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PRIDDY CIRCLE 1 SOMERSET REPORT ON GEOPHYSICAL SURVEYS, MARCH 2013

Neil Linford, Paul Linford and Andy Payne

REMOTE SENSING

ENGLISH HERITAGE

Research Report Series 61-2013

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SUMMARY

A Ground Penetrating Radar (GPR) survey was conducted over a circular earthwork enclosure, known as Priddy Circle 1, one of a group of four similar scheduled monuments on the upland Mendip plateau close to the village of Priddy, Somerset. Following extensive levelling of the earth works and the subsequent prosecution of the landowner through the Ancient Monuments Act, a programme of mitigation work was agreed, including geophysical survey in advance of evaluation excavations to recover information and offset the impact of the damage. The site was surveyed using a vehicle towed, multi-element air-launched GPR array to provide high sample density coverage of the monument to complement fluxgate gradiometer coverage commissioned separately. Due to concerns over the signal penetration achieved in the field by the air launched array a comparative area over the damaged earth work was also conducted with a ground coupled impulse GPR system, using a 450MHz centre frequency antenna.

CONTRIBUTORS

The field work was conducted by Neil Linford, Paul Linford and Andy Payne from the English Heritage Geophysics Team.

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ARCHIVE LOCATION

Fort Cumberland.

DATE OF FIELDWORK AND REPORT

The fieldwork was conducted between 25-28th March 2013. The report was completed on 24th September 2013. The cover photograph shows an aerial view of the site photographed at the beginning of April 2013, immediately following the geophysical survey visit 27627_007 2 April 2013 © English Heritage.

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INTRODUCTION

Priddy Circle I is a circular earthwork enclosure located in the Mendip Hills Area of Outstanding Natural Beauty, the southernmost of a series of four similar monuments that extend for 1.2km on a north-north-east to south-south-west alignment close to the village of Priddy, Somerset. All four Circles are scheduled (UID No. 1015498), and lie upon the upland Mendip Plateau within a landscape that has a high concentration of prehistoric monuments, many of which are still extant. Following extensive levelling of the ditch and bank to the south of Priddy Circle I, in a misguided attempt by the landowner to landscape the site, a programme of mitigation work, including limited field investigation of the damaged areas, was determined to recover information and offset the impact of the damage (McMahon 2012; Leary *et al* 2013).

Geophysical survey was included in this programme prior to the evaluation excavations over damaged parts of the monument, initially through a fluxgate gradiometer survey commissioned directly by the landowner (Sabin and Donaldson 2013). Additional Ground Penetrating Radar (GPR) coverage was suggested to complement the magnetic results through NHPP Activity 8A5 Offsetting loss through knowledge dividend; Protection Result 8A5.2 Emergency investigation assistance for threatened heritage outside the planning process. The aim of the work was to determine whether geophysical investigation can augment the existing earthwork surveys (Leary *et al* 2013, Figs. 2 and 3) in providing information on the depth of infilling over the original earthwork land surface and possibly identify remains of earlier phases of the monument that may still survive beneath damaged sections of the bank.

The site is located on the junction of three geologies: the majority of the site lies over a Dolomitic Conglomerate, although the northern limits (including the presumed entrance) is on Harptree Beds, while its western side is on Black Rock limestone (Allen and Scaife in Lewis and Mullin 2011). Fine silty over clayey soils of the Nordrach association are recorded over the site (Soil Survey of England and Wales 1983) and there are a number of swallets (geological sinkholes through the limestone) in the vicinity of Priddy Circle I some of which were augered during archaeological investigations in 2008 while one was excavated (Allen and Scaife in Lewis and Mullin 2011). They were clearly of significance to the monument's builders, who appeared to incorporate some of these swallet features within the enclosure. The site was down to pasture for grazing, but includes some areas of scrubby vegetation and topography that could not be covered by the survey. Weather conditions during the field work were bright and sunny, although extremely cold with the near surface soil and any standing water frozen solid throughout the day.

METHOD

Ground Penetrating Radar (GPR) air launched antenna array survey

A 3d-Radar GeoScope Continuous Wave Stepped-Frequency (CWSF) radar system was used to conduct the survey, collecting data with a 21 element V1821, air launched antenna array towed by lightweight all terrain vehicle (Linford *et al* 2010). A roving GPS receiver was mounted on the GPR antenna array to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 1. Data were acquired at a 0.075m x 0.075m sample interval across a continuous wave, stepped frequency range from 50 to 1250MHz in 2MHz 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.

Post acquisition processing using in-house software (Linford 2013) involved conversion of the raw data to time-domain profiles (through a time window between 0 and 50ns), 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 3 including topographic correction using a vertical exaggeration based on the average sub-surface velocity. To aid visualisation amplitude time slices were created from the entire data set, after applying a 3D-migration algorithm, by averaging data within successive 1.2ns (two-way travel time) windows (eg Linford 2004). An average sub-surface velocity of 0.0608m/ns was assumed following constant velocity tests on the data, and was used for both the migration velocity field and the time to estimated depth conversion. Each of the resulting time slices, shown as individual greyscale images in Figures 2, 4 and 5, therefore represents the variation of reflection strength through successive ~0.04m intervals from the ground surface. Further details of both the frequency and time domain algorithms developed for processing this data, including the variable hyperbola velocity model used for the migration can be found in Sala and Linford (2012). Where appropriate a tilt correction algorithm was applied to the data to compensate for the translation of the anomalies due to variations in topography along each profile (Goodman *et al* 2006).

