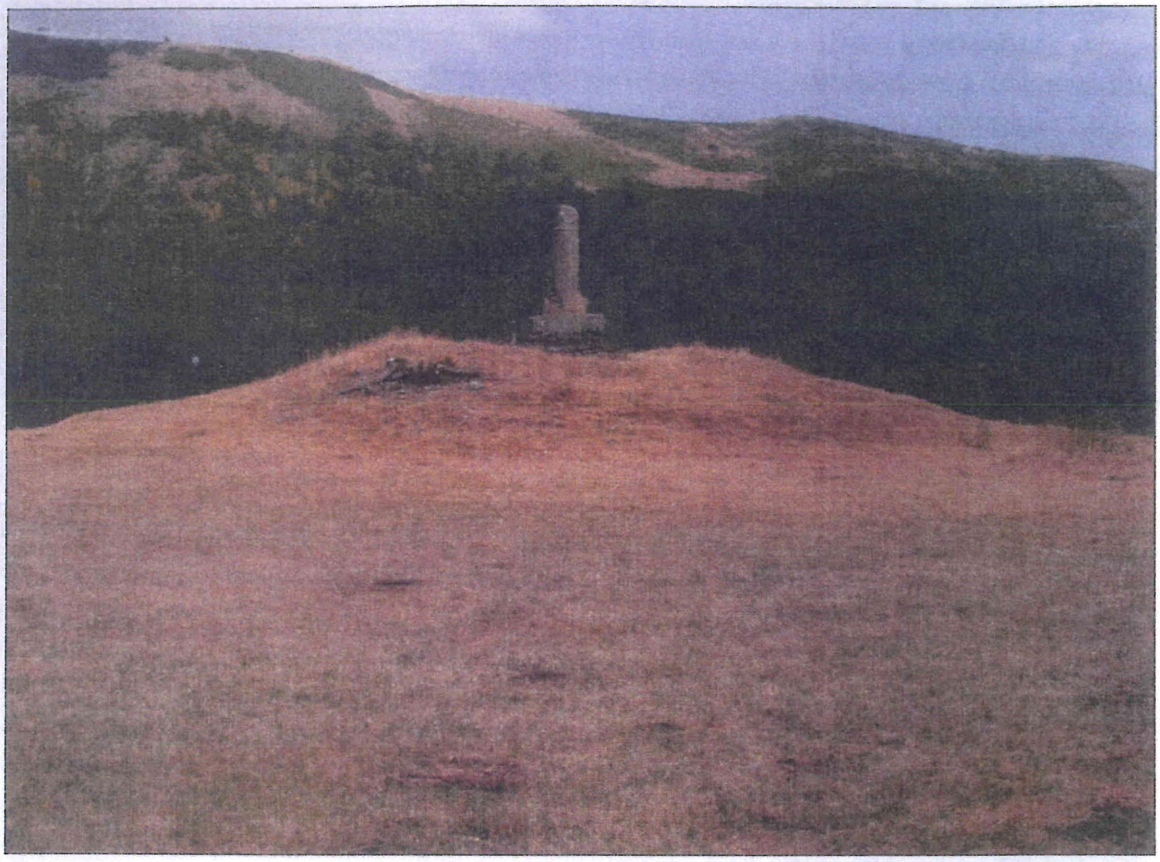
ANNEXE 6

Geophysical and Topographic Surveys, Pillar of Eliseg



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Abstract

Gradiometer, resistivity and GPR surveys were carried out at the Pillar of Eliseg, Denbighshire in 2006 and 2008 at the request of Dai Morgan Evans as part of a non-intrusive investigation to support an application for permission to undertake future excavation. The aims of this group of integrated surveys was to identify the trenches from the antiquarian intervention carried out in 1779 by John Lloyd of Trevor Hall (Sayce 1909, 43-48) and to elucidate the precise location and character of buried archaeological remains visible on aerial photographs of the area immediately surrounding the monument. The combined survey detected a series of anomalies that could be interpreted as the remnants of a series of possible enclosures. Further investigation would be required to provide evidence of an association between these features and the monument.

Further investigation of the monument involved the use of a total station to undertake a topographic survey, with the intention of providing a three dimensional record of the mound. GPR survey was used to detect the known antiquarian intrusions into the monument and provide their location in relation to the position of permanent markers placed around the mound by Inspectorate of Ancient Monuments, Wales and revealed in the gradiometer survey carried out in 2006.

Introduction

Gradiometer, electrical resistance, Ground Penetrating Radar (GPR) and topographic surveys were carried out on and near the Pillar of Eliseg, Denbighshire during July 2006 and March 2008 by Dai Morgan Evans, Sarah Semple (University of Durham), Alex Turner (SAT Surveys), and Susan Youngs. This integrated group of surveys aimed to identify the trenches from the antiquarian intervention carried out in 1779 by John Lloyd of Trevor Hall (Sayce 1909, 43-48) and to determine the precise location and character of buried archaeological remains visible on aerial photographs of the area immediately surrounding the monument.

Topography and geology

The site, centred on NGR 320266 344527, lies at the end of a north-south ridge in an area between the valley of the River Eglwyseg to the east and the steep sides of the Llantysilio mountain range to the west at an altitude of 125 metres (figure 2). The underlying bedrock geology is mudstone, siltstone and sandstone with an overlying superficial geology of sands and gravels (figure 1).

