GeoArch

Report 2015/32

Geophysical Surveys at Rhossili medieval settlement, Swansea

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25th November 2015

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Abstract

Geophysical surveys, employing 250 MHz ground penetrating radar (GPR) and ground resistivity, were conducted over an area of the Rhossili medieval settlement in an attempt to investigate the potential for geophysical techniques in the mapping of the settlement though its sand cover. The survey worked out from the known church site (excavated in 1980), the walls of which extend to surface.

Imaging of aspects of the church were achieved by both techniques, but in neither case entirely satisfactorily. Resistivity imaged both western and eastern ends of the church, but did not locate the walls of the church where they had been excavated in 1980, in the damper central hollow. Ground penetrating radar survey was not possible over much of the church because of the topography, so was focused on the central hollow through the remains. The church walls were not well imaged by the GPR, and the church floor only formed a clear radar reflector where it had been exposed by excavation.

Much of the ground resistivity away from the church was controlled purely by topography. One small area with a rectilinear outline, 15m north of the church, produced a suspicious resistivity anomaly. The western edge of this area coincided in part with a possible radar anomaly. The area showed large stones on the surface of the dune, suggesting a link with the stone-built archaeological features. It is not certain whether this is an indication of in-situ archaeology, or of a stone dump associated with the 1980 excavation, the site caravan for which was positioned very close to this location.

The slightly negative results for both techniques away from the church must be tempered with consideration that it is unknown whether there are any further significant archaeological features within the surveyed area.

On present evidence it is unclear further work with GPR would be justified, although further (potentially very time-consuming) processing of the existing dataset might be able to clarify this to some extent. The resistivity survey has produced a suggestion of a further building that could be tested archaeological, but it is clear that most of the resistivity signal is controlled by the topography of the dunes and their drainage.

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Methods

Survey rationale and background

The survey was undertaken as a part of attempts to improve management of the archaeological site of Rhossili medieval settlement (NPRN 15446; Scheduled Ancient monument GM414). The survey focused on the site of the church (known as Old Church; NPRN 310526; [SS41488833]), with the survey area straddling the northern boundary of the SAM.

The rationale behind the survey approach was to investigate the geophysical visibility of the buried structures, by working outwards from the church, the walls of which extend to (and locally above) the present ground surface and which have been well characterised by excavation.

The solid geology of Devonian Old red sandstone rocks is deeply buried by Devensian diamictites, overlain by blown sand. The blown sand has covered the medieval structures, and may have been the reason for the abandonment of the settlement. The sand is in the form of modified dunes

The ground resistivity surveys were conducted on 23rd – 25th September 2015, under hot, dry weather conditions. The undergrowth had been cleared prior to survey by National Trust volunteers. Much of the resistivity survey was conducted by school groups, forming one part of the public engagement activities focused on the medieval village. The ground penetrating radar survey (GPR) was undertaken over the 24th and 25th of September 2015 by staff from Terradat UK Ltd.

The survey was commissioned by Claudine Gerrard of the National Trust.

Survey layout

Surveys were laid-out using a Trimble survey-grade RTK GPS system (4700 base station and 5800 rover). A temporary base-station was created on open ground just outside the northern part of the site (STN1). GPS data were logged by the Trimble 4700 base receiver during the survey layout period, enabling post-processing of locational data. The data logged were first converted to RINEX format (using Trimble's '*RinexConvert*' utility) and then were (together with RINEX files from the five closest OS passive net stations) backdated using the '*RinexDates'* utility to permit baseline processing in '*Trimble Geomatics Office'* (TGO). The data files were then post-processed to give a location for the base-station accurate to within approximately 15mm.

The survey was staked out, using the on-the-fly base station location, to design locations at 'round-number' 20m intervals of National Grid using the Trimble 5800 rover. The grid pegs were positioned to within 40mm of the relative design location reported by the GPS.

Topographic base

The base mapping for the survey was generated using the Trimble RTK GPS system, set up as described above.

Ground resistivity

The ground resistivity survey was undertaken with a Geoscan RM15 resistivity meter, operating a 'parallel twin electrode' configuration, employing three electrodes with 0.5m probe spacing on a PA5 frame, via an MPX15 multiplexer.

In this configuration, the adjacent mobile electrode pairs had a 0.5m spacing (giving the main component of the response from 0.5-0.7m depth), with 0.5m between centres, to give a 0.5m effective traverse interval. The outer probes therefore had a 1.0m spacing (giving the main component of the response from 1.0-1.5m depth), with a 1.0m traverse interval. Data were collected as a series of three measurements (left 0.5m-, right 0.5m-, 1.0m-spaced). Data were collected with a 0.5m sample interval (i.e. the raw 0.5m-spaced data has 0.5 x 0.5m node spacing and the 1.0m-spaced data has a 0.5 x 1.0m node spacing). Grids were walked on South to North traverses in a zig-zag pattern.

Data were downloaded from the instrument and collated using Geoscan Research's '*Geoplot*' software. The left and right datasets at 0.5m mobile probe spacing were merged into a single composite.

Data processing was then limited to one or two passes of the 'despike' function in Geoplot, with radius set to 1 and a threshold of 3 std. dev., using Gaussian statistics.

Data were then exported from Geoplot and imported to Golden Software's 'Surfer'. The data were gridded by kriging to a node-spacing of 0.125m for production of the final, less pixelated, image.

Ground-penetrating RADAR

The Ground Penetrating Radar survey was carried out by staff of Terradat UK Ltd, using a Mala RAMAC GPR system with 1.0m spaced lines employing a 250 MHz centre frequency antennae. The system was mounted on a rough-terrain cart. Data were collected on walked south to north lines 20m in length.

Data were investigated with two approaches. For the area around the church, only a limited number of lines (six) could be surveyed, because of the extreme and exposed walls. These lines were positioned though the hollow which passes through the centre of the church and which was the location of much of the earlier excavation. These lines have been investigated solely through the use of radargrams. For the area to the north of the church, access was simpler and acquisition of a large block of lines (31 lines) was possible over the gentler terrain. For this area, interpretative focus was based on examination the data in time-slices, processed using SLICE. Data processing for the GPR surveys was undertaken by Alex Lewis of Terradat UK Ltd.

