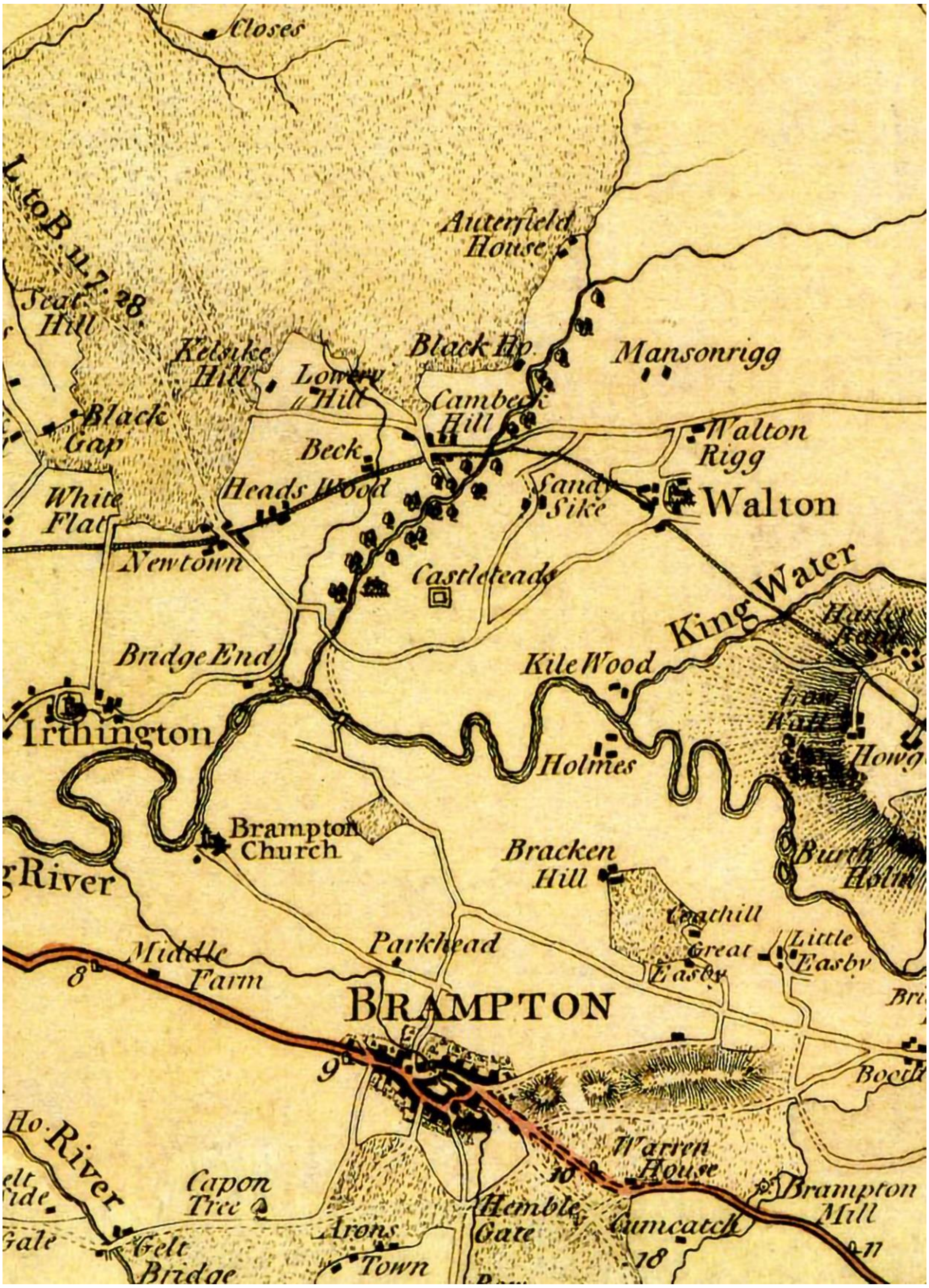
Geophysical Surveys at Cam Beck, Cumbria 2019 and2021

Report by Alex Turner



Extract from Thomas Donald’s map of Cumberland, 1774

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Introduction

As part of the Hadrian's Wall Community Archaeology Project, two geophysical surveys were undertaken, over a period of two days, in advance of excavation at Cam Beck, Cumbria. The 2019 resistivity survey was undertaken by Project volunteers under the supervision of members of the WallCAP team and the 2021 gradiometer survey was undertaken solely by the author due to the restrictions imposed by Covid 19.

Location

The site is located 480 metres southwest of the Swainsteads and 420 metres northeast of Cambeckhill. The site of the Roman fort of Camboglanna lies 420 metres to the south. The site is centred on Ordnance Survey grid reference NY 51147 63905 (Figure 1).