Ground Penetrating Radar (GPR) ground coupled antenna survey

For comparison a 30m x 30m grid (Figures 1 and 2 inset) was established over the damaged area of ditch and bank to the S of the henge with a Trimble RTK GPS and subsequently surveyed using a Sensors and Software Pulse Ekko PE1000 console with a 450MHz centre frequency ground coupled antenna, recording reflections through a 60ns window. Individual GPR traces were collected at 0.05m intervals along parallel profiles separated by 0.5m. Post acquisition processing was similar to the multi-channel GPR survey and a comparative profile is presented on Figure 3, together with amplitude time slices illustrated as a greyscale images in Figures 6 and 7.

RESULTS

A graphical summary of the significant GPR anomalies [gpr1- 19] discussed in the following text, superimposed on the base OS map data, is provided in Figure 8.

i) General response

Water logged soil conditions at the site have led to the rapid attenuation of the radar wavefront and limited the depth of penetration to approximately 1m from the ground surface. Despite the frozen ground surface at the time of the survey the air launched GPR antenna array has been affected more detrimentally by the reflectance at the air-soil interface than the ground coupled system. This has led to both a lower signal to noise ratio and the prominence of artefacts in the data due to the surface micro-topography. These effects were further accentuated by a defective repair to the antenna, which has subsequently been rectified.

A series of visible vehicle ruts [gpr1] appear throughout the data set and impinge upon the ditch and bank of the monument to the S, showing a slight deviation from the track marked on the OS mapping. Additional vehicle damage appears as a low amplitude anomaly [gpr2] on a NS alignment passing through the centre of the monument. A similar low amplitude linear anomaly [gpr3] may, due to its orientation, indicate a vehicle track predating the recent damage to the ditch and bank (cf Leary *et al* 2013, , Figures 2 and 3).

Areas of diffuse, near-surface high amplitude response [eg gpr4 and 5] were found to correlate with concentrations of mole hills on the surface. The variation in response of these anomalies with depth through the data set suggests they may represent a combined response to both the irregular surface topography over the mole hills and a network of subterranean burrows. Unfortunately, the response to similar concentrations of animal burrows throughout the survey area, perhaps not always marked by surface soil casting, may obscure the identification of more significant anomalies.

ii) Damaged ditch and bank

The damaged area of the southern ditch and bank produces a diffuse anomaly [gpr6] running for approximately 4m wide running from the field boundary to west until it meets and is obscured by [gpr1], which is well resolved between 1.2 and 7.2ns (0.04 to 0.22m) along its full length. Beyond this depth [gpr6] is better resolved in the more limited ground coupled GPR coverage (Figures 6 and 7) and demonstrates a gradual reduction in width through successive time slices. There is some considerable variation in the response of [gpr6] that partly respects both the discontinuity in the earthworks prior to the recent damage and the presence of standing water pooled in the vehicle ruts [gpr2 and 3] crossing the ditch. It is difficult to discern the full nature of this complex response, although it would be appear that is due mainly to the infilled section of the original 'V' shaped ditch (similar to the magnetic survey), here approximately 4m wide to a maximum depth of approximately 1m.

iii) Henge interior

Some continuation of the ditch anomaly appears evident at [gpr7] where there is another break in the visible earth works. There would also appear to be some significant GPR anomalies coinciding with earthworks found at [gpr8] and with depressions associated with the larger swallet holes across the site [gpr9], although care must be taken to distinguish any response here possibly due to burrowing animal activity. A series of near-surface anomalies [gpr10] are found following the internal NW arc of the henge bank, perhaps related to the negative magnetic response found in this area. However, it was not possible to traverse the upstanding bank with the vehicle towed array and whilst the high amplitude reflectance from [gpr10] would certainly concur with the presence of a buried stone revetment, also partially visible in the field, it is questionable whether the GPR coverage correlates sufficiently well with the magnetic survey.

A more tentative, linear anomaly [gpr11] coincides with the presumed location of Tratman's 1967 excavation text, identified from the earthwork survey. Two low amplitude pit-type anomalies, [gpr12], at the southern extent of [gpr11] in the centre of the henge may, potentially, also be related to these excavations. Some further tentative linear anomalies [gpr13 - 16] do not appear to be represented by earthworks within the henge although these, in part, correlate with a negative magnetic responses (Sabin and Donaldson 2013). It seems possible that [gpr13 - 16] forms an extension of the field system recorded by the earthwork survey to the south of the henge.

A break in the continuity of the henge bank and ditch is apparent at [gpr17], although analysis of the earthwork survey suggests this may be due to more recent activity at the site (J Leary *pers comm*), perhaps associated with the linear topographic feature approaching the henge from the S which is also replicated in the GPR data. A similar discontinuity also appears within the magnetic response and correlates with the location of [gpr17].

There is only limited coverage with the GPR survey beyond the interior of the henge to the S and few significant anomalies appear to be present. A broad, low amplitude linear response [gpr18] may be associated with part of the field system identified in the earthwork survey, although this does not continue along the full length of the topographic expression. High amplitude reflectors at [gpr19] are possibly due to rubble deposits introduced to improve vehicle access from the road.

CONCLUSION

The success of the wider area GPR system has been marred by the saturated soil conditions at the time of the survey and the impact of the defective repair to the air launched antenna array. Comparison with the ground coupled array suggests a good degree of correlation throughout the near-surface data (to approximately 25ns), but the fidelity of the wider area survey appears more questionable at greater depth. A number of GPR anomalies do correlate with the previous magnetic survey, including some subtle linear anomalies in the interior and the southern arc of the henge ditch and bank. It is surprising that the strong negative magnetic anomaly found around the NW circuit of the monument has not been replicated in the GPR data (Sabin and Donaldson 2013, anomaly (5)), although this may only have been partially described within the GPR coverage that did not extend over the bank of the henge. However, it is unclear whether the GPR survey has been able to identify any additional significant activity that was not previously known from the existing earthwork and magnetometer surveys.