Use of this report

The techniques chosen for the survey, magnetic gradiometry and ground resistivity, were selected for their utility in detecting a wide range of feature types. As with any geophysical technique, it is always possible for archaeological features to be present, but not to be distinguished, or distinguishable, by variation in the physical properties being examined at the time of survey – in this case magnetic susceptibility and water content. Absence of detectable geophysical anomalies cannot be taken as indicative of the absence of archaeological features. All anomalies have been interpreted as far as possible, with contrasting possible interpretations given where appropriate. Geophysical techniques cannot provide an unambiguous evaluation of buried features. Where a higher degree of certainty is required, physical ground-truthing of any geophysical anomalies resolved by the survey will be required.

Results

Ground resistivity

Data quality at both 0.5m and 1.0m probe spacings was good (Figures 3 and 4). The georeferenced cleaned data are shown in Figures 5 and 6.

Ground-penetrating RADAR

Data are presented in Figures 7 (for the radargrams from the lines in the southern part of the site) and Figure 8 (for the time-sliced data from the northern part). Data quality was good, with evidence for penetration of the radar energy down to 2m below surface locally.

Interpretation

Ground resistivity

The ground resistivity surveys show very similar patterns of resistivity distribution. The resistivity shows a strong relationship with the topography, with the upstanding dunes having much higher resistivity than the intervening slacks. The church is moderately well imaged, although the imaging of walls owes much to poor electrode contact on exposed stonework. A slight negative resistivity 'halo' outside the wall is a marked feature of the western side of the church at 0.5m probe-spacing. At 1.0m probe spacing the area of the GGAT 1980 excavation is more clearly delimited. Both surveys show mainly a raised resistivity (although some areas show a lowered resistivity) on the lines of the modern informal paths.

It is significant that neither survey showed any anomaly over the nave walls where they were exposed in the 1980 trench in the low ground over the centre of the church. This is surprising given the known thickness (0.9m) and apparently still very shallow depth of burial of these features.

The only other noteworthy aspect of the resistivity surveys, is an irregularly elevated resistivity over an approximately rectangular area that lies approximately 15m north of the centre of the church. This area corresponds to a slight topographic feature forming a protrusion from the east side of the dune running northwards from the west end of the church.

Ground-penetrating RADAR

The plan of the 1980 survey accompanying the GGAT excavation (Davidson *et al.* 1987, Figure 4) does not coincide precisely with the survey produced during the current work. The present work suggests that the nave may be slightly shorter than estimated in 1980 (although the external face of the west wall is not known with certainty). The resistivity anomaly that is associated with the west side of the 1980 excavation trench also lies slightly further west than the plan would suggest, although it is possible this is purely as a result of either collapse of the side during reinstatement, or a moisture gradient that is steepest within the undisturbed edge, rather than precisely on the cut. However, despite this slight error on the fit, some comparison may be made between the radar lines and the expected underlying deposits:

Line 1 – this is likely to pass across the church entirely through deposits undisturbed by the 1980 excavation

Line 2 – this is likely to pass through the church is undisturbed deposits but may overlie the trench to the south of the church for a very short distance.

Line 3 – this is likely to pass through the church is undisturbed deposits but may overlie the trench to the south of the church for a very short distance.

Line 4 - this is likely to pass over the excavation trench from south of the church, passing over the deep section within the church until close to its north wall.

Line 5 - this is likely to pass over the excavation trench from south of the church, passing over the deep section within the church and over the shallow trench outside the north wall for a very short distance (half way from the church to the end of the line)

Line 6 - this is likely to pass over the excavation trench from south of the church until the end of the line. Inside the trench it passes over the shallow excavation of the east end of the nave.

Although the radar lines are difficult to interpret, and the walls themselves very poorly imaged, there are some important degrees of correlation with the above suggestions:

- Trenches 2 to 6 all show a narrow zone with little internal stratigraphy to the south of the church – potentially correlating with the fill of the excavation trench in this area.

- The ‘floor’ at c. 2m depth in the church was only well-imaged by lines 4 and 5 – these were the only two lines over the deep trench that exposed the church floor
- The northern parts of section 5 and 6 shows a much more abrupt base to the zone of reflectors, than do trenches 1 to 4 – only trenches 5 and 6 passed over the excavation trench north of the church.

These factors suggest that although clear reflectors are hard to pick within the radargrams, the character of the fill of the archaeological trenches contrasts with the natural and archaeological deposits. The church floor was only well-imaged in the area where is had been excavated.

In summary, radar imaging of the church structure was extremely poor, even the solid floor of the nave was only imaged where it was overlain by excavation backfill, rather than in-situ deposits.

In the area to the north of the church, for which time-sliced data are available, strong energy returns were made by the compacted ground of the informal path towards the west of the surveyed area (upper two time-slices on Figure 8. The only other response that appears coherent is an approximately north-south line on the deepest time-slice (approximately 2.03m below surface), starting from 7.5m n of grid line at 29 m from west and running to the northern margin of the survey.

This anomaly approximately coincides with the crest of the dune running northwards from the west end of the church. It is possible that this is an artefact of this geometry, but does provide a possibility that there is a linear feature (wall?) below the dune that is just shallow-enough to be imaged.

Discussion

Neither technique produced good imaging of the known archaeology. Both tools provided some information on the church, with the ground resistivity imaging both ends, but not the central section and the GPR apparently resolving the floor in the central section (but not imaging the walls well).

The resistivity data do indicate other areas with similar resistivity properties to those of the church (e.g. areas centred on 5m and 15m north of the church).

For the area immediately north of the church, the area of elevated resistivity corresponds closely to the dune crest and it would appear likely, though not certain, that this anomaly is purely the product of the dune topography.

For the area 15m north of the church, the interpretation of the anomaly is less certain. The location corresponds to a considerable amount of large stone on the surface around the eastern dune margin. Such stone is unusual for the site, and strongly suggests a link to the buried archaeology. The strongly rectilinear shape of the anomaly is suggestive of a buried building (particularly the data from the 0.5m spaced probes, Figure 5). However, much of the stone on the surface appeared loose, suggesting an alternative interpretation, that the stone might be a dump of loose stone left over from the 1980 excavation. The location is close to a dump of sand visible in a photograph of the excavation (Davidson *et al.* 1987, Plate III), behind which was positioned the ‘site caravan’.

It may possibly also be significant that the western side of this rectilinear resistivity anomaly corresponds approximately with the location of the radar reflector on the deepest of the time slices, as shown in Figure 8.

