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CVJV/AAR
3rd Floor
Longross Court,
47 Newport Road,
Cardiff
CF24 0AD

Results of the Electrical Resistivity Tomography and Electro-magnetic Surveys

Martin R. Bates and Charles R. Bates

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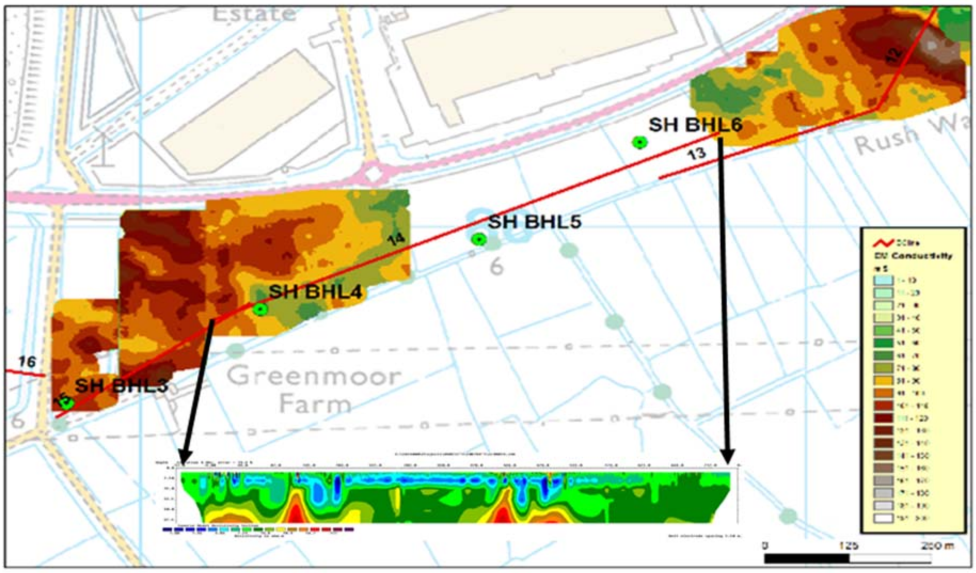

School of Archaeology, History and Anthropology
University of Wales Trinity Saint David
Lampeter
Ceredigion
SA487ED

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Executive Summary

S.1 This report describes the results of a geophysical investigation carried out along the route of the proposed M4 Corridor around Newport (M4CaN) between Castleton and Magor (hereinafter referred to as 'the Scheme'). The survey was undertaken using an Electrical Resistivity Tomography system (ERT) and an electro-magnetic system (EM) (EM-31/CDM Explorer) to investigate the buried sequences preserved along the route. Fieldwork was conducted between 3rd August and 12th September 2015.

S.2 The aims of the current survey were designed to enhance understanding of the following.

- The basic geometry of the buried sediment sequences (i.e. the depth to bedrock along the new section of motorway alignment).
- The presence and possible courses of former channels.
- The edge of any upstanding areas of dry, higher ground now buried beneath the marsh.

S.3 The objectives of the study were to provide information suitable for integration in the ground investigation model, to understand the distribution of the main lithological units and to provide targets where buried archaeological material may be present along the edges of former channels.

S.4 The results of the survey have indicated that the combined use of both sets of geophysical survey have allowed the base of the Holocene to be modelled within the framework of the transects surveyed. Possible palaeochannels and channels have been identified both in section (ERT) and in plan (EM) and underlying bodies of Pleistocene sands and gravels identified.

S.5 The results clearly demonstrate that sequences east and west of the River Usk appear different in terms of the architecture. To the east of the Usk up to five potential palaeochannels have been identified that appear to be features cut to depth in the sequence (i.e. they probably owe their origin to the Late Pleistocene). Two additional channel like features are also present in the Central Array (east of the Usk) that appear to have been cut from higher in the sequence and are probably more recent in origin. There is considerable variability within the Holocene sediments east of the Usk with changes from organic-dominated to more minerogenic dominated sediments common. No clearly identified bodies of Pleistocene sands and gravels could be identified in the geophysics east of the river.

S.6 By contrast, sequences west of the river appear to lack palaeochannels and large channel forms, the internal pattern in the Holocene alluvium is simple moving from minerogenic near the river to organic dominated to the west. Large bodies of Pleistocene sands and gravels appear to be common beneath the marsh here.

1 Introduction

1.1.1 This report describes the results of a geophysical investigation carried out on land along the proposed new section of motorway between Castleton and Magor (Figures 1-3).

1.1.2 The survey was undertaken using an Electrical Resistivity Tomography system (ERT) (Figure 4) and an electro-magnetic system (EM-31/CDM Explorer) (Figure 5) to investigate the buried sequences preserved along part of the new section of motorway. This was designed to provide information suitable for integration in the ground investigation model being compiled by Wessex Archaeology, to understand the distribution of the main lithological units and to provide targets where buried archaeological material may be present along the edges of former channels.

1.1.3 Electrical properties are among the most useful geophysical parameters in characterizing earth materials. Variations in electrical resistivity (or conductivity) typically correlate with variations in lithology, water saturation, fluid conductivity, porosity and permeability. Depending on the particular site, these variations may be used to map stratigraphic units, geological structure, sinkholes, fractures and groundwater. Previous work (Bates and Bates, 2000; Bates *et al*., 2007; Bates and Stafford, 2013) has demonstrated the applicability of the method to resolving sub-surface Holocene stratigraphic sequences in southern England and here the approach was deployed to provide information on buried sequences along the alignment of the new section of motorway.

2 Aims and objectives

2.1.1 The study was designed to allow rapid characterisation of the near surface sediments (to bedrock) along the alignment of the new section of motorway. The two methodologies utilised were designed to complement each other and provide information suitable for integration with geotechnical data and geoarchaeological investigations undertaken by Wessex Archaeology.

2.1.2 In particular the aims of the current survey were designed to enhance our understanding of the following.

- The basic geometry of the buried sediment sequences (i.e. the depth to bedrock along the new section of motorway alignment.
- The presence and possible courses of former channels.
- The edge of any upstanding areas of dry, higher ground now buried beneath the marsh.

2.1.3 The objectives of the study were to provide information suitable for integration in the ground investigation model and to understand the distribution of the main lithological units.

3 Survey Methods

3.1 Introduction

3.1.1 The methodology was developed in order to provide a rapid, cost effective, evaluation of the floodplain sediments in order to supply information useful for archaeological prospection. The survey was undertaken in accordance with Guidance supplied by Historic England (2008) and the Chartered Institute for Archaeology (2014). The combination of techniques applied were selected to complement each other in supplying information to address the key site objectives. Geophysics was ground truthed through the selection of a number of boreholes available from site investigation for the area (these boreholes only represent a small sub-set of the total available for study). These are listed in Annex A and depths to bedrock or Pleistocene gravel (i.e. thickness of Holocene alluvium) represented on individual figures as blue rectangles (e.g. Figure 9).

3.1.2 Limitations of the effectiveness of the survey and the interpretations that could be extracted from the survey are noted. It was not possible to survey the entire route corridor due to land access issues as well as existing infrastructure. Additionally the narrow route corridor for the survey limits the interpretation of features seen (particularly) in the EM data survey.

3.2 Electrical Resistance Tomography (ERT) Survey

3.2.1 The work was undertaken using a tomography system comprising of a number of electrodes linked together via multi-core cables, a switch-box that facilitates access to any combinations of electrodes, a power source and a measuring unit (Figure 4). Fieldwork was conducted by a team led by Dr Martin Bates and Dr Charles Bates between 3rd August and 12th September 2015. A total of 19 transects were surveyed (Figures 1-3) and the results from the transects are presented in Figures 6, 8-10, 12, 13, 15-17, 19-21, 23, 24, 26-28, 30-32, 34 and 35.

3.2.2 The LUND Resistivity System and Field Computer was used in the survey where electrodes were deployed along the traverse lines and inserted into the ground to a depth of approximately 15 cm. The resistivity data collected were recorded via complex combinations of current and potential electrode pairs to build up a pseudo cross-section of apparent resistivity beneath the survey line. The depth of investigation depends on the electrode separation and geometry, with greater electrode separations yielding bulk resistivity measurements to greater depths. Electrode spacings of 5 m were used to examine the full depth of sequence present.

3.2.3 All transects were surveyed and full position and elevation data for the transects were obtained.

3.2.4 The transects presented are shown as corrected for elevation and data are presented colour coded to show low resistance colours in cool shades (blues to greens) and high resistance colours in hot shades (yellows to reds). The horizontal scale is in 2 m increments. It should be noted that reading the sections plots below 22 m depth should be treated with caution as relatively few readings are derived from these depths.

3.3 Electro-magnetic (EM) Survey

3.3.1 A surface ground conductivity survey was conducted using a Geonics EM31 or CMD Explorer. This equipment uses a varying electromagnetic field to measure changes in near surface conductivity. For example clays and silts are more conductive to electrical currents than sands and gravels. From a measure of changes in ground conductivity on a grid of continuous recording stations across the site it is possible to produce a 2D map as a proxy for the distribution of sands, gravels and finer grained sediments in the near surface zone. Such techniques are ideal for locating buried channels as well as identifying the surface expression of buried sand and gravel islands within the alluvium.

3.3.2 The equipment was chosen for the geoelectrical survey because at low electrical induction numbers the terrain conductivity is directly proportional to instrument reading (of secondary to primary magnetic field). The ground conductivity is a function of the electrical conductivity of the material (soil or rock), the fluid content and the thickness or depth of individual layers within the ground. Because the instrument uses an electromagnetic field, maps of geologic variations and subsurface features associated with the changes in ground conductivity can be produced without the recourse to directly placing electrodes into the ground. In the field, ground conductivity measurements were directly recorded together with a DGPS location for real time spatial positioning. Some advantages of the selected equipment over conventional resistivity methods are the speed with which surveys can be performed, the precision with which small changes in conductivity can be measured and the continuous readout and data collection while traversing the survey area.

4 Results

4.1.1 The data are presented in three segments, Eastern, Central and Western (Figures 1-3). For each segment a composite stitched together profile of the ERT data is shown with a map containing the transect lines and the EM data (Figures 6, 17 and 28 respectively). A series of detailed maps are then presented for each area showing ERT transect lines, EM data and ground truth boreholes used in this study (Figures 7, 11, 14, 18, 22, 25, 29 and 33). Finally individual transect panels are presented for the ERT data for each of the segments (Figures 8, 9, 10, 12, 13, 15,16, 19, 20, 21, 23, 24, 26, 27, 30, 31, 32, 34 and 35).

4.1.2 EM data are mapped by colour coordinated values to conductivity, thus cool colours (blues and greens) represent low conductivities (high resistance) while reds and browns (hot colours) represent high conductivities (low resistance). The ERT data are also colour coded with blues and greens (cool colours) matched to low resistance (high conductivities) and reds and browns (hot colours) to high resistance (low conductivities).

4.1.3 The ERT profiles are all scaled to a similar vertical and horizontal scale and in most cases two versions of the profile are shown with the bottom panel orientated from east (right) to west (left). Positions of ground truth boreholes are shown where appropriate and the blue bars represent the depth of Holocene sediments (i.e. depth to bedrock or Pleistocene gravel).

4.1.4 Because of the nature of the survey techniques the size and scale of features identified will vary between places and methods. Thus the identification of a channel feature in the EM data is likely to include channel features from a few meters across to major drainage axes across the floodplain (100’s m). By contrast the deeper seeking ERT data only identifies major palaeochannels. There can therefore be a tension in the scale of interpretation between the two methods. This is likely to be further compounded when palaeochannels have been identified in boreholes and trenches where again scales of feature will vary between the methods used to identify the features.

4.2 Eastern Array

4.2.1 The EM data from the Eastern Array (Figures 1, 6, 7, 11 and 14) show a clear distinction between low conductivities/high resistance mapped around the two eastern most ERT profiles (Figures 12 and 26) and much higher conductivities to the west (this boundary is marked as boundary 1 in Figure 7). This major change in conductivity values is also noted with a similar pattern within the ERT data that is particularly well illustrated in Line 12 (Figure 9) where a pod of high resistance/low conductivity is mapped at the eastern end of this line. Ground truth borehole (SI BH570) records only 4.2 m of probable Holocene sediments at this location above bedrock. Both sets of geophysical survey data appear to be mapping the subsurface of the bedrock geology here, which is the Tintern Sandstone Formation, covered by a thin veneer of Holocene sediments.

4.2.2 Moving west along Line 12 is it clear that a pod of low resistance/high conductivity sediments (blue/green colours on the ERT data) are appearing and thickening west to a depth of c.10-11 m. This corresponds to the EM mapped data showing generally higher conductivity values in this area to the west of boundary 1 (Figure 7). This is likely to be the mapped depth of the Holocene alluvium. Ground truth borehole SH BHM2 supports the notion that this layer of conductive material represents the Holocene alluvium.

4.2.3 The western end of Line 12 appears to contain a large feature that may be interpreted as a possible palaeochannel (P1, Figure 9) at around grid reference 341034 186221 (Figure 9). Other palaeochannel complexes have tentatively been identified within the Eastern Array at grid references 340813/186146 and 340451/185943 (Line 14, Figure 12, P2 and P3 respectively) and 338929/185608 (Line 17, Figure 16, P4). Other changes along the Eastern Array relate to variations in resistivity in the ERT profiles within the Holocene alluvium marked by changes between blue and green colours (in the low resistance / high conductivity spectrum). These changes appear to reflect differences in organic content when matched to borehole data. For example, along Line 14 (Figure 12) very low resistance values (blues) dominate the central part of the transect. These have been ground truthed by borehole SH BHL5 which is dominated by sandy clays with some organics. To the west resistance values increase slightly and the sediments (ground truthed with borehole SH BHL4) contain increased organic content. Similar patterns can be seen at the eastern end of Line 16 (Figure 15) where a pod of green (slightly more resistant material) is present.

4.2.4 Simple relationships between the EM and ERT data in this sector are not however, always apparent. Thus within the central part of the Eastern Array (Figure 11), unfortunately where we have missing EM coverage due to land access issues, the EM data appear to indicate changes to less conductive material in the area around SH BHL5 (bounded by boundaries 2 and 3). This is the apparent opposite to the conclusions drawn from the ERT data from this sector (Figure 12, see above). None the less both techniques indicate change along the central part of this sector.

4.2.5 One factor to note across this sector is the relatively uniform thickness of the Holocene alluvial pod (the base of this layer is picked across the sections and can be seen to be relatively horizontal in many cases) down to depths of approximately 10 m below marsh surface.

4.3 Central Array

4.3.1 ERT transects through the Central Array reveal a somewhat simpler pattern to that of the Eastern Array. The base of Holocene sequence is uniformly about 10 m below marsh surface (Figure 17). The sequences show little evidence of significant palaeochannels extending to depth here with the exception of a possible palaeochannel (P5) at grid reference 336154/185838 (east end of Line 20, Figure 21).

4.3.2 Along much of the eastern and central parts of the transect (Figures 19, 20, 21, 23, 24 and 26) the ERT data show low resistance units dominate and are interpreted as low organic/high minerogenic dominated sediments. Occasional shifts in resistance are seen in places where slightly more resistant units are inferred (east end of Line 18, Figure 19, central part of Line 19, Figure 20 and the central part of Line 21, Figure 23).

4.3.3 Two significant features of the ERT data are noted however. More resistant units are noted forming a downward dipping pod in the centre of Line 21 (Figure 23) and towards the western end of Line 21 (Figure 23). These pods dip into low resistance units either side of them. The second feature is the higher conductivity values noted at the western end of the Central Array (Line 355, Figure 27). In both cases the ERT data indicate a possible coarsening of grain size within these zones to account for the increased resistance of the sediment.

4.3.4 The EM data have a number of discrete changes through the fields with particularly clear boundaries present within the central part of the array (Figure 22) where 4 boundaries (4-7) have been identified isolating low conductivity areas. These equate with the downward dipping pods of higher resistance seen in the ERT profile from Line 21 (Figure 23). These features are interpreted as channels (C1 and C2) perhaps of recent origin as they contrast in their geophysical signature from the palaeochannels noted to the east.

4.3.5 Finally the EM data from the western end of the Central Array (Figure 25) show a zone of low conductivity bounded by boundary 8 that corresponds with the zone of higher resistance sediments shown in the ERT results from Line 355. These are interpreted as coarser sediments and the evidence from the EM data suggests they may lie in a small channel complex developed in the marshland.

4.4 Western Array

4.4.1 EM data from the Western Array suggest that highest conductivity sediments lie to the east (closest to the Usk) and decrease in conductivity westwards. Three possible zones have been identified and are separated by boundaries 9 and 10 (Figure 29).

4.4.2 ERT data clearly show the presence of the Holocene low resistance units across the full width of the surveyed corridor. In general these appear to have lower resistance to the east (Line 29, Figure 30) becoming slightly more resistant to the west (e.g. Lines 31, 32 and 33, Figures 32, 34 and 35). This probably reflects the change from more minerogenic sediments at the east end to more organic dominated sediments westwards. No obvious palaeochannel complexes or channels (as identified in the Eastern and Central Arrays) were noted in the Western Array. Another distinct feature of the Western Array is the slightly thinner nature of the Holocene alluvial horizon by comparison with the other arrays.

4.4.3 Finally, a major resistive unit is present beneath the Holocene alluvium in places in the Western Array. This is particularly well developed in Line 29 (Figure 30), Line 30 (Figure 31), Line 31 (Figure 32), Line 32 (Figure 34) and Line 33 (Figure 35). Ground truth evidence from boreholes SI BH 402/405/406 indicate this is Pleistocene gravels and consequently we can see the extensive nature of these sequences west of the Usk. Similar units to do appear east of the Usk in the geophysics.

5 Discussion

5.1 Stratigraphic Architecture

5.1.1 The results of the survey have indicated that the combined use of both sets of geophysical survey have allowed the base of the Holocene to be modelled within the framework of the transects surveyed. Possible palaeochannels and channels have been identified both in section (ERT) and in plan (EM) and underlying bodies of Pleistocene sands and gravels identified. A schematic model for the sequences is presented in Figure 36.

5.1.2 The results clearly demonstrate that sequences east and west of the River Usk appear different in terms of the architecture (at least within the areas investigated). Thus to the east of the Usk (Figure 36A) a number of potential palaeochannels have been identified (5) that appear to be features cut to depth in the sequence (i.e. they probably owe their origin to the Late Pleistocene). Channel like features (2) are also present in the Central Array that appear to have been cut from higher in the sequence and are probably more recent in origin. There is considerable variability within the Holocene sediments east of the Usk with changes from organic-dominated to more minerogenic dominated sediments common. Finally no clearly identified bodies of Pleistocene sands and gravels could be identified in the geophysics east of the river.