LIST OF ENCLOSED FIGURES

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Figure 1

PRIDDY CIRCLE 1, SOMERSET

Location of GPR surveys, March 2013

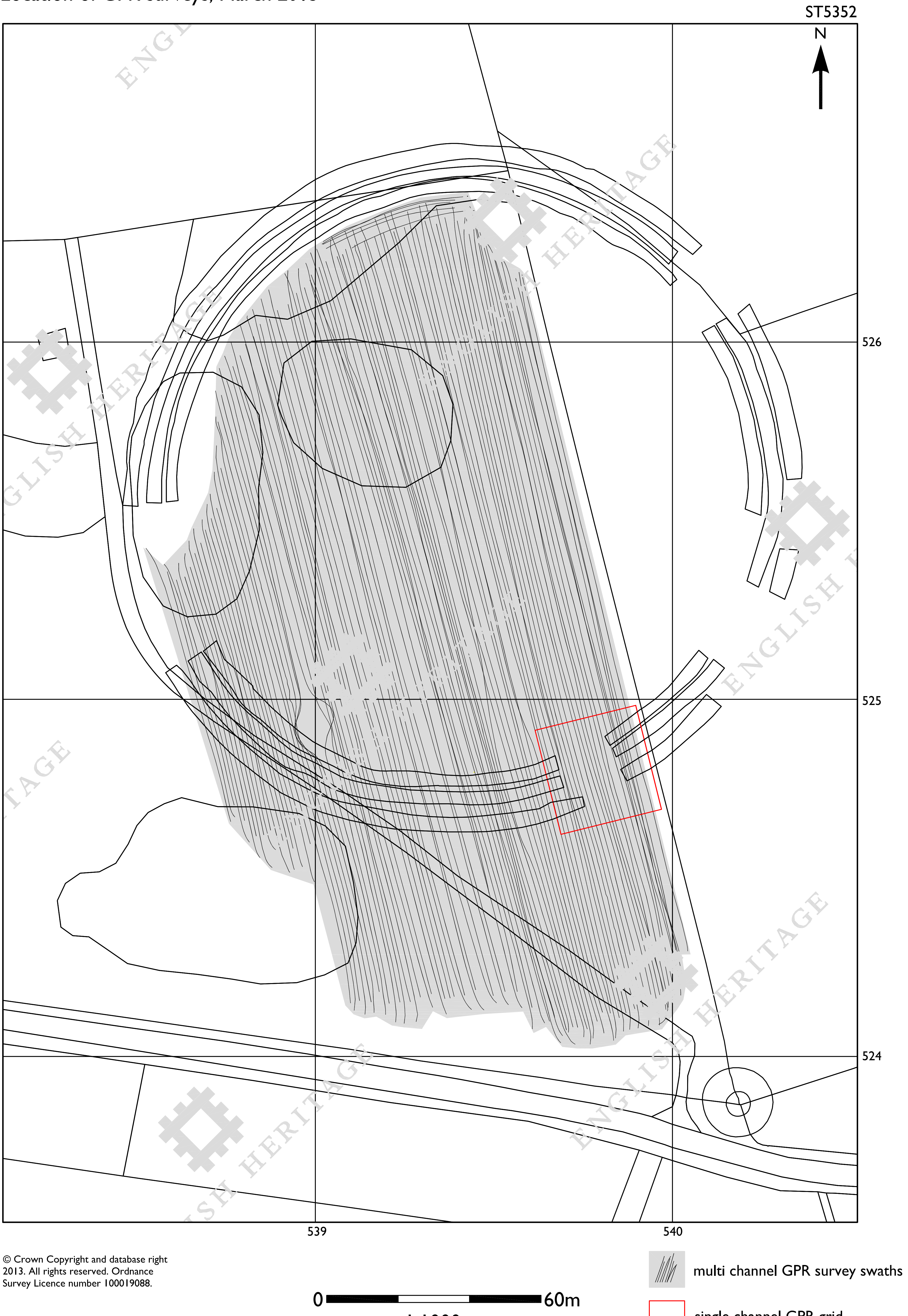

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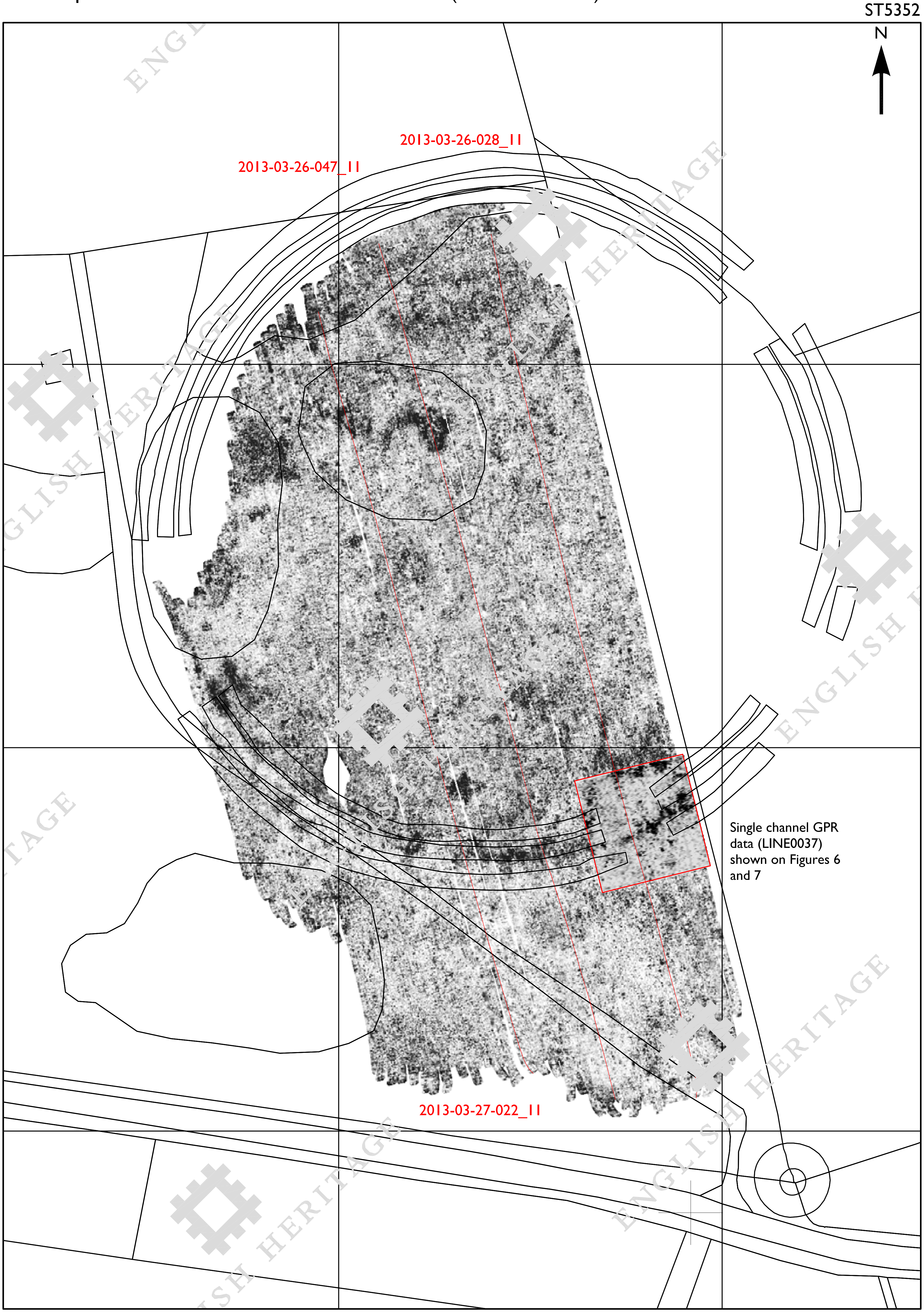
Figure 2