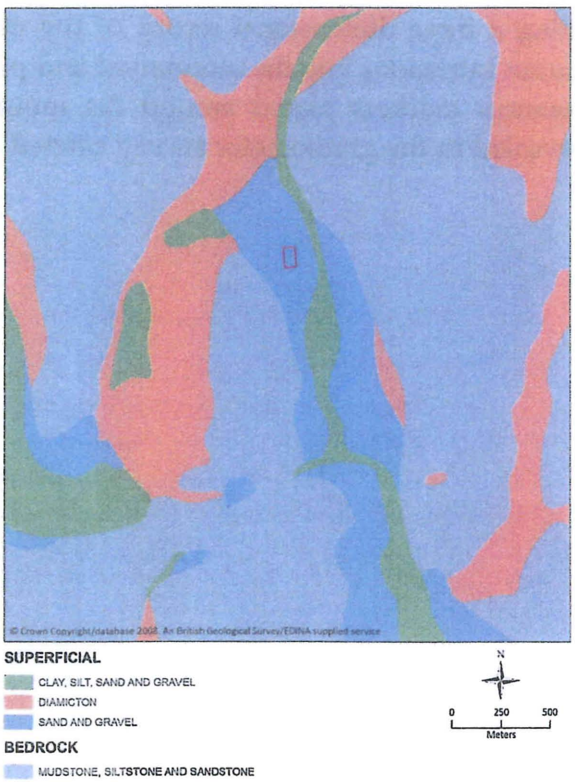


Figure 1 survey site and surrounding geology

Gradiometery has been documented as returning an 'average to poor' response over this type of bedrock geology with a similar response expected from the superficial geology covering the site. (EH 1995, 10). Results from the survey indicate that, although it was possible to obtain reasonable data using magnetic methods, the strength of response was attenuated by the effects of the local superficial geology. The free-draining nature of this superficial geology was also a significant factor for resistance survey since sufficient levels of moisture were required to gather usable data from the site.

Survey location

The 2006 gradiometer survey, measuring 100 x 40 metres (0.4ha), was centred over the area of the scheduled mound and a further area to the north of the monument that displayed a potential palimpsest of buried remains observed on aerial photographs.

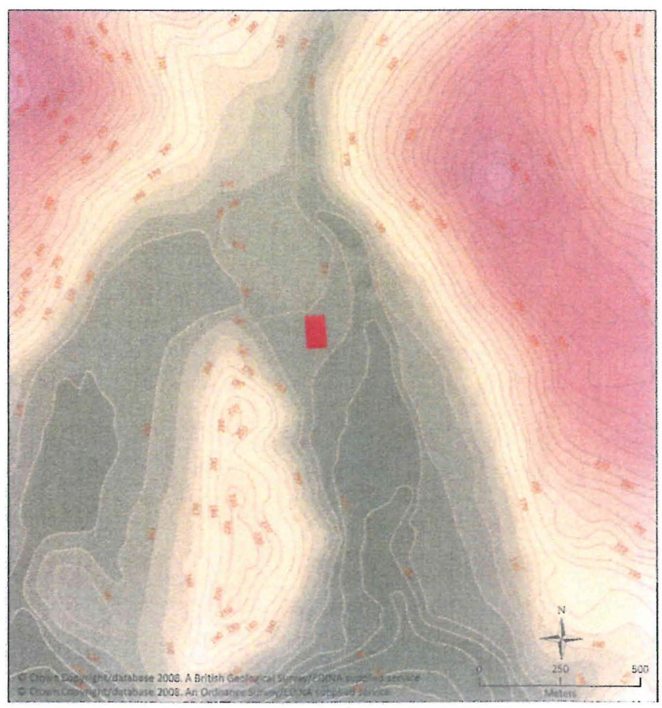


Figure 2 survey site and surrounding topography

The 2008 resistance survey, measuring 100 x 60 metres (0.6ha), concentrated on an area to the north of the monument overlapping with the previous gradiometer survey of 2006. The 2008 GPR survey was carried out on a 20m x 20m grid (0.04ha), encompassing the mound and its immediate vicinity. Location of the 2006 and 2008 survey grids on an aerial photograph georeferenced to an Ordnance Survey digital 1:2500 Mastermap revealed a problem with the location of the monument as shown by the digital map data with a discrepancy in position of between two and three metres to the south and east of the mound (figure 3) a level of inaccuracy that was duly documented within the underlying OS data table.

Figure 3 Location of survey grids and OS map error

Survey conditions

The dry survey conditions of 2006 proved to be ideal for gradiometer survey but an attempt in the same year to repeat the survey using electrical resistance was thwarted by the 'freely draining acidic loamy soils' (NSRI, http://www.landis.org.uk/soilscapes/) that produced an unacceptably high soil contact resistance and made the acquisition of usable data extremely difficult. This was overcome by returning to the site, in March 2008, when soil moisture levels were more conducive to resistance survey. Since near-surface measurement of electrical resistance 'largely reflects local concentration of soil moisture' (Linford 2006, 2211) the survey period was carefully chosen to enable the collection of a useful resistance data set. GPR survey was carried out over the mound using a series of parallel transects and provided an interesting but variable data set, largely due to the difficult ground conditions over some parts of the monument. Both in 2006 and 2008 the survey site was under pasture for sheep grazing and provided ideal conditions for a geophysical survey.

Survey methods

In 2006 parallel base lines at 20 metre intervals were laid out using tapes and sub-divided with survey pegs at 20 metre intervals. The first baseline was aligned to magnetic north and the second was orientated at 90 degrees to the first. The survey area was then divided into a series of 20 metre x 20 metres squares again using tapes. The process was repeated in 2008 but logistical considerations, particularly in relation to the positioning of the GPR survey, resulted in a slight deflection from the baselines established in 2006.