5.1.3 By contrast, sequences west of the river (Figure 36B) appear to lack palaeochannels and large channel forms, the internal pattern in the Holocene alluvium is simple moving from minerogenic near the river to organic dominated to the west. Finally large bodies of Pleistocene sands and gravels appear to be common beneath the marsh here.

5.2 Archaeological Significance

5.2.1 The significance of the various sequences in terms of possible associated archaeology are based on the assumption that ecotonal zones (i.e. dry to wet ground or channel marginal situations, see Bates and Whittaker, 2004 for an explanation) are likely foci of human activity.

5.2.2 The presence of potential palaeochannel systems through the study area (P1-5) indicates possible locations along the margins of these systems for human activity. Evidence from Barlands Farm, where a boat was found in one of these systems (Nayling and McGrail, 2004), supports this notion. In Figure 11, boundaries 2 and 3 possibly represent the extent of the palaeochannel complex associated with this discovery. The presence of any palaeochannel system within the study area is likely to be associated with raised archaeological potential. It should however be noted that the nature, extent and distribution of any palaeochannels identified in the narrow survey corridor are likely to be part of more complex networks and that the relationship of mapped channels to those know historically or through excavation should be treated with caution until mapped more extensively.

5.2.3 It is difficult to be certain about the archaeological significance of the other mapped lithologies. Sediments with the increased minerogenic input might be interpreted to indicate mudflat contexts of deposition of potentially lower archaeological significance, but without detailed integration with the full geotechnical data set it is difficult to make such assumptions. The presence of archaeology within the mapped Pleistocene gravels is considered low and any finds in such contexts likely to be reworked. However, localised conditions for preservation may exist in such deposits.

5.2.4 The Holocene alluvial sequences have been noted to be relatively uniform in thickness either side of the Usk. To the east typically the depth to base of Holocene (beyond areas in which palaeochannels may exist) is approximately 10 m on the basis of our evidence. West of the Usk the sequences appear to be shallower, perhaps 6-8 m depth. Consequently these figures can be used to guide depths to the early Holocene topographic template (sensu Bates and Whittaker, 2004). This buried landsurface may contain evidence for final Upper Palaeolithic and earliest Mesolithic archaeology. No evidence of 'islands' or sand and gravel or drier areas within the alluvium were identified in this survey.

5.3 Limitations of the Study

5.3.1 Caution should be applied to the data. The use of the terms 'channels / palaeochannels' is problematic in the context of comparing 'channels / palaeochannels' as identified within the geophysical data with 'channels / palaeochannels' as identified within archaeological excavations and trenches. The term channel/palaeochannel as used in this report is for large scale features 10's of meters wide. Minor channelling, as identified in excavations, can be significantly smaller than those used here and therefore it is probable that confusion may occur when attempting to integrate different scales of investigation. This is perhaps something to consider when an attempt is made to integrate the geotechnical/geoarchaeological investigation with our geophysical investigation.

5.3.2 The narrow corridor of investigation is also problematic. Understanding EM data and the relationship between mapped conductivities and channel like features is difficult where only a narrow strip of land has been surveyed. Greater certainty in interpretation would be gained through a broader survey area. Additionally some areas of the new section of motorway alignment were not surveyed due to land access issues and consequently key areas of data are missing. For example that area south of the Tesco warehouse within the Eastern Array.

5.3.3 Finally it is noted that additional data are likely to be present within the ERT sections that currently cannot be identified and will only be resolved by very careful cross examination with the full set of ground investigation data (of which only a sub-set was used in this study for ground truthing).

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Figures

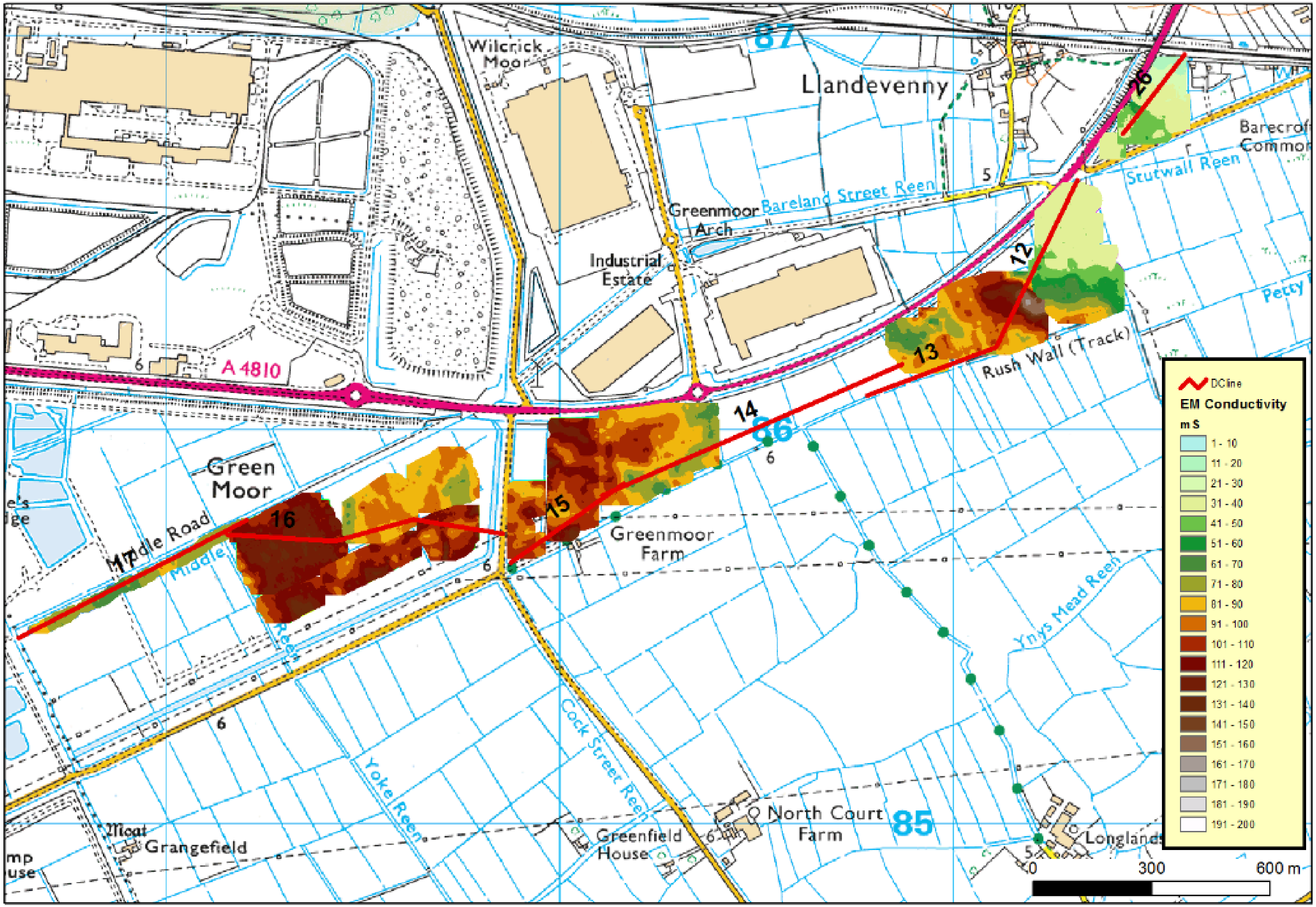


Figure 1. Eastern array.

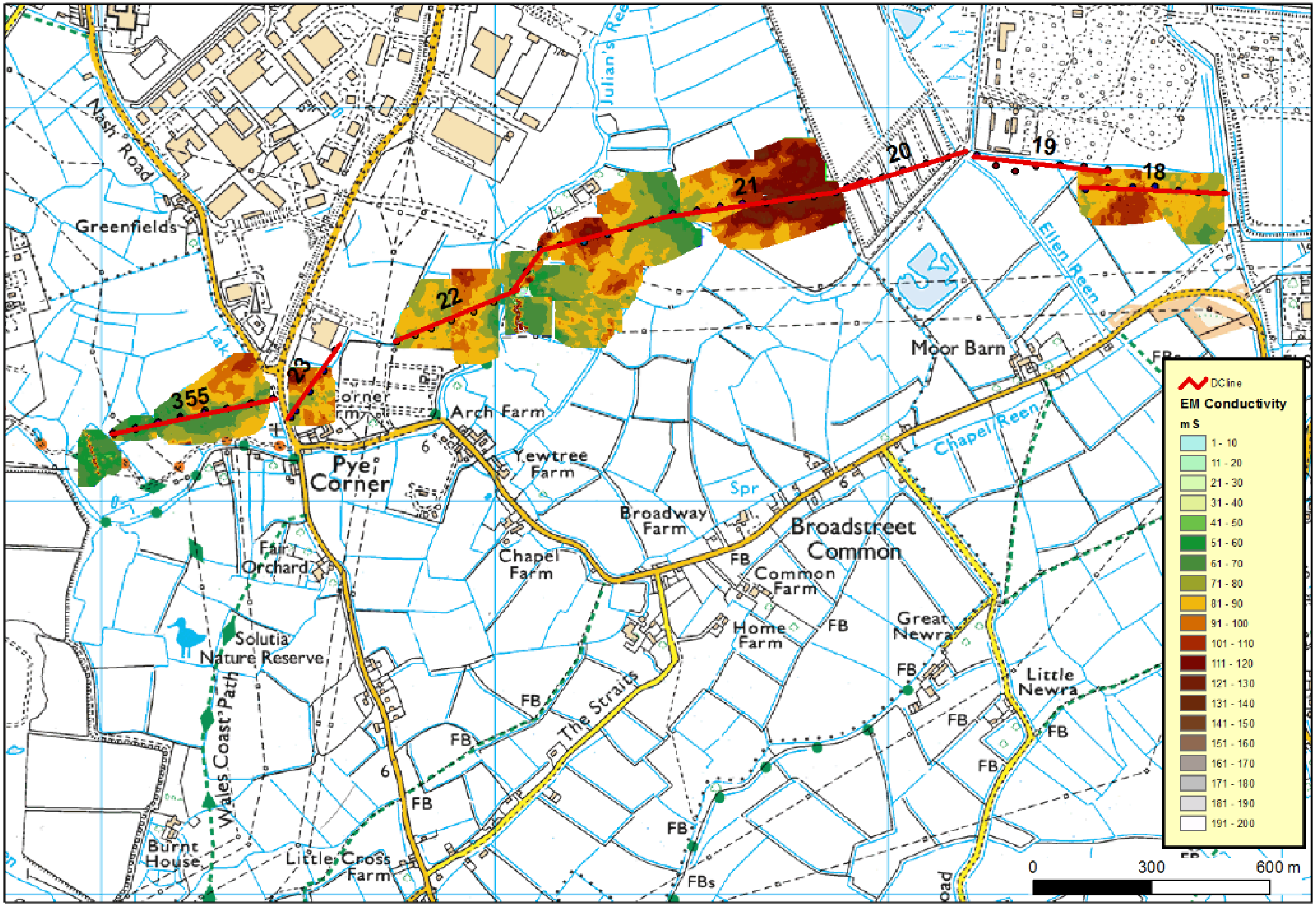


Figure 2. Central array.

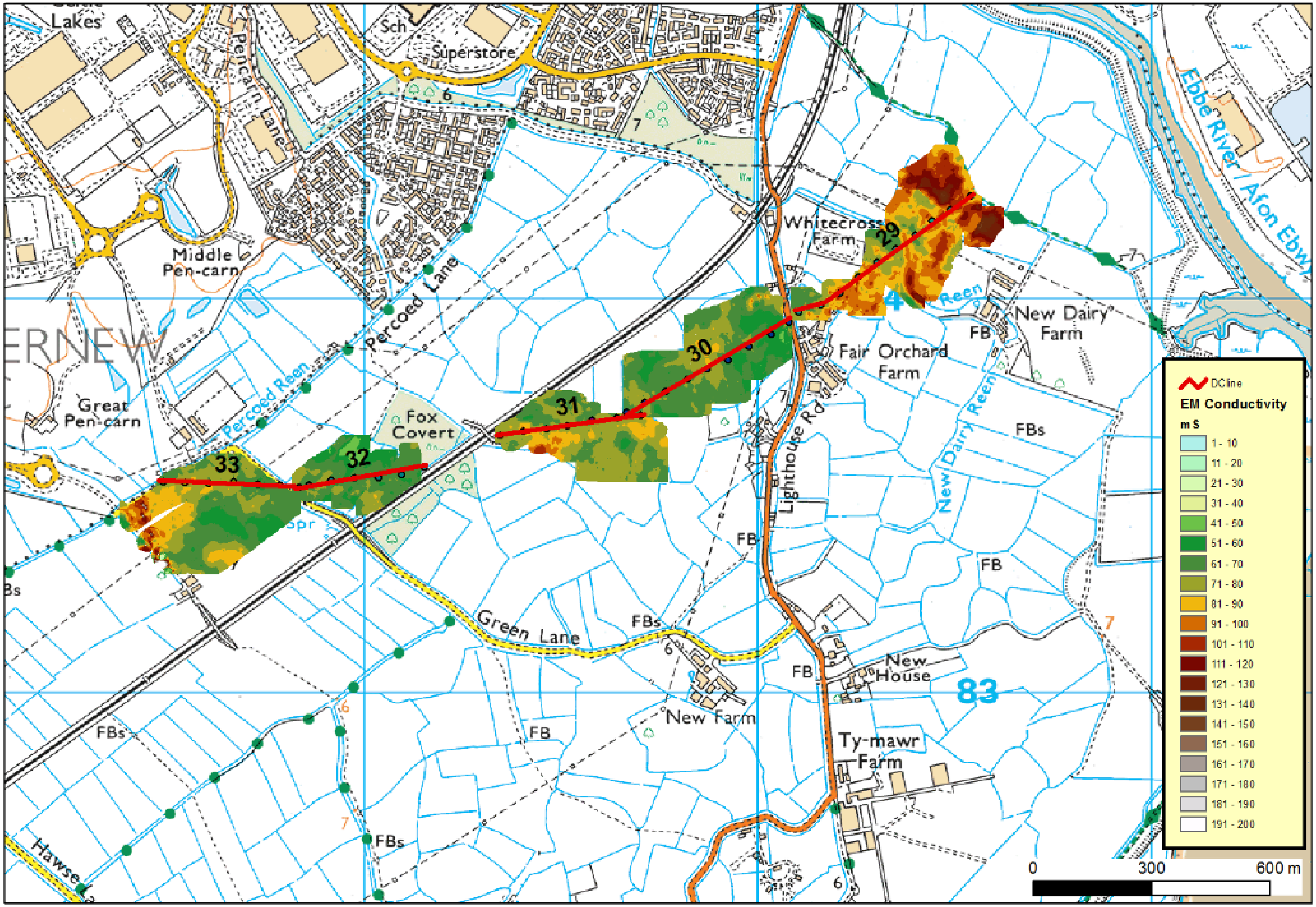


Figure 3. Western array.

Figure 4. ERT survey. **A:** cables and electrodes positioned in ground. **B:** Controller and battery connected to cables.

Figure 5. Electromagnetic survey using an EM31 ground conductivity meter.

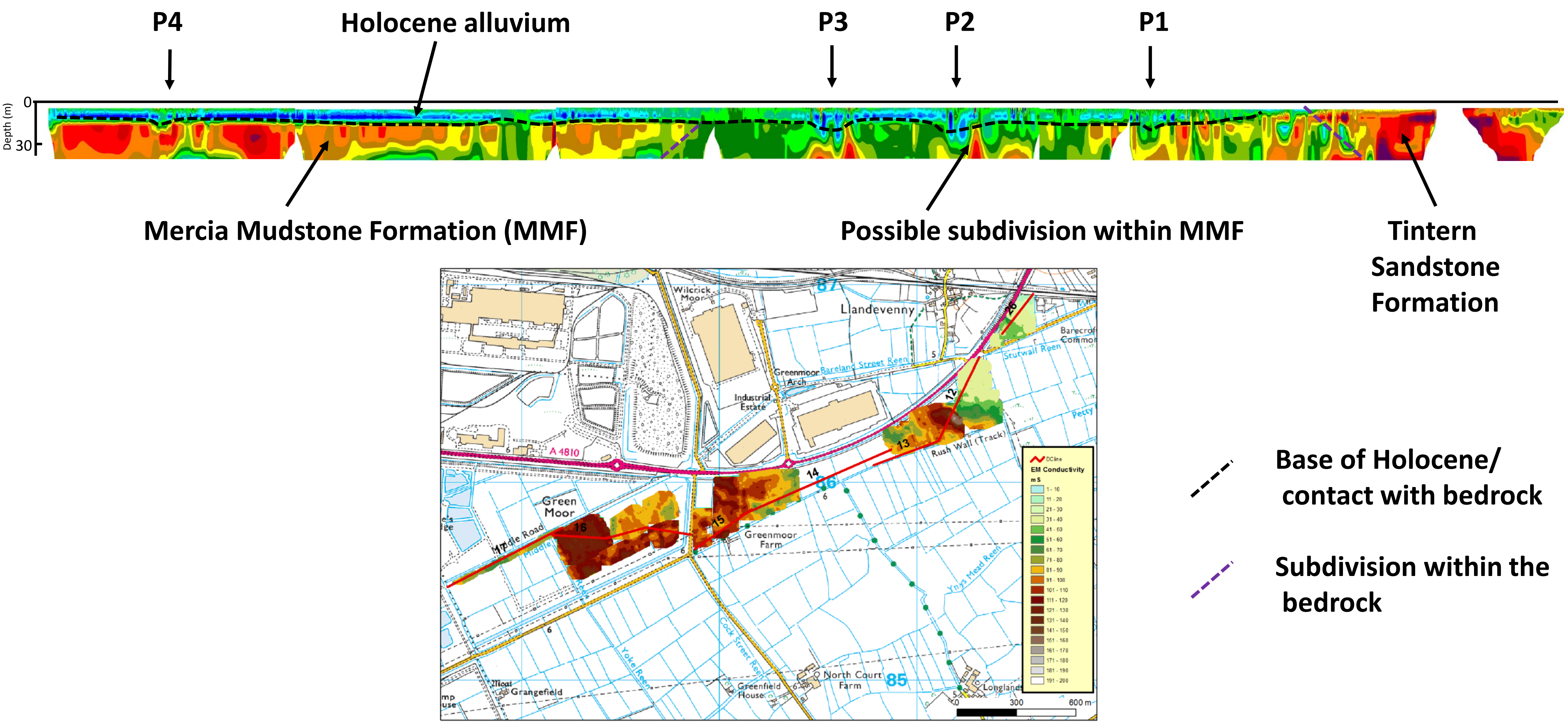


Figure 6. Eastern array with stitched together transect.