In summary, although the church remains were imaged where they extend to surface, both resistivity and radar appear poor in differentiating the buried remains. An area 15m north of the church shows a rectilinear resistivity anomaly (somewhat similar in character to that of the church) and is associated with a possible radar anomaly. This area may conceal a further buried building, or alternatively it may be an accumulation of rock within the dune, perhaps as spoil from the GGAT excavation.

In order to test the potential utility of geophysical techniques further, then limited archaeological investigation of the anomaly 15m north of the church might prove useful.

References

A.F. Davidson, J.E. Davidson, H.S. Owen-John and L. A. Toft, 1987, 'Excavations at the Sand Covered Medieval Settlement at Rhossili, West Glamorgan', *Bulletin of the Board of Celtic Studies*, **34**, 244-269

Figure Captions

Figure 1.
Left: *Location of the survey area, showing temporary and survey grid markers (red crosses), surveyed topography (contours at 0.5m intervals), tracks/paths (pecked lines) and exposed stonework (hatched areas).*
Right: *Topographic survey results as shaded relief contour image (illuminated from the NW).*

Figure 2*: Topographic survey showing layout of the GPR survey.*
Left: *GPR survey details – northern block of lines at 1m spacing is the area with red fill, southern lines at 1m spacing in red, line 1 to the west, line 6 to the east. Also shown are the above ground traces of walls (black and white crosshatch) and the 1980 GGAT excavation trench (orange) with solid fill where this was deepened to expose the floor at approximately 2m below surface.*
Right: *GPR survey details as above, but overlain on the 1.0m probe-spaced ground resistivity survey data (see also Figure 6).*

Figure 3*. 0.5m probe-spaced ground resistivity data, as bitmapped images from Geoplot. N to top, squares 40m.*
Upper: raw data (greyscale black 50Ω to white 400Ω measured resistance)
Middle: cleaned data (greyscale black 50Ω to white 400Ω measured resistance)
Lower: cleaned data adjusted greyscale (greyscale black 70Ω to white 300Ω measured resistance)

Figure 4*. 1.0m probe-spaced ground resistivity data, as bitmapped images from Geoplot. N to top, grid squares 40m.*
Upper: raw data (greyscale black 10Ω to white 400Ω measured resistance)
Middle: cleaned data (greyscale black 10Ω to white 400Ω measured resistance)
Lower: cleaned data adjusted greyscale (greyscale black 70Ω to white 170Ω measured resistance)

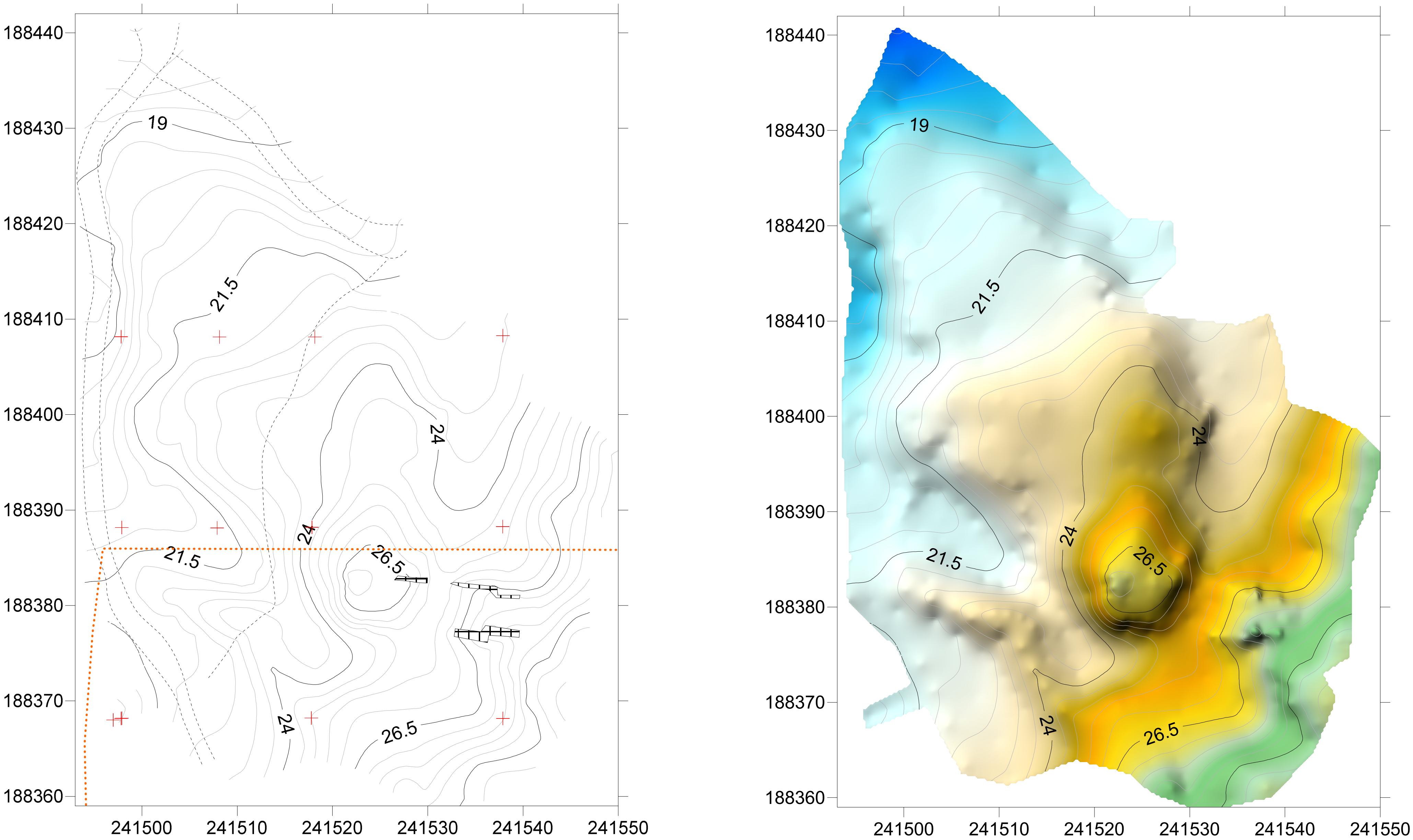
Figure 5*. Resistivity data, as interpolated data from Surfer: 0.5m probe spacing*

Figure 6*. Resistivity data, as interpolated data from Surfer: 1.0m probe spacing*

Figure 7*. Radargrams from the GPR traverses across the southern part of the survey area*

