GEOPHYSICAL PROSPECTION OF THE BRONZE AGE SITE AT CALDICOT, MONMOUTHSHIRE

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The Bronze Age site at Caldicot, Monmouthshire was excavated from 1988-1992 during the creation of a recreational lake in the ground of the early 13th to the late 14th century castle (Nayling 1992; Nayling and Caseldine 1997). The excavations uncovered Bronze Age wooden structures, including one of the oldest sewn plank boats in Europe, within a series of intersecting palaeochannels of the River Nedern (Nayling 1992). This study revisits the site to conduct a geophysical survey over the area to the north of the original excavations. Its aim is to investigate the buried archaeology of the sedimented valley floor and the relationship of the archaeology to the palaeochannels and the dryland edge. A range of geophysical prospection techniques were used, including EMI (Electromagnetic Induction), GPR (Ground Penetrating Radar), ERT (Electro Resistivity Tomography) and magnetic gradiometry, along with a coring transect to ground truth the results.

The high resistivity and high attenuation of the fine grained sediments within the sequence of intercutting palaeochannels are not ideal for geophysical surveys. However, the choice of low frequency (200MHz) GPR and EMI surveys allowed the EMI and GPR surveys to detect large landscape-scale feature. These included the interface between the alluvium and bedrock, palaeochannel features, and the potential continuation of a wooden post alignment found during the archaeological excavation.

INTRODUCTION

The Bronze Age site at Caldicot is situated in Monmouthshire, South Wales (Figure 1). The site was discovered during the excavation of a lake in the grounds of Caldicot Castle and Country Park (Figure 2). Waterlogged Bronze Age timbers were preserved within palaeochannel deposits, which were uncovered by a mechanical excavator in 1988 (Nayling and Caseldine 1997). As the extent of the timbers was realised, the mechanical excavations were suspended and archaeological excavations took place from 1988 to 1992. Finds from the excavation included stone strews, timber alignments (including find 472, Figure 2), metal artefacts and palaeochannels and associated palaeoenvironmental sequences (Nayling and Caseldine 1997). Eight phases of intersecting, palaeochannels were identified which produced radiocarbon dates spanning from the Mesolithic to the Iron Age (Nayling and Caseldine 1997). The palaeochannels were infilled with sands, silts and clays, attributed to a phase of Mesolithic-Neolithic estuarine clays, followed by a series of Bronze Age cut and fill sequences and, finally, the post Bronze Age valley alleviation (Nayling and Caseldine 1997). The build-up of sediments is thought to be due to marine transgressions during

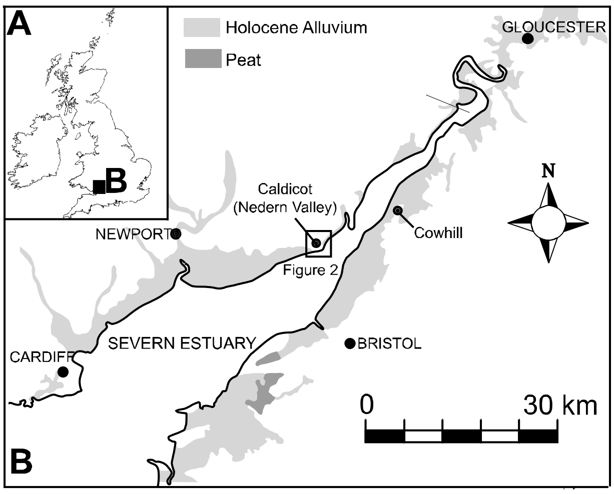


Figure 1. Map of the Severn Estuary showing the location of the Bronze Age site at Caldicot. Detailed map of Caldicot shown in figure 2.

the Holocene, trapping sediments within the Nedern Valley (Allen 1990; Murray and Hawkins 1976; Nayling and Caseldine 1997; Nichols and Biggs 1985).

At the foot of the medieval castle is the Nedern Brook, the remnant of the River Nedern, which created the Nedern Valley (Figure 2). The Nedern Valley continues from the site into the Severn Estuary, 3 km to the south. The site of the archaeological finds is within a series of intersecting palaeochannels at the edge of the fluvial-estuarine interface. The Nedern Valley is incised to a depth of –10 m OD (Allen 2001) into a bedrock of recent terrace gravels, Triassic sandstone and Keuper Marl and the Old Red Sandstone and Carboniferous beds. The medieval castle at Caldicot is situated on a promontory of Triassic sandstone, to the west of the Nedern Brook, overlooking the archaeological site. This sandstone also occurs to the north of the lake as a marked slope defining the edge of the valley. Both of these raised valley edges are potential sites for a dryland settlement associated with the Bronze Age archaeological remains (Nayling and Caseldine 1997).

There are significant similarities between the discoveries from Caldicot and those on the estuary foreshore. The Bronze Age activity of the Caldicot and Wentlooge Levels has been extensively surveyed and excavated (Bell *et al* 2000). Buildings, timber post alignments (fishing structures, trackways, and jetties) and occupation scatters are frequently associated with palaeochannels, such as at Peterstone Great Wharf (Bell and Brown 2005, 2007), Redwick (Bell 2001) and the foreshore between Redwick and Coldharbour Pill (Bell 2001). Many of the most significant sites and finds have been from tidal channels (such as the River Nedern) or pills (Allen and Rippon 1994). The finds at Caldicot were from within the palaeochannel sequence. Also associated with palaeochannels are Iron Age structures at Goldcliff (Bell *et al* 2000), the Barland's Farm boat (Nayling and McGRail 2004), the Romano-British settlement at Oldbury (Hume 1992), a medieval timber and stone quay at Grange Pill (Fulford *et al* 1992) and similarly at Hill Pill (Allen and Fulford 1992). Palaeochannels are deeper than the former landsurfaces on which archaeological sites are found, leading to the necessary use of prospection methods that can penetrate deep sedimentary sequences (*c* 1 to 10 m). This is especially important within the deep sedimentary sequences behind the seawall, where the sediments are protected from erosion and the archaeology remains concealed. This paper proposes the use of a suite of archaeological prospection techniques, coupled with ground truthing, as a potential way of finding these palaeochannel sequences and mapping the former landsurfaces with which they are associated.

Coastal and riverine sites, such as Caldicot, have been used throughout the prehistoric and historic periods, providing a wealth of resources, such as food, water, transport and defences. Alluvial sediments generally preserve archaeological artefacts well, due to waterlogging and rapid sediment accumulation. Waterlogged sediments may preserve plant remains, pollen, seeds, wood and other organic remains that would otherwise decay quickly on exposed dry sites. This paper also explores the use of geophysical prospection techniques to identify the location of these sediments and thus potential areas for preservation of archaeological remains.

Geophysical methods have been used extensively to look for archaeological built structures, such as roads and buildings within shallow (0-0.5 m) sediments, from Romano-British, post-Roman and medieval periods (Gaffney *et al* 2000; Neubauer *et al* 2002; Seren *et al* 2004). The focus of this research is to study 'ephemeral' archaeological features, such as buried landsurfaces, wooden artefacts, stone strews and post alignments within alluvial sedimentary sequences. Whilst there are a wide range of geophysical techniques in use for archaeological prospection, it is important that the instrumentation is selected correctly for the type and depth of archaeology and associated features, and the sediments within which these are contained. This paper is part of a wider study by the author of the use of multiple geophysical prospection techniques coupled with ground truthing to reconstruct the buried topography of coastal and riverine archaeological sites in the UK. The other study sites investigated were Cowhill, Gloucestershire, on estuarine alluvium of the English Severn Estuary, and Ufton Green, on the riverine alluvium of the River Kennet in Berkshire (Mansfield 2007).