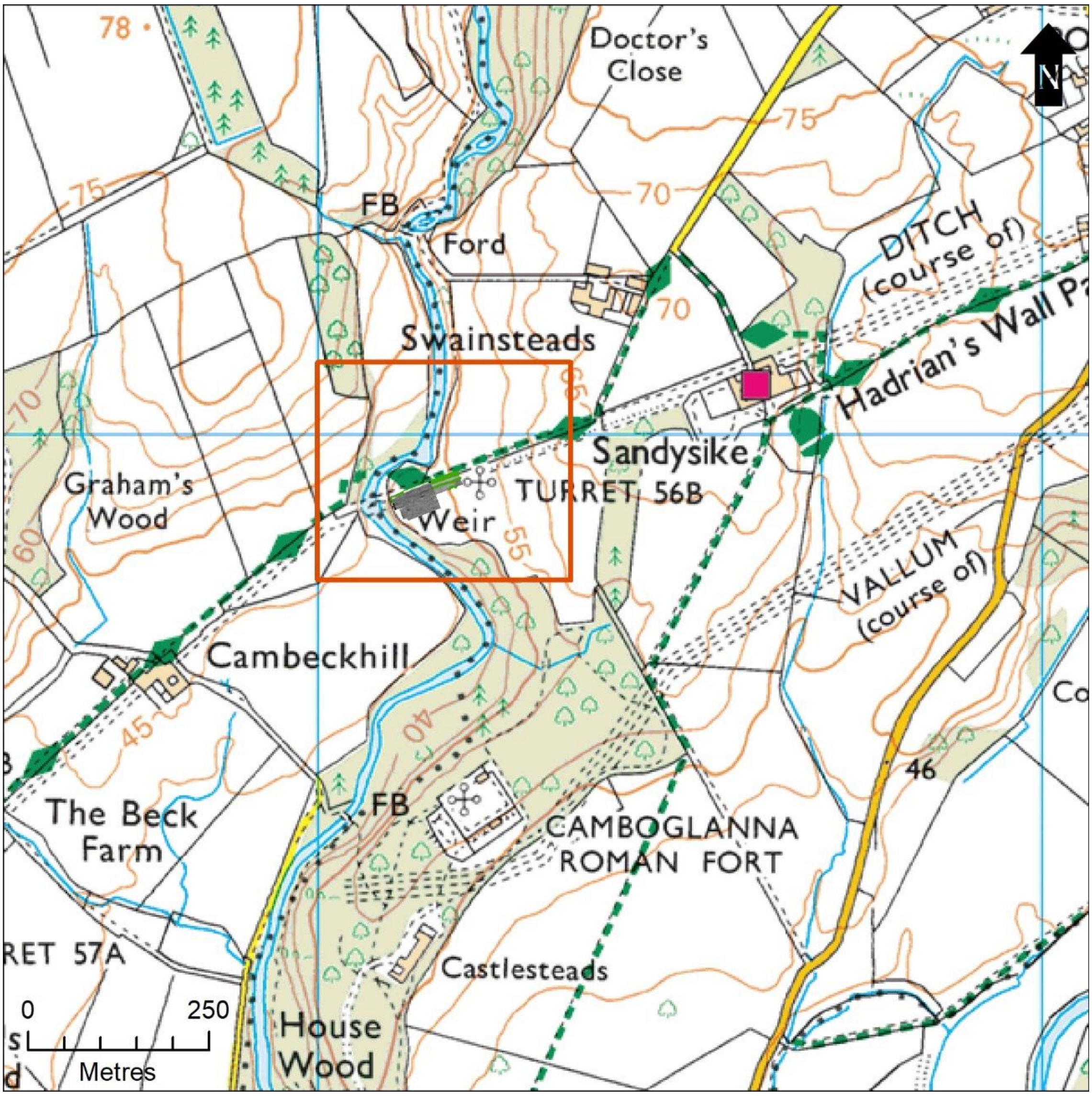

Figure 1 - Location of Cam Beck. The survey area is within the red rectangle

The survey area was laid to pasture and separated from the woodland to the north and west by a wire fence. The ditch to the north of the survey area was crossed by made ground that incorporated a draining pipe and a substantial quantity of building rubble. At the time of the gradiometer survey, the gateway was undergoing repair to correct drainage problems between it and Sandysike Farm, 400 metres to the east. No further obstructions were present.