Figure 8*. Time-sliced GPR data from the northern part of the survey area. The slices are at, approximately, from top to bottom, 0.28m, 0.52m, 1.04m, 1.56m and 2.03m below surface.*

Figure 1



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188420
188410
188400
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188360
241500
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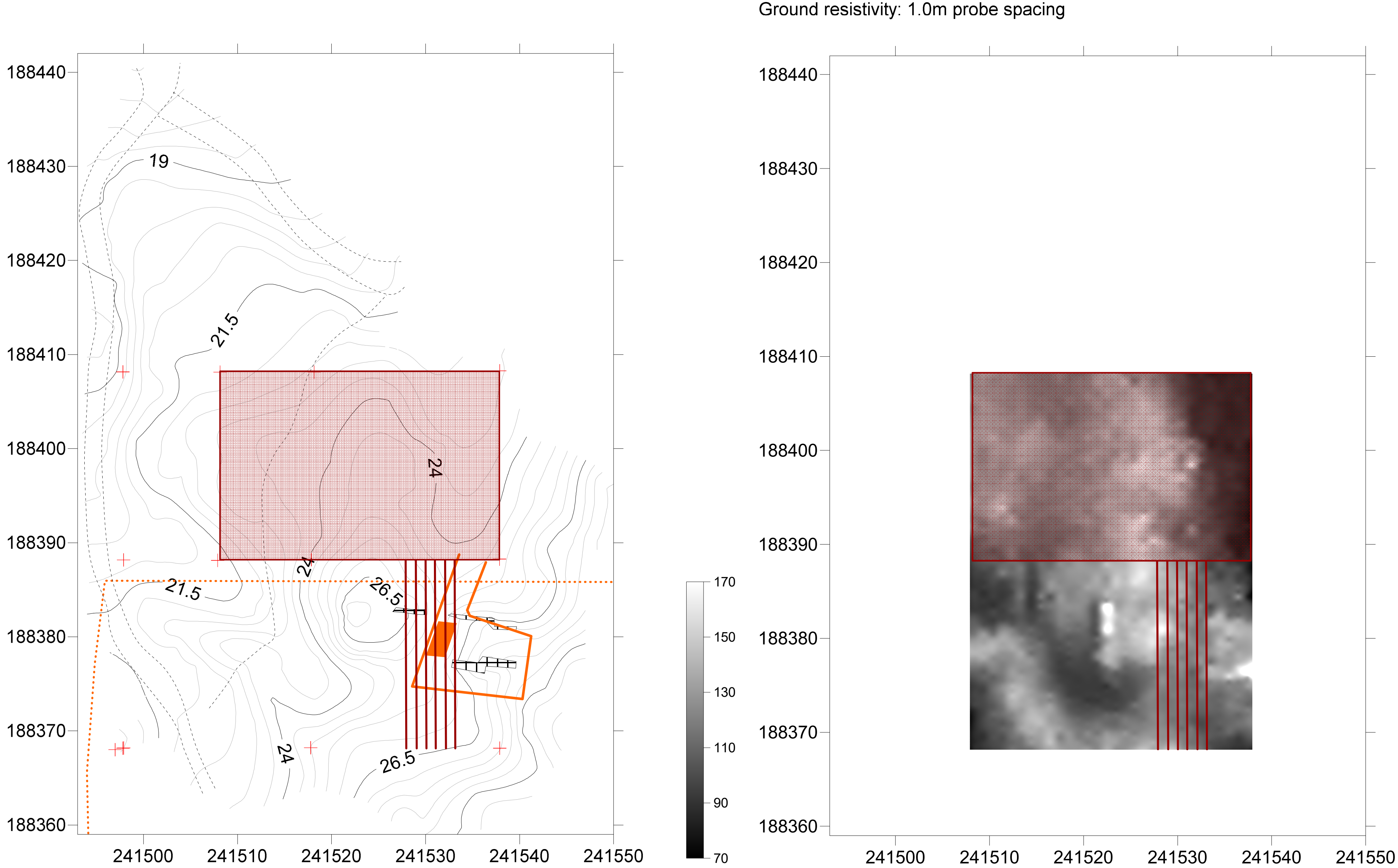
241520
241530
241540
241550
19
21.5
24
26.5

Figure 2



Ground resistivity: 1.0m probe spacing
188440
188430
188420
188410
188400
188390
188380
188370
188360
241500
241510
241520
241530
241540
241550
19
21.5
24
26.5
170
150
130
110
90
70