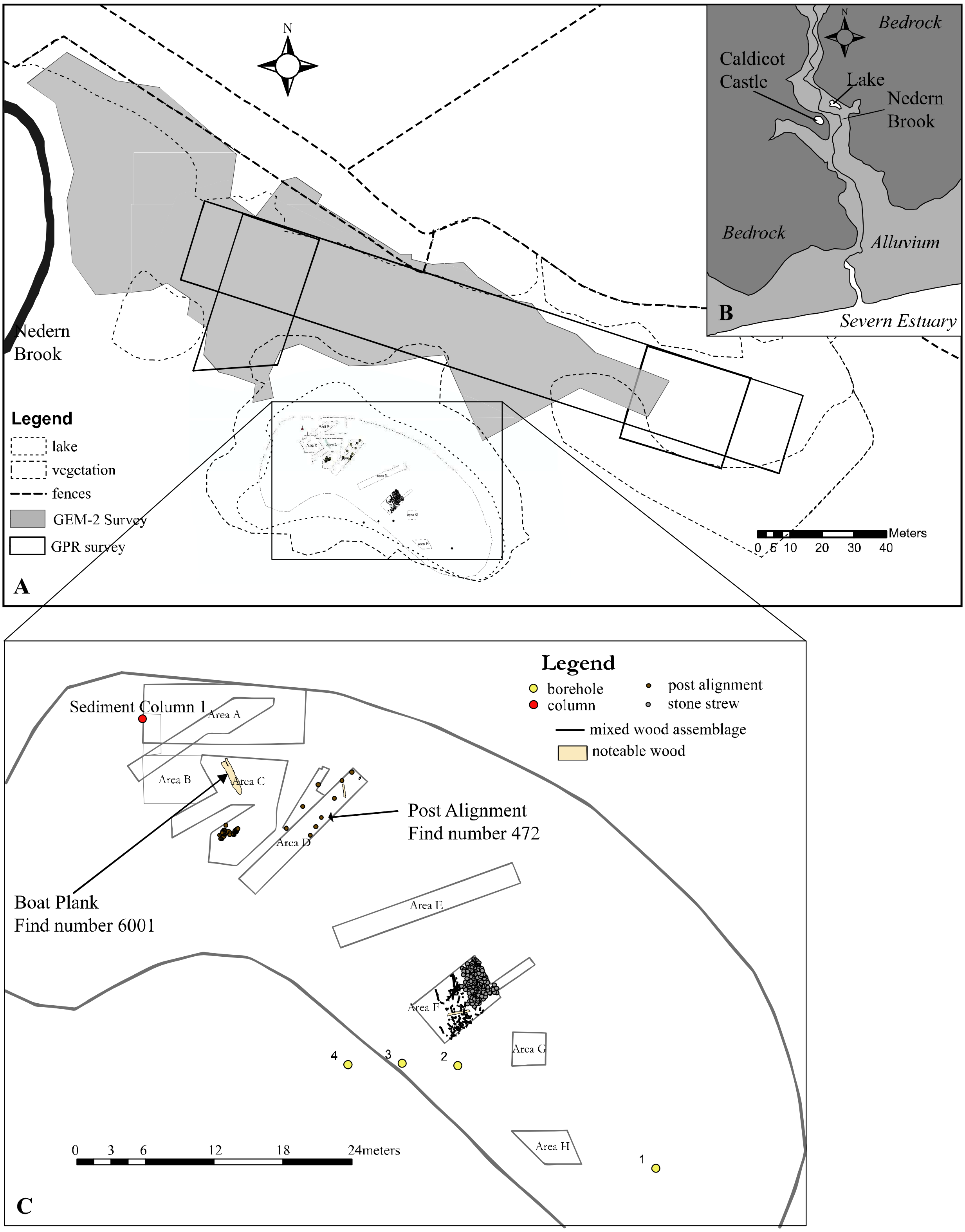


Figure 2. A - location of the GEM-2 and GPR surveys at Caldicot; B - Map of the area surrounding Caldicot Castle showing the location of the bedrock, alluvium and lake; C - Plan of the main features and trenches (Areas) excavated (based on information from Nayling and Caseldine 1997).

METHODS

EMI (Electromagnetic Induction), GPR (Ground Penetrating Radar), ERT (Electro Resistivity Tomography), magnetic gradiometry and coring were used to place the Bronze Age finds from Caldicot in their landscape context. EMI, 200 MHz GPR and ERT were used to map the edge of the palaeochannel sequence and determine a potential location for the dryland occupation site. Magnetic gradiometry was used to determine the ability of this frequently used archaeological prospection tool in locating the presence of palaeochannels. The 3D modelling of the GPR data will be used to determine the depth and shape of the palaeochannels, and if multiple channels are detected, their relative ages. Coring and sedimentary analysis from the excavation were used to determine the sedimentary features responsible for the anomalies detected.

Electromagnetic Induction (EMI)

A Geophex GEM-2 was used to survey the area to the north of the excavation. The GEM-2 is a fast data collection technique allowing large volumes of data to be collected rapidly and produces maps of broad scale conductivity and magnetic susceptibility features. This technique is used first on the site to determine areas where further investigations are needed using finer resolution techniques. Data was collected for both the in-phase and quadrature mode. Lines were spaced at approximately 1 m intervals and data points were located using a GPS receiver. The data was gridded using natural neighbour interpolation to form single polygons, using Surfer 8. The GEM-2 data output also contains calculated readings for apparent electrical conductivity (EC) and magnetic susceptibility (a non-dimensional number x 1000), the sum of quadrature and the total electrical conductivity (Total EC) for each frequency.

The Geophex GEM-2 is a multi-frequency, broadband electromagnetic sensor with a linear coil arrangement. Standard electromagnetic induction techniques use variation in coil separation to control the depth over which the conductivity is measured. However, the GEM-2 can alter the depth of penetration by altering the frequency of the electrical current creating the primary field. The introduction of a *buck* (third coil) to the instrument reduces the saturation effect of the primary field on the secondary field and therefore allows the GEM-2 to be much smaller than its contemporaries. A digital bitstream also means that the GEM-2 can collect multiple frequencies of data, up to 5 frequencies, at any one time. Data at Caldicot was collected at 475, 1175, 3925, 13575 and 47025 Hz for both quadrature and in-phase components. The depth of features imaged with the GEM-2 is complex and depends on the ground conductivity, target volume and ambient electromagnetic noise (Huang and Won 2000). It is estimated that this is up to about 30-50 m in resistive areas (>1000 ohm.m, eg bedrock), and 20-30 m in conductive areas (<100 ohm.m, eg loose sediments) assuming an ambient noise of 5 ppm (Geophex Ltd 2004).

Ground Penetrating Radar (GPR)

200, 270 and 400 MHz GSSI antenna coupled to a SIR-20 computer system were used to collect data at Caldicot. The GPR data radargrams were combined into 3D blocks using Radan. 2D vertical Radargrams and 2D horizontal time slices have been presented herein to show the features identified. A variety of antenna frequencies were used due to the trade off between depth of penetration and size of feature identified. As the frequency of the antenna is reduced the depth of penetration is increased; the resolution is reduced. This may mean that smaller archaeological features are not recorded with the 200 MHz antenna, compared to the 400 MHz antenna, but a greater depth of penetration would be gained. Therefore, the 200 MHz antenna was used to collect data over a large area of the site to the north of the lake, whilst the 400 MHz antenna was used to concentrate on a 100x20 m area of potential bedrock rise identified by the EMI and 200 MHz GPR results. This was considered to be the most likely location for traces of dryland occupation within the area of the geophysical surveys. Features are best detected through geophysical survey when they are perpendicular to the survey lines.

An opportunity to trial the 270 MHz GSSI antenna was presented at Caldicot. The increased power of the 270 MHz antenna will result in a loss of some of the deepest information recorded by the 200 MHz antenna. However, it is hoped that the increase in resolution will lead to a greater clarity of the features identified. The two surveys were conducted on the same day; therefore ground conditions should not have a discernable effect on the two datasets.

All the GPR surveys were carried out with the use of a marker wheel to ensure that readings were accurately located within the grid. The 200 MHz and 270 MHz antenna were large enough to be towed behind the vehicle allowing large areas to be surveyed rapidly. The 400 MHz antenna had to be towed by hand, and therefore the surveys covered a much smaller area of the site.

Magnetic Gradiometry

A magnetic gradiometry survey was carried out to the north of the lake using a Geoscan FM256. A sample interval of 0.25 m and a traverse interval of 0.5 m were used over five 30 x 30 m grids. The magnetic gradiometer passively measures the vertical gradient of the earth's magnetic field, through the use of vertically arranged sensors within the instrument. The most commonly identified archaeological features are burnt features such as kilns and hearths and organic rich pits and ditches. The depth to which an object can be detected by a magnetic gradiometer is dependent on sensor separation, the background magnetism of the sediments, the size of the anomaly, the depth to the water table and the physical and chemical properties of the sediments (Weston 2001). The FM256 has a sensor separation of 0.5 m which generally provides evidence of archaeological features within about the topmost 0.5 m of sediment.

Electrical Resistivity Tomography (ERT)

Six Wenner array ERT surveys were conducted across the site. Surveys 1 and 6 were 48 m long, with a 1 m electrode separation and were orientated west to east. Surveys 2 to 5 were 24 m long, with a 1 m electrode separation and were orientated north to south. These are 2D vertical resistivity sections, which show changes in resistivity (the inverse of conductivity) with depth. The survey lines were planned to target features identified by the EMI data, in order to provide vertical resistivity (conductivity) information.