PRIDDY CIRCLE 1, SOMERSET

GPR amplitude time slice between 23.8 and 25ns (0.072 to 0.76m)



0 60m

1:1000

Low *High*
relative reflector strength

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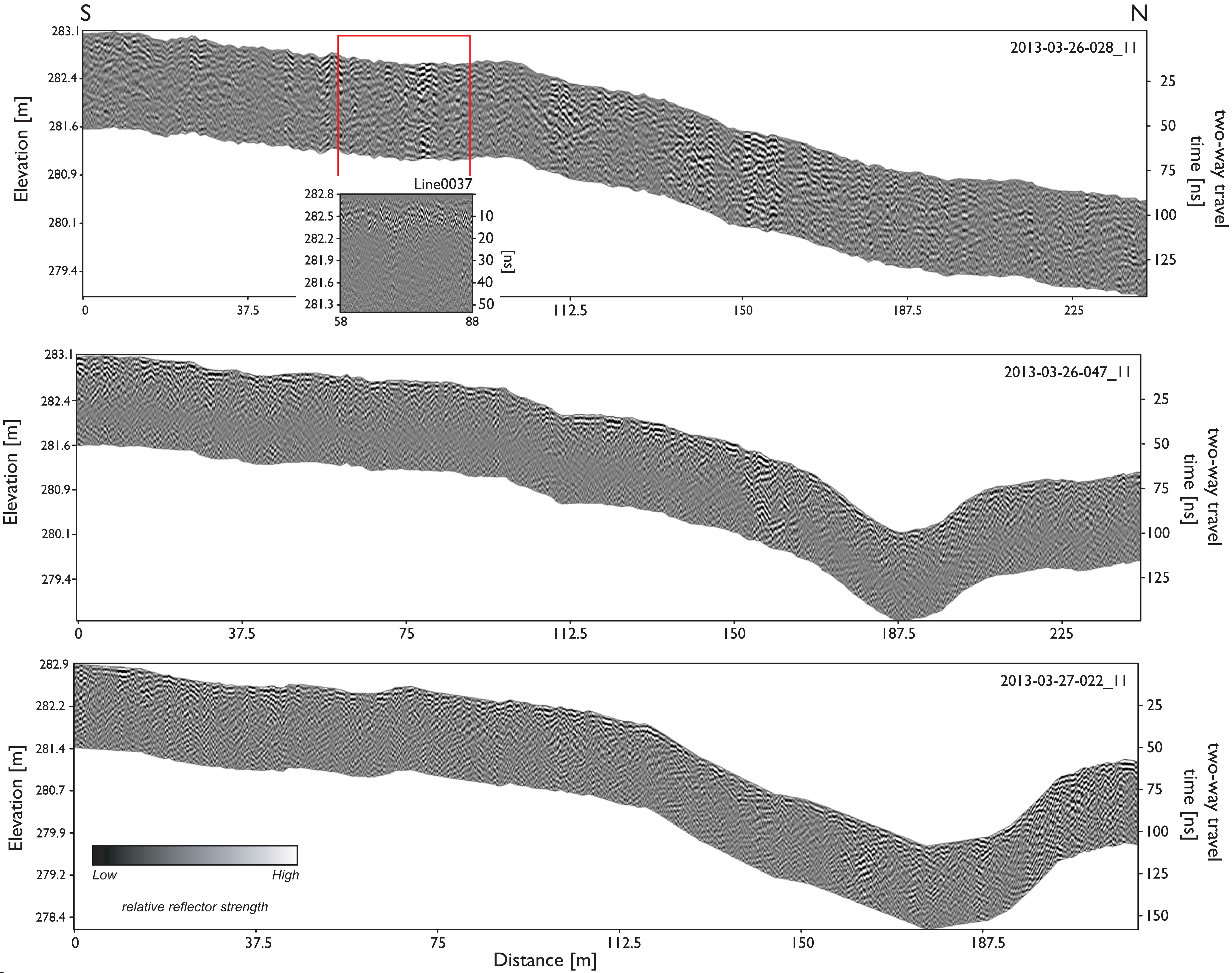
PRIDDY CIRCLE 1, SOMERSET
Selected GPR profiles, March 2013