Figure 3

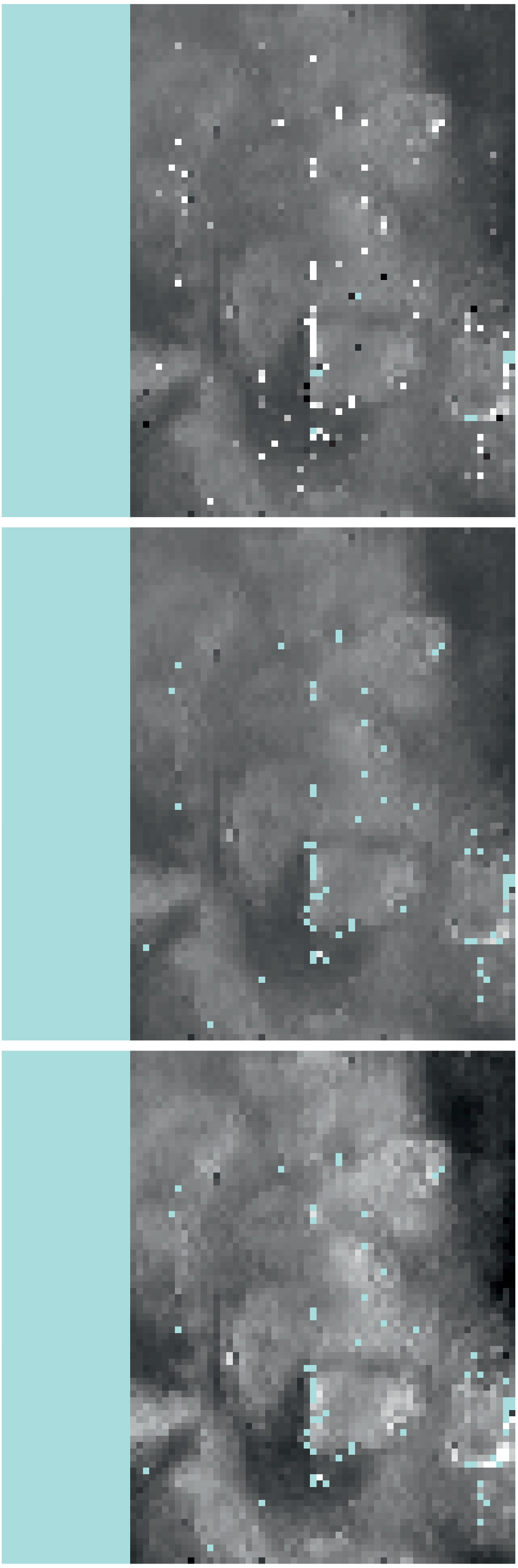


Figure 4

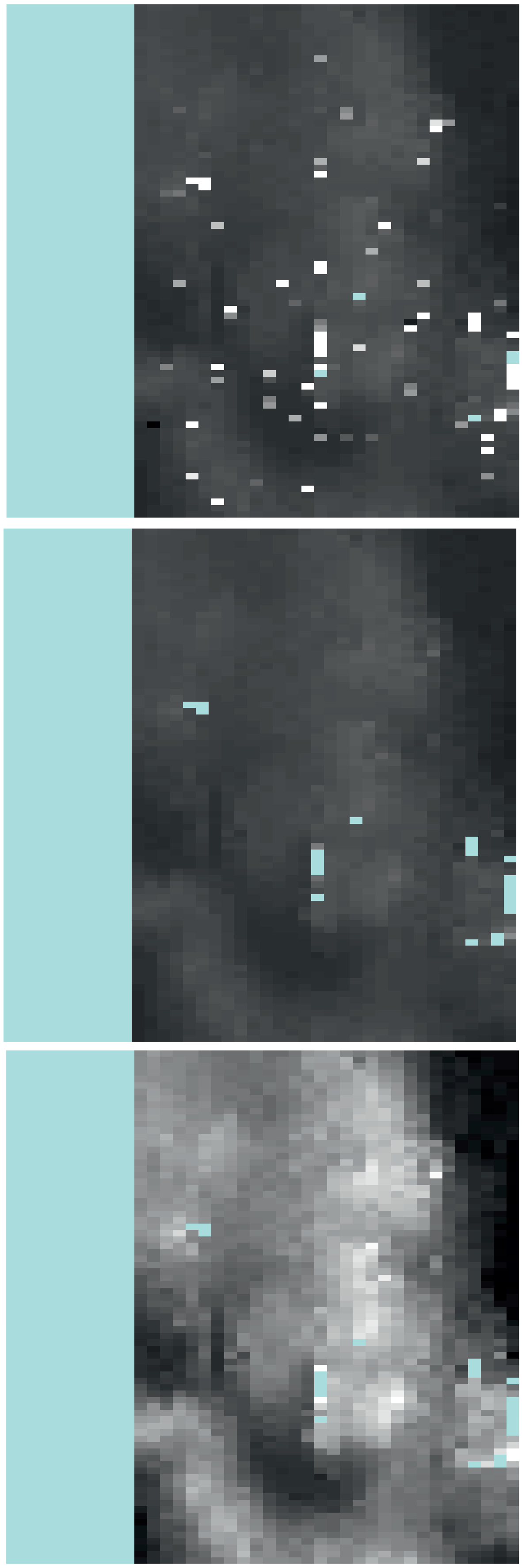
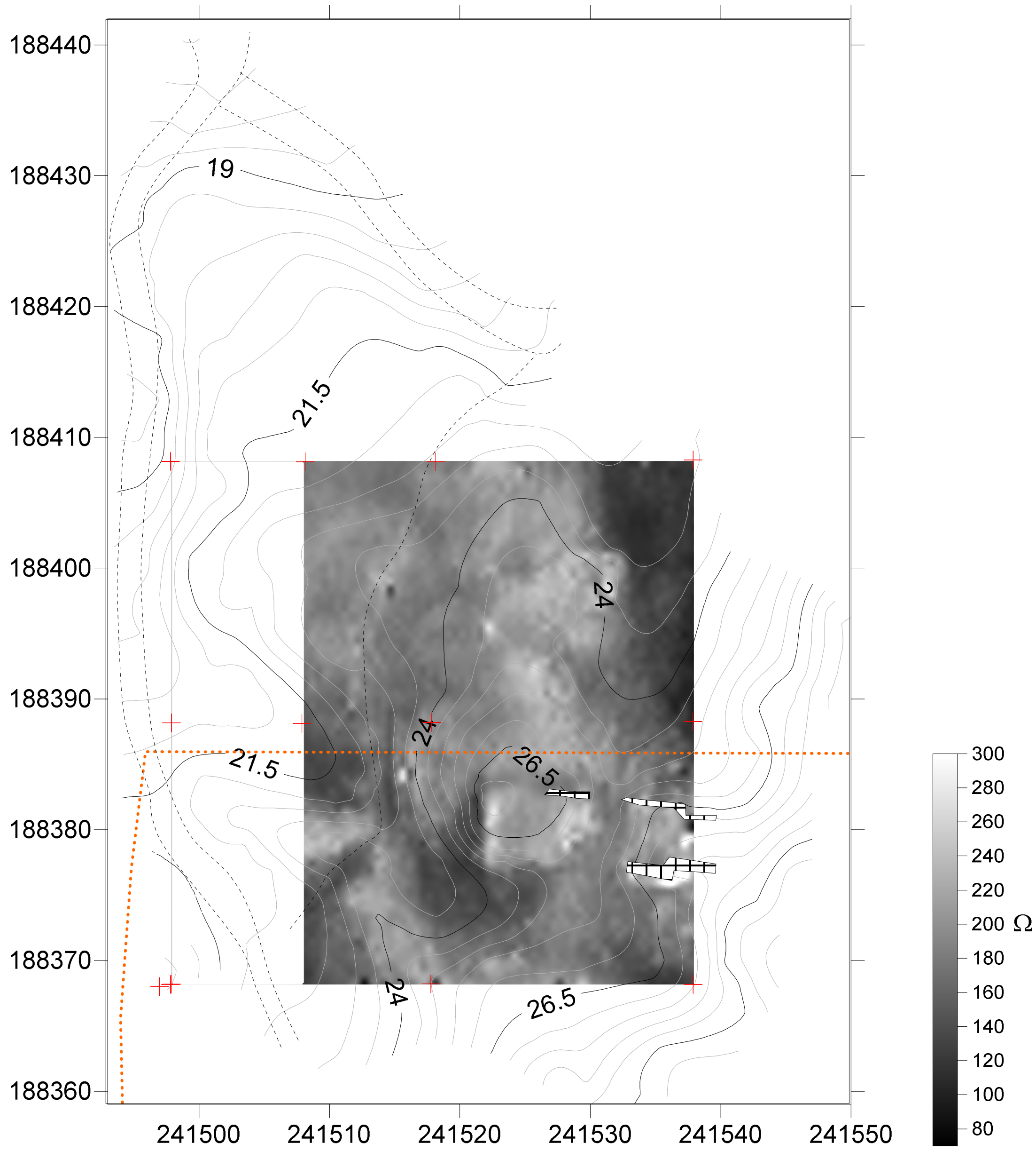