Topography and Geology

Topography

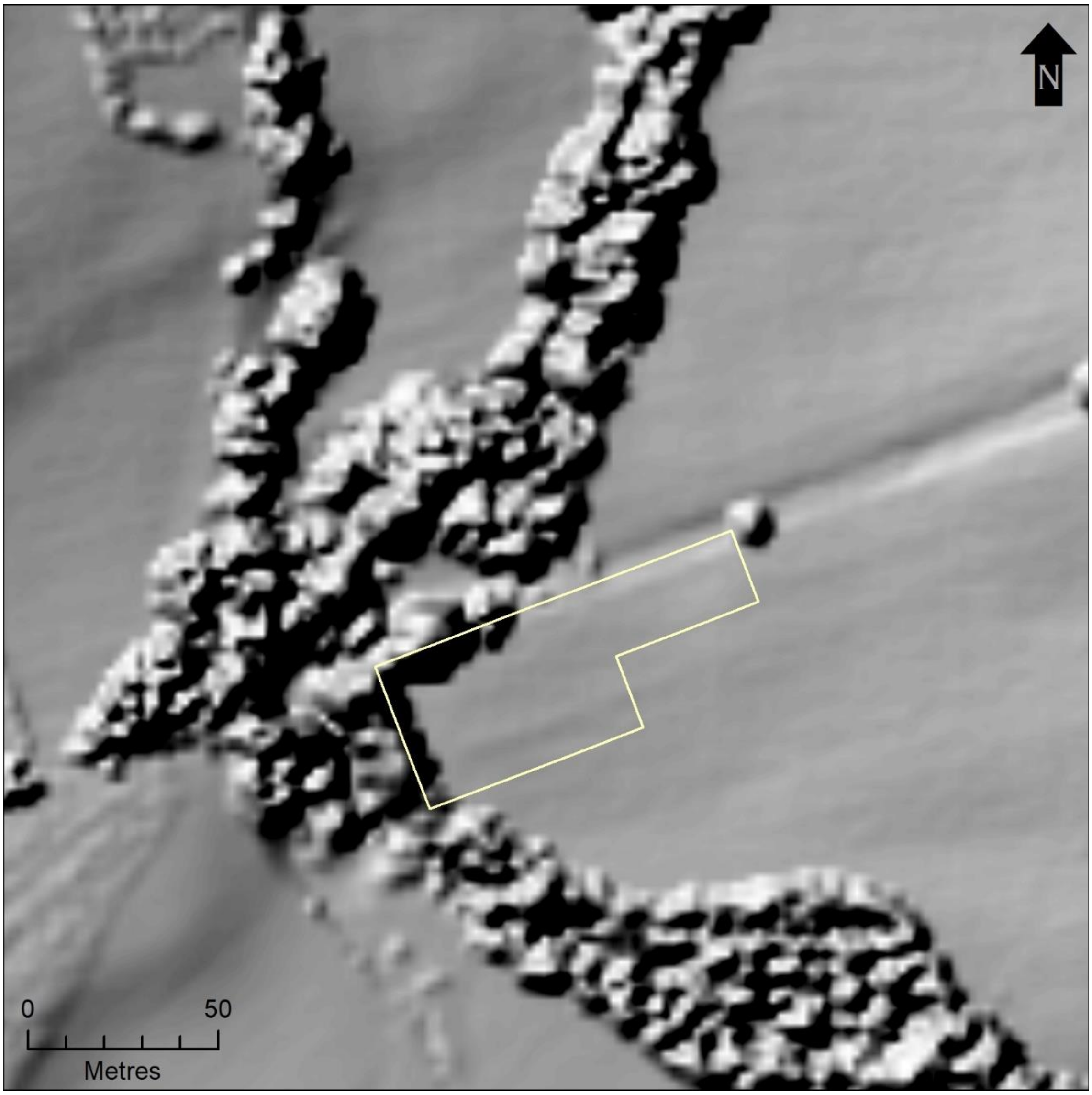

Figure 2 - Lidar digital terrain model (DSM) of the survey area

The sloping topography of the field to the north of the survey flattened out as it reached the survey area but a significant short sharp slope existed parallel to the fence at the northwest end of the survey. The earthwork and ditch of Hadrian's Wall to the northeast of the survey (Figure 2) promoted a slightly increase in the response from the resistivity due to the increased drainage in this area. The sharp slope presented a challenge for the gradiometer survey but this was overcome by significantly decreasing the data collection speed in this area.

Geology

The underlying bedrock geology of the survey area is a Helsby Sandstone Formation that is clearly visible in the cutting formed by the river to the west (Figure 3). The plough soil layer is a sand>loam with a loam soil to the northeast and south(Figure 4). The dominant minerals in the soil are quartz and feldspar with some silica. Soil makeup has a significant effect on the effectiveness of any geophysical method. The background sub-surface makeup of the survey area was deemed, in this case to be suitable for both electrical resistance and gradiometer survey. The only limiting factor, attested to during the first excavation of the site, was that the eastern boundary of the site was prone to flooding and that the electrical resistance survey should be conducted during drier spells of weather. This flooding is unlikely to have been caused by the underlying geology and it more likely to be due to an aged and broken field-drainage system. Examination of the survey results showed a number of varied linear responses in this area that probably represent these compromised drains.