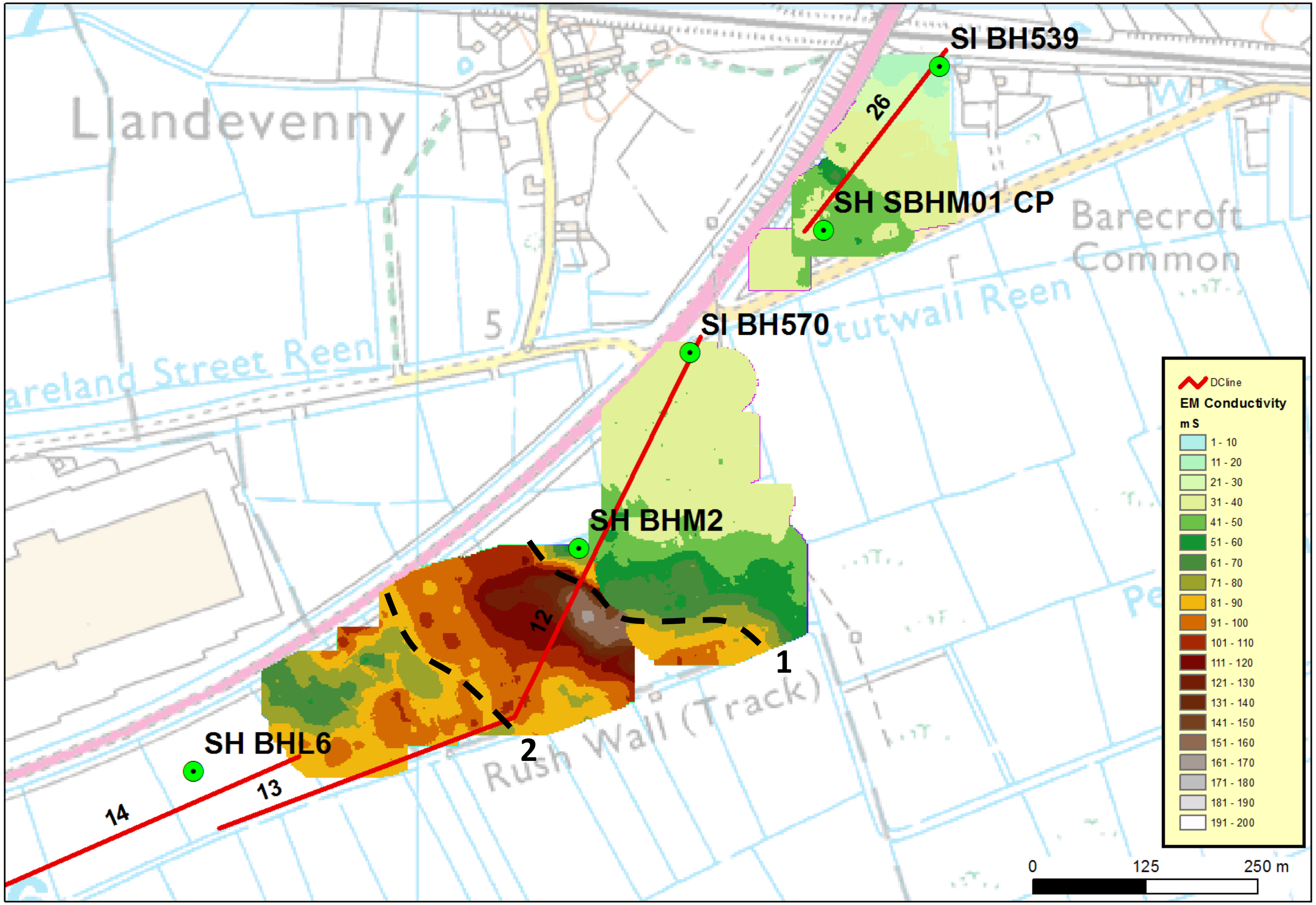


Figure 7. Eastern array (1), ground truth boreholes and edge of interpreted features (indicated by dashed black lines).

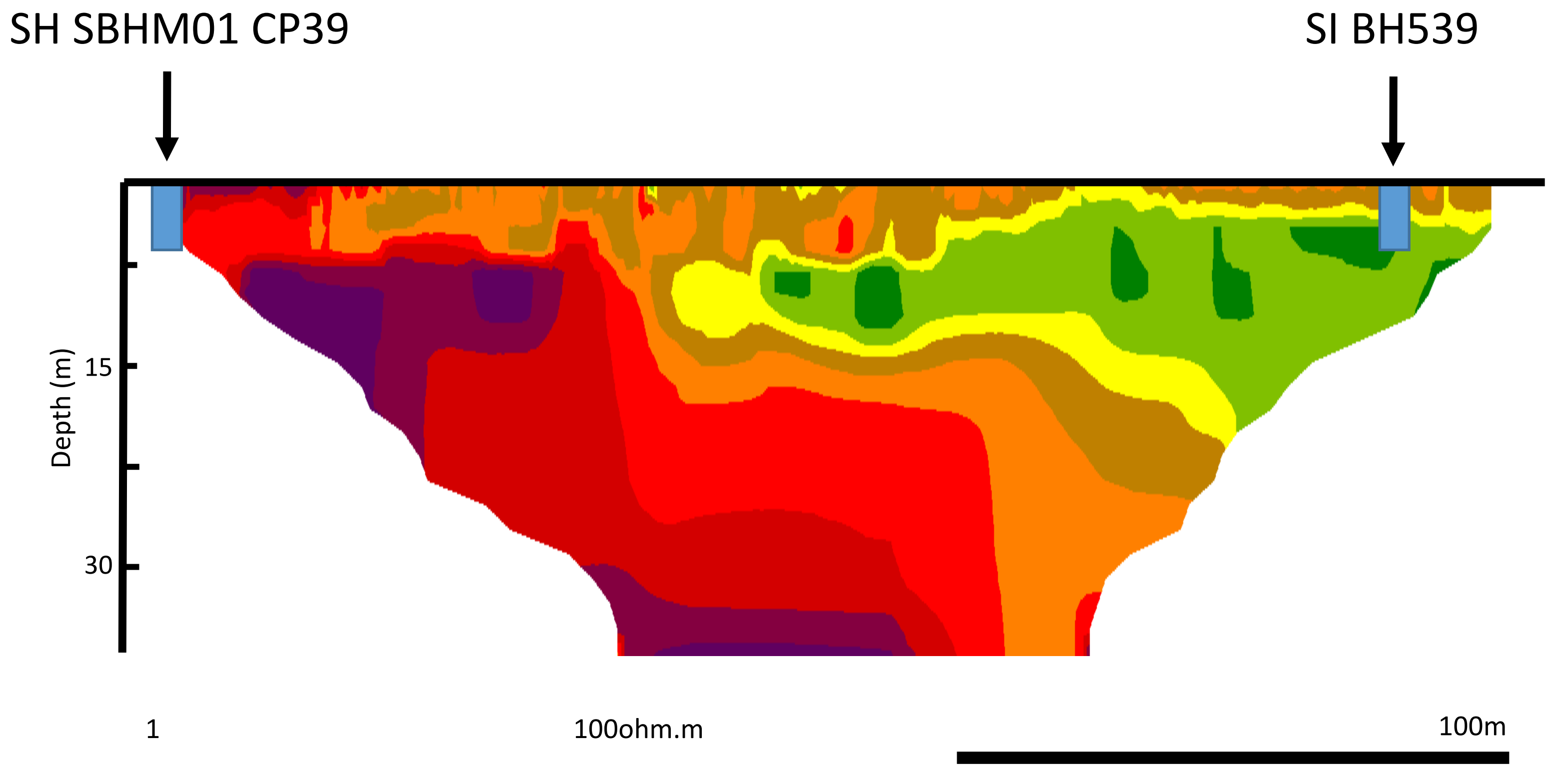


Figure 8. Line 26.

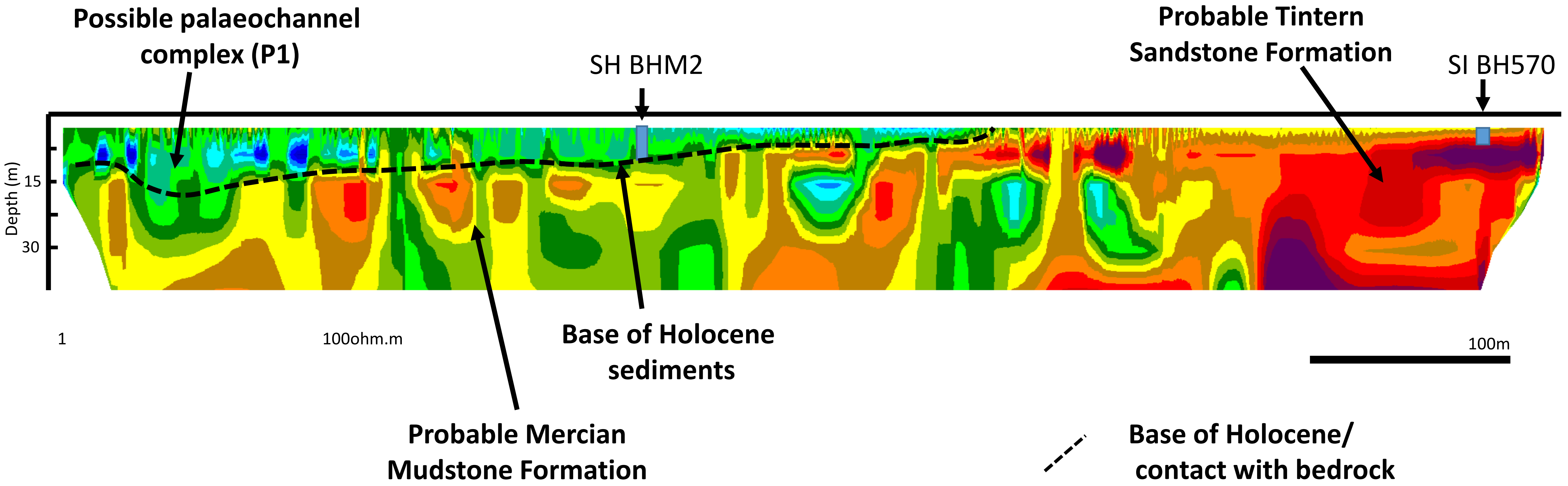


Figure 9. Line 12.

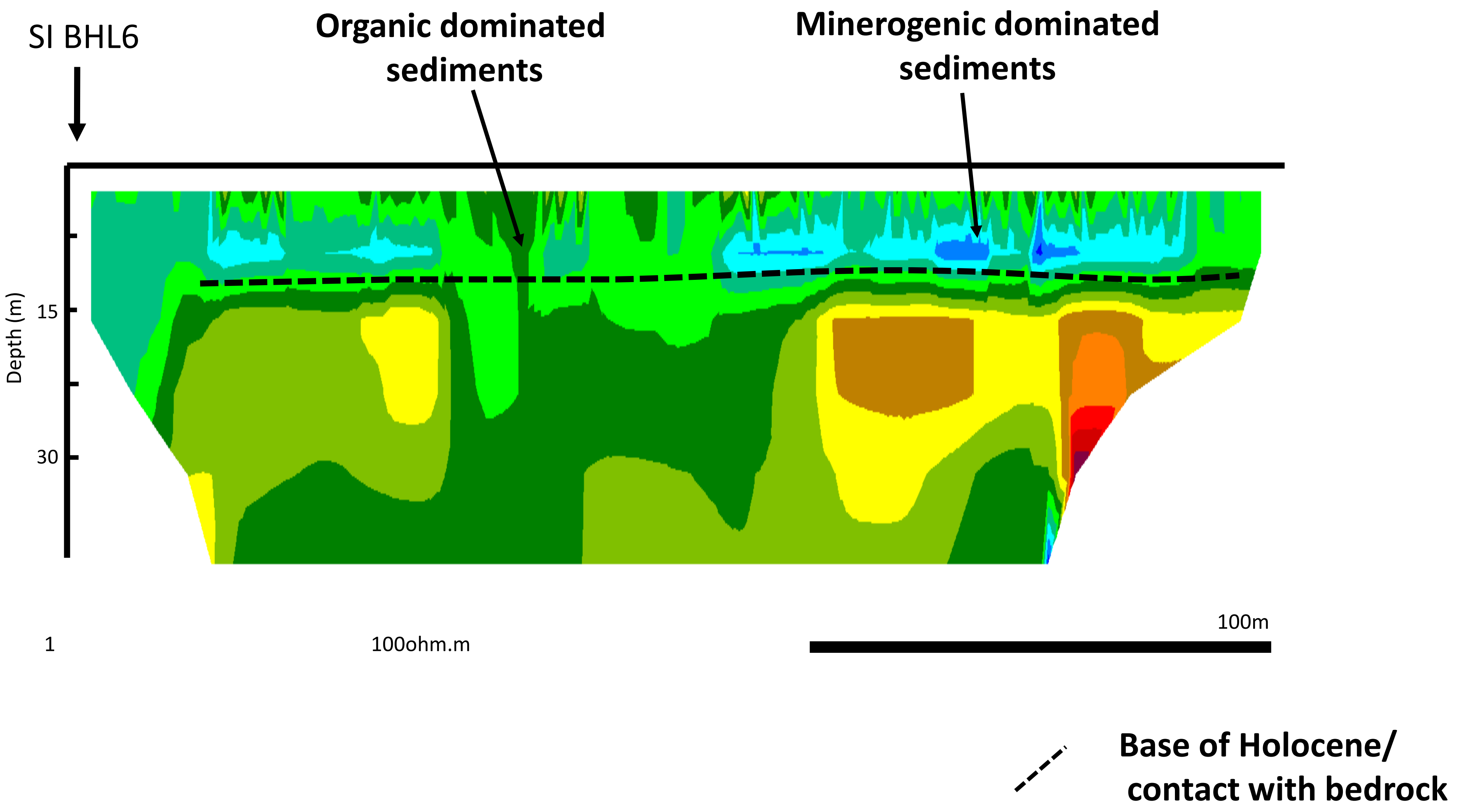


Figure 10. Line 13.

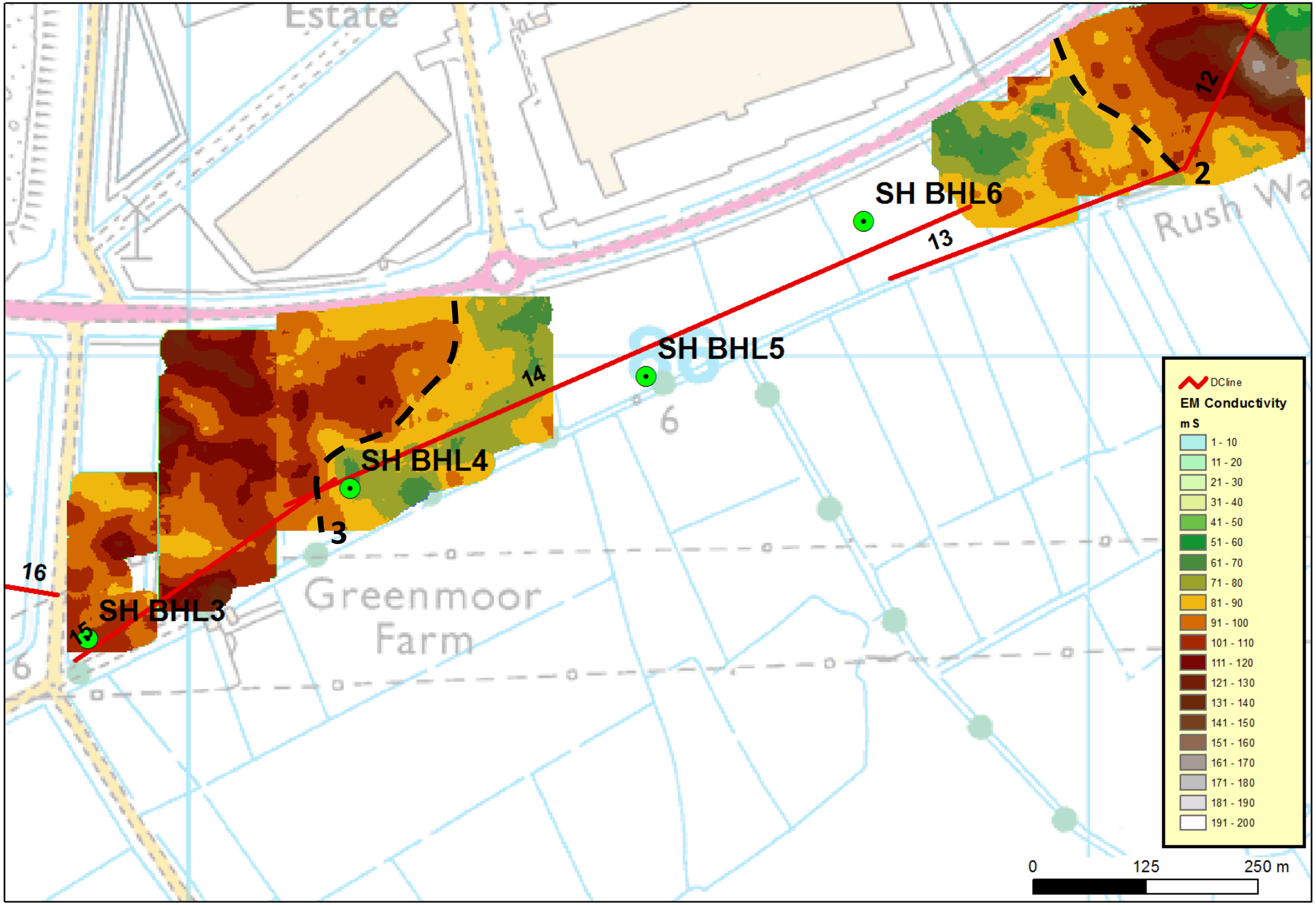


Figure 11. Eastern array (2), ground truth boreholes and edge of interpreted features (indicated by dashed black lines).