Each square was surveyed by making successive zigzag traverses, one metre apart for gradiometery and 0.5 metres apart for resistivity, in a south-north direction. Gradiometer data was collected using a Geoscan FM36 fluxgate gradiometer automatically logging measured magnetic variation along each traverse at 0.25 metre intervals. Resistivity data was collected using a RM15

Advanced with a PA5 frame and 0.5 metre mobile probe separation automatically logging data at 0.5 metre intervals. In both cases the collected data was periodically downloaded to a portable computer for storage and verification.
The GPR survey was carried out using a Mala RAMAC X3M equipped XV11 monitor and a 500 MHz antenna. Parallel traverses were surveyed at 0.5 metre intervals using two parallel tapes for traverse measurement and sample readings were taken along each traverse at 0.2 metres intervals. Sample measurement was controlled by a calibrated measuring wheel attached to the antenna. The GPR equipment was pulled using a tow handle since the uneven ground surface of the mound precluded the use of the rough terrain cart.

Data processing and presentation

Upon completion of the survey, the geophysical data was transferred from the portable computer to a desktop PC and processed using Geoplot 3.0, Reflexw, Reflex3Dscan and ArcGIS 9.2. Digital map data from the Ordnance Survey and the British Geological Society, was used to produce the base maps for locating and presenting the survey results. Adobe Illustrator CS3 and Word 2008 were used for report production.

Results: gradiometry

A number of problems were encountered with the data collected from the gradiometer survey. The most difficult to deal with were the markers placed around the monument to define the Guardianship boundary and presumably, judging by the strong ferrous spikes , fixed with metal ground pins. This meant that much of the data collected from the mound and its immediate

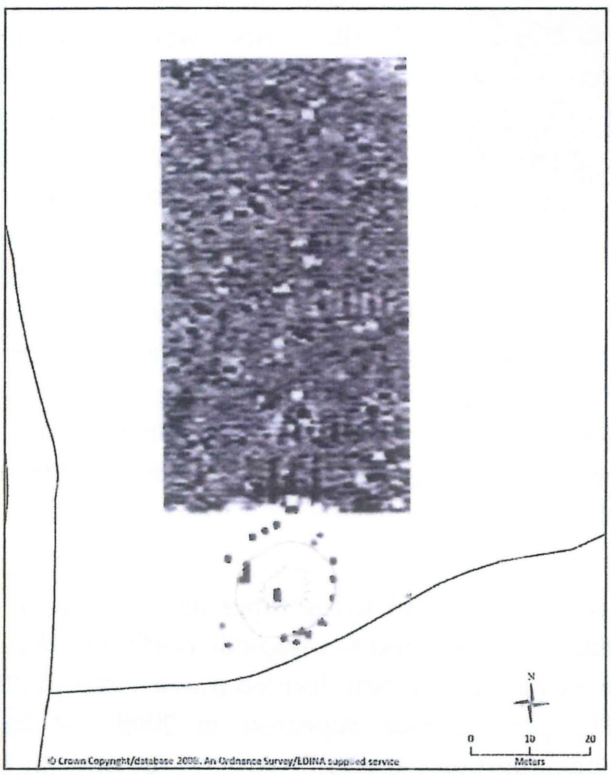


Figure 4 Plot of gradiometer data interpolated

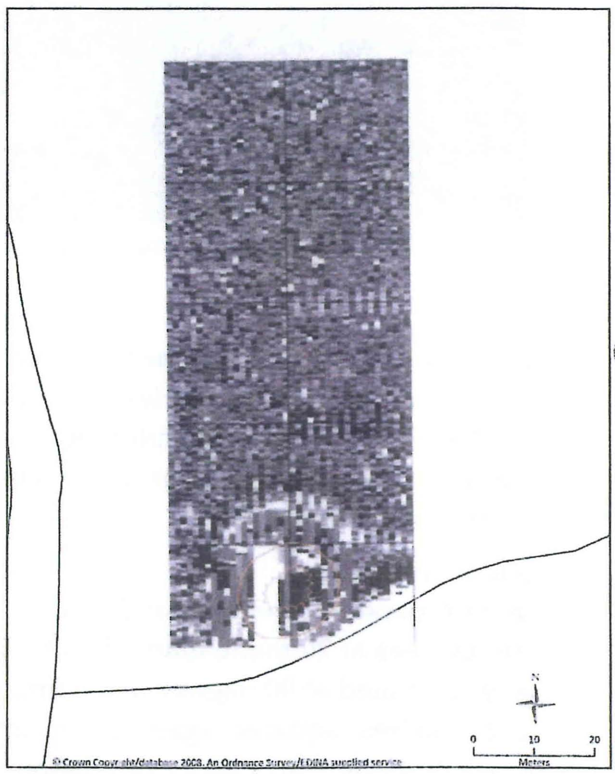


Figure 5 Plot of processed gradiometer data. Spikes caused by the markers around the monument have been removed.

vicinity had to be heavily processed to obtain any meaningful data. This manifested itself as the heavily striped areas around the monument (figure 5). As a consequence some reservation of judgment had to be applied when considering the features closest to the monument. The remaining portion of the survey area was unaffected by 'ferrous litter' and produced a number of interesting, if somewhat faint, features. The combination of the superficial and underlying bedrock geology would appear to mask the response from the gradiometer survey. Many of the features shown on the interpretation (figure 6) are only detectable as intermittent responses which may be indicative of the lack of magnetically enhanced material within there fills. Indeed if the anomalies giving a positive magnetic response, and therefore representative of physically negative features, are compared with the response from the resistance survey where negative features produced higher resistance readings, then it may indicate in both cases that these features are filled with a large proportion of natural sand and gravels derived from the superficial geology. Some correspondance between the results obtain from gradiometery and those obtained from the resistance survey was observed but it is clear that a significant number of differences between the results from the two data sets exist to suggest that one method of survey alone would probably have been insufficient to produce a clear pattern of the archaeological activity in the area.