Figure 3



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PRIDDY CIRCLE 1, SOMERSET

GPR Array amplitude time slices from between 0.0 and 12ns (0 - 0.36m), March 2013

Figure 4

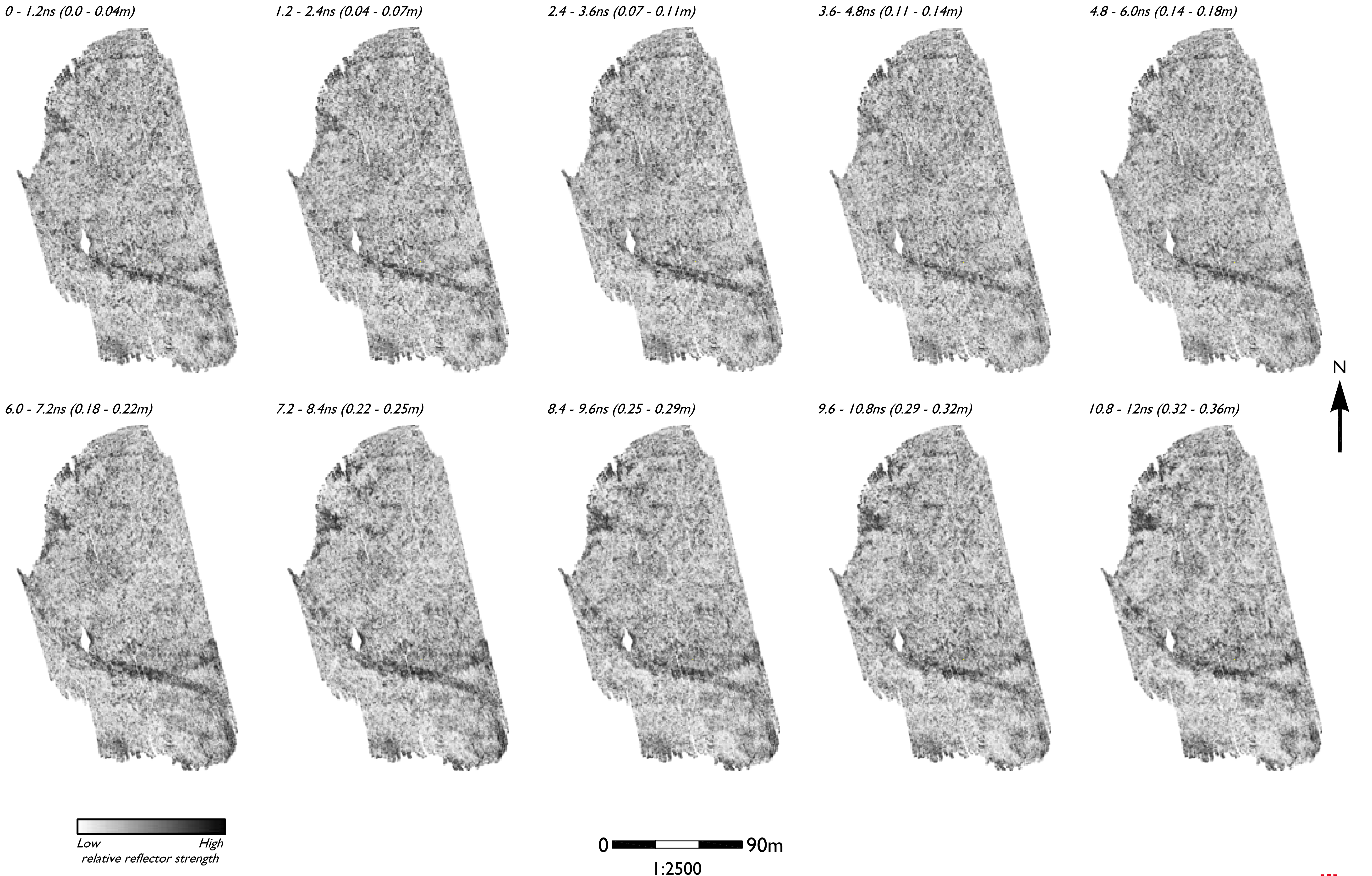

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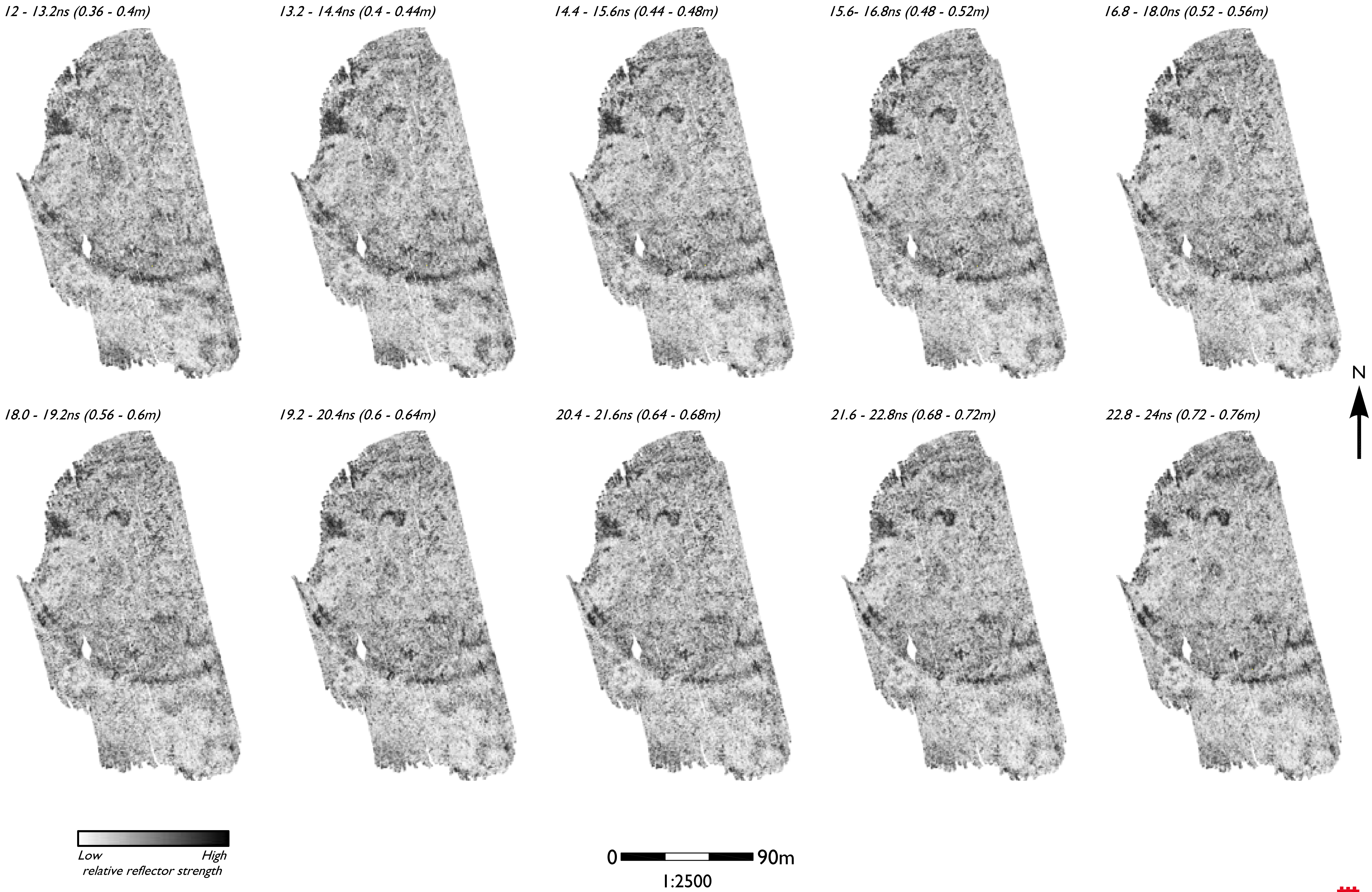
Figure 5

PRIDDY CIRCLE 1, SOMERSET

GPR Array amplitude time slices from between 12 and 24ns (0.36 - 0.72m), March 2013



PRIDDY CIRCLE 1, SOMERSET

GPR single channel amplitude time slices from between 0.0 and 18ns (0 - 0.54m), March 2013