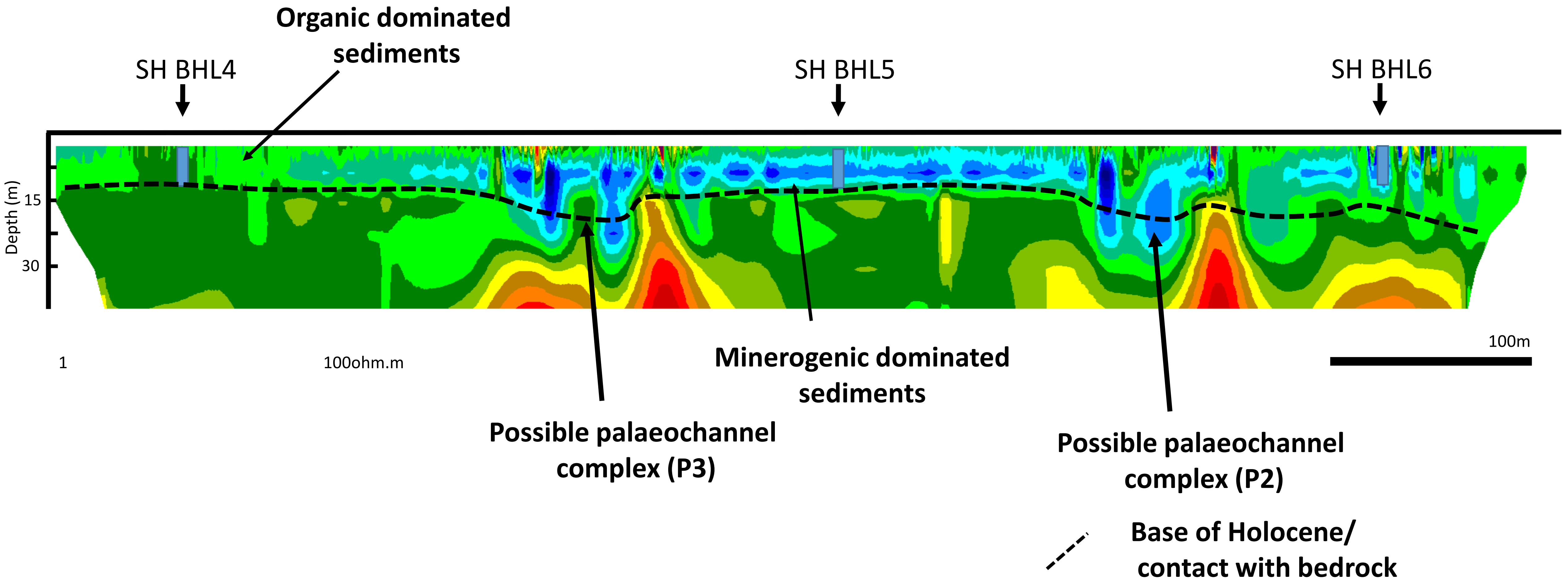


Figure 12. Line 14.

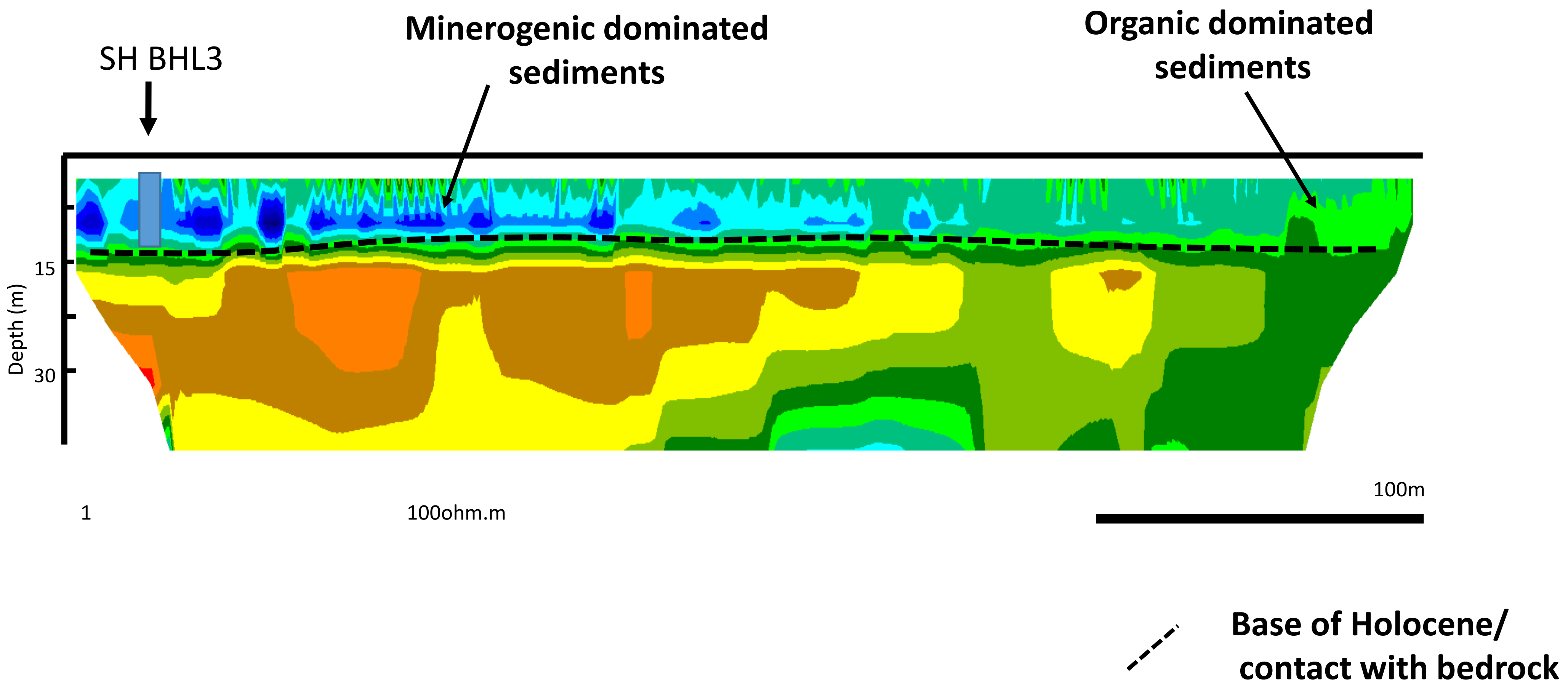


Figure 13. Line 15.

Figure 14. Eastern array (3), ground truth boreholes and edge of interpreted features.

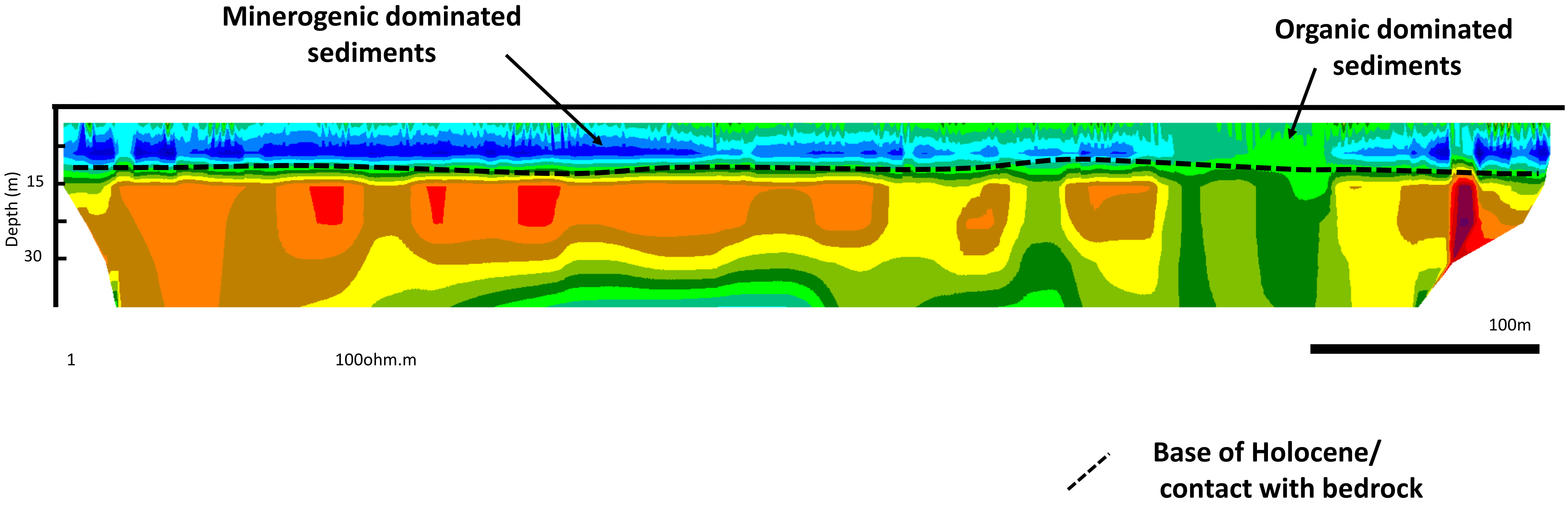


Figure 15. Line 16.

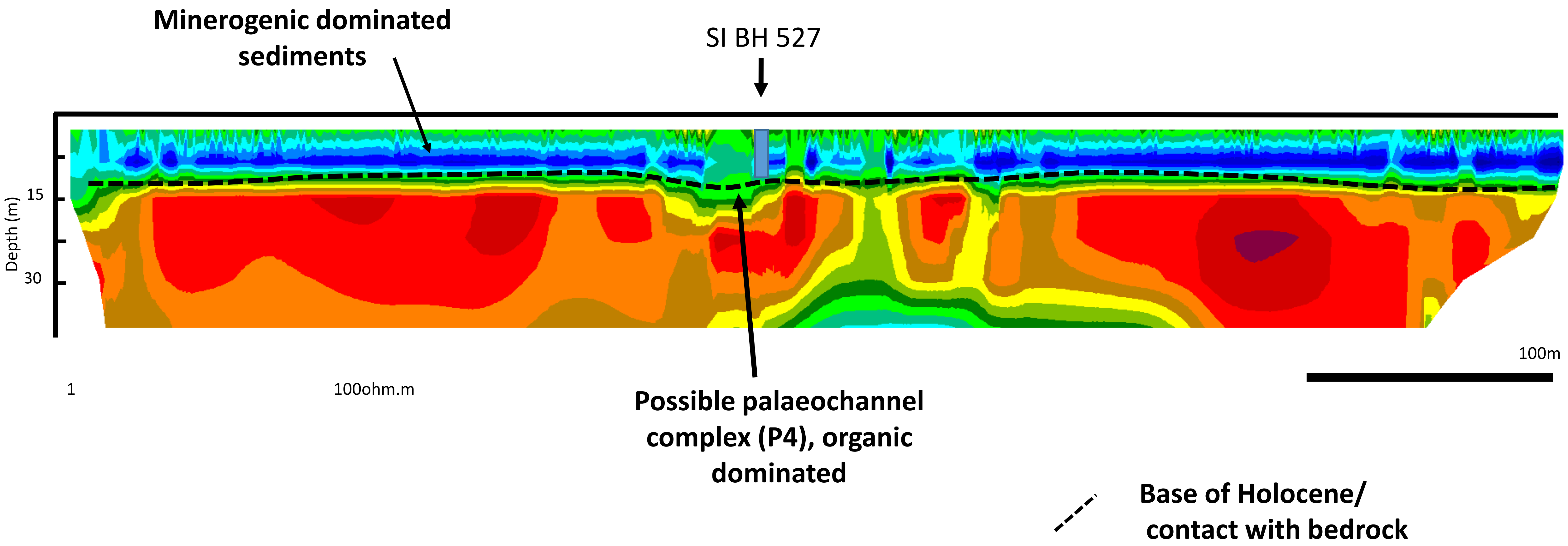
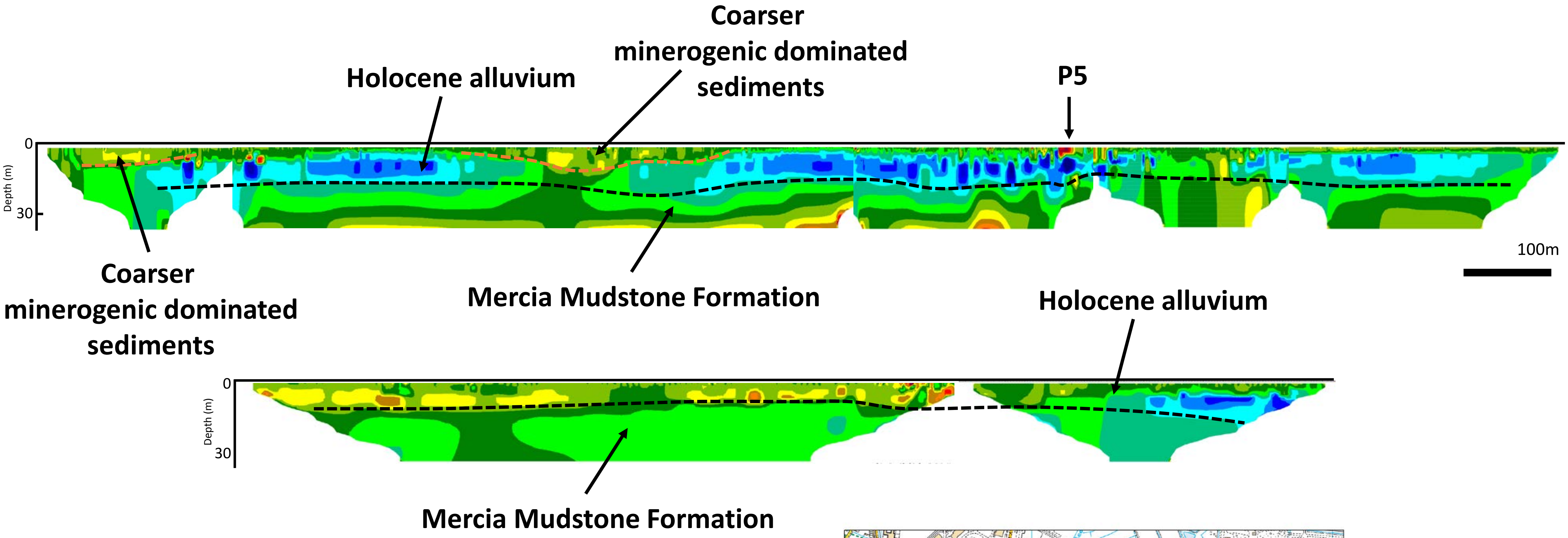
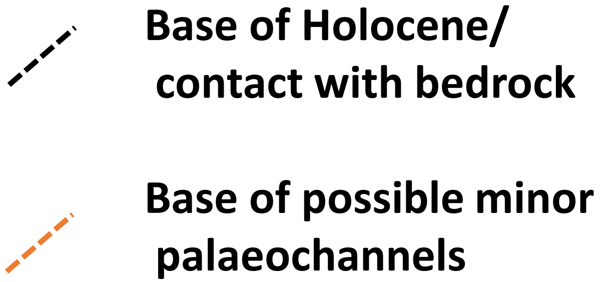


Figure 16. Line 17.





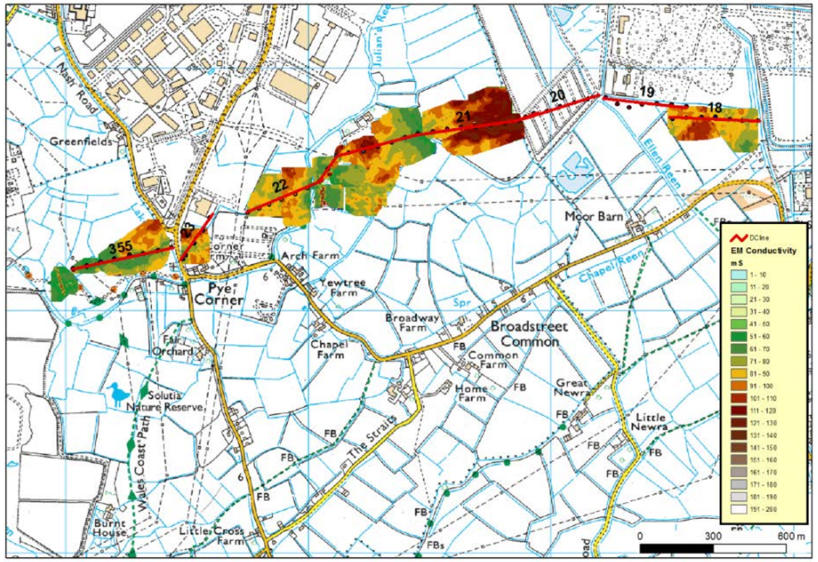


Figure 17. Central array with stitched together transect.

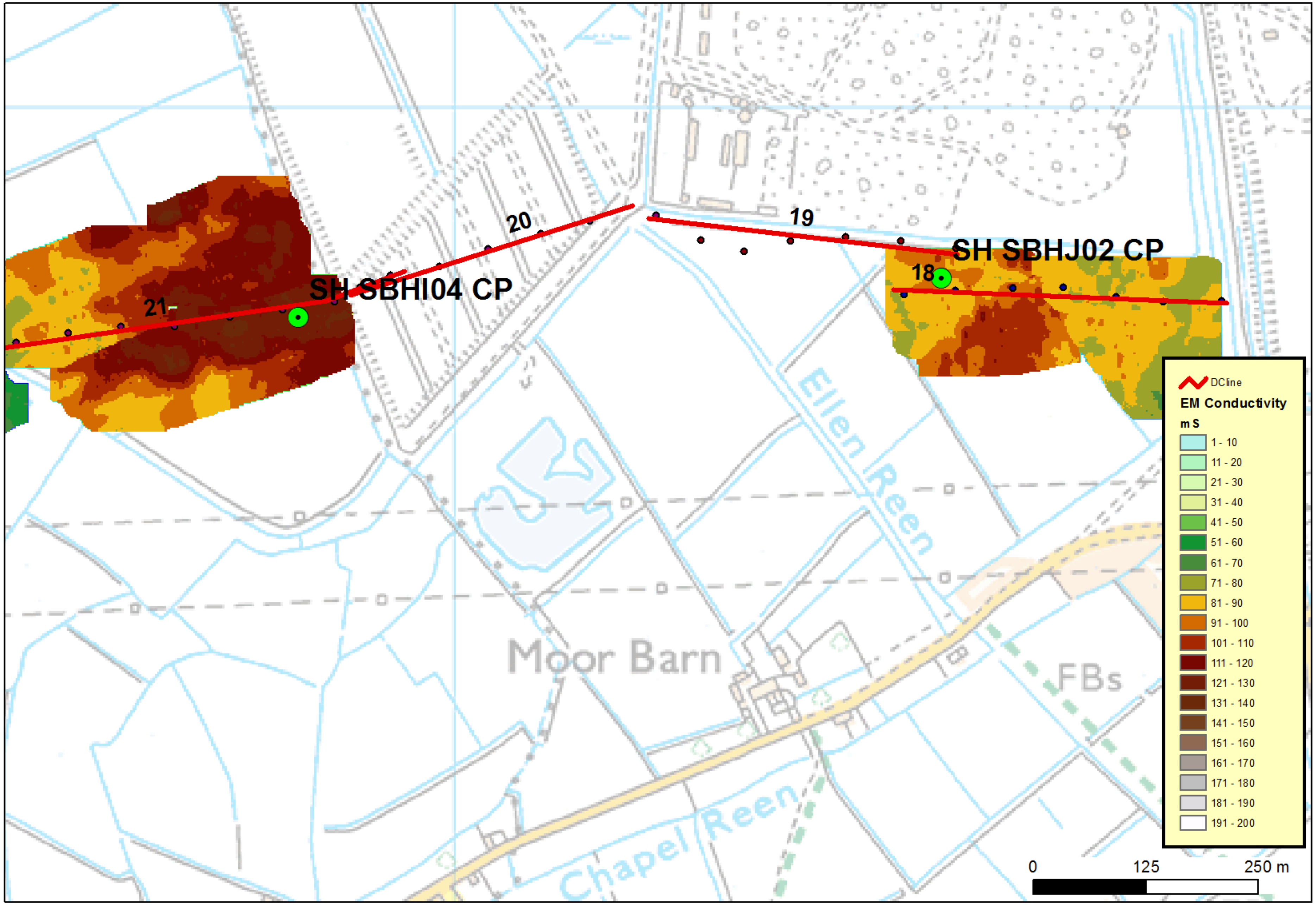


Figure 18. Central array (1), ground truth boreholes and edge of interpreted features.