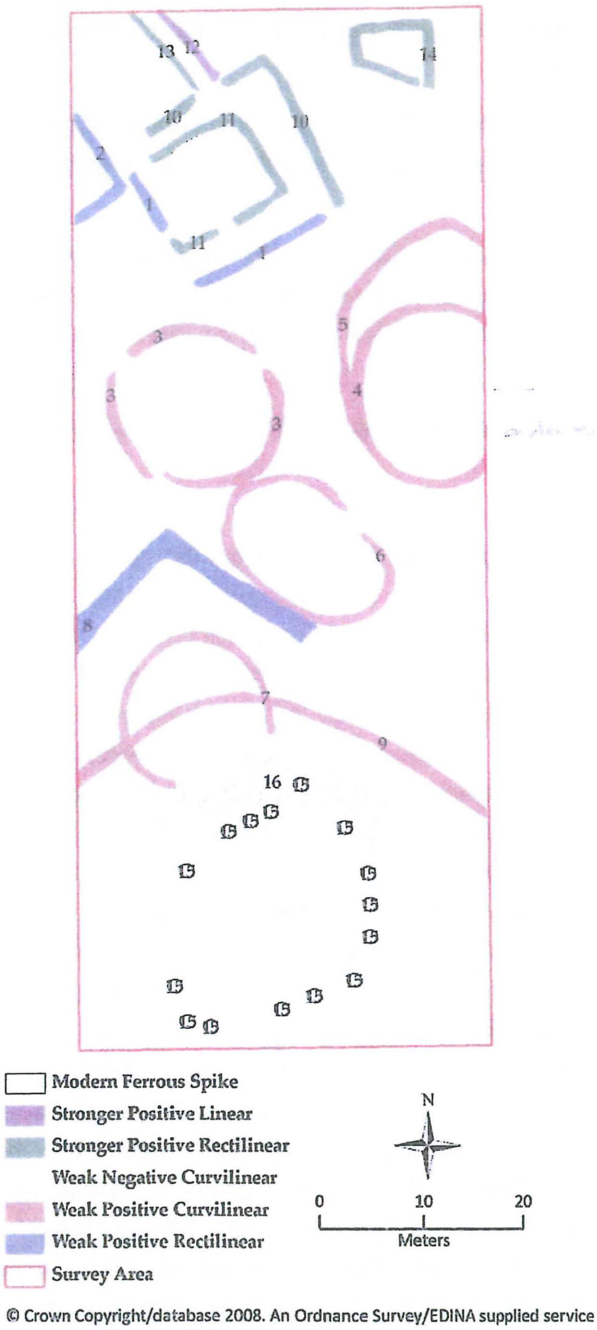


Figure 6 Interpretation of the gradiometer data

Interpretation: gradiometry

Interpretation of the gradiometer data is based on analysis of the data from groups of features. Where cross-reference is made between feature groups the paragraph letter (in italics) will be used rather than detailing individual features numbers.

a: Four weakly positive sub-circular features that range in size from 14 metres to 17 metres in diameter and may represent a series of enclosures [3], [4], [6] and [7]. The response from the features is intermittant and may indicatate the ephemeral nature of these anomalies. A fifth feature [5], whilst incomplete, appeared to be larger (24 metres in diameter) and more irregular in shape.

b: A curviliear weakly positive anomaly [9] that seems to mirror the shape of the mound. Some caution in interpretation of this feature is needed since it could potentially be a misleading byproduct of the filtering applied to remove the distortion in the data caused by the markers placed around the monument.

c: A series of rectilinear positive anomalies that appear intermittantly at the northern edge of the survey area. Whilst [10] and [11] could represent some form of rectangular enclosure with [1] and [2], whose signature is less strong, forming part of this. [12] and [13] are suggestive of a trackway leading up to the northeast edge of this feature. As a note of caution, however, the results from the resistivity should be taken into consideration here and there could be a case to argue that these anomalies represent the remnants of cross-ploughing.

d: A rectilinear weak positive anomaly [8] in the southern half of the survey area. It appear to be on a similar alignment to the features discussed in *c:* but produced a much broader signature. It may represent a geological response.

e: A curvilinear area of weak negative response [16] immediately to the north of the monument. Whilst this corresponds to the higher resistance features discovered around the monument during resistivity surveying, some caution should be exercised, as with *b:* due to the close proximity of the highly magnetic markers around the monument.

f: A series of ferrous spikes [15] that represent the markers placed around the monument by the former Ministry of Works (now Cadw).