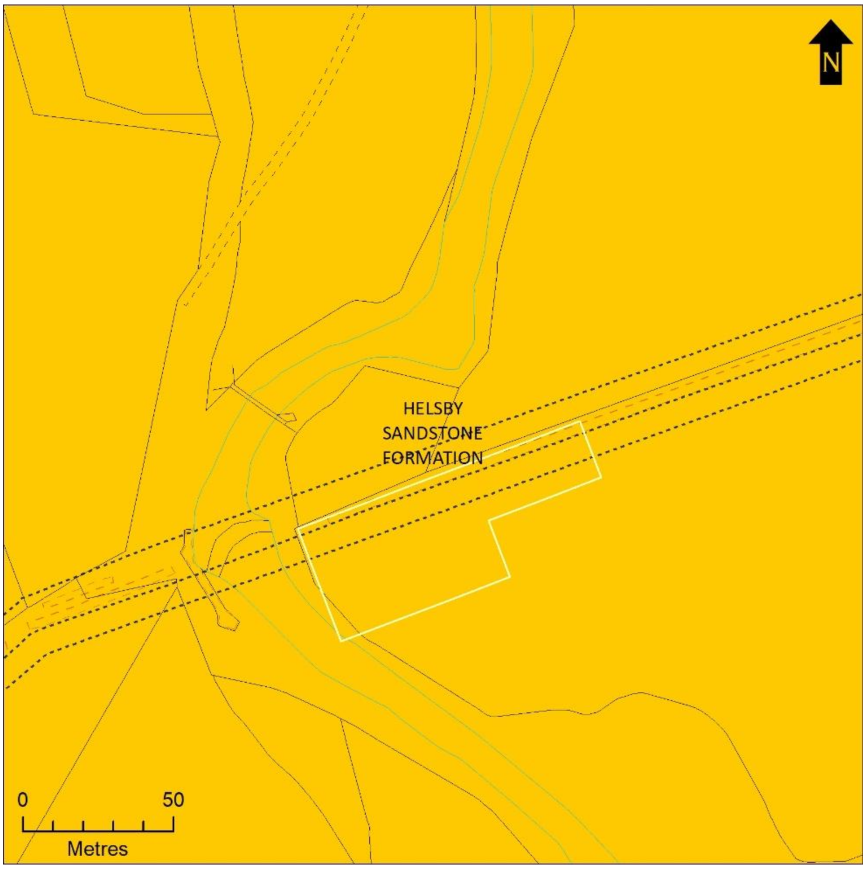

Figure 3 - Bedrock geology for the survey area

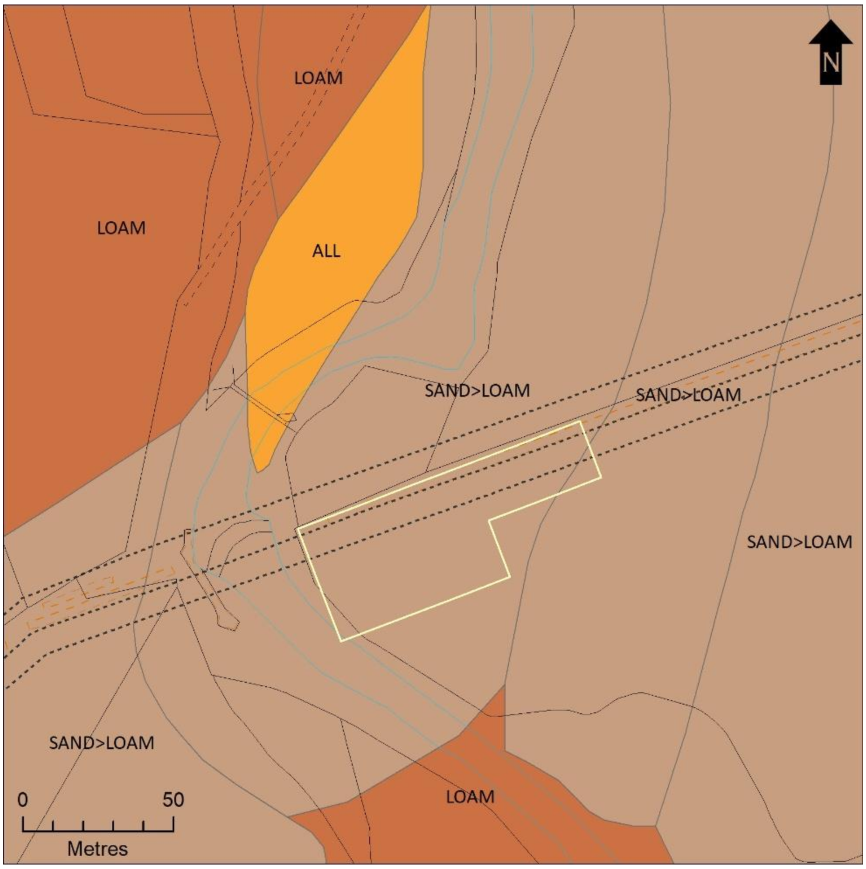

Figure 4 - Soil types for the survey area derived from BGS 1:50,000 geology data

Survey Methodology

Methods - Survey Grids and Markers

A survey grid consisting of 11 full and partial 20m x 20m squares was laid out using a Leica GNSS differential survey grade GPS connected to the Leica RTK Smartnet network. Temporary grid pegs were used to mark out the grid and the lack of livestock in the fields meant these could be left overnight. The survey grid coordinates were derived from Mastermap digital data and stored as a feature class within the survey ArcGIS geodatabase. Grids and flags were numbered sequentially in an east-west series of rows from south to north. Given the time constraints of the survey, where partial grids were involved, these were restricted to a series of simple rectangles. The grid was layout was chosen to avoid any close proximity to the ferrous intrusions within or enclosing the field. The gradiometer and resistivity grids (Figure 5) were truncated at the western edge due to the presence of the boundary fencing containing ferrous material and overhanging trees. The position of trees in relation to the survey can be clearly seen on the 25cm resolution aerial photograph from 2018 (Figures 5 and 6). Possible interference with the resistivity survey results, due to the presence of large tree roots, was mitigated by careful positioning of the survey grid.

Figure 5 - Location and numbering of the gradiometer survey grids with 25cm AP as background

Figure 6 - Location and numbering of the resistivity survey grids with 25cm AP as background

Methods - Fluxgate gradiometer survey

The survey was carried out using a Bartington Grad 601/2 fluxgate gradiometer with two vertical sensors spaced one metre apart. Following an initial scan of the survey site, a magnetically sterile area was identified for the creation of the survey control point. This was used to calibrate the gradiometer before each day of survey and after any significant stoppages. In accordance with accepted practice (Schmidt et al 2016, 12) data was collected along a series of zig-zag traverses spaced one meter apart with sample readings being taken every 25 centimetres. This gave an effective resolution of 1600 reading for each 20m x 20m survey grid. The uneven topography at the northern edge of the survey area required a reduced rate of data collection to minimise the stagger between adjacent zig-zag traverses.

Methods – Electrical resistance survey

Electrical resistance survey was carried out using a Geoscan RM15D Advanced equipped with a MPX15 multiplexer. Due to the number of volunteers and the time available, the data was collected using a 0.5 metre traverse and 0.5 metre sample. This enabled four times as much data to be collected as the standard 1 metre x 1 metre survey. This gave the same effective resolution for each survey square as the gradiometry at 1600 reading per 20m x 20m survey grid.

Data processing and presentation

The data from both the resistivity and gradiometer surveys were processed using Geoplot 4.0. The resulting plots were exported as raster images to ArcGIS 7.1 where they were scaled and georeferenced using the latest vectored Mastermap data. This enabled comparison with a combination of modern and historic Ordnance Survey mapping data, Environment Agency Lidar data and aerial photographs downloaded from

Digimap. The integration of digital output from the geophysical survey with the Digital Terrain Model (DTM) obtained from the Environment Agency Lidar data also enabled detailed topographic examination of the survey terrain. Digital overlays were created for features identified within the survey output and formed the basis of the final interpretation of the data.

Reference to Historic Ordnance Survey

As part of the interpretation process, an examination of all the editions of the Ordnance Survey at 1:2500, was carried out. Historic Google Earth images were also consulted for the first decade of this century but provided no additional information of significance. The study of the historic maps showed that the arrangement of field boundaries was different in the late 19th century with a more open field system adjacent to the river and a stand of trees within the ditch to the north of the survey area (Figure 7). The 1901 first revision of the 1:2500 County series shows the removal of boundaries and the absence of trees on the northern boundary. This open arrangement is also shown on the map for 1926 (Figure 8) but strangely has reverted to the previous 19th century divisions field divisions when the 1:2500 National Grid first edition is