Figure 5

0.5m probe spacing



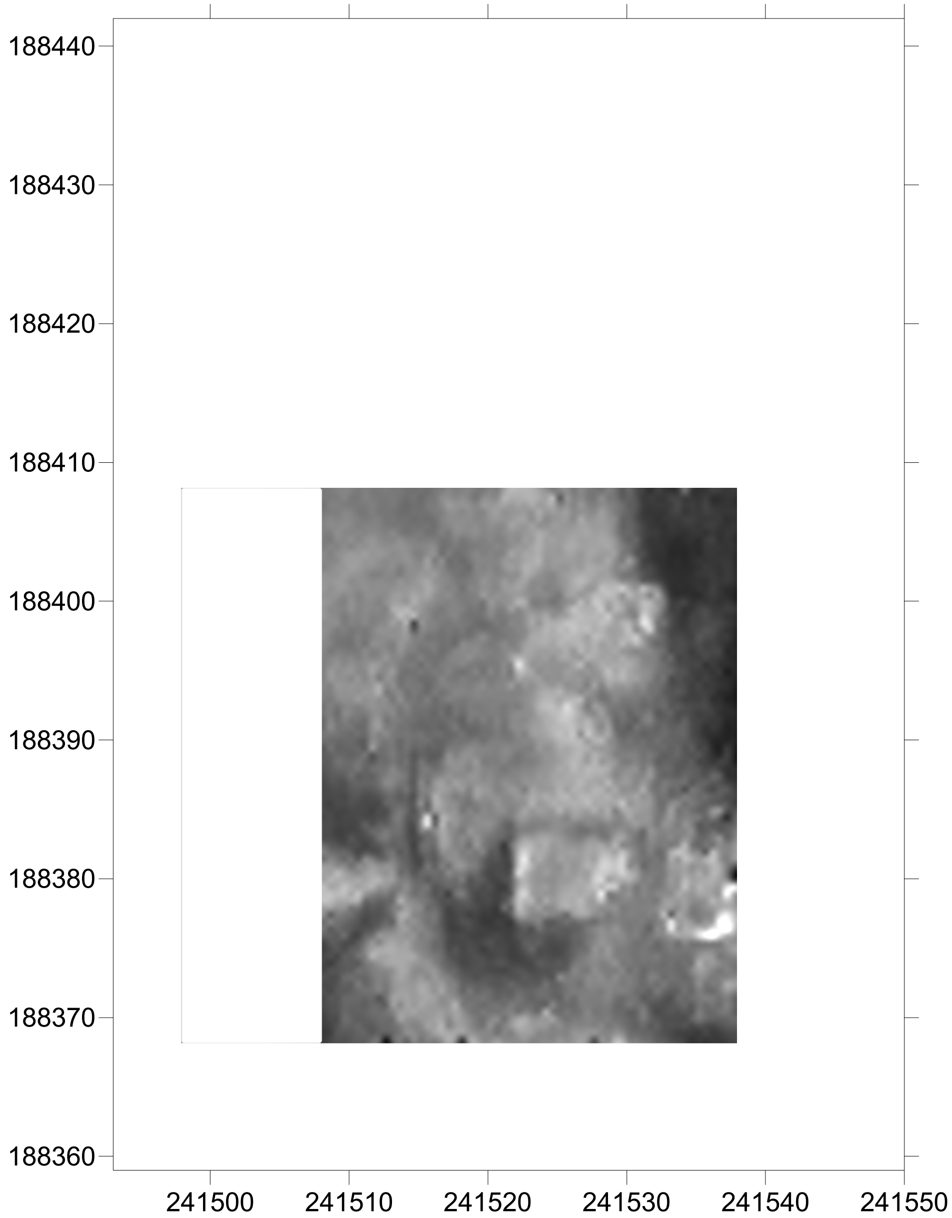