Ground truthing

The geophysical data were ground-truthed by comparison with the descriptions of the sediments in excavation trenches and borehole data recorded during the previous archaeological investigation (Nayling and Caseldine 1997, fig 12) and through a coring transect positioned along ERT 5. The archaeological sensitivity of the site limited the amount of coring and sedimentary analysis that was possible at Caldicot.

DESCRIPTION AND INTERPRETATION OF THE GEOPHYSICAL ANOMALIES

GEM-2

The GEM-2 survey showed six features, which are identified on Figure 3 and Figure 4. Features A and D were characterised by high magnetic susceptibility and low apparent conductivity. These contrast with the low magnetic susceptibility and high apparent conductivity features (Features B and C). Low conductivity is associated with low pore water content, generally linked to good drainage caused by a large grain size. Soils and sediments many produce a high magnetic susceptibility due to biogenic maghematite (Thompson and Oldfield 1986). Features A and D correlate with the higher topography to the north of the lake and their low conductivity suggests that they delineate the northern edge of the main palaeochannel (Figure 4). Features B and C show variation within the high conductivity sediments of the palaeochannel.

Feature E is a high magnetic susceptibility spike, suggesting the presence of metal; however, the later gradiometry survey is a much better method of determining the presence of metal and therefore this feature will be considered below. Feature F is a high magnetic susceptibility linear feature; however, the conductivity change is hardly discernable from Feature C which surrounds it. It is possible that Feature F is caused by an increase in biogenic maghematite and therefore represents a linear feature with a more organic fill.

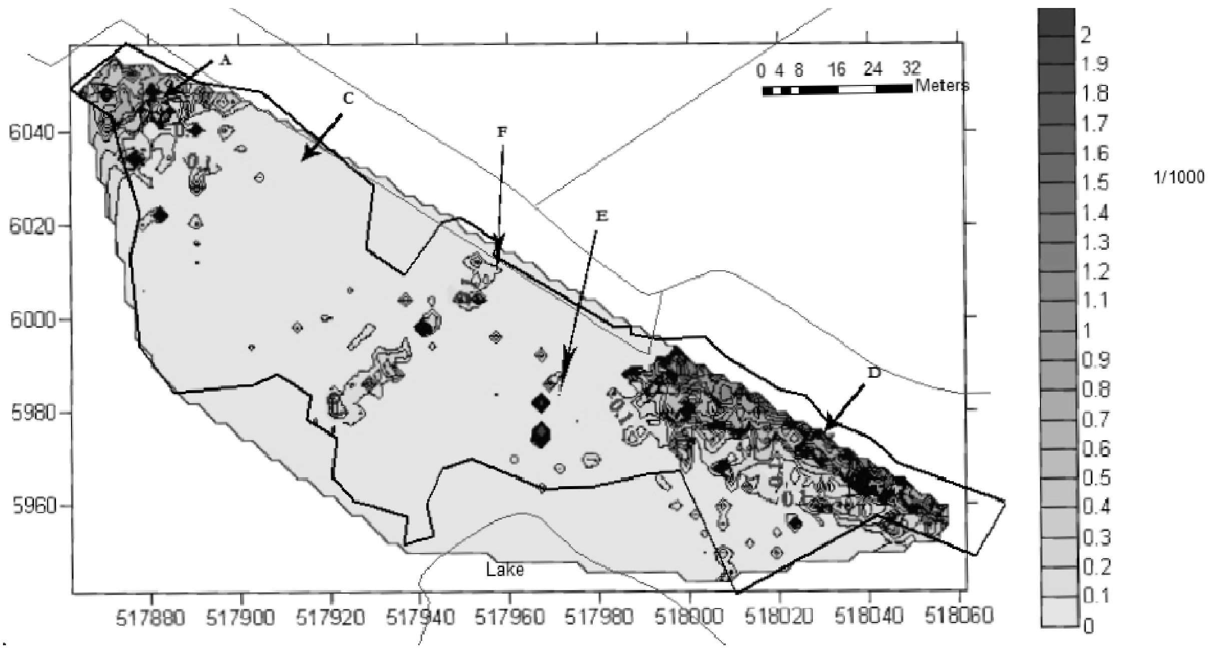


Figure 3. GEM-2 survey showing the magnetic susceptibility as calculated from the 1175 Hz data.

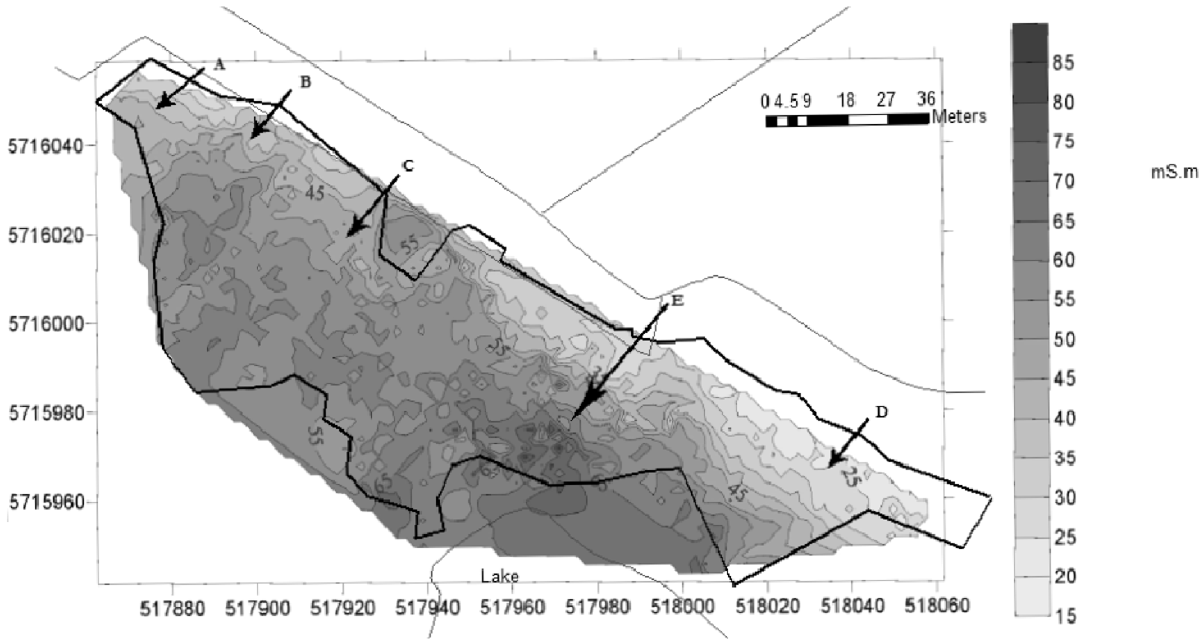


Figure 4. GEM-2 survey showing apparent conductivity as calculated from the 3925 Hz data.

GPR 200 MHz survey

The three antenna frequencies each showed different features within the time slices. The 200 MHz antenna identified the greatest number of features, suggesting that the features were buried at depths beyond the detection limit the other two antennae (Figure 5). The 200 MHz antenna detected high reflectance bedrock to the east of the survey area, Feature J, containing an area of low reflectance, Feature M (Figure 5). A low reflectance feature was recorded on the 19 ns time slice, which, from its form and reflectance suggests that it may be one of the intersecting palaeochannels within the main palaeochannel. On the 12 ns (Figure 6) and 19 ns (Figure 7) time slices there are a series of features which could be interpreted as archaeological. Feature H shows