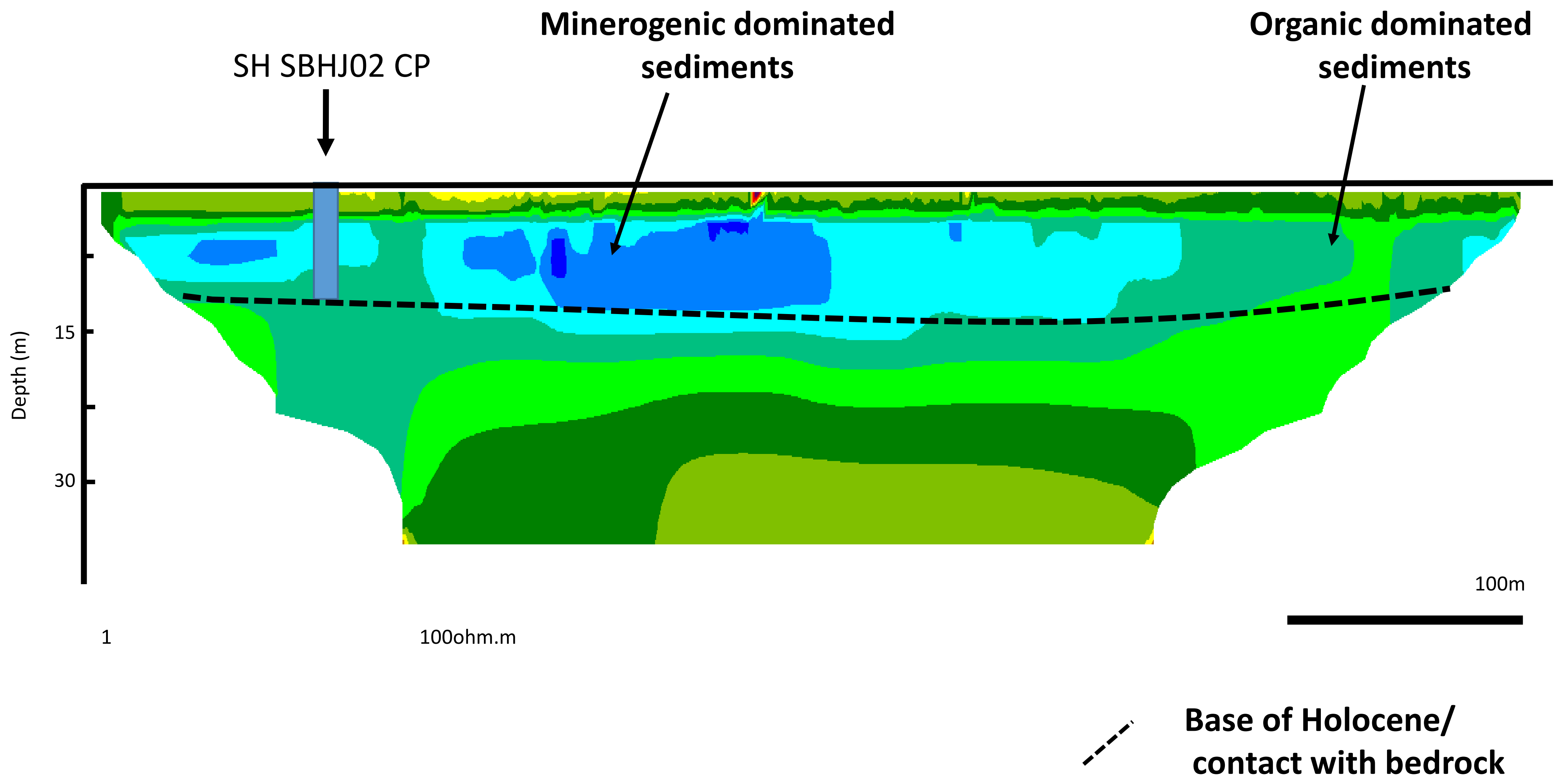


Figure 19. Line 18.

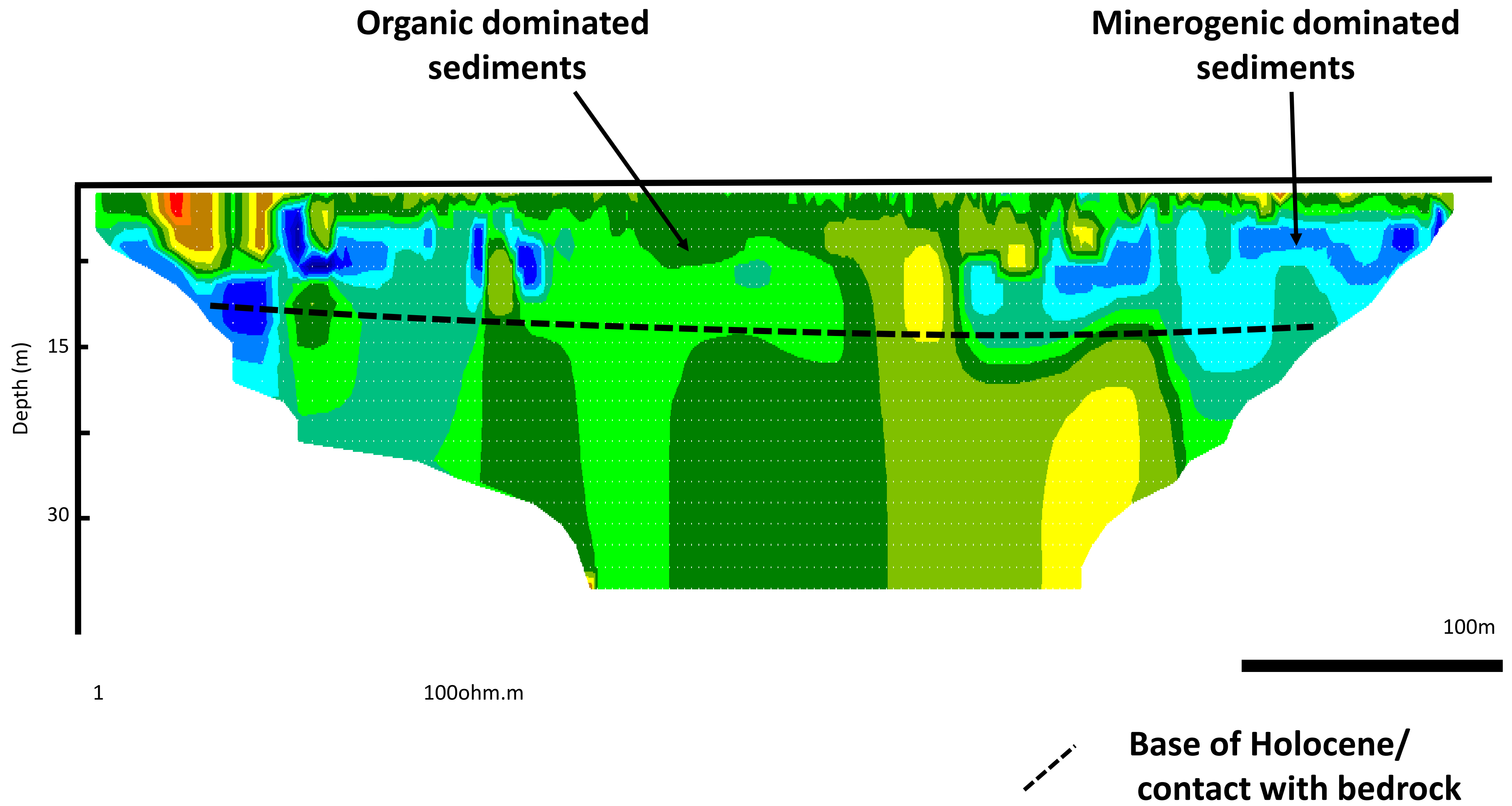


Figure 20. Line 19.

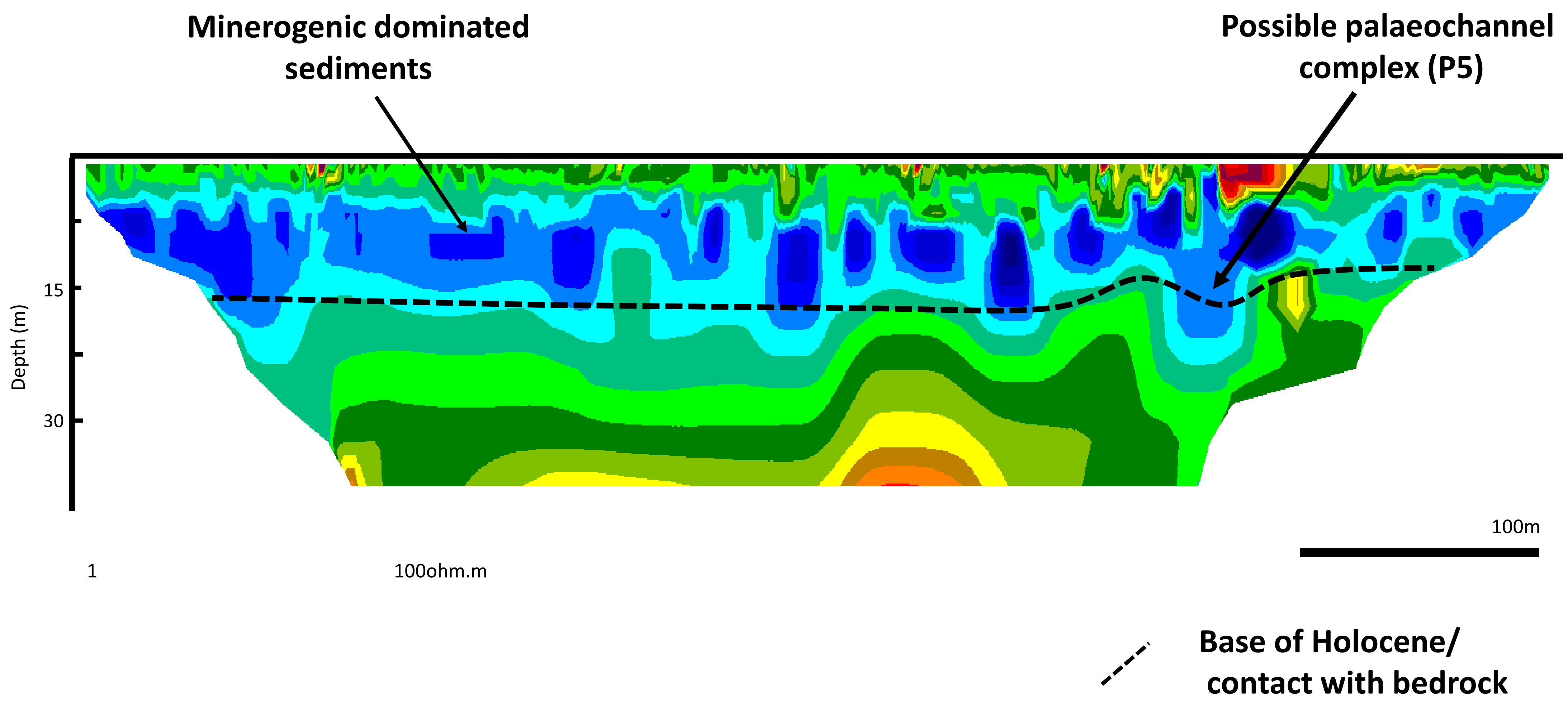


Figure 21. Line 20.

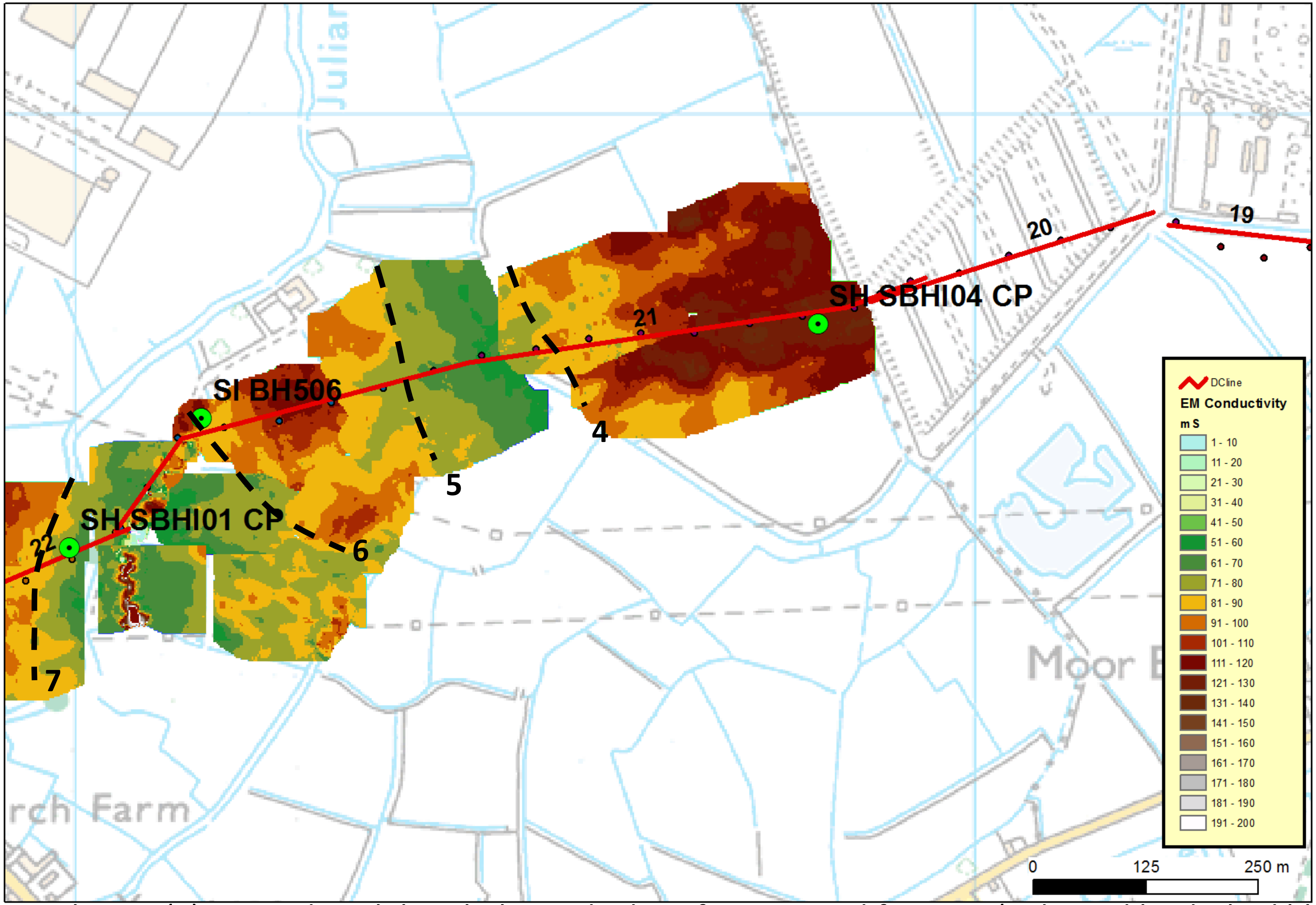


Figure 22. Central array (2), ground truth boreholes and edge of interpreted features (indicated by dashed black lines).

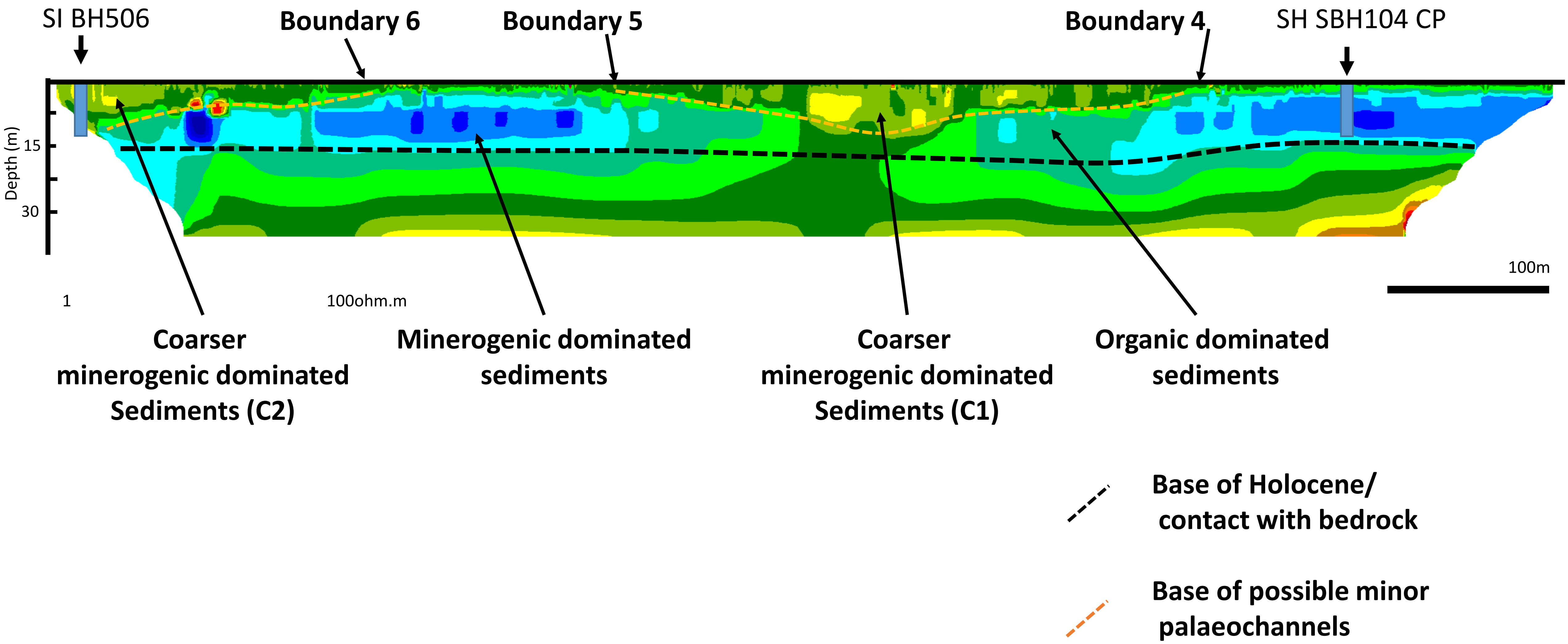


Figure 23. Line 21.