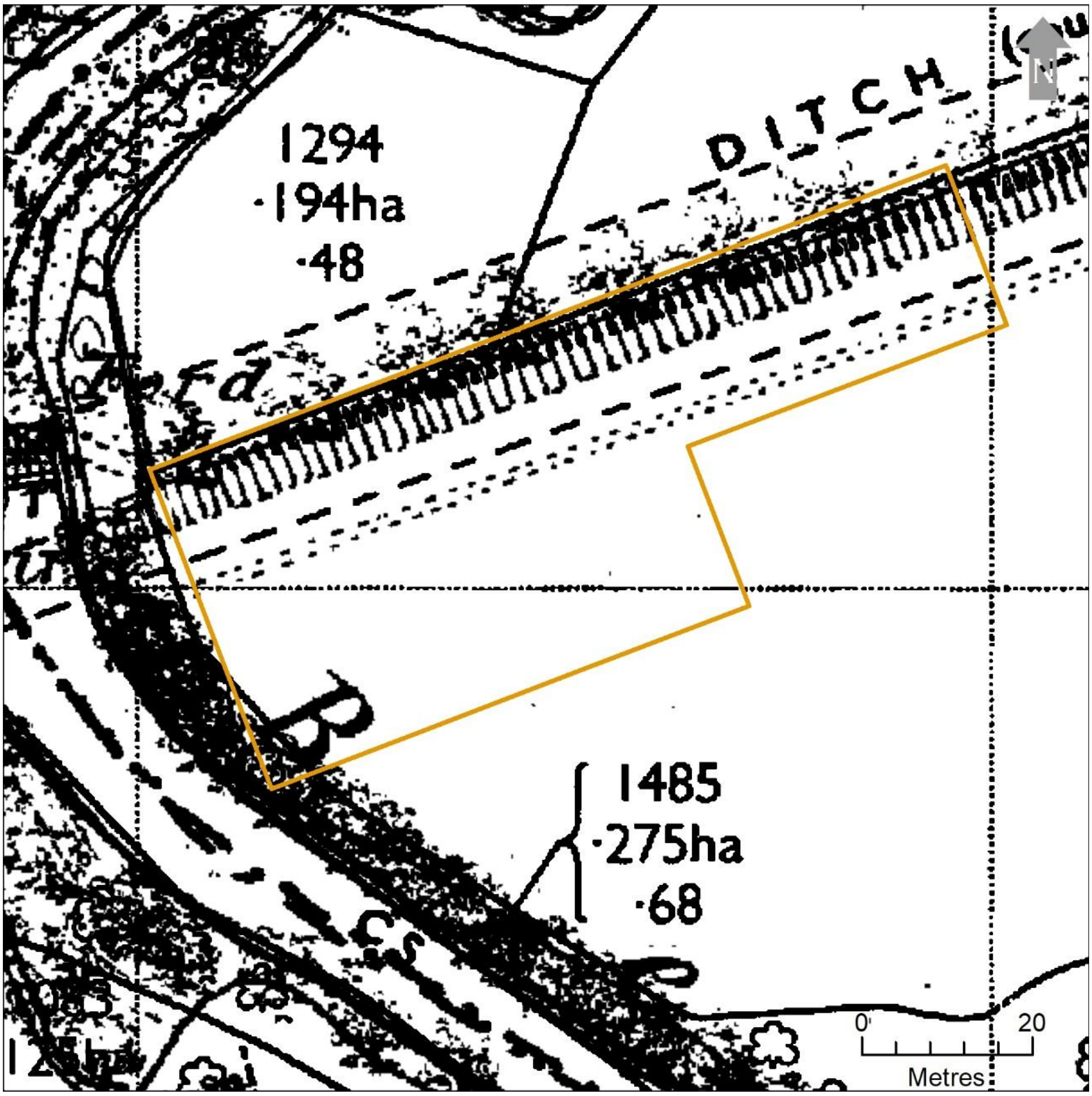

Figure 7 - Survey area shown on Ordnance Survey 1:2500 County Series First Edition 1895

published in 1973 (Figure 9). It is possible to suspect that these divisions were traced from the earlier map, although the stand of trees from the County Series is conspicuous by its absence. The current location of Turret 56b is also shown as this is the first map to be published following Simpson, Hodgson and Richmond's excavations of 1933. Their description of it as 'found 2138 yards west of turret 55a', when checked against the modern map, is accurate to within a few metres when measured along the line of the wall (Simpson, Hodgson and Richmond 1934, 132).

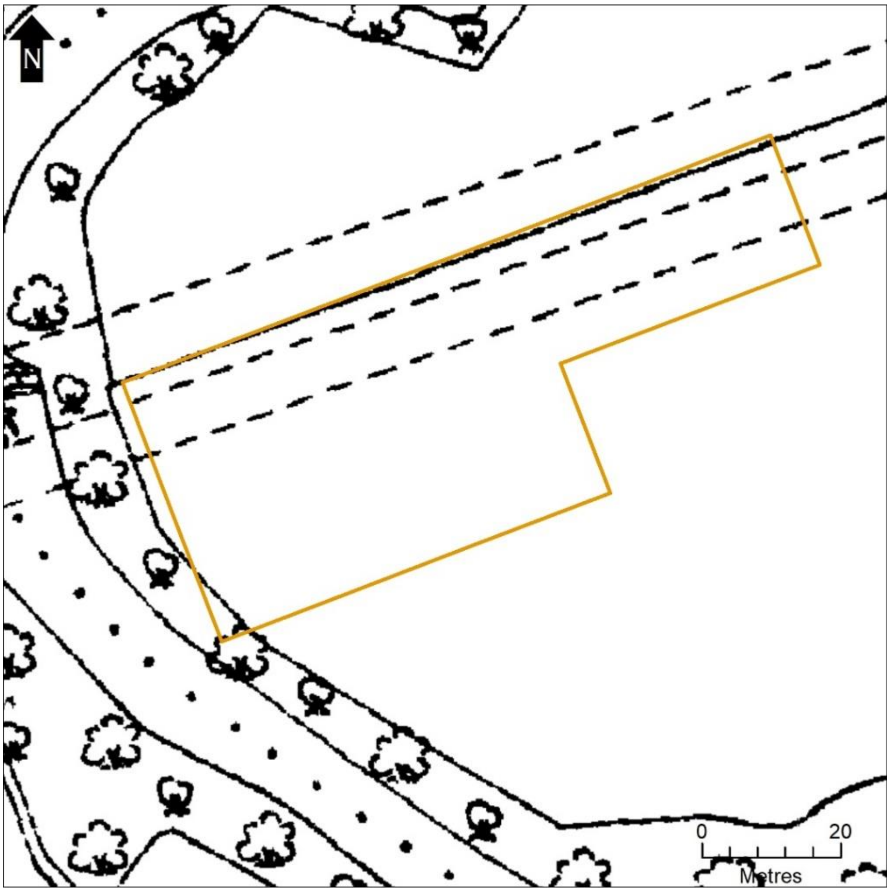

Figure 8 - Survey area shown on Ordnance Survey 1:2500 County Series 2nd Revision 1926