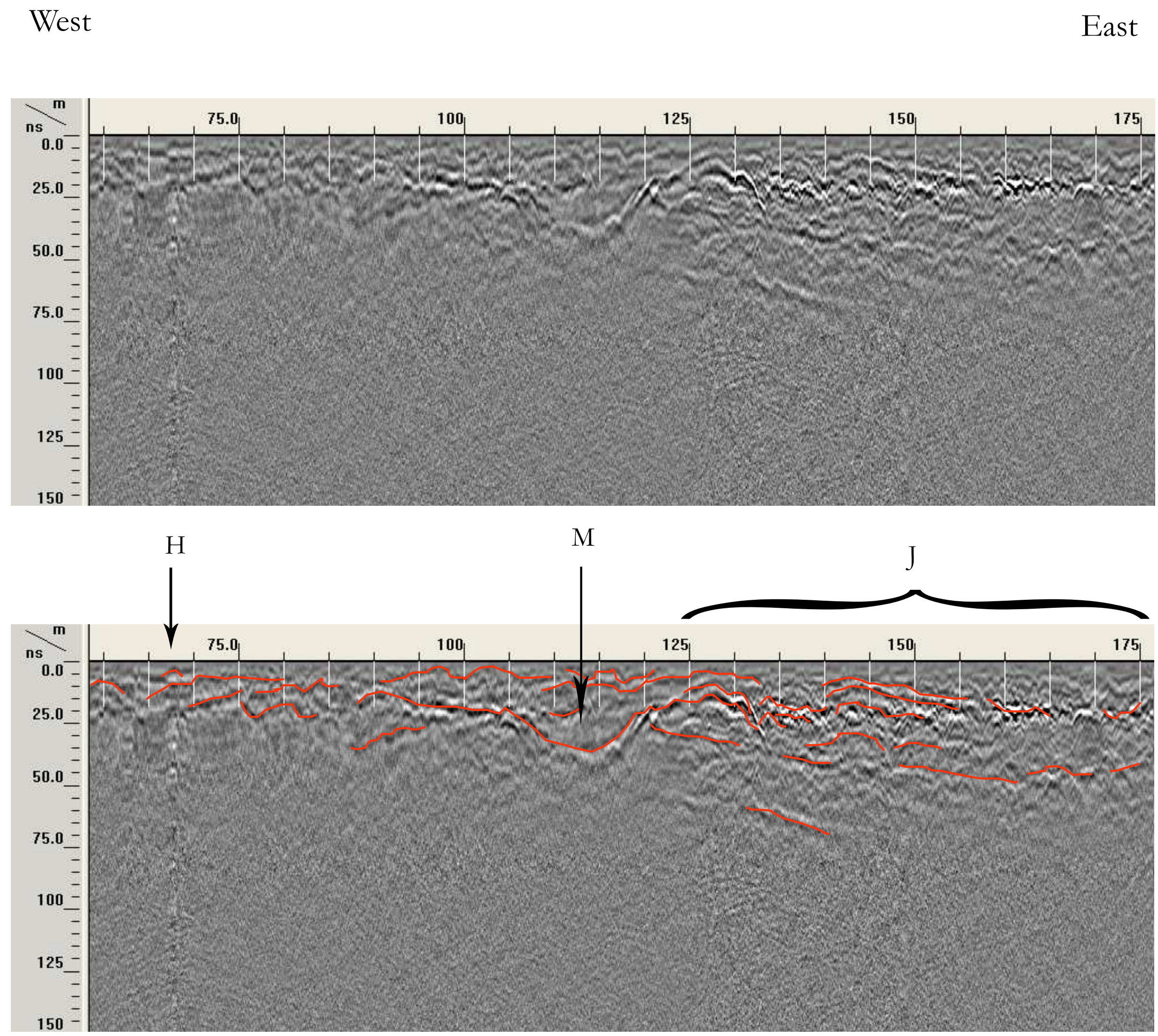


Figure 5. 200 MHz GPR radargram 15 (Grid 1).

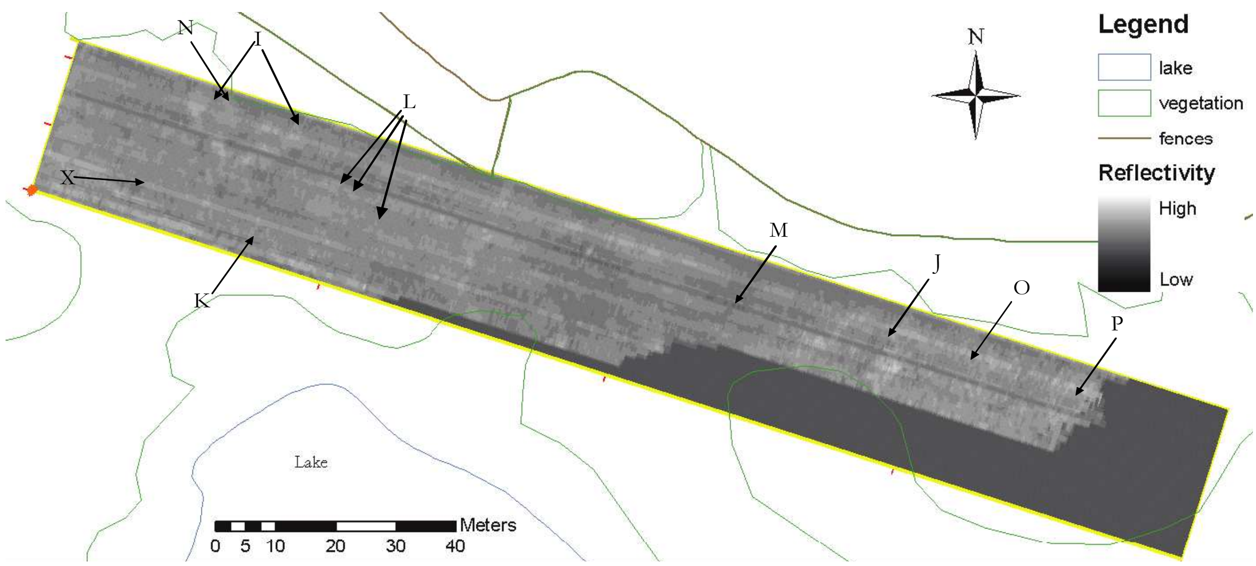


Figure 6. 200 MHz time slice of grid 1 at 12 ns (averaged over a 5 ns time window).

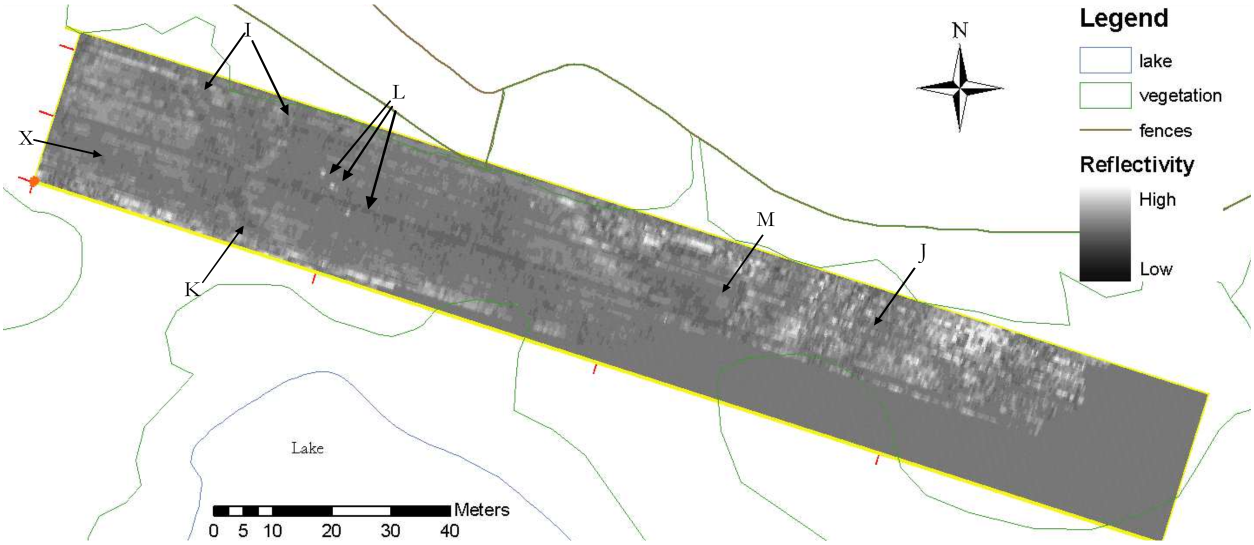


Figure 7. 200 MHz time slice of Grid 1 at 19 ns (averaged over a 5 ns time slice).

up on the 12 ns time slice of the 200 MHz survey as a linear feature of high reflectivity (Figure 7).

To the east of the 200 MHz survey area there is a semi-circular feature of paired low and high reflectivity (Feature I); this first shows on the 6 ns time slice of the 200 MHz survey. The high and low reflectance coupling may indicate the structure of the feature. From the radargrams it can be determined that this feature is composed of two inward dipping reflective surfaces. These meet together at their southern extend and appear to meet Feature K (Figure 8) which is a low reflectance linear feature which heads from Feature I towards the lake.

At around 6 ns, Feature G, is at approximately 0.3 m, if a 0.1 m/ns effective velocity is assumed. EDM surveying of the site showed that these features correlated with the location of paths cut into the grass. The higher compaction of the sediments, and the shorter grass, on these paths enabled the antenna to couple with the ground more effectively and therefore created less ringing within the top fraction of the radargram.