Results: resistivity

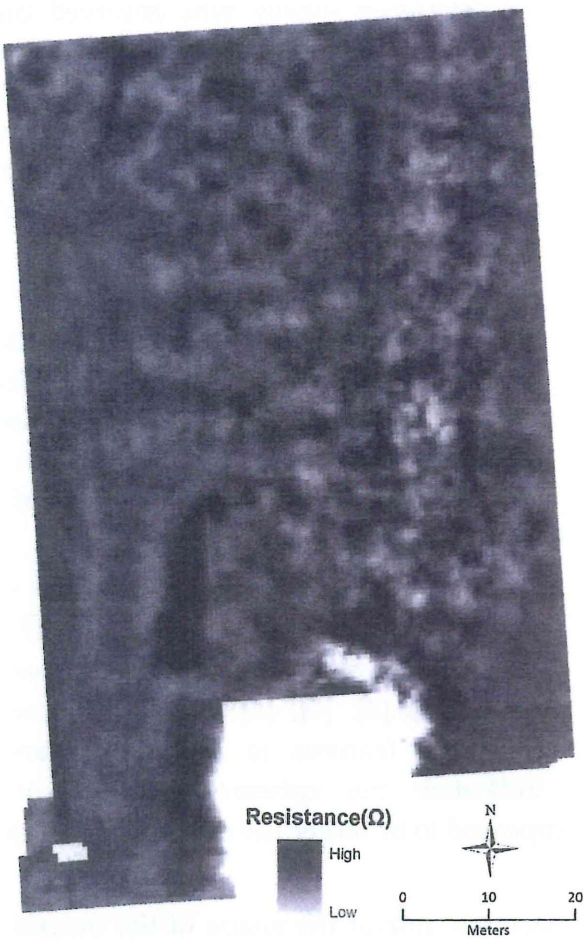


Figure 7 Plot of the 2008 resistance survey data

It is clear from the plot that the ground conditions at the time of the survey were reasonably favourable for resistance survey and a number of potential archaeological features have been recorded. In order to emphasise the anomalies shown on the geophysical plot presented in figure 7 , a series of digital overlays were used to mark the features. These appear in the interpretation diagram figure 8 and colour coding has been used to distinguish between types of potential archaeological, non-archaeological and geological features. Additionally, individual/groups of anomalies in the diagram are accompanied by a numeric annotation which are discussed in the interpretation section and referenced in the text with brackets (e.g. [X]). High resistance readings are represented on the greyscale plots as darker shades of grey and are differentiated on the interpretation diagram in terms of the strength of response. A high resistance response is normally indicative of structural remains, for example wall foundations but may also occur as the result of negative features such as ditches being filled with material with a higher resistance. Typically this could be rubble-filled pits or ditches but may also be the results of the presence of high levels of natural gravels within the fill of these features. Vertical sorting of material by percolatory actions within a ditch may produce this effect. Lower resistance features are shown on the plot as shades of lighter grey or white and a normally associated with the moisture rich fills of pits or ditches. Areas of low resistance can also be seen on the plot as the result of agricultural regimes, for example around the field gate where the ruts produced by tractor wheels filled with water after overnight rain. Another area of low resistance at the base of mound is typical of the increased moisture levels found at the base of a slope.