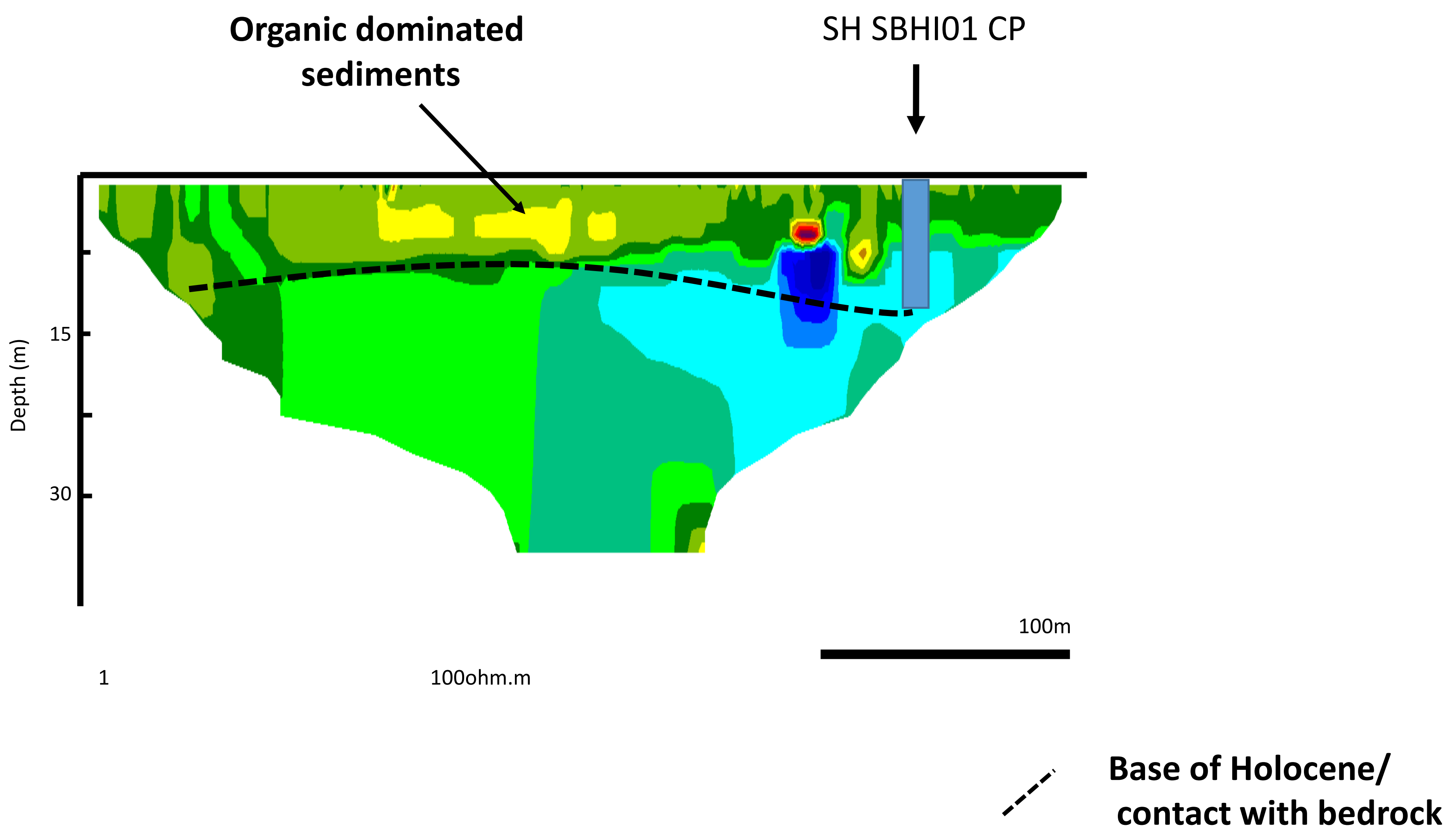


Figure 24. Line 22.

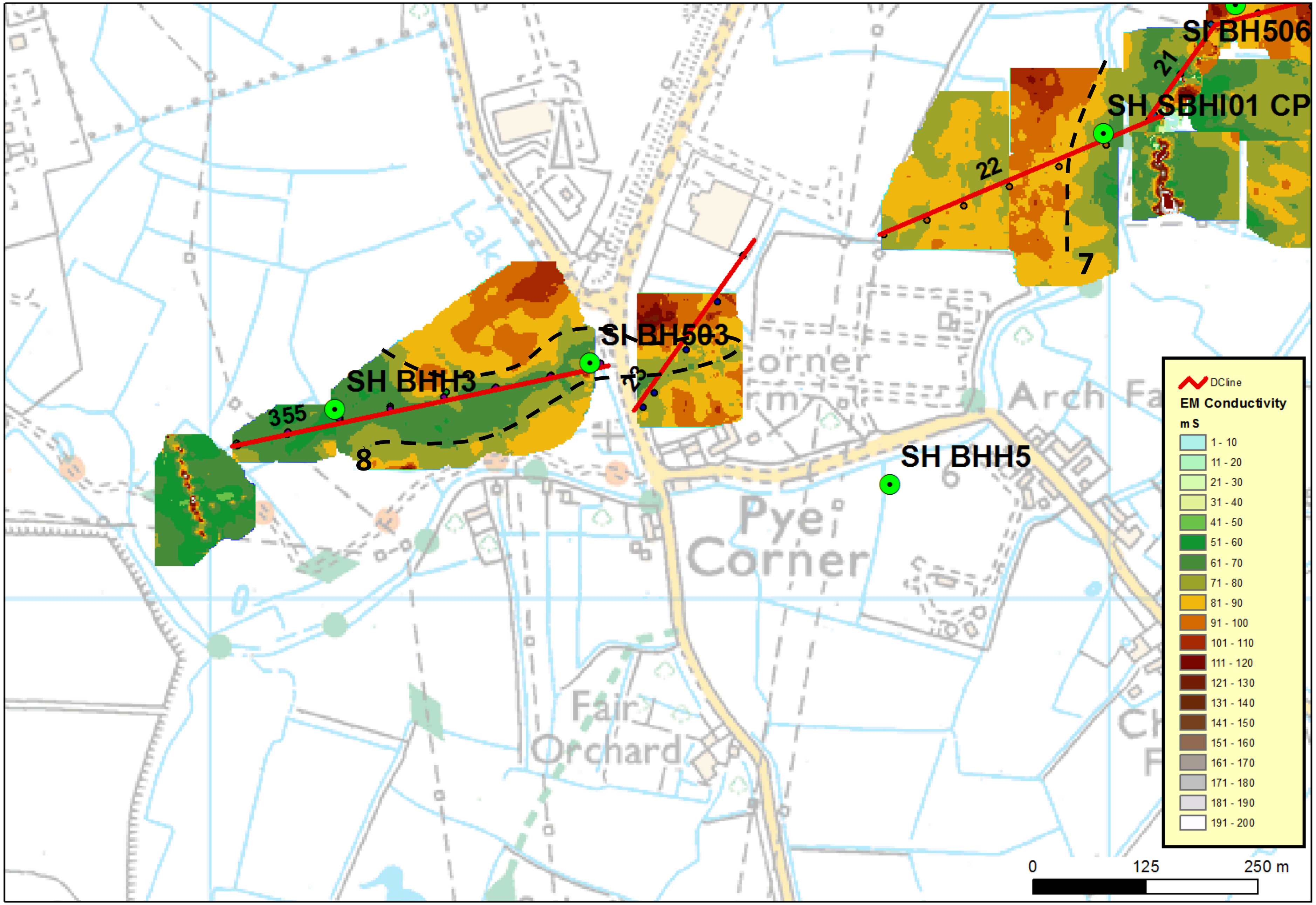


Figure 25. Central array (3), ground truth boreholes and edge of interpreted features (indicated by dashed black lines).

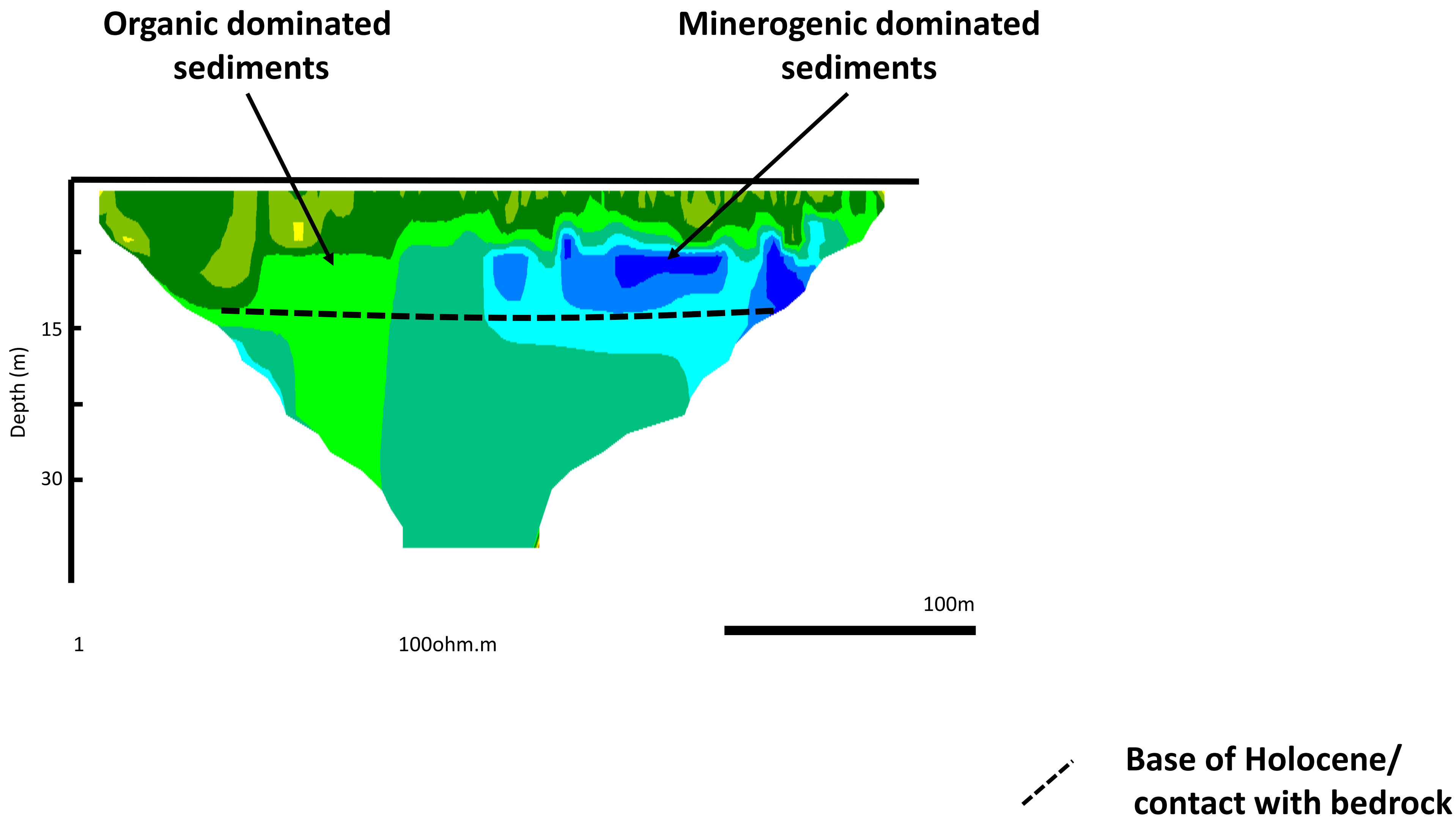


Figure 26. Line 23.

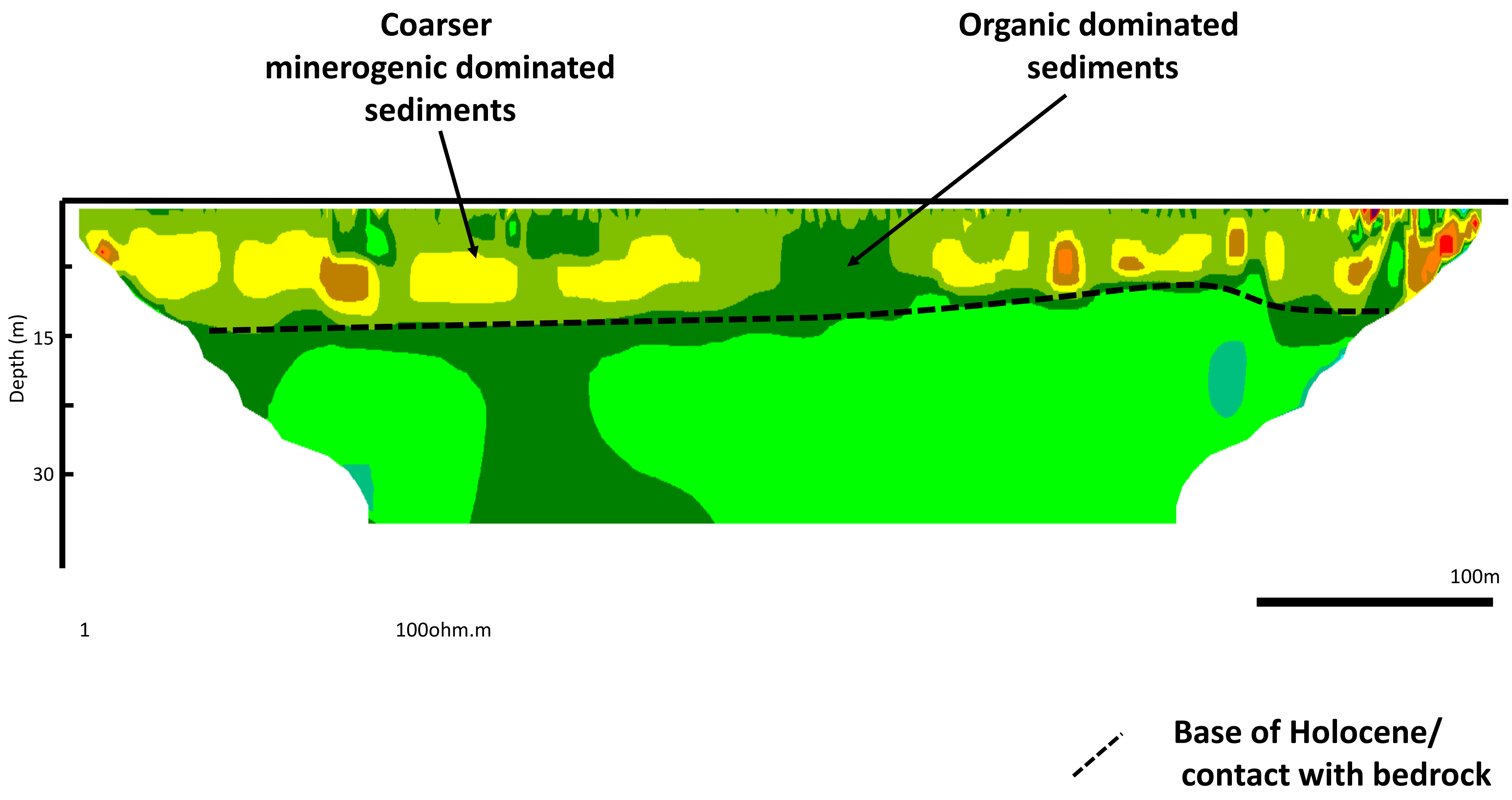
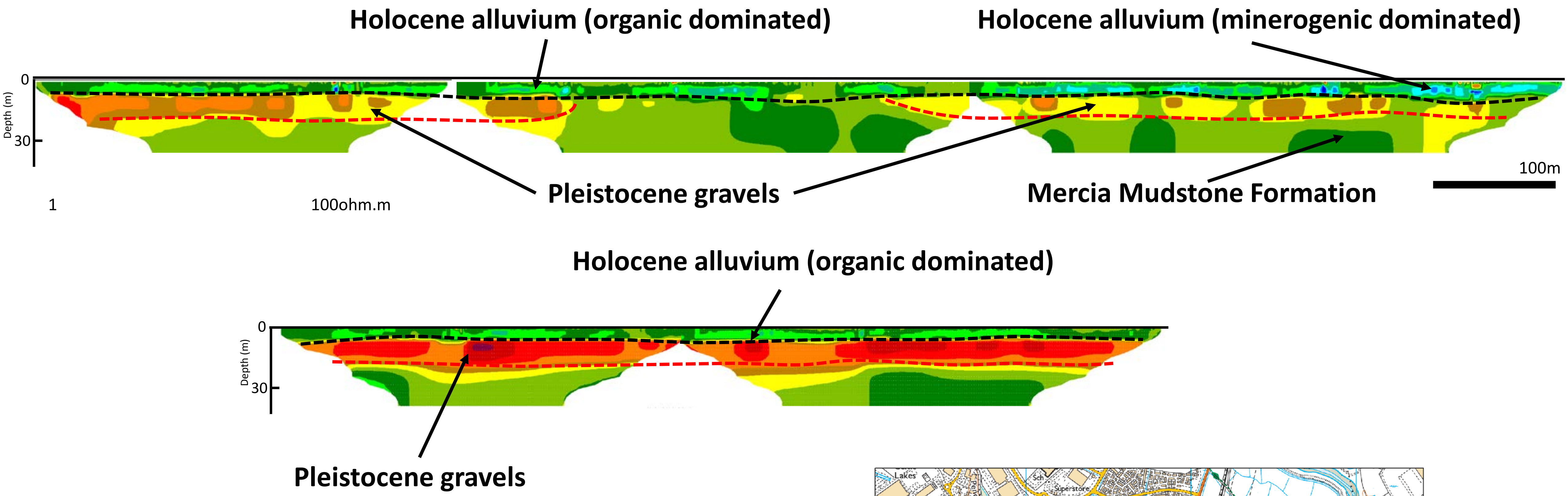


Figure 27. Line 355.



