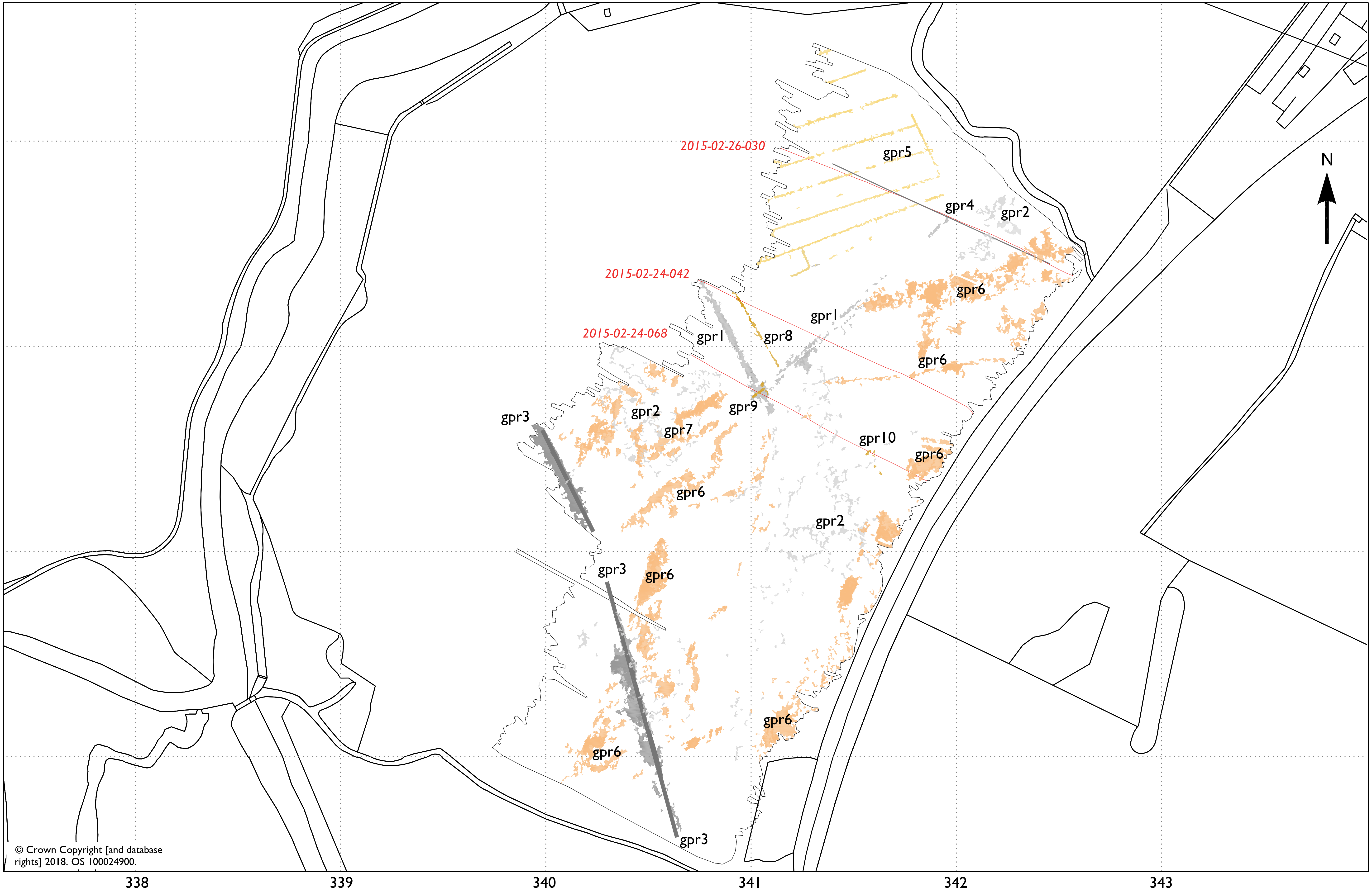
Figure 12

BOSSINGTON, HAMPSHIRE
Graphical summary of significant GPR anomalies, February 2015

SU3330



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