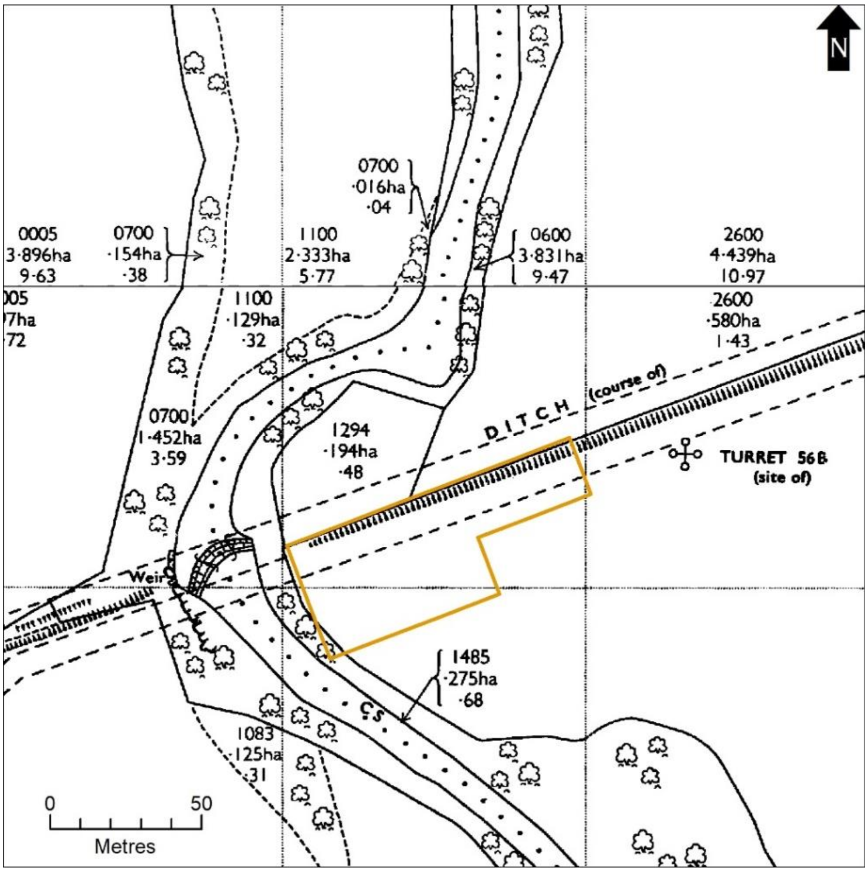

Figure 9- Survey area on National Grid 1:2500 1st edition 1973 showing site of Turret 56b

Survey Results and Interpretation

Gradiometer Results – process summary

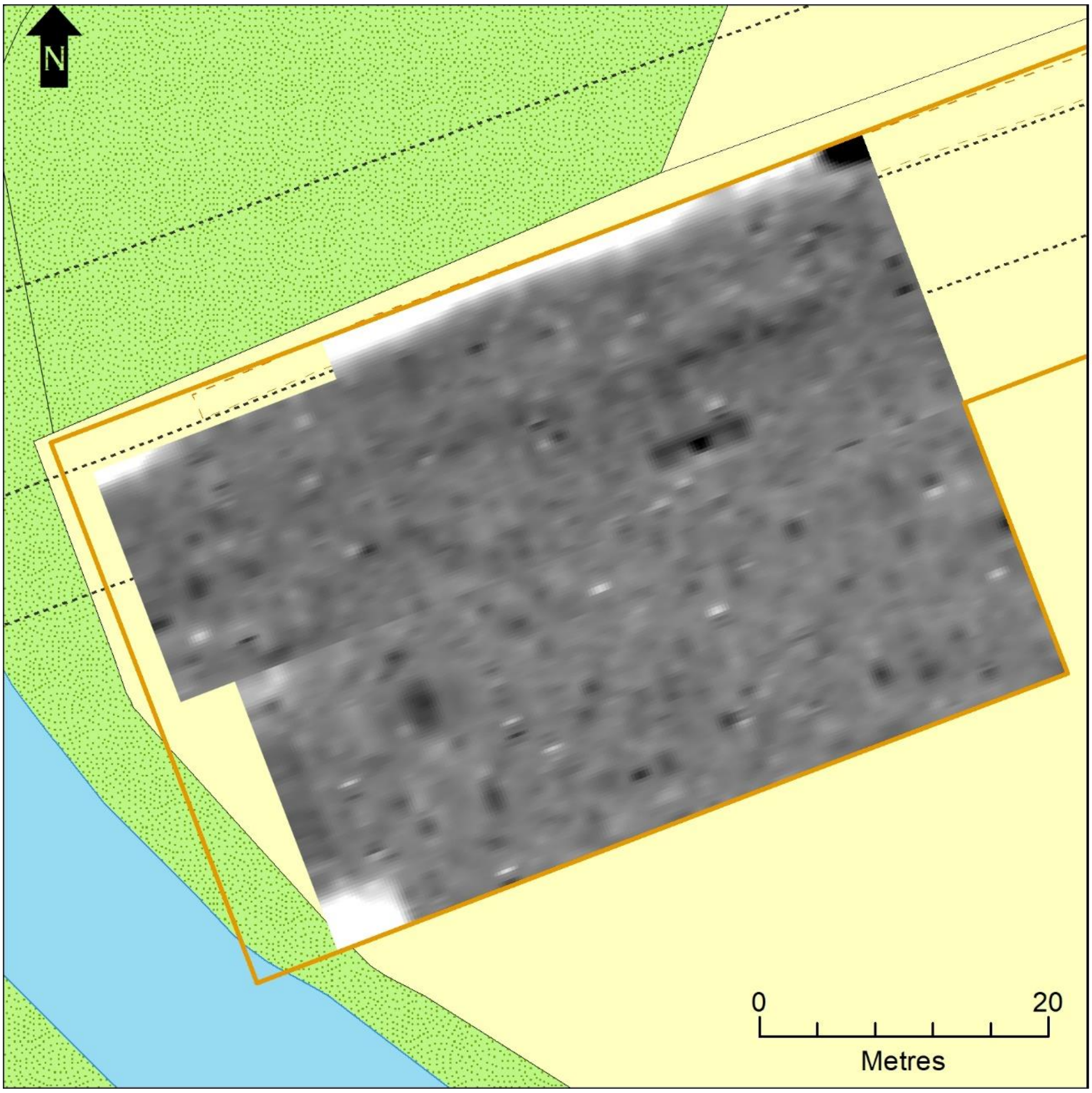

Figure 10 - Plot of the results of the gradiometer survey with greyscale parameters +/-3SD