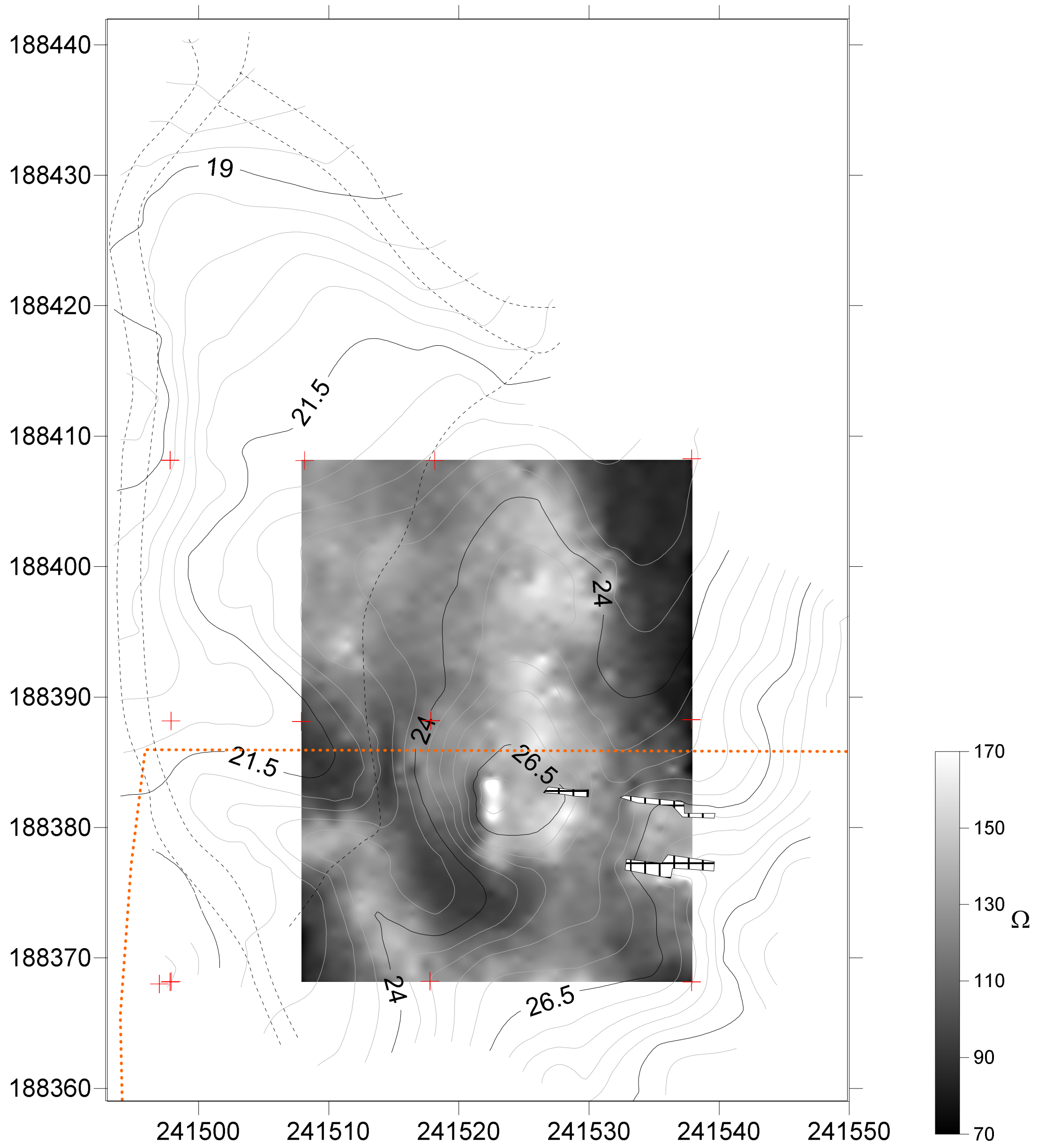
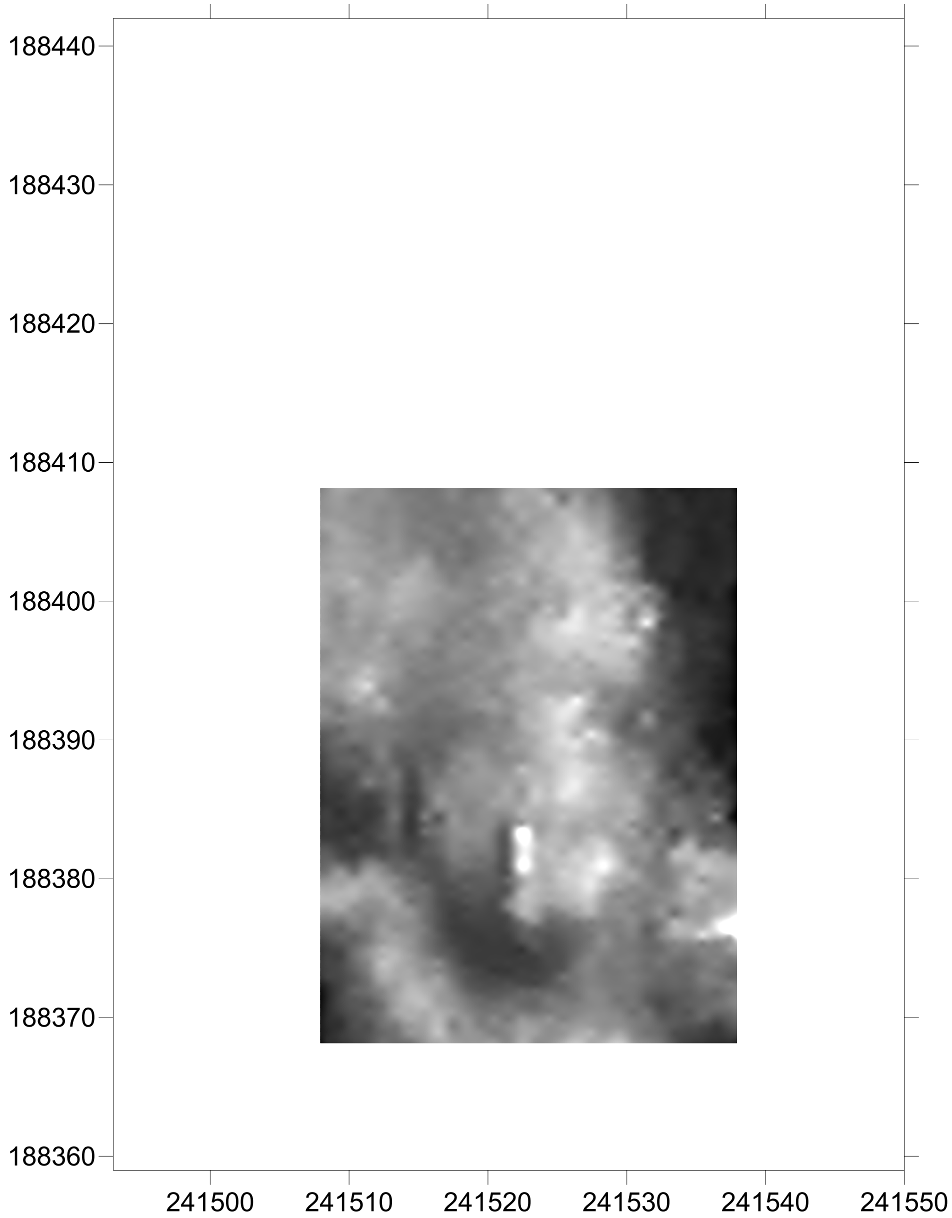