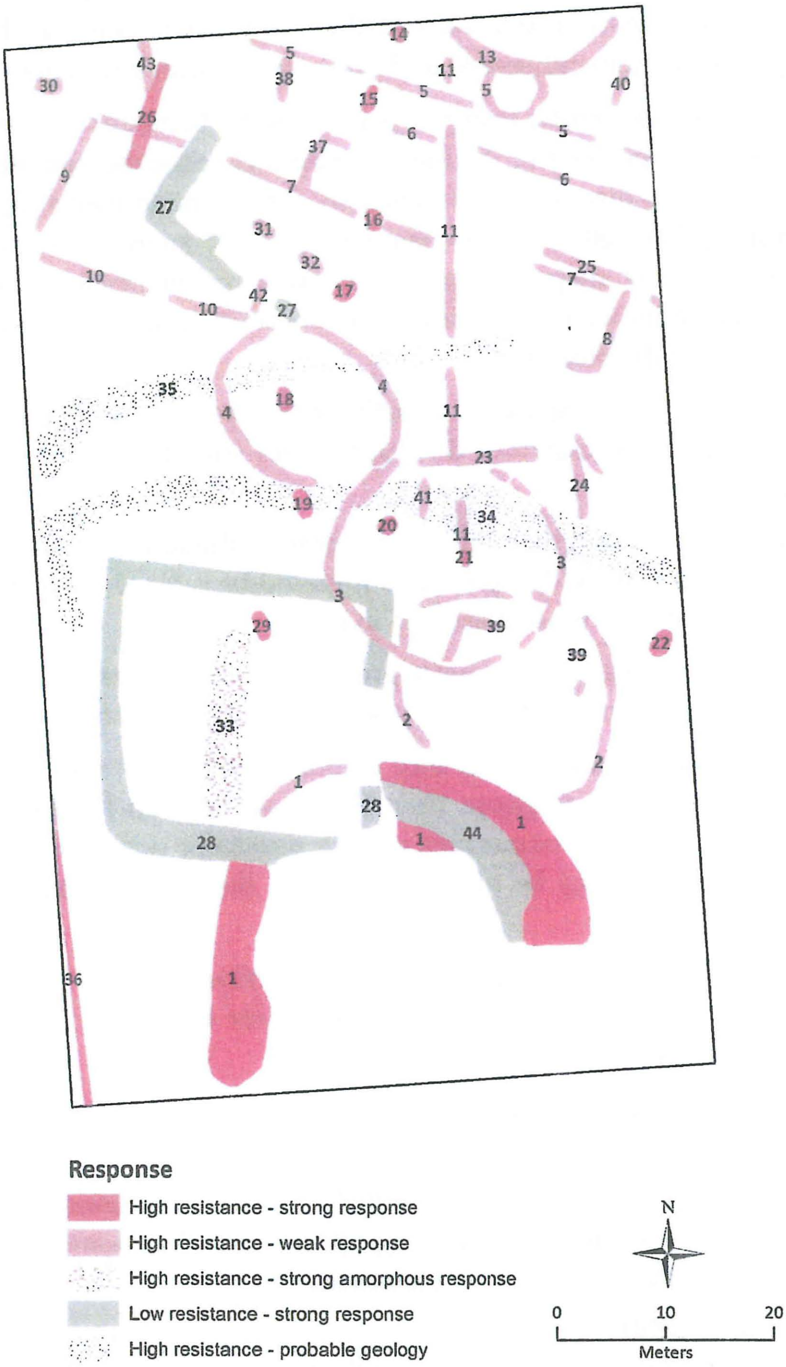


Figure 8 Interpretation of the 2008 resistance survey data

Interpretation: resistivity

a: [1] An area of high resistance around the mound. This may be the result of a combination of gravel upcast from a possible ring ditch and drainage into the adjacent negative feature [44]. The area between [1] and the quadrant immediately to the northeast of the mound did produce an amorphous area of low resistance and this may represent the location of a ring ditch around the mound. An alternative explanation is that both areas represent a ring ditch around the monument filled with highly variable material.

b: A linear high resistance feature [26] in the northwest corner of the survey area. This may be associated with [5], [6], [7], [8], [9], [10], [25] and [37] and may be the remnants of gravel infill of cross-ploughing. The ephemeral nature of these features would tend to suggest that they are relatively shallow and survive only sporadically, hence the absence of any corresponding features in the southern half of the survey.

c: A series of circular/sub circular higher resistance features running northeast-southwest [14], [15], [16], [17], [18], [19] and [29]. These may be associated with a series of perpendicular features [20],

[21] and [22] running northwest to southeast. The response corresponds with that normally expected from tree bowls although cartographic evidence from the survey area suggests that trees were only present around the monument itself. Two further features of similar shape and alignment [21], [30], [31] and [32] were more ephemeral and produced a lower resistance response.

d: Segments of what appears to be a sub-circular feature approximately 22 metres in diameter [2]. The shape is suggestive of a prehistoric enclosure. The higher resistance response from this feature mirrors that obtained from the features discussed in *b:* and may reflect the influence of the local superficial geology. Three features [13] (c. 20 metres in diameter), [4] (c.15 metres in diameter) and [3] (c. 22 metres in diameter) of similar shape produced the same higher resistance response. Analysis of the data for these feature indicates that they are evanescent in nature and may only survive as shallow traces at the base of the ploughsoil.

e: A series of segments of linear features running in a north-south direction [43], [11], [24], and [38]. These may represent the edge of the crown of the north-south spur that terminates at the southern end of the survey area.

f: Two areas of higher resistance response [39] that appear to represent the return at the northwest and northeast corner of a feature. This may be deceptive and it would be safer to assume that they represent the remnants of features similar to those discussed in b:.

g: A small circular feature [5] circa five metres in diameter producing a higher resistance response at the northern edge of the survey area. Its northern edge appears to be truncated by [13].

h: A square feature (26mx26m) producing a low resistance response [28] to the northwest of the mound. This features appears to mask the response from the possible ditch [1] which would suggest that it post-dates the mound. An amorphous area of high resistance within this enclosure, given its lack of clearly definable shape, may be natural, although there is a possibility that it relates to upcast from ditch construction.

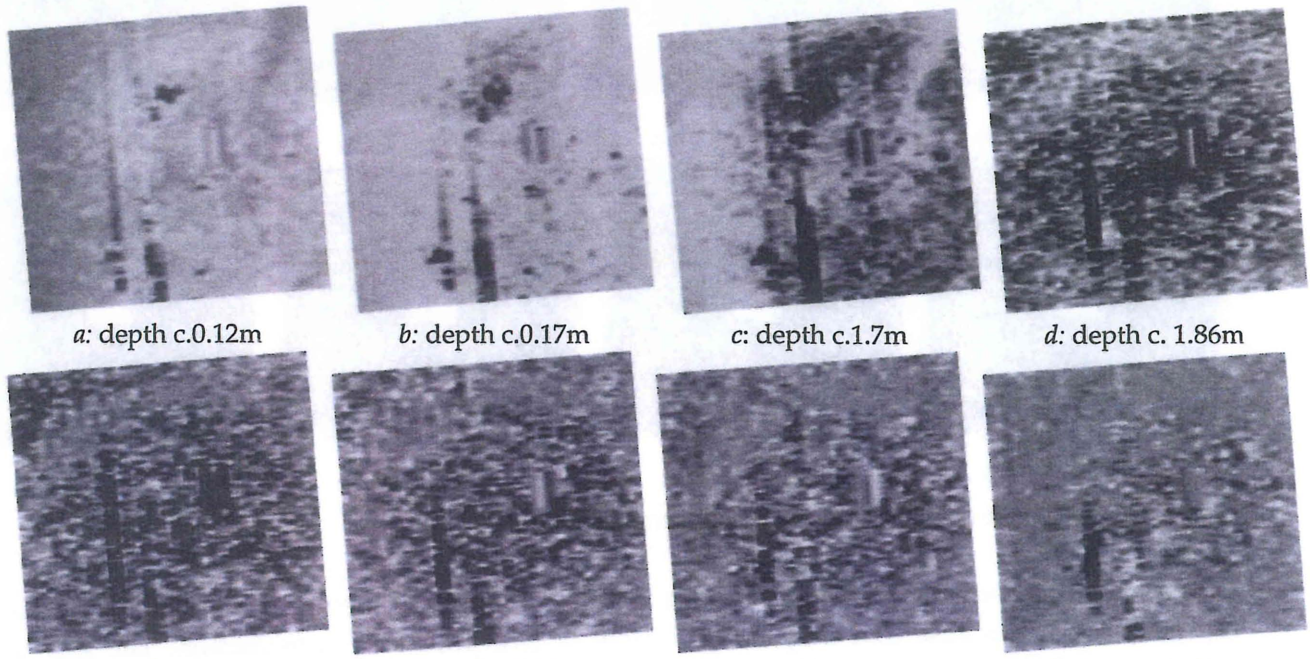
i: A distinctive L-shaped low resistance linear feature [27] in the northwest corner of the survey area. Although similar in character to [28] it has a completely different alignment. It may be the remnant of a small rectangular ditched enclosure.