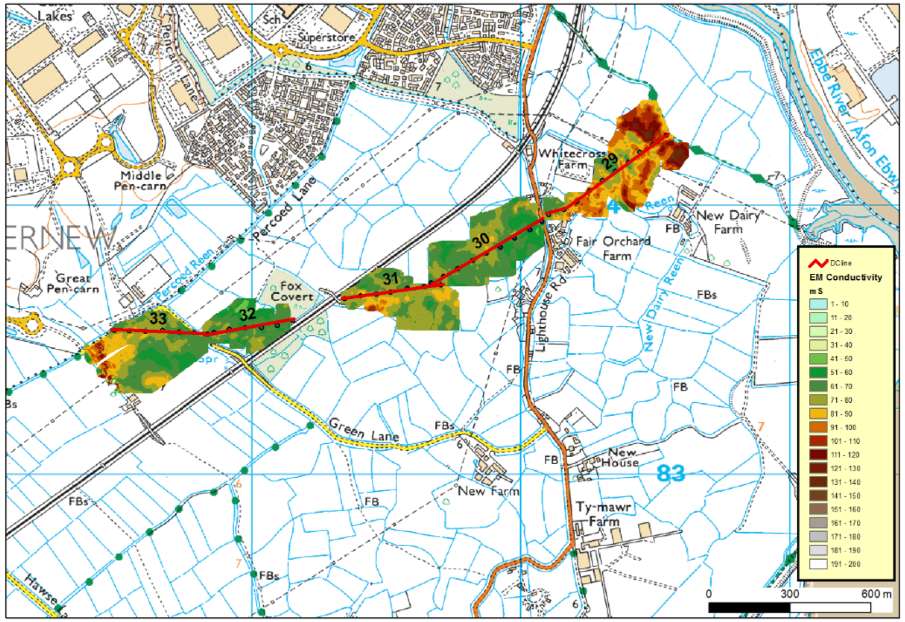


Figure 28. Western array with stitched together transect.

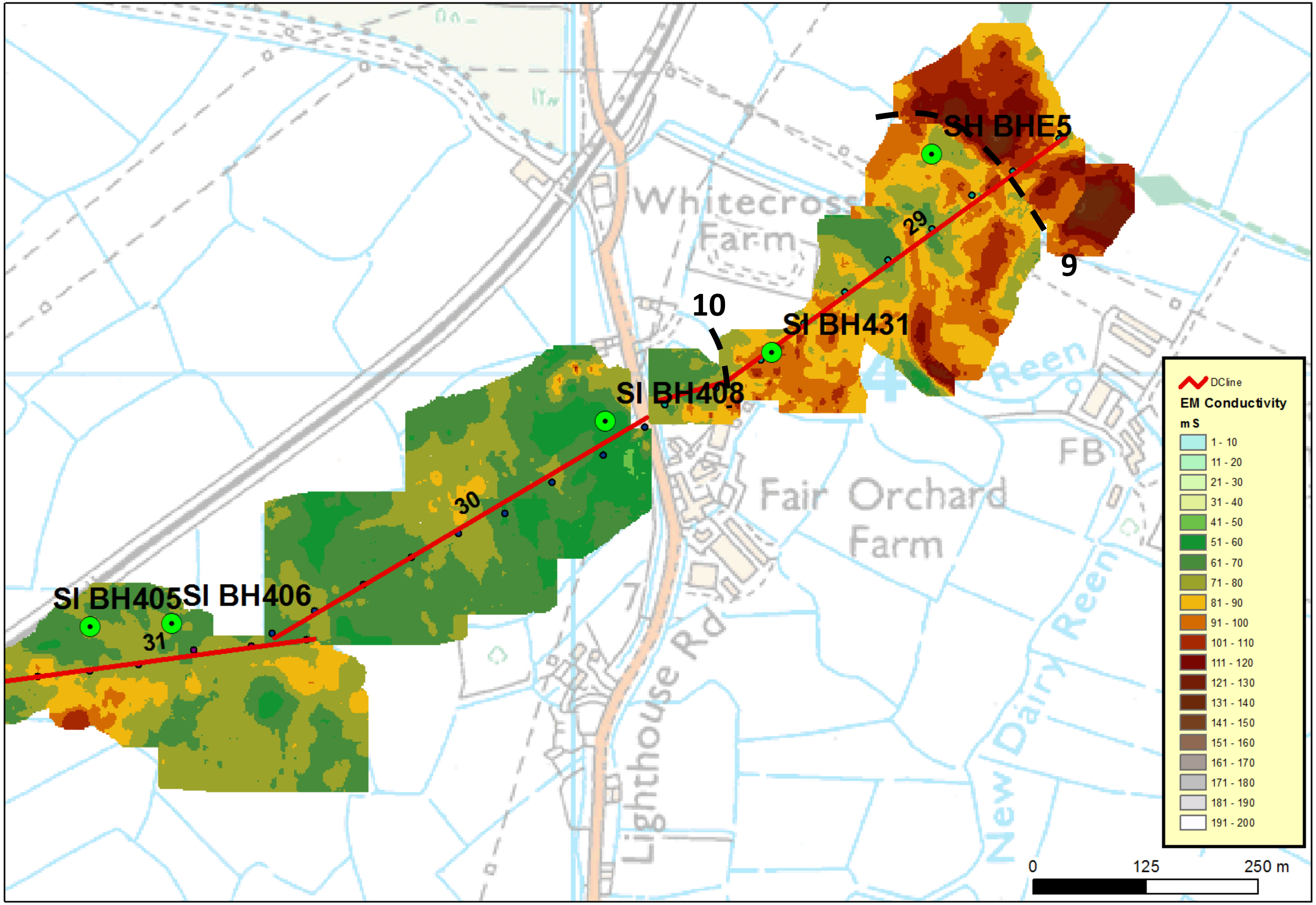


Figure 29. Western array (1), ground truth boreholes and edge of interpreted features (indicated by dashed black lines).

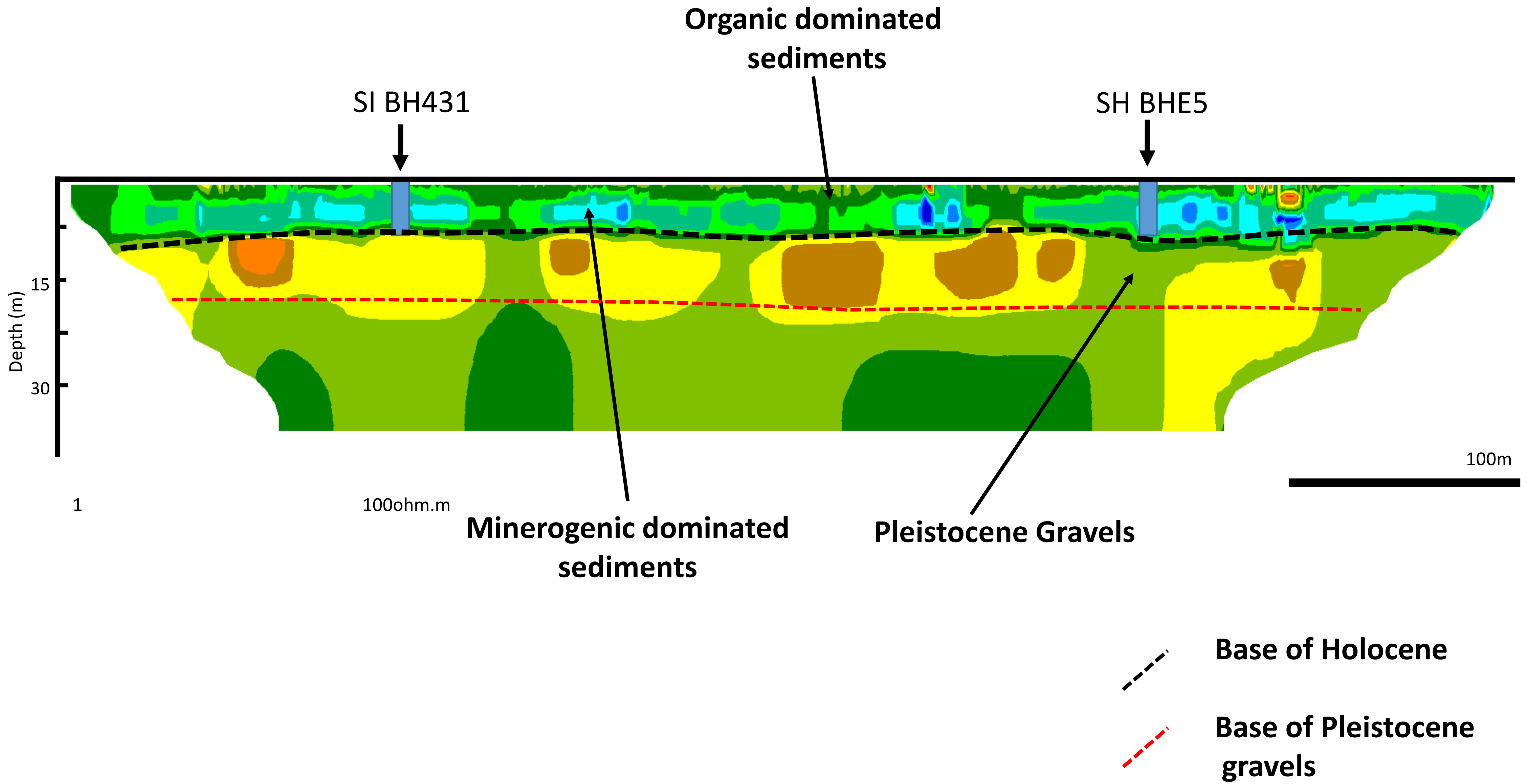


Figure 30. Line 29.

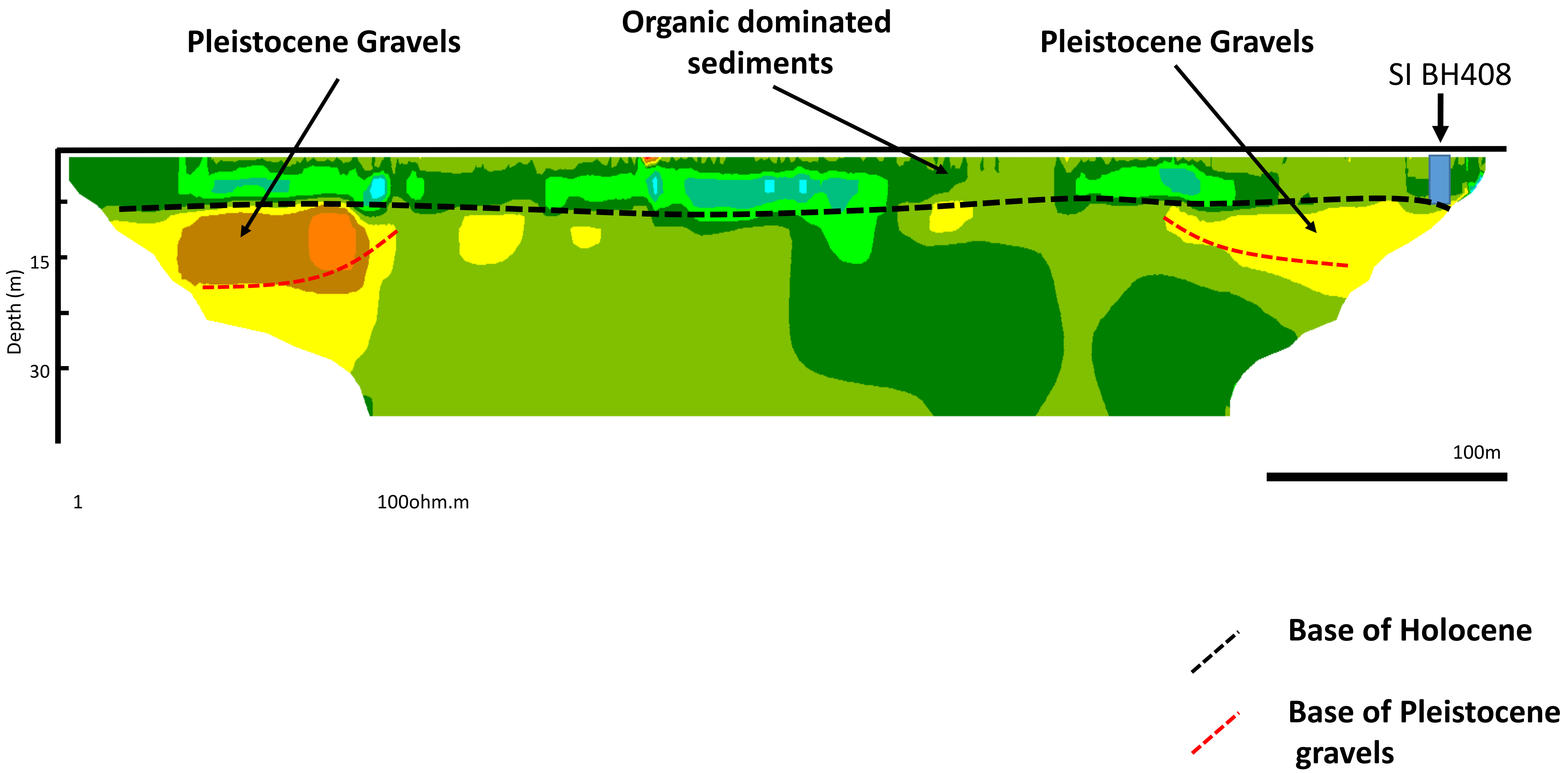


Figure 31. Line 30.

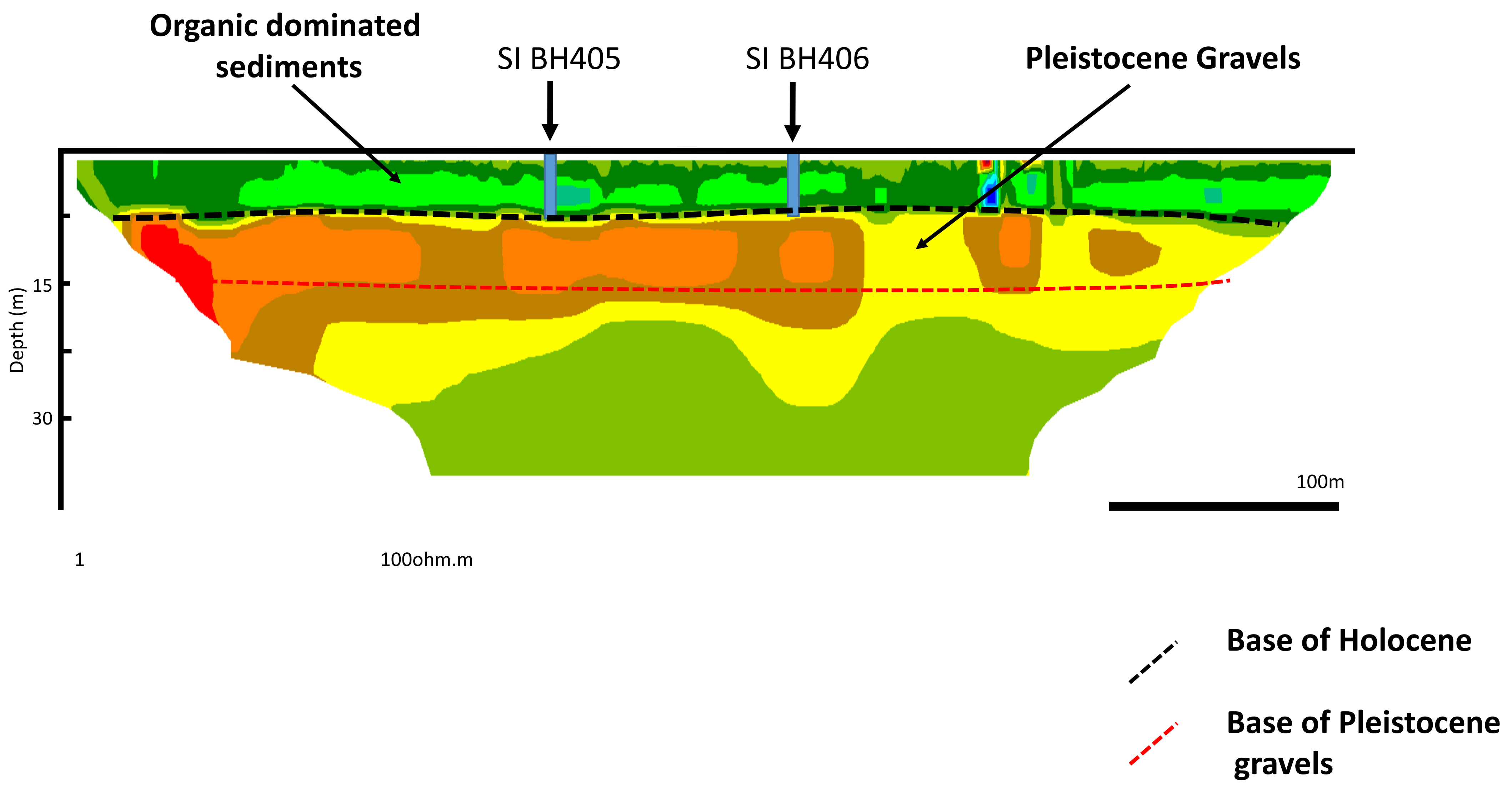


Figure 32. Line 31.

Figure 33. Western array (2), ground truth boreholes and edge of interpreted features.