GPR 270 MHz Survey

An opportunity to trial a new 270 MHz antenna alongside the 200 MHz was taken during fieldwork at Caldicot. The increased power of the 270 MHz antenna will lead to the loss of some of the deepest information recorded by the 200 MHz antenna, but the increase in power should permit a greater resolution of features. The 270 MHz data was collected over the same area as the 200 MHz survey to allow direct comparison.

The features identified at 36 ns are L, J and M (Figure 9). The radargrams from the 270 MHz dataset show indistinct features within the top 25 ns from 0 to 75 m. The main features identified through the 270 MHz survey is that of Feature J, the high reflectance bedrock, composed of dipping and undulating surfaces of high reflectivity. Feature M is an area of lower reflectivity, which from the radargrams and time slices appears to be a arc-shaped depression within Feature J. Feature L is a discrete area of high reflectivity, probably representing a point source. On the 14 ns time slice, not shown here, there are two arc shaped features of high reflectivity (Feature I). This is imaged on the radargrams as inward dipping high reflectance surfaces.

GPR 400 MHz Survey

The 400 MHz surveys detected two points of high reflectance, but otherwise did not show any features that were not detected by the other surveys. Therefore the data from the 400 MHz is not presented here.

ERT

The location of the ERT transects are shown in Figure 10. ERT 2, 3 and 4 have high resistivity at the bottom of the section and to the north, grading to low resistivity towards the top of the section

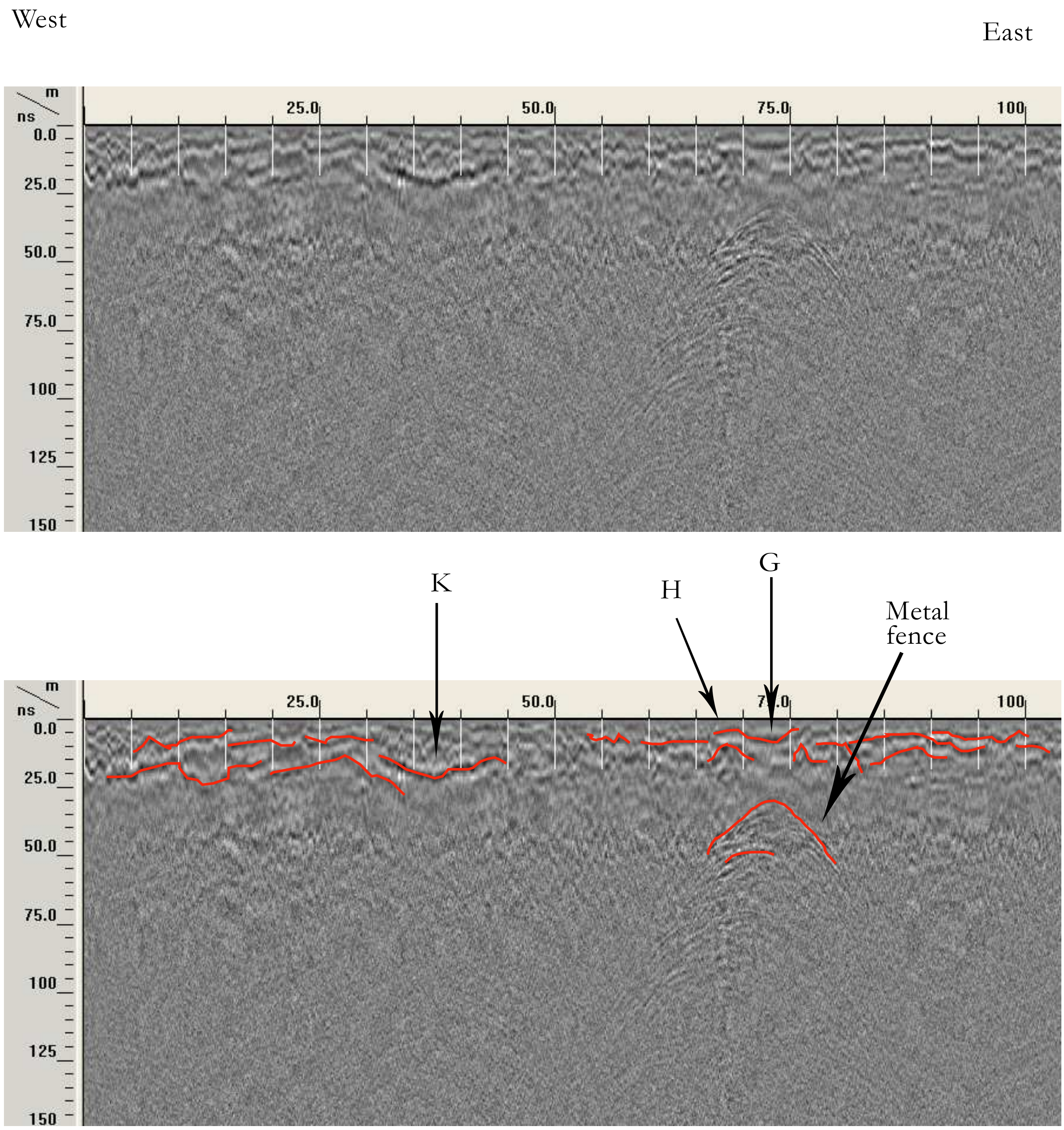


Figure 8. 200 MHz radargram 31 (Grid 1).

and south (Figure 11). This correlates with the change in conductivity in the EMI data between the low conductivity of Feature D and the high conductivity of Feature C. The exception is a patch of high resistivity to the top of profile ERT 2 at 0.75 m. Comparing the location of this with the GPR 200 MHz results, suggests that this is potentially Feature I. The shape of this high resistivity and its location compared to the EMI and GPR data, suggests that this is the edge of the palaeochannel. ERT 1 has high resistivity at the base of the profile (>90 ohms.m) with decreasing resistivity up the profile to *c* 2.5 m where there are some patches of slightly elevated resistivity (23.8 ohns.m). The overall resistivity of the section is low, which is expected as it is the most southerly profile, and therefore furthest away from the palaeochannel edge.

Magnetic Gradiometry

The magnetic gradiometer survey at Caldicot showed magnetic spikes across the site (Figure 12a). Features S is an areas of high magnetism, the white halo being due to the tight clipping range of -15 to 15 nT, which forces anything

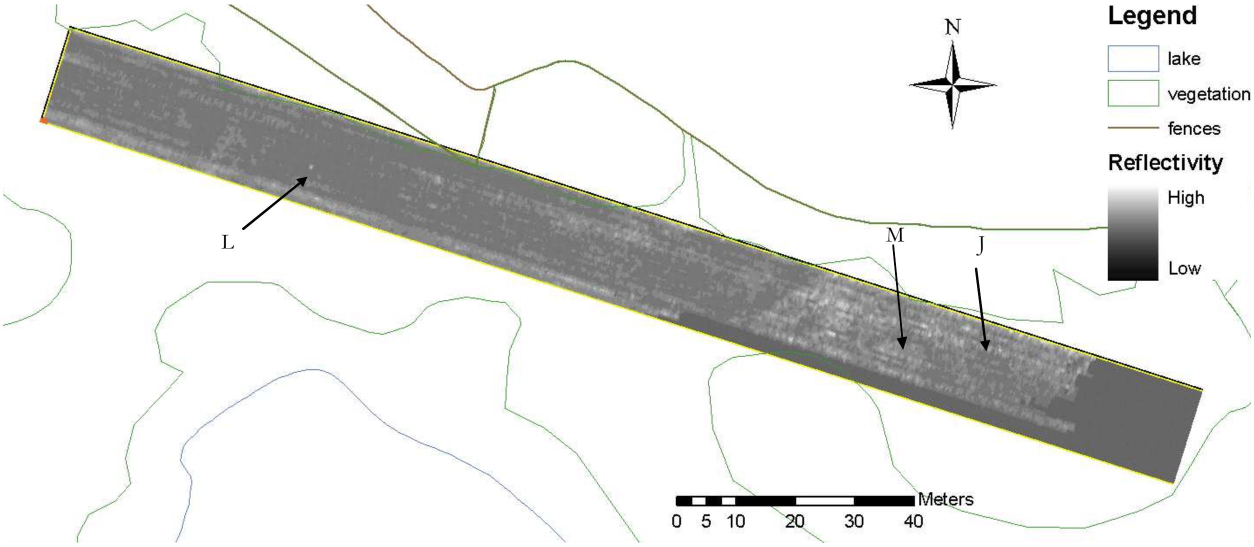


Figure 9. GPR time slice from the 270 MHz antenna, data at 36 ns (averaged over a 15 ns time window).