j: Two linear bands [35] and [34] of what appears to be geology running east-west across the centre of the survey area.

k: A linear high resistance feature running parallel to the hedgeline in the southwest corner of the survey area. This feature is also visible on the aerial photograph (figure 3) and may represent a build-up of material along the field boundary caused by ploughing.

Results: Ground Penetrating Radar (GPR)

The results from the GPR survey are somewhat mixed and reflect the difficult ground conditions for this type of survey. The presence of tree stumps, kerb stones and the metal fencing, surrounding the pillar on top of the mound, made it difficult to maintain a stable platform for the 500mhz antenna. This is reflected in the interference to the signal shown on the plots of some of the transects in the eastern half of the survey area. Nevertheless some useful data were obtained and it seems clear that although significant problems exist, the deployment of this type of survey over the mound, in addition to the other survey methods, has produced a number of useful clues as to the composition of the mound. As with all GPR survey the computation of depth is reliant on an understanding of the velocity of the electro-magnetic signal through the material being surveyed. The variability of the material makeup of the mound means that by default correct determination of depth of survey can only be seen as approximate. Rather than produce individual overlays for



a: depth c.0.12m *b:* depth c.0.17m *c:* depth c.1.7m *d:* depth c. 1.86m

e: depth c.2.08m *f:* depth c.2.37m *g:* depth c.2.73m *h:* depth c.3.12m

Figure 9 Plots of the GPR data

each time/depth slice through the mound, the results are presented here as a series of annotated and enhanced plots along with the unmodified originals. The presentation of the results as two dimensional images belies the fact that the survey encompassed an area of pronounced topographic change. Antenna tilt, caused by this topographic change, can 'drastically affect the results of GPR survey over complex ground surfaces' (Goodman, Nishimura, Hongo and Highashi 2006, 157) Failure to correct for significant changes in topography would produce significant distortion of the shape of subsurface features as well as notable errors in their geographic location. Remodelling of the data to correct the distortion caused by antenna tilt was undertaken utilising the topographic data obtained from the Total Station survey. At the time of the original 2006 topographic survey such a use for the data had not been envisaged and the resultant corrective three dimensional slices through the mound should be seen as a 'best fit'. Further analysis of the relationship between the plots and the topography of the mound was carried out using a series of drapes over a digital terrain model (DTM) using data obtained from the 2006 survey. This enabled some of the GPR data slices to be viewed over a remodelled version of the mound where some of the distortive effects of the overlying topography had been removed.

Interpretation: Ground Penetrating Radar (GPR)

Presented in figure 10 are a series of annotated slices taken from a much larger series of plan-view profiles through the mound. Slices [a] and [b] indicate the extent of the spread of the mound at the upper level. The white square in the centre of the plot represents the pillar and the iron fence placed around it. Whilst a persistently strong feature, to the right of the pillar, is possibly associated with work around the pillar base and its protective fence. The features shown on slice