The data was processed using Geoplot 4 and exported as a raster image to the ArcGIS 7.1 project for the survey (Figures 11 and 12). Only basic processing was necessary within Geoplot 4. The grids were despiked with a threshold of +/- 3SD and the Zero Mean Traverse filter was applied to reduce any striping as a result of changes in the orientation of the gradiometer during zig-zag survey. A uniform High Pass Filter, to filter any changes in the geological background, was applied with a window of 10 readings in both the X and Y direction. Interpolation was carried out between traverses so that the final data had an X and Y resolution of 0.25 metres. The plots were then scaled and georeferenced to the British National Grid in ArcGIS using coordinates derived from the differential GNSS. The results from the gradiometer survey were slightly disappointing and revealed less than the resistivity survey, although neither survey added to what was already known about the area

Gradiometer Results – Interpretation

The scaled and georeferenced geophysics plots were used to produce an interpretive overlay within ArcGIS. Each of the drawn polygons or polylines was given a unique reference number that is used within the interpretive discussion (Figure 11).

1-2: This was a band with a strong positive response caused by the wire fencing beyond the northern edge of the survey area.
3: An area of strong positive response caused by wire fencing to the west of the survey area.
4: A patch with a strong positive response may represent a negative feature**.**
5: Dipolar response from buried ferrous object.
6: Weak positive linear response that coincides with the edge of the ditch.

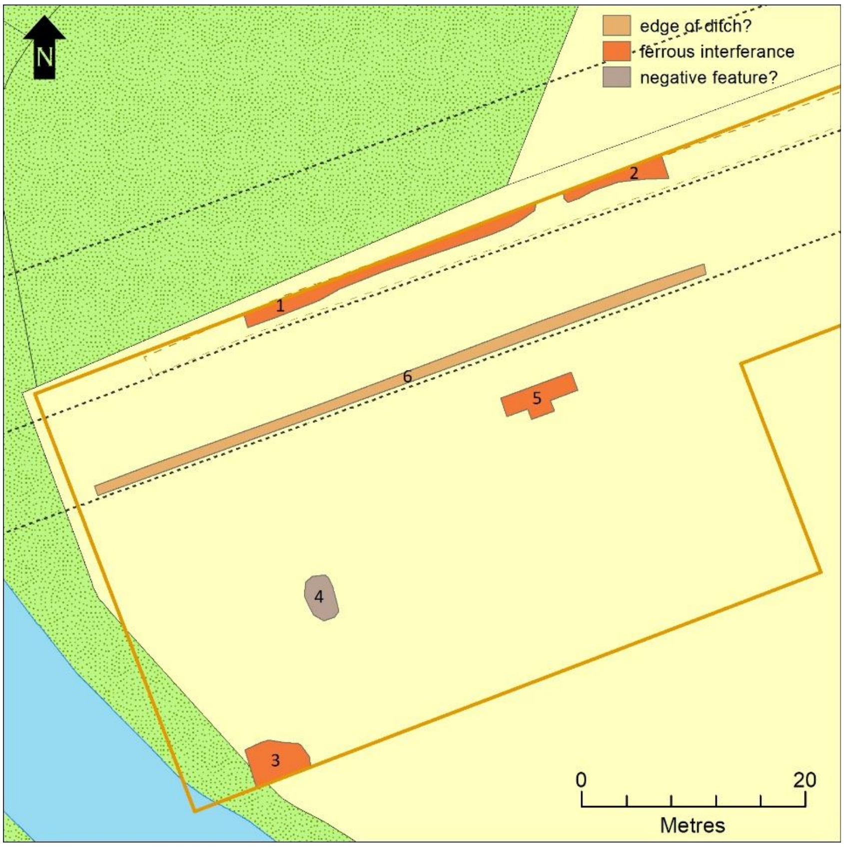

Figure 11 - Interpretation of the gradiometer survey results

Resistivity Results – process summary

The data was processed using the same software as the gradiometer survey. The data was despiked with a threshold of +/- 3SD and then a Gaussian high pass filter was applied with a window of 10 reading in the x and y directions to minimise the effect of background geology. A low pass filter with a window of 1 reading in the X and Y directions was used to smooth the data and enhance any large weak features. Interpolation of the data was carried out in the X and Y directions to give data plots with a final spatial resolution of 0.25m x 0.25m. This was an equivalent resolution to the gradiometer data. The results, shown in Figure 12 revealed few archaeological anomalies, consistent with the results from the gradiometer survey.

Resistivity Results – Interpretation

1: Line of high resistance representing the edge of the ditch
2-3: Patches of higher resistance with indistinct outline. Possible areas of disturbance associated with the wall?
4: Area of high resistance caused by presence of trees to the west of the survey area.