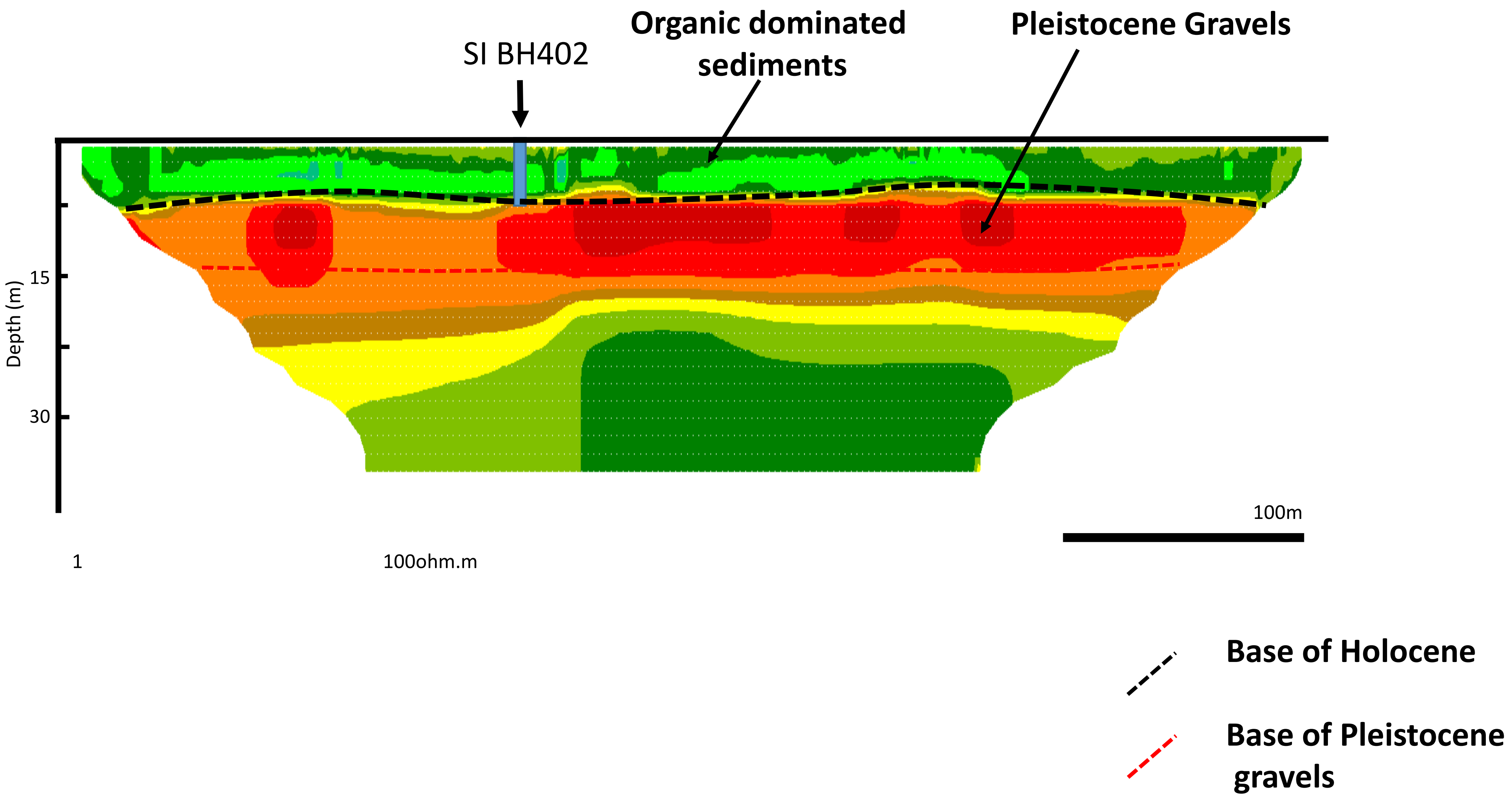


Figure 34. Line 32.

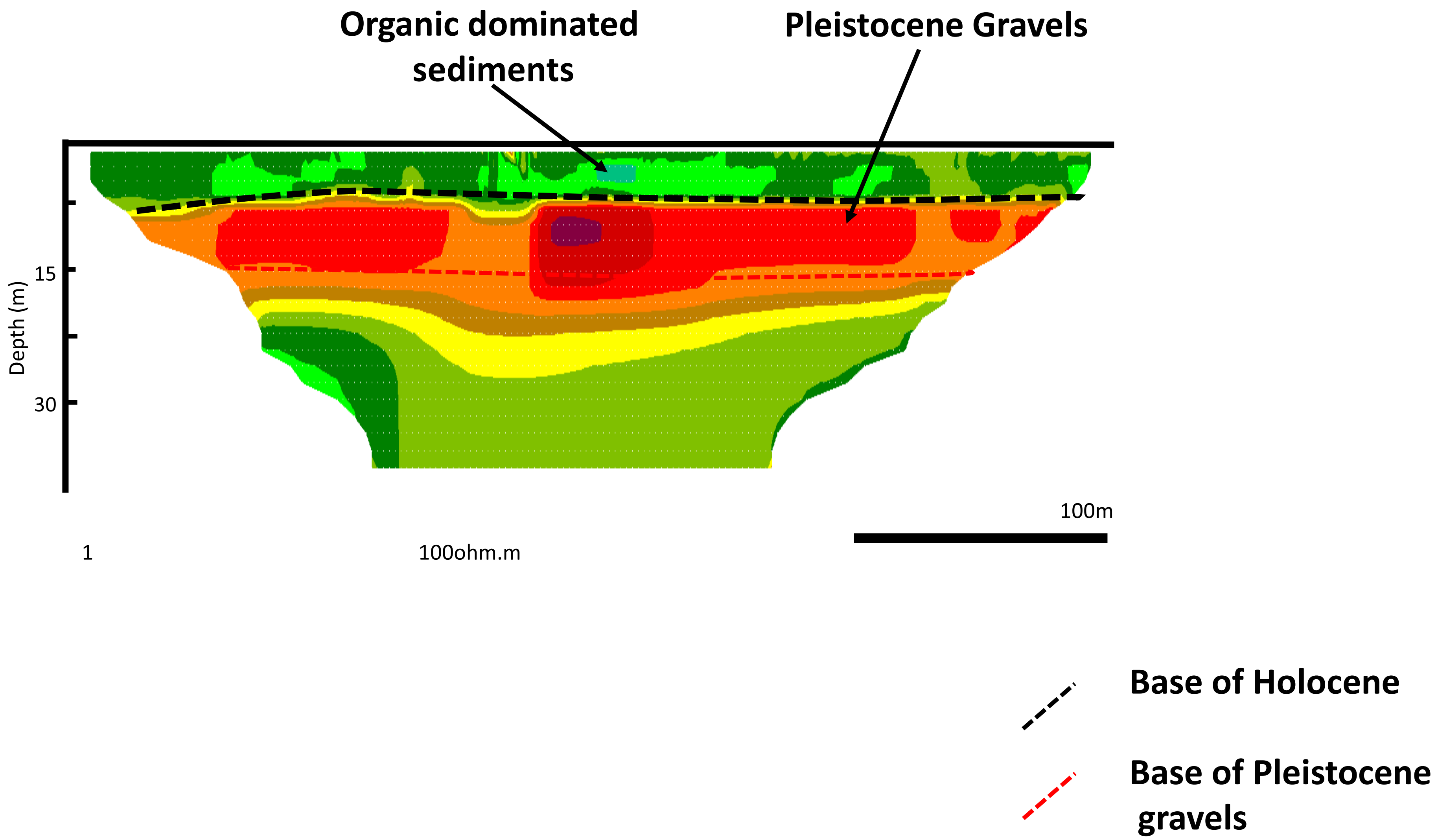


Figure 35. Line 33.

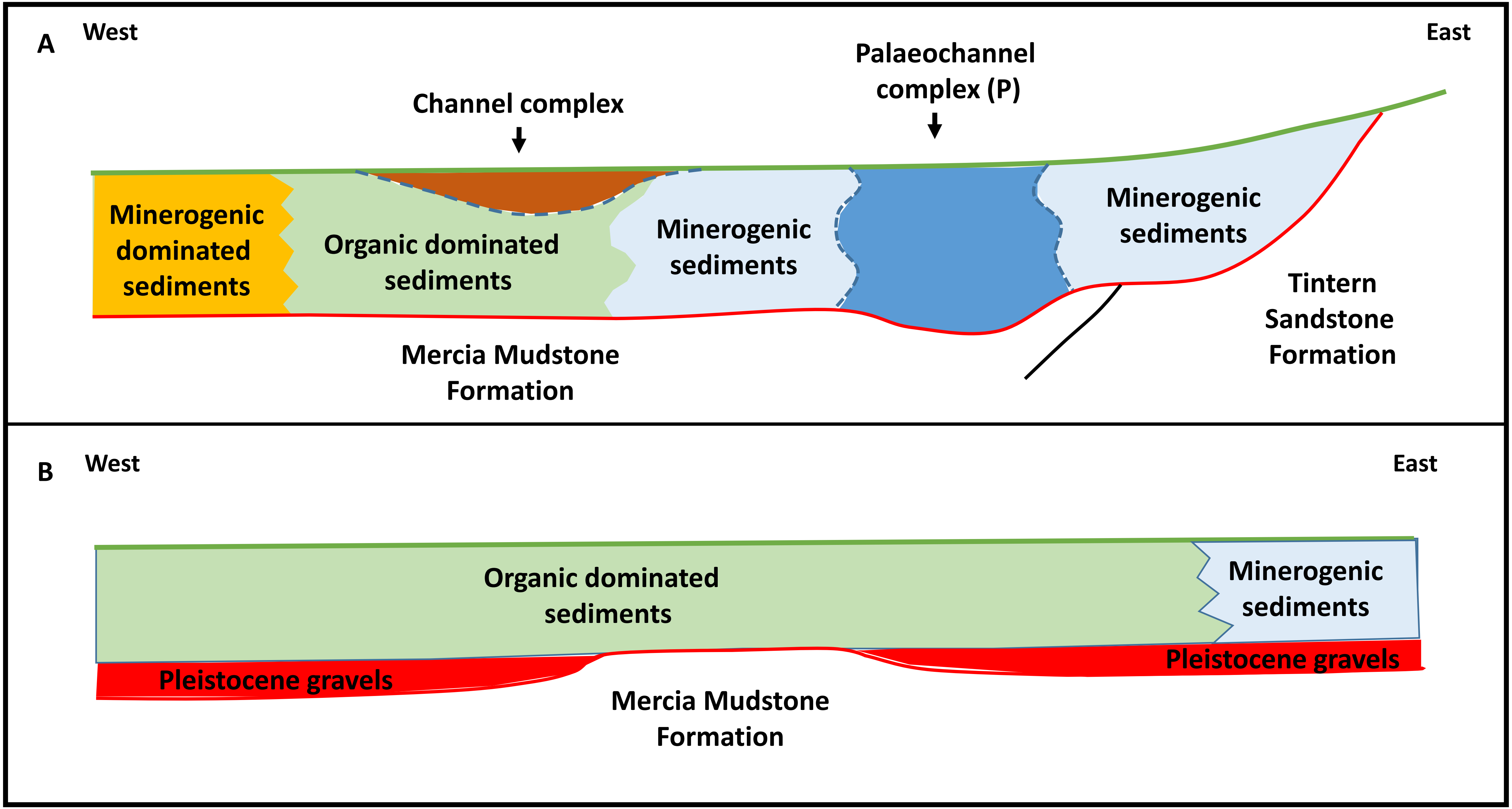


Figure 36. Schematic models for major lithological units inferred from geophysical survey. **A:** east of Usk. **B:** west of Usk.

Annex A

Borehole	Depth1	Depth2	Lithology	Comment
SH BHE5	0	0.1	Made Ground	topsoil
SH BHE5	0.1	5.05	Sandy Clay	estuarine alluvium
SH BHE5	5.05	8.1	Organic Clay	estuarine alluvium
SH BHE5	8.1	13.5	Gravelly Sand	Pleistocene
SH BHE5	13.5	15.15	Sandy Clay	Bedrock
SH BHH5	0	0.35	Made Ground	topsoil
SH BHH5	0.35	4.5	Sandy Clay	estuarine alluvium
SH BHH5	4.5	4.8	Organic	
SH BHH5	4.8	7	Organic Clay	
SH BHH5	7	7.4	Organic	
SH BHH5	7.4	12.3	Organic Clay	
SH BHH5	12.3	14.2	Clay	Bedrock
SH BHL3	0	0.4	Made Ground	topsoil
SH BHL3	0.4	5.1	Clay	estuarine alluvium
SH BHL3	5.1	6	Organic	
SH BHL3	6	9.7	Organic Clay	
SH BHL3	9.7	25	Clay	Bedrock
SH BHL4	0	0.3	Made Ground	topsoil
SH BHL4	0.3	1.9	Silty Clay	estuarine alluvium
SH BHL4	1.9	2.1	Organic	
SH BHL4	2.1	2.9	Organic Clay	
SH BHL4	2.9	4.5	Organic	
SH BHL4	4.5	6.3	Organic Clay	
SH BHL4	6.3	6.6	Sandy Clay	
SH BHL4	6.6	7.5	Clay	
SH BHL4	7.5	10.5	Clay	Bedrock
SH BHL5	0	0.6	Made Ground	topsoil
SH BHL5	0.6	4.4	Sandy Clay	estuarine alluvium
SH BHL5	4.4	6.6	Organic	
SH BHL5	6.6	8	Sandy Clay	
SH BHL5	8	8.45	Sandy Gravel	Pleistocene
SH BHL5	8.45	9.6	Sandy Clay	
SH BHL5	9.6	12	Silty Clay	Bedrock
SH BHL6	0	0.4	Made Ground	topsoil
SH BHL6	0.4	4	Organic Clay	estuarine alluvium
SH BHL6	4	5.7	Organic	
SH BHL6	5.7	7.7	Organic Clay	
SH BHL6	7.7	8.3	Sandy Clay	
SH BHL6	8.3	12	Clay	Bedrock
SH BHM2	0	0.6	Made Ground	
SH BHM2	0.6	1.2	Organic Clay	estuarine alluvium

Borehole	Depth1	Depth2	Lithology	Comment
SH BHM2	1.2	4	Organic	
SH BHM2	4	6	Organic Clay	
SH BHM2	6	6.8	Organic	
SH BHM2	6.8	7.3	Sandy Clay	
SH BHM2	7.3	8.7	Clayey Sand	Pleistocene
SH BHM2	8.7	20.3	Clay	Bedrock
SH SBHI01 CP	0	0.4	Made Ground	topsoil
SH SBHI01 CP	0.4	1.5	Gravelly Clay	estuarine alluvium
SH SBHI01 CP	1.5	2.5	Clay	
SH SBHI01 CP	2.5	3.45	Organic Clay	
SH SBHI01 CP	3.45	5	Organic	
SH SBHI01 CP	5	11.5	Silty Clay	
SH SBHI01 CP	11.5	12.5	Organic	
SH SBHI01 CP	12.5	14.6	Gravelly Clay	Bedrock
SH SBHI04 CP	0	0.3	Made Ground	topsoil
SH SBHI04 CP	0.3	2.5	Gravelly Clay	estuarine alluvium
SH SBHI04 CP	2.5	4.5	Organic	
SH SBHI04 CP	4.5	6	Organic Clay	
SH SBHI04 CP	6	6.3	Organic	
SH SBHI04 CP	6.3	11	Organic Clay	
SH SBHI04 CP	11	11.8	Gravelly Clay	
SH SBHI04 CP	11.8	13.5	Gravelly Clay	Bedrock
SH SBHI04 CP	13.5	14.5	Clay	Bedrock
SH SBHJ02 CP	0	0.2	Made Ground	topsoil
SH SBHJ02 CP	0.2	4	Organic Clay	estuarine alluvium
SH SBHJ02 CP	4	5.9	Organic	
SH SBHJ02 CP	5.9	9.5	Silty Clay	
SH SBHJ02 CP	9.5	10.9	Clayey Silt	
SH SBHJ02 CP	10.9	12.5	Sandy Gravel	Pleistocene
SH SBHJ02 CP	12.5	13.6	Gravelly Clay	Bedrock
SH SBHJ02 CP	13.6	13.7	Clay	Bedrock
SH SBHM01 CP	0	3.1	Organic	
SH SBHM01 CP	3.1	4	Organic Clay	
SH SBHM01 CP	4	5.3	Sandy Clay	estuarine alluvium
SH SBHM01 CP	5.3	7.6	Gravelly Clay	Bedrock
SI BH402	0	4.2	Organic Clay	
SI BH402	4.2	5.2	Silty Clay	
SI BH402	5.2	6.7	Organic Clay	
SI BH402	6.7	12.8	Gravel	Pleistocene
SI BH402	12.8	15.5	Gravelly Clay	Bedrock
SI BH402	15.5	21	Silty Clay	Bedrock
SI BH405	0	1.2	Silty Clay	
SI BH405	1.2	1.3	Organic	

Borehole	Depth1	Depth2	Lithology	Comment
SI BH405	1.3	4.9	Silty Clay	
SI BH405	4.9	5.3	Organic	
SI BH405	5.3	6	Organic Clay	
SI BH405	6	6.3	Organic	
SI BH405	6.3	6.55	Silty Clay	
SI BH405	6.55	7.4	Gravel	Pleistocene
SI BH405	7.4	8.3	Sand	Pleistocene
SI BH405	8.3	12.4	Gravel	Pleistocene
SI BH405	12.4	19.3	Gravelly Clay	Bedrock
SI BH406	0	1	Sandy Clay	
SI BH406	1	6.7	Silty Clay	
SI BH406	6.7	13.5	Gravel	Pleistocene
SI BH406	13.5	20	Gravelly Clay	Bedrock
SI BH408	0	8	Silty Clay	
SI BH408	8	11.3	Gravel	Pleistocene
SI BH408	11.3	23	Gravelly Clay	Bedrock
SI BH431	0	2.6	Silty Clay	
SI BH431	2.6	3.8	Organic	
SI BH431	3.8	7.4	Silty Clay	
SI BH431	7.4	7.6	Organic	
SI BH506	0	3.8	Silty Clay	
SI BH506	3.8	4.5	Organic	
SI BH506	4.5	6.7	Organic Clay	
SI BH506	6.7	7.1	Organic	
SI BH506	7.1	10.15	Organic Clay	
SI BH506	10.15	12.8	Clay	
SI BH506	12.8	16	Gravelly Clay	Bedrock
SI BH527	0	1.75	Made Ground	
SI BH527	1.75	4.6	Silty Clay	
SI BH527	4.6	4.7	Organic	
SI BH527	4.7	9.5	Organic Clay	
SI BH527	9.5	13.1	Gravelly Clay	Bedrock
SI BH527	13.1	14.25	Clay	Bedrock
SI BH527	14.25	17.7	Clay	Bedrock
SI BH527	17.7	18	Gravelly Clay	Bedrock
SI BH527	18	19.1	Clay	Bedrock
SI BH539	0	1.6	Gravelly Clay	
SI BH539	1.6	2.35	Sandy Clay	
SI BH539	2.35	4.8	Sand	
SI BH539	4.8	7.85	Sand	Bedrock
SI BH539	7.85	8.8	Clay	Bedrock
SI BH539	8.8	10.8	Sand	Bedrock
SI BH539	10.8	11.2	Silty Clay	Bedrock

Borehole	Depth1	Depth2	Lithology	Comment
SI BH539	11.2	14.2	Sand	Bedrock
SI BH570	0	1.2	Organic gravel	
SI BH570	1.2	3.95	Organic	
SI BH570	3.95	4.2	Silty Clay	
SI BH570	4.2	4.4	Gravel	Pleistocene