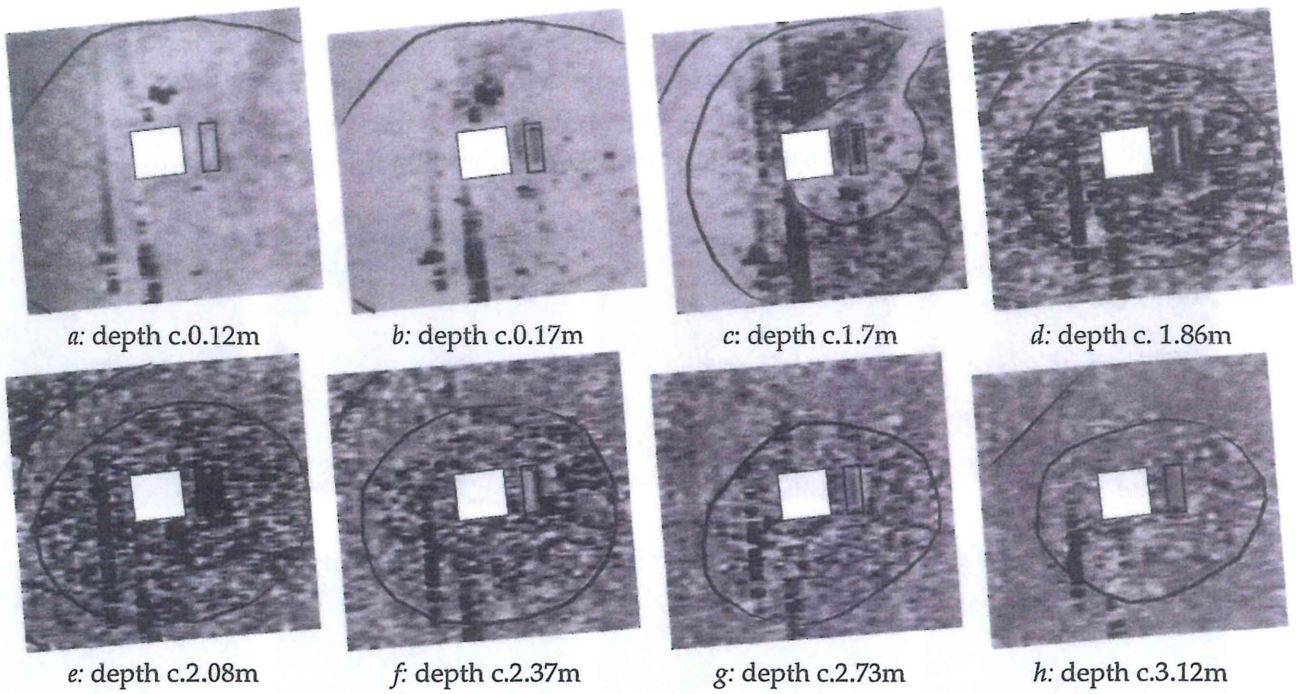


Figure 10 Plots of the GPR data with interpretative annotation

[c] possible represent the visible difference, seen on the ground, between the top construction of the mound and its base and may be indicative of two phases of construction. The gap to the northeast and the inner feature slightly to the right of centre of the plot could indicate the disturbance caused by the construction of the pillar base. An original thought that this might represent a chamber within the mound seems to be negated by the evidence from [d] and [e] where the feature is no longer visible and only the outline of the mound construction remains. The calulated difference in depth between these slices [c] and [d] is only c.16 centimetres. In the northwest corner of plots [a] to [f] there appears to be some indication of a ditch surrounding the monument. This feature is very faint in [g] and can no longer be seen in [h]. The linear southwest – northeast feature shown on [h] seems to be aligned with features visible on the resistivity survey and may represent geology. One disappointment of the GPR survey of the mound is that the evidence of antiquarian intrusion, seen on the topographic survey, is not visible in the plots presented in figures 9 and 10.

Topographic Survey

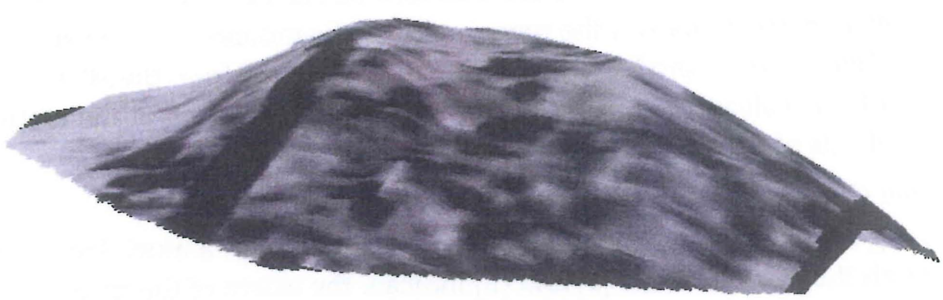


Figure 11 DTM of the topographic survey data with GPR surface drape

In addition to the geophysical survey work undertaken in 2006 a topographic survey of the mound using a Leica TC407 total station was undertaken. This was carried out over the mound as a series of XYZ points chosen by reference to changes in the topography rather than as a formalised gridded survey. The results of the survey were then transferred to ArcGIS 9.0 for georeferencing and the resultant data used as the basis for a Digital Terrain Model (DTM) presented in figure 11. Here slice *[c]* of the GPR data has been draped over the DTM. The feature, observed on the ground as a depresession on the western side of the mound, can quite clearly be seen on the model. The uneven surface would appear to be evidence of slumping into a linear trench cut in the face of the mound, probably as part of the antiquarian excavation.

Conclusions

The application of a range of geophysical techniques, in the pursuit of an understanding of the buried archaeology surrounding the Pillar of Eliseg, has clearly revealed that the monument is only part of a much wider spread of human activity within the upper reaches of the valley. The palimcest of potentially pre-historic features to the north of the mound, revealed by the resistance survey and to some extent confirmed by the gradiometer survey, is overlain by what could potentially be a complex of later field systems. However, conclusions as to the relationship between the mound and this potential longevity of agricultural and settlement activity cannot be directly determined from the application of these non-intrusive techniques. However, it is possibly to show that, on one occasion at least, activity in close proximity to the mound appears to have had an impact on the original form of this monument. Further investigation, through more intrusive methods, will be necessary to determine the exact nature of this relationship. The confirmation of two potential phases of construction for the mound hinted at by the GPR and topographic survey data would also require further physical intervention. Nevertheless the surveys have been successful in showing that the integrated application of a range of survey techniques and the marrying of this with GIS and digital mapping data can produce a useful picture of the archaeological potential in the area around the monument and thus provided a focus for such intervention.

Acknowledgements

We would like to thank Mr John Davies, Abbey Farm for permission to undertake the surveys on his land and his staff at the Caravan Park reception for their help. Cadw kindly gave permission to enter the Guardianship area to survey and a licence to carry out geophysical work on the scheduled monument. Dr Siân Rees, the Cadw Inspector has been a constant and friendly source of advice and help. We would also like to thank David Crane of the Llangollen Museum for his interest and help and also Dr Nancy Edwards, Dr David Petts, Dr Howard Williams and Dr Meggen Gondek for their involvement and support.

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