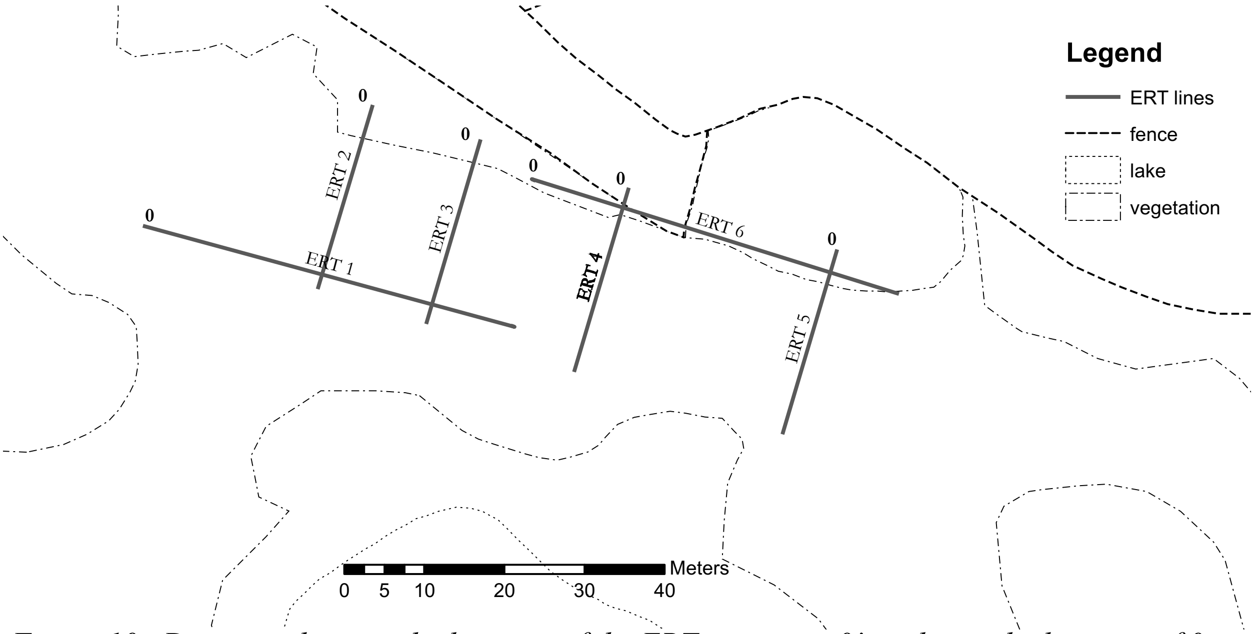


Figure 10. Diagram showing the location of the ERT transects. 0's indicate the location of 0 m on the ERT transects of Figure 11.

outside this range to either appear black or white. The size of the halo suggests that this is either a highly magnetised feature, a large object, or that it is situated very close to the surface. Due to the archaeologically sensitive nature of the area, no excavations were conducted to ground-truth the magnetic spikes. The positive and negative coupling of feature T suggests that this may be a buried pipe, laid in sections. Feature U represents two spikes of high magnetism to the south of the plot close to the archaeological excavation and the site of the spoil heap. It is possible that this is either contamination from the excavation of the lake, or metal left behind by the archaeologists (eg 6 inch nails). A narrower display setting of -2 to 2 nT was used to highlight potential archaeological and geomorphological features (Figure 12b). This revealed a sinuous high magnetic feature, Feature X, which could potentially be a palaeochannel.

GROUND-TRUTHING

Due to the archaeological sensitivity of the site it was only possible to conduct one coring transect to the north-east of the main site of the archaeological finds. The coring transect along

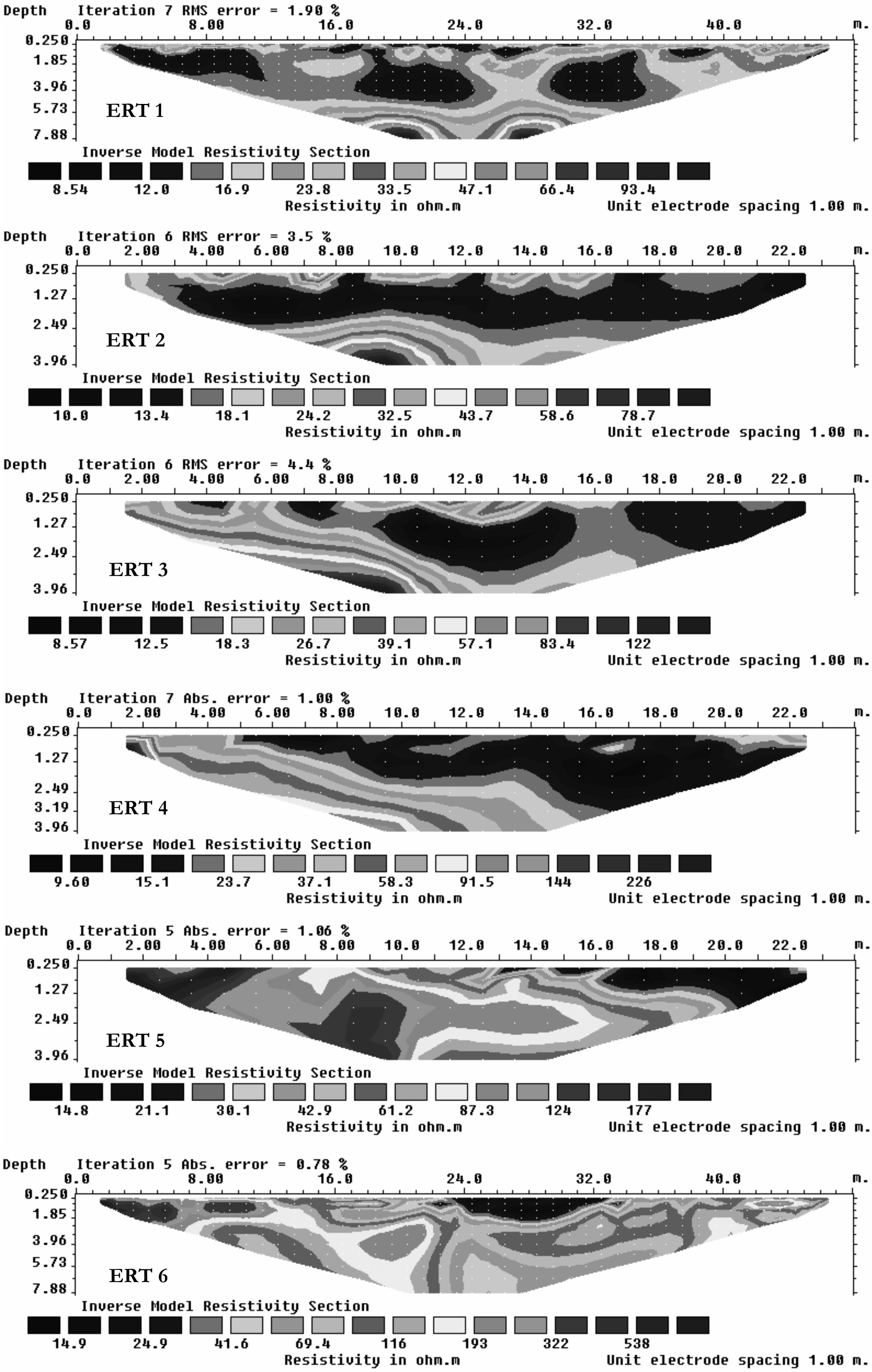
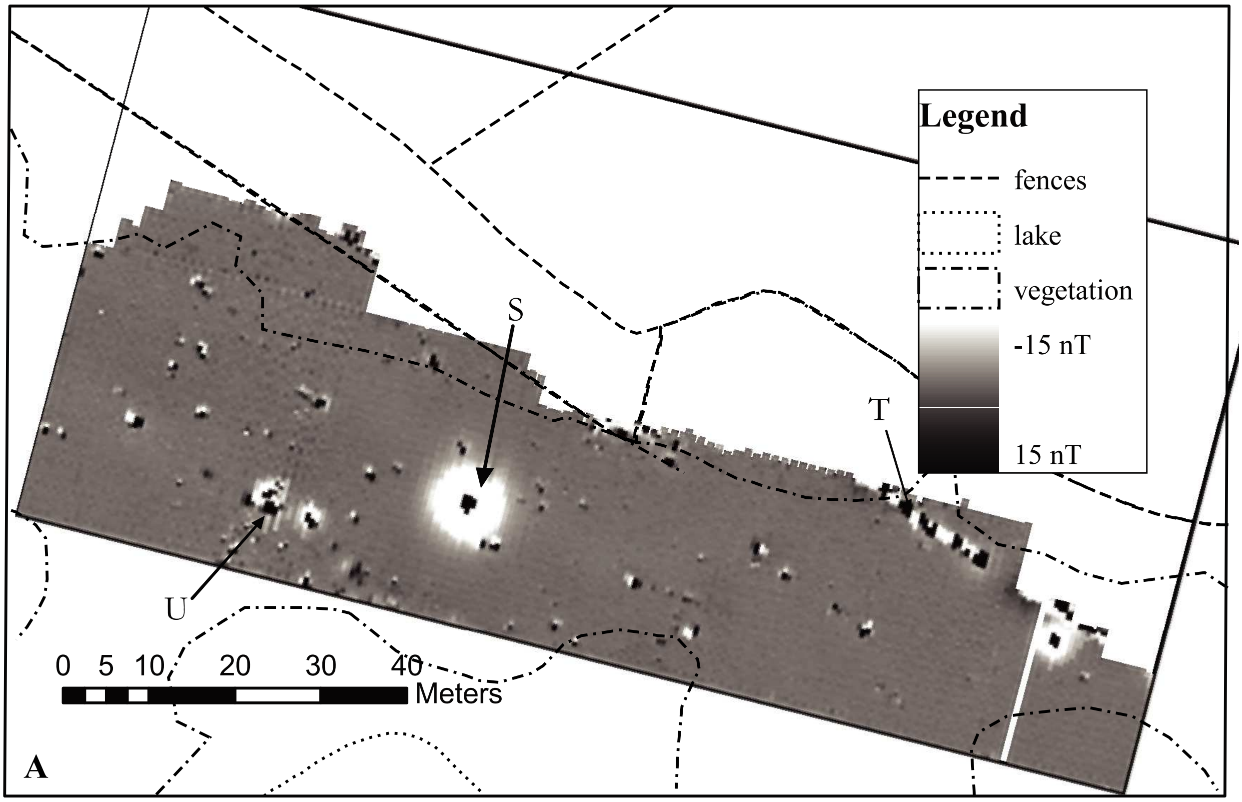