Figure 6

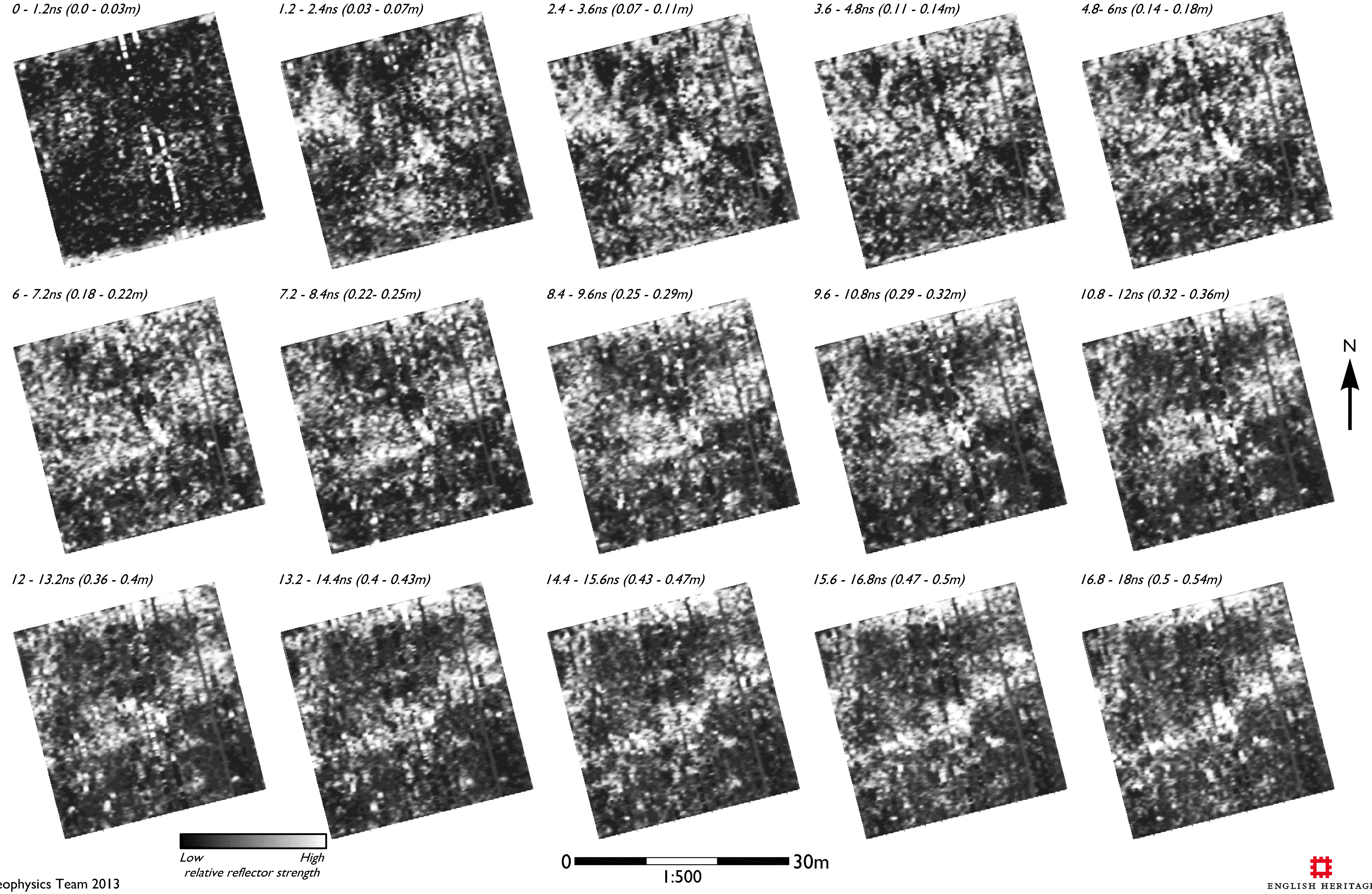


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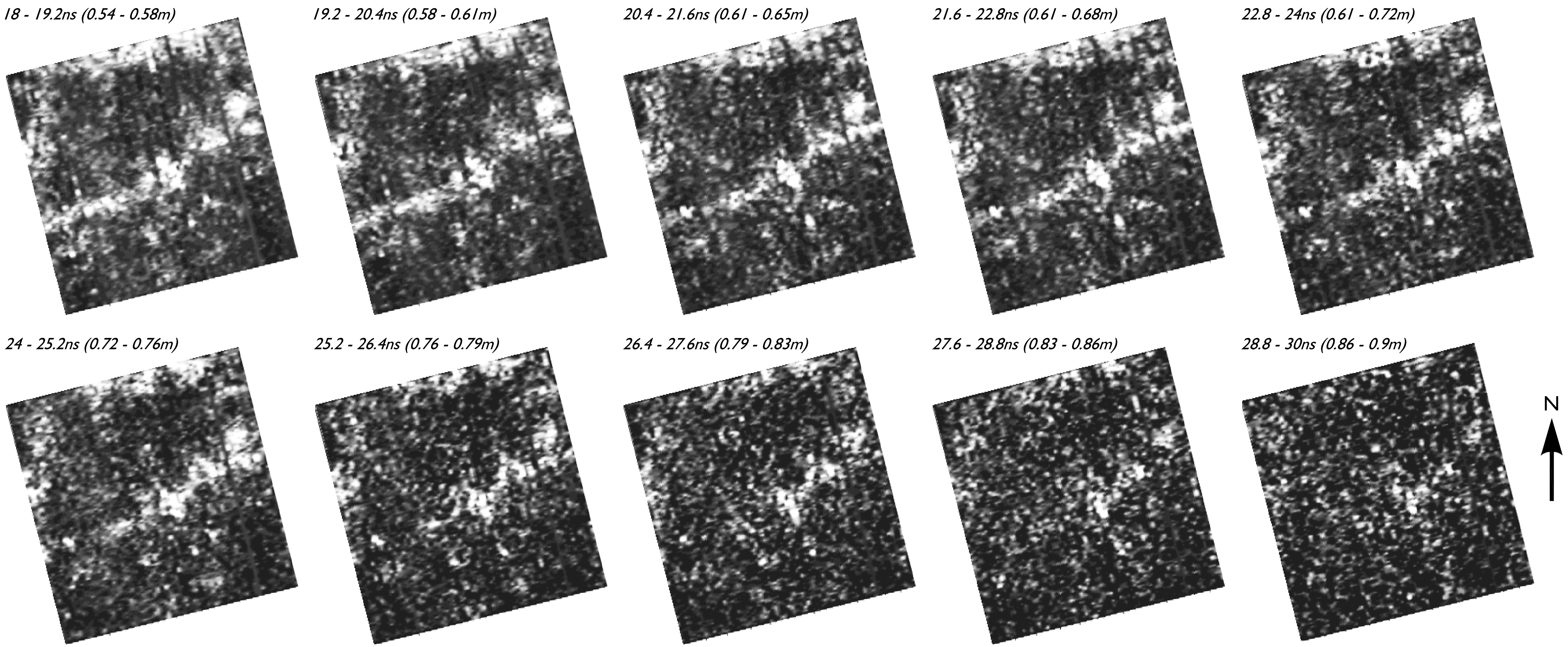
Figure 7