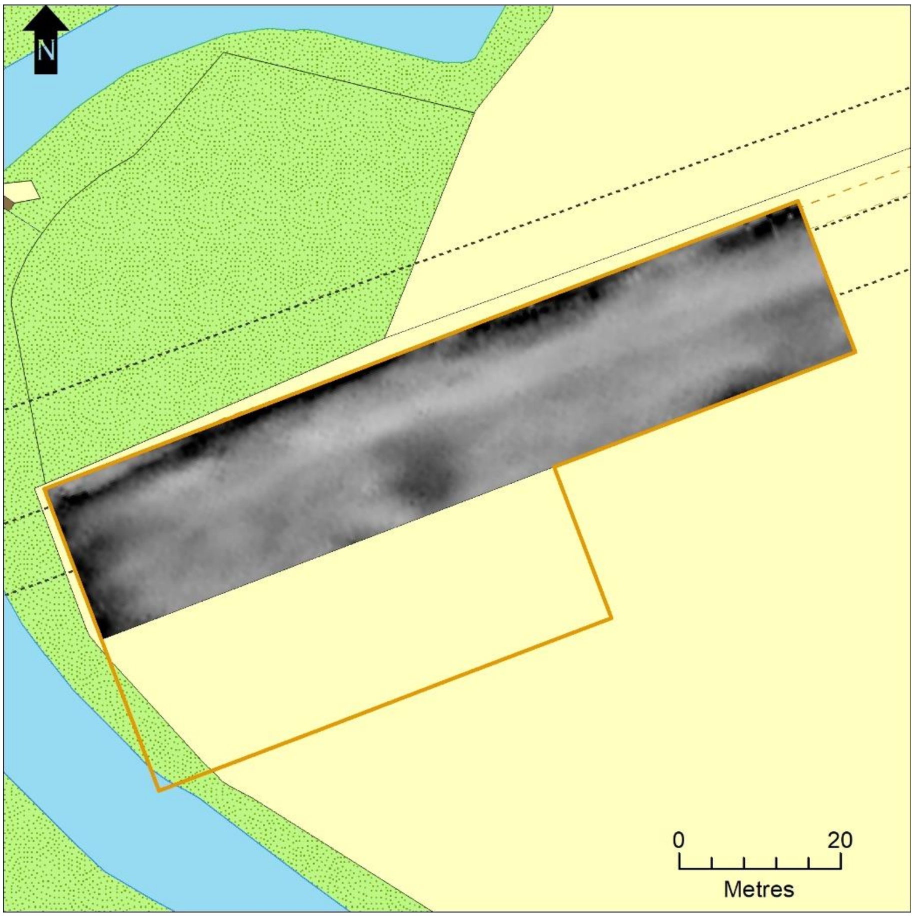

Figure 12 - Plot of the resistivity data with greyscale parameters of +/- 3SD

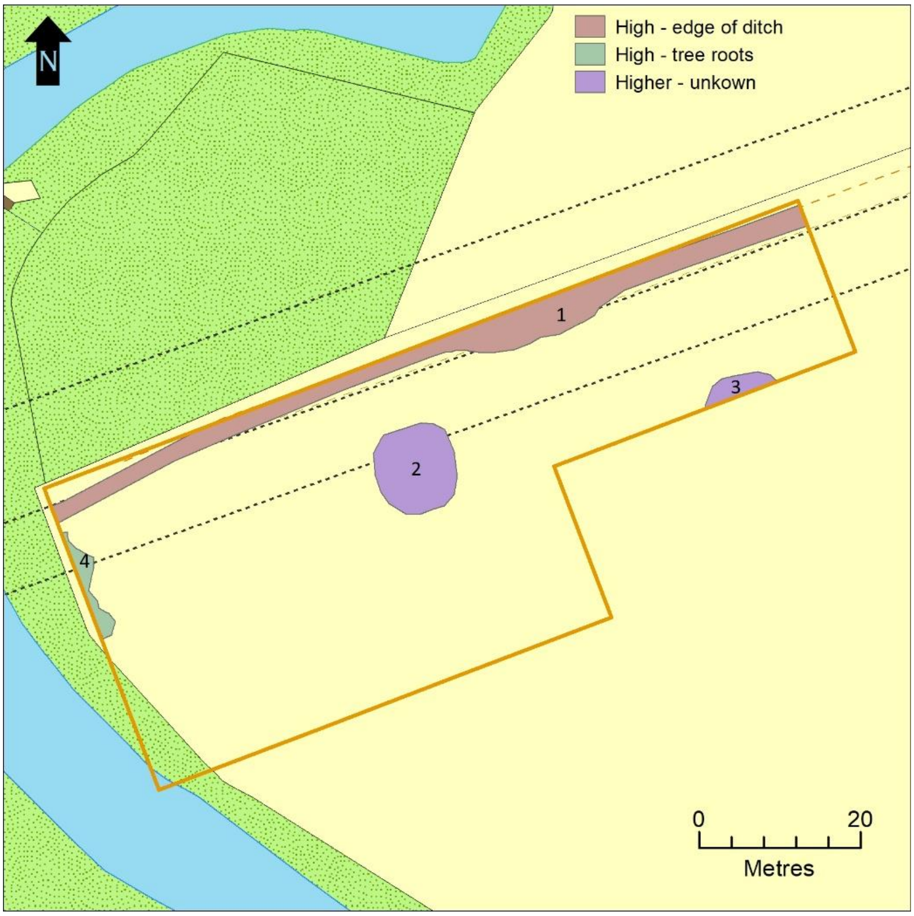

Figure 13 - Interpretation of the resistivity survey data

Summary

The lack of real success with both gradiometry and resistivity surveys in detecting significant sub-surface features is surprising given the location of the survey area in relation to the line of the wall and ditch. There seems to be no evidence from the geophysics of even the slightest remains of a turf constructed wall. Simpson, Hodgson and Richmond's account of the discovery of turret 56b suggests that it is a turf turret on the southern edge of a five-metre berm (Simpson, Hodgson and Richmond, 1934, 132). If this were the case, it is possible that the resistivity survey didn't extend far enough south to catch any wall features. However, the gradiometer survey extended 25 metres south of the line of the ditch and also failed to reveal anything of great significance. Although not currently visible, the supposed line of the vallum is marked on earlier maps but this was significantly further south to that of the survey area. It is unfortunate that the Ground-penetrating Radar equipment was unavailable at the time of survey, as that could have been usefully employed across the line of the wall and ditch to give greater ground penetration.

Sources and References

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Simpson F, Hodgson K and Richmond I (1934) New Turret-Sites on the Line of the Turf Wall and the Type of Stone Wall Later Associated with Them in *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society Series 2 Volume 34*