Figure 11. ERT transects, showing the calculated apparent resistivity pseudosections. Note that each section has its own resistivity scale. The depth scale is shown on the left of each pseudosection in meters.



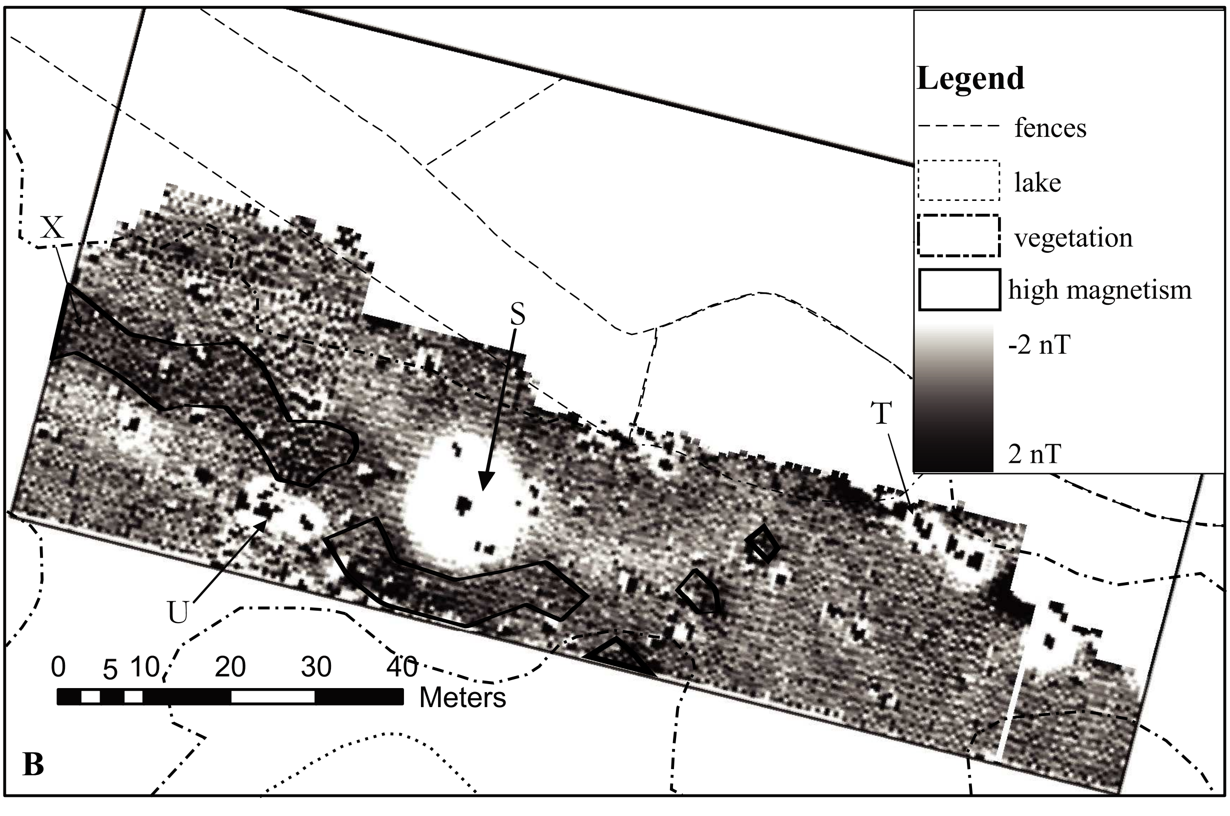


Figure 12. Magnetic gradiometer survey data. A - Clipped at -15 to 15 nT to highlight the presence of metal features; B - Display at -2 to 2 nT to highlight the presence of archaeological and geomorphological features.

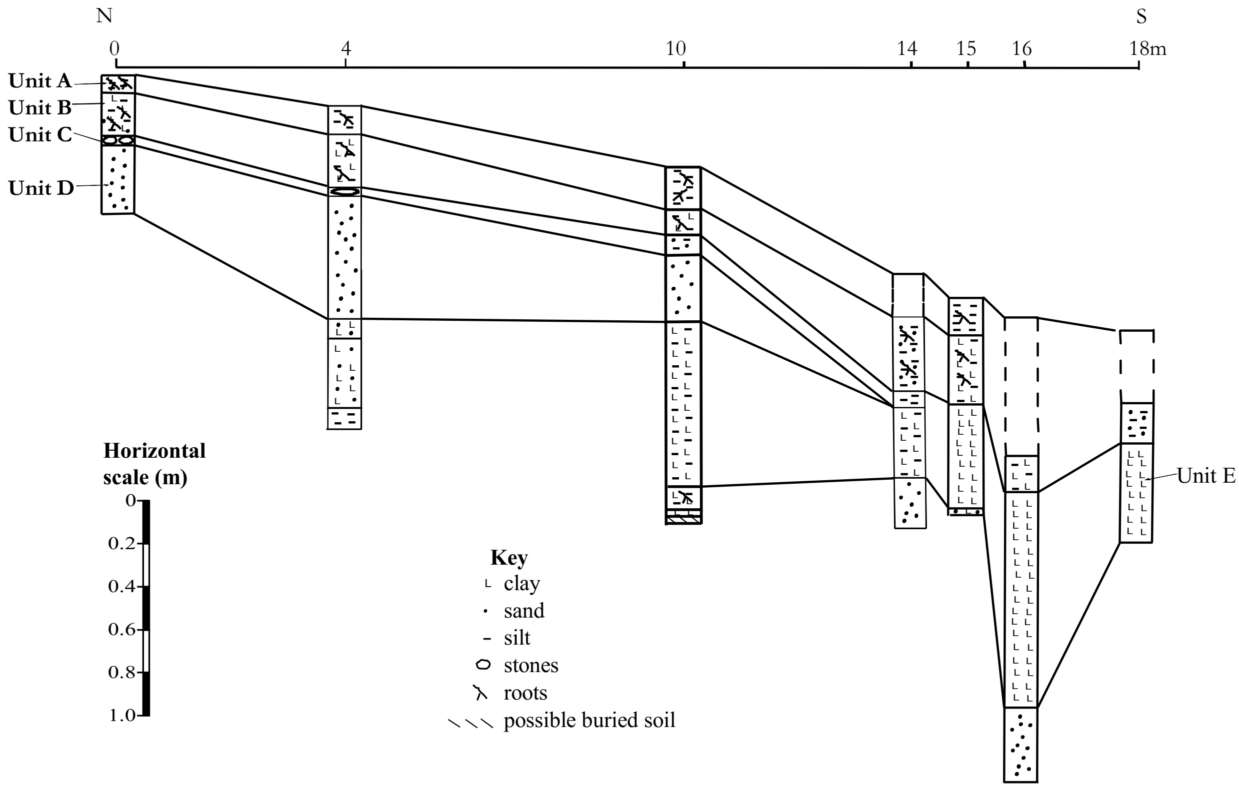


Figure 13. Coring transect CL05, situated along ERT 5 (see Figure 10).

the line of ERT 5 is shown in Figure 13. The anomalies within the geophysical prospection surveys were ground-truthed through both this coring transect and the finds of the archaeological excavation and borehole data from the report by Nayling and Caseldine (1997) and the use of geological reports and maps of the area.