PRIDDY CIRCLE 1, SOMERSET

GPR single channel amplitude time slices from between 18 and 30ns (0.54 - 0.9m), March 2013



Low *High*
relative reflector strength

0 30m
1:500

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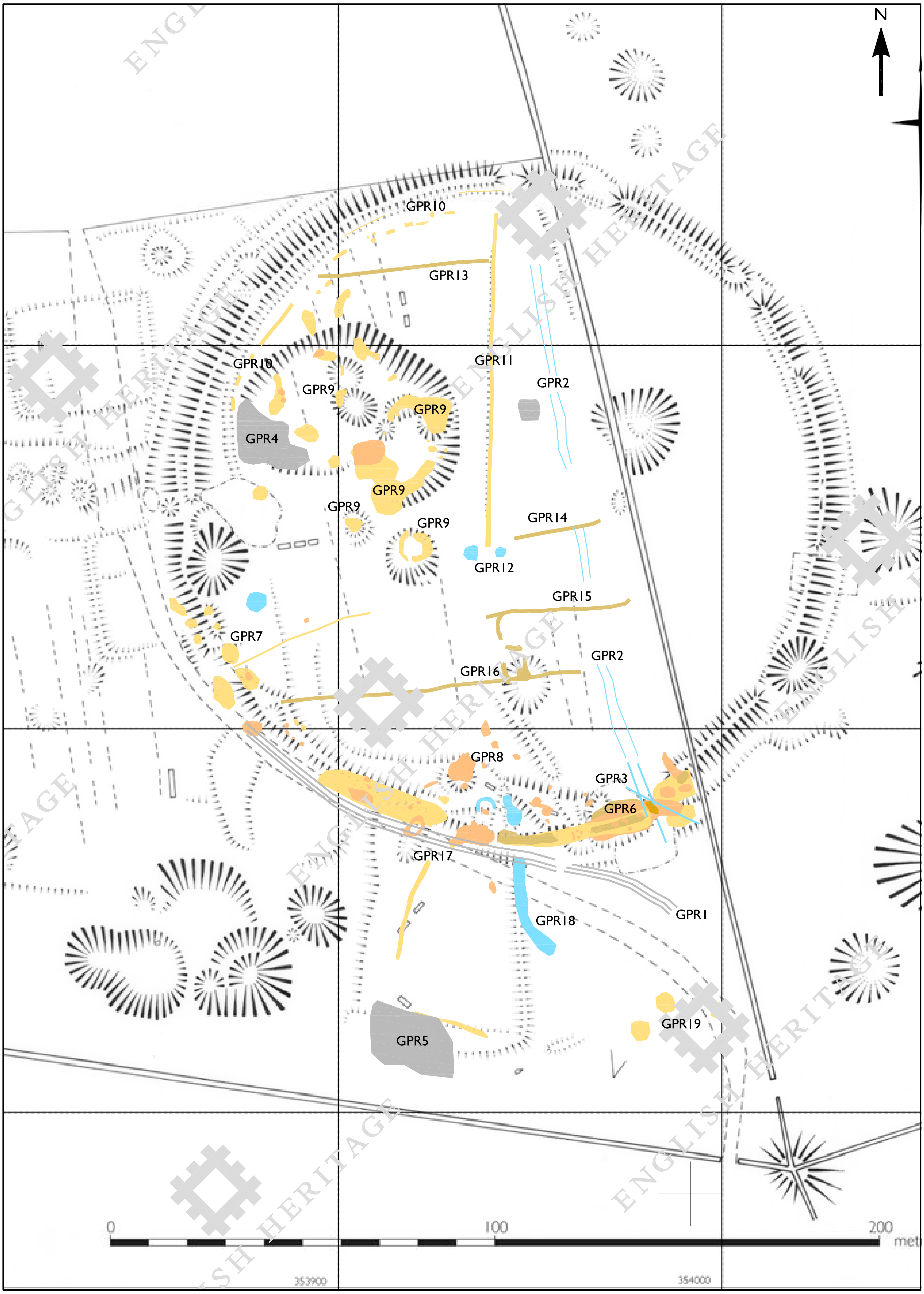
Figure 8

PRIDDY CIRCLE 1, SOMERSET

Graphical summary of significant GPR anomalies, March 2013



0 60m
1:1000

- low amplitude reflectors
- high amplitude reflectors
- anomalies of recent/known origin

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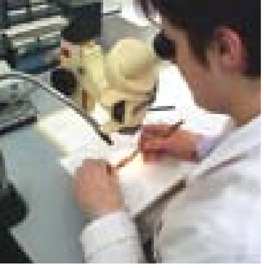
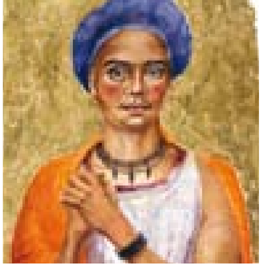



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