Figure 6

1.0m probe spacing





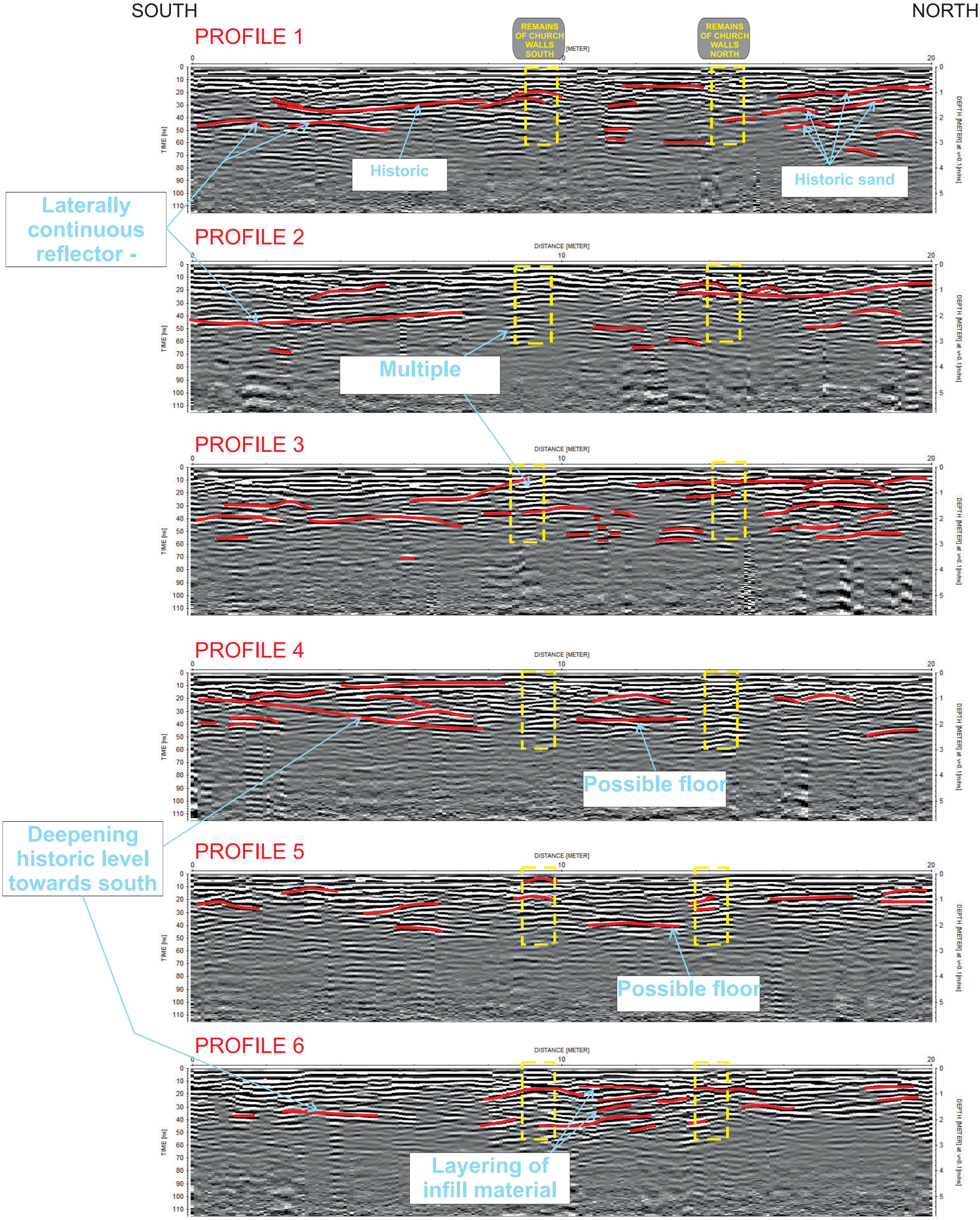
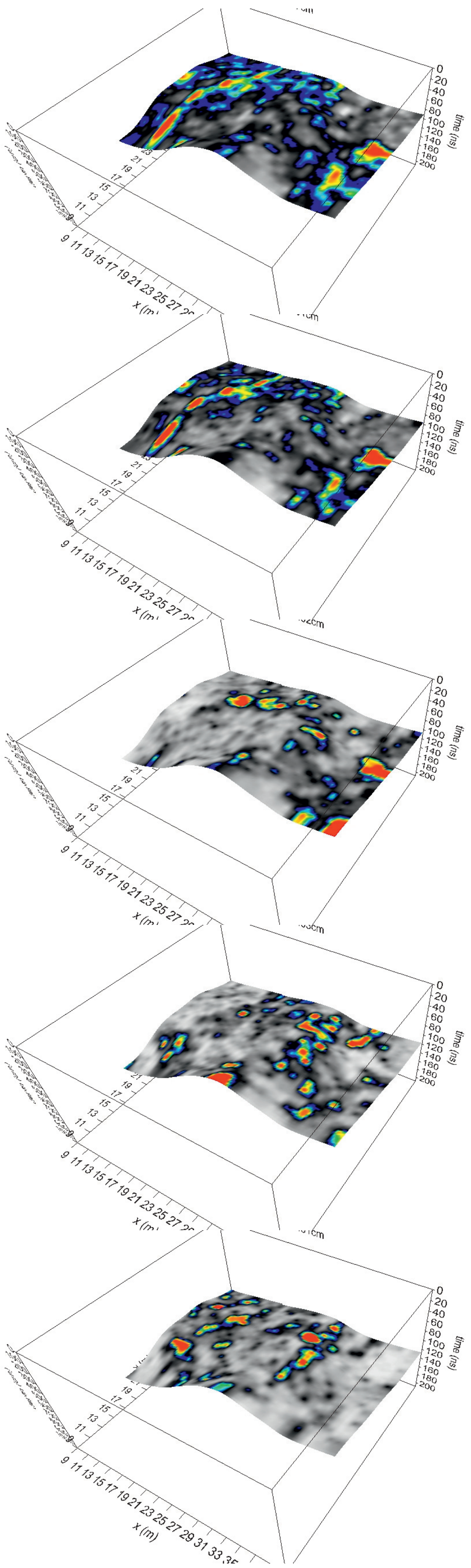

SOUTH
NORTH
PROFILE 1
REMAINS OF CHURCH WALLS SOUTH
REMAINS OF CHURCH WALLS NORTH
Historic
Historic sand
Laterally continuous reflector -
PROFILE 2
Multiple
PROFILE 3
PROFILE 4
Possible floor
Deepening historic level towards south
PROFILE 5
Possible floor
PROFILE 6
Layering of infill material
DISTANCE [METER]
TIME [ns]
DEPTH [METER] at v=0.1 [m/ns]

Figure 8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time (ns)
x (m)
9 11 13 15 17 19 21 23 25 27 29 31 33 35

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