The sediments of the intercutting palaeochannels investigated by this research and previously by Nayling and Caseldine (1997) show a dominance of silty clays. The silts are fairly homogeneous which made definition of the channels through boreholes and coring very difficult. The excavation revealed a series of palaeochannels that were distinguished from one another by slight differences in colour and organic content. The sediments from coring transect CL05 were generally sandier than those analysed from the excavation trench, suggesting a terrestrial input. The sandy sediments found within the cores at 1 to 10 m along the profile indicate a proportion of Holocene colluvium from the slope to the north. Above this is a layer of stonier sediments, represented by a few large stones within the cores. This is again thought to be of colluvial origin with the stony horizon possibly representing earthworm sorting of a soil. Roots and pedogenic features were found in the bottom of the core at 10 m along the profile, suggesting the presence of a buried soil.

At lower topographies, beyond 10 m, the base of the sequence is composed of sand and sandy clays. Above this are silty sediments, the presence of which, and the U-shape of the sedimentary units, suggests a channel feature. These sediments may correlate with the channel sediments found during the excavation and borehole survey. The silty sediments are overlain by the possible soil horizon, found within all the cores.

GEOMORPHOLOGICAL AND ARCHAEOLOGICAL FEATURES LOCATED THROUGH GEOPHYSICAL PROSPECTION

Bedrock

The geomorphology of the site is dominated by a bedrock outcrop of Triassic sandstone. This was identified through the GPR surveys as an area of

Figure 14. Interpretation of the GPR data from the 200, 270 and 400 MHz antennae, Showing the main features identified. The lake area is shown in more detail in Figure 2C.

high reflectance (Feature J, Figure 7). The geological map of the area shows that the Triassic sandstone correlates with the high magnetic susceptibility of Features A and D on the GEM-2 survey (Figure 4). This is where the bedrock rises from under the alluvial sediments of the Nedern Valley (Figure 2), thereby defining the edge of the main palaeochannel. The different extents of the bedrock found by the GPR and GEM-2 surveys are probably due to the differing depths to which the two instruments can image features. Within the bedrock the 200 MHz GPR imaged an embayment, Feature M (Figure 14). This may be manmade or natural, but would have occurred at the edge of the main palaeochannel and therefore created a quiet piece of water suitable as a harbour or fishing location.

Palaeochannels

The sediments within the main palaeochannel are largely homogeneous with low reflectivity (GPR) and high conductivity (GEM-2). The archaeological excavation of the site recorded that there were a number of intersecting palaeochannels, but that they were difficult to distinguish, except through slight differences in colour or organic content. The 200 MHz antenna and magnetic gradiometry may have detected two of these intersecting palaeochannels, as lower reflectance or high magnetism features. A small palaeochannel feature was identified through the magnetic gradiometry survey (Feature X; Figure 12).

Modern activity

The modern footpaths, of shorter grass and more compacted soils, were detected on the GPR surveys (Feature G; Figure 8 and 14). These are not of archaeological interest, but do show the importance of mapping modern features at the sites so that they can be easily identified and removed from any archaeological interpretation.

Potential Archaeological Activity

Features I (Figures 6, 7 and 14) is composed of high reflectance curving features, which roughly form a semi-circle. On the 200 MHz radargrams, it appears as two diagonal high reflectance features which converge towards the base (Figures 7 and 14). These correlate with the topographic rise to the north west of the survey area, and potentially represent archaeological activity. Feature K (Figures 6, 7, 8 and 14) is a roughly linear, low reflectance feature, which is tangential to Feature I and appears to head towards the archaeological remains uncovered during the previous excavation. To the east of these features there is a second linear feature of low reflectance, (Feature H; Figure 5 and 8). This appears to correlate with the post alignment (Feature 472, Figure 2C and 14) discovered during the archaeological excavation. These three features suggest a possibility of prehistoric activity on the Triassic sandstone rise at the edge of the palaeochannel.

Buried Soil

A buried soil was located in coring transect CL05 (Figure 13) within the core at 10 m. This was determined from the presence of signs of pedogenesis and roots, and may account for the increase in magnetic susceptibility in this region, as detected by the GEM-2 survey. This suggest the presence of a stable landsurface that was safe from wind and water erosion long enough for soil forming processes to occur. The date of this buried soils is not know, but its presence in the core below the silty palaeochannel sediments, suggests that it is earlier than these sediments, and therefore potentially pre-Neolithic.

COMPARISON OF THE GEOPHYSICAL RESULTS

The scrubby vegetation, field boundaries and grassed over spoil tips from the lake digging and excavation restricted the area where the various methods could be conducted and the orientation of collection transects (Figure 2). The least affected method was the GEM-2 as there is no need for contact with the ground to collect data and the use of GPS for locating data points means that the data collection is not restricted to grids. The large GPR antennas (200 and 270 MHz) needed to be towed by a vehicle and therefore this reduced the areas where these grids could be located, as they had to allow for an area for the vehicle to turn at the end of each survey line. This meant that the location of the 200 and 270 MHz surveys were restricted by the presence of vegetation and topography.

The GEM-2 imaged the broad landscape features of the site, allowing the archaeological findings to be placed into their landscape context. The wetland-dryland edge was identified, and a potential area of prehistoric activity. The GPR 200 MHz surveys, showed a high- and low-reflectance coupled feature in this location (Feature I) which creates greater evidence for the potential of archaeological activity in this location. The 200 MHz GPR also located Feature H (Figure 14) which appears to be a possible extension of the wooden post alignment, Feature 472, Area D of the previous excavation (Figure 2C).

The 200 MHz antenna identified a greater number of features than the 270 and 400 MHz antenna. This is probably due to the high attenuation rates of wet alluvial sediments and the depth of the archaeological and landscape features. The loss in power between the 200 MHz antenna and the 270 MHz antenna appears to have been such that many of the archaeological and landscape features were not identified at Caldicot.

The magnetic gradiometer survey showed magnetic spikes across the site (Figure 12). Although these could not be linked to any known archaeological features, the presence of metal artefacts associated with this and other Bronze Age wetland sites, suggest that these could be artefacts. However, they may also be modern debris, including 6 inch nails, which may be left behind after archaeological excavations or metal objects dropped by modern visitors to the castle grounds. The presence of a potential palaeochannel was only identified when the display window was shortened to -2 to 2 nT. This shows that the way in which geophysical data is displayed can greatly affect the interpretation of the results. This is especially important where the features being surveyed are similar in nature to the surrounding sediments, as here with a series of intercutting palaeochannels.

CONCLUSIONS

The archaeological and landscape features that were detected by the suite of geophysical techniques is greater than that established by any one method alone. Through the use of multiple techniques it is possible to build up a picture of both the landscape context of the Bronze Age wooden structures found during previous excavation and identify other possible locations of further archaeological potential. The alluvial nature of the sediments in which the arfetacts were found means that the sediments are still frequently waterlogged. This limits the resistivity and conductivity contrast of the sediments and reduces the attenuation of the GPR wave. Therefore, alluvial sediments are not ideal for geophysical investigation. However, the geophysical techniques outlined above do represent a possible way of locating areas which may contain sensitive waterlogged remains, which are expensive to preserve, and potential areas of activity on the associated dryland. Other sites with post alignments that are comparable to Caldicot include Flag Fen (Pryor 2001), Fiskerton (Field and Parker Pearson 2003), Shinewater, East Sussex (Jennings *et al* 2003), and Harters Hill and Greylake, Somerset Levels (Brunning 1998). Geophysical prospection techniques could be used to determine the nature and length of buried post aligments and aid the assessment of appropriate arrangements for heritage management.

The trial of the 270 MHz antenna did not show any great advantage of data resolution at Caldicot. It is thought that this is due to the depth of the features being identified at Caldicot. This shows the importance of understanding the sediments when conducting archaeological geophysical surveys and the advantages to using multiple techniques. Geophysical surveys which produce an absence of any significant anomalies may be due to the selection of the geophysical method, rather than the absence of suitable features or unsuitability of the sediments. This is especially true when working with difficult sedimentary sequences such as those in coastal and and riverine settings.

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