Geophysical Survey Report No. 40

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Ardboe Abbey,

Co. Tyrone

LOTTERY FUNDED

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with Ruth Logue & Grace McAlister

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Image on the cover ‘Ardboe Church & Cross c. 1920’ courtesy of Pat Grimes.

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Summary of results

Evaluation resolution electrical resistance and magnetic gradiometery surveys were carried out over a total area of *c.* 2.5 hectare in a single large field on a promontory on the western shores of Lough Neagh in a project undertaken during the period from 20th March – 7th April 2017 on behalf of the Lough Neagh Landscape Partnership, funded by the Heritage Lottery Fund. The area is relatively flat and low laying with shallow drumlins forming 'islands' which are surrounded by open pasture. Situated below the 20m contour mark, the archaeological features (TYR 040:003/TYR 040:004/TYR 040:005) at the core of the medieval ecclesiastical site are located on a modest knoll with a good aspect over the lough to the east clockwise through to wetter lowlands to the west. Lowering of the lake levels since the mid-19th century have seen the shoreline recede further reducing the pronounced nature of the promontory (Figure 2).

The archaeological geophysical survey has identified a number of anomalies and multiple phases of activity on the headland. This reflects the complex, if limited, evidence gleaned from the historical archive and surviving built fabric. A distinctive, large linear feature appears to have enclosed the headland within which a series of long, linear structures appear set. This may well be associated with the early ecclesiastical settlement of the promontory. These structures are truncated at a later stage by an episode of straight, linear enclosures – perhaps field boundaries. Later still a highly magnetic serpentine anomaly is cut into the large enclosing feature this may be related to some form of industrial or agricultural activity perhaps kilns or furnaces. Modern drainage works are evident to the west of the survey area.

Site Specific Information

Site Name: Ardboe Abbey, Co. Tyrone

Townland: Sessia and Farsnagh

SMR No: TYR 040:003/TYR 040:004/TYR 040:005

Grid Ref: H 9653 7565

County: Tyrone

Date of Survey: 20th March – 7th April 2017

Surveyors Present: Siobhán McDermott, Grace McAlister, Ruth Logue & Ruairí Ó Baoill, Centre for Archaeological Fieldwork, School of Natural & Built Environment, Queens University Belfast.

Size of area surveyed: 2.5 hectares

Weather conditions: Changeable but mainly mild

Solid Geology: Interbasaltic Formation

Superficial Geology: Diamicton till moving to Lacustrine Beach Deposits over the eastern two thirds

Soil Type: Stagnosol

Current Land Use: Farmland

Intended Land Use: N/a

Survey methodology overview

Survey type
Magnetic gradiometery
Instrumentation:
Bartington Grad601-2 magnetic gradiometer
Probe spacing:
1m
Grid size:
30m x 30m
Traverse interval:
1m
Sample Interval:
0.125m
Traverse Pattern:
Zig-zag

Electrical resistance
Instrumentation:
Geoscan RM85
Probe spacing:

Multiple five probe array (1m x 2, + 0.5m x 4)
Grid size:
30m x 30m
Traverse interval:
1m/0.5m
Sample Interval:
1m/0.5m (the higher resolution 0.5m sampling was targeted over grid squares G5, G6 & F6)
Traverse Pattern:
Parallel

Lecia CS15 diff-GPS/GNSS rover
Survey grid setup:
Established with differential GNSS
Survey Internal Accuracy:
Survey grade accuracy (<3cm)
Georeferencing:
The EDM data will be used to georeference the geophysical survey datasets exported from Geolplot v.4/TerraSurveyor in ArcMap 10.3.

Data processing:
The geophysical data was processed in TerraSurveyor with the electrical resistance data composited in Geoplot v. 4 software. The primary processes applied were high pass filtering (HPF) to remove geological 'background' noise and low pass filtering (LPF) which helps to eradicate minor spikes in the data. The datasets were also interpolated which creates a smoothing effect.

Visualisations:
The datasets were visualised within TerraSurveyor using shade, trace, compression and relief plots. Processed datasets and bitmap graph plots were exported from TerraSurveyor and imported into ArcGIS 10.3. Once georeferenced statistical analysis were carried out on the rasters within ArcGIS 10.3 and they were interpreted in relation to the available historical Ordnance Survey maps of the area and orthorectified aerial imagery.

Digital archive:
The geophysical datasets were collected, processed and archived in accordance with Archaeological Data Services best practice.[1]

[1] Schmidt, A. & E. Ernenwein, 2011, Guide to good practice: Geophysical data in Archaeology [Online] http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_Toc

Introduction

Characterisation resolution earth resistivity and magnetic gradiometery surveys were carried out over a total area *c.* 2.5 hectare within a large field situated on a promontory on the western shores of Lough Neagh. To the east clockwise through to the south is a collection of archaeological sites and monuments (TYR 040:003/TYR 040:004/TYR 040:005) which form the core of an early ecclesiastical complex. Before this current episode of archaeological survey little was known about the plan and location of the complex, if indeed it was present.

The two geophysical survey methods were applied together to maximise their potential to identify and evaluate the archaeological character of the site. The electrical resistivity data was surveyed at Ardboe using a 2m beam collecting six readings at each sample position which were then correlated into two separate datasets at two probe spacings: 0.5m and 1m. Resistivity is measured in ohm-meter (Ω-m) or the resistance of one meter cube of the material when a potential difference of one volt is applied.[2] So conductors such as copper have low resistivity whereas insulators, such as clay and stone, have high resistivity. Electrical resistance survey is especially useful for identifying buried stone walls and foundations, and cut features with higher resistance fills than the surrounding soils. It can also identify ditches and pits with more waterlogged soils, which have lower rates of electrical resistance. It requires direct contact with the ground and is a slower, with a consequently lower resolution, form of geophysical survey. Magnetometer survey identifies thermoremanent magnetized features such as kilns and hearths as well as in-filled ditches and pits. Soils and features become thermoremanent magnetized when they are heated to a very high temperature which facilitates distinctive, significant, changes in their magnetic signature. The majority of anomalies of archaeological potential identified using magnetometry tend to be associated with more subtle changes in the magnetic signature, such as in-filled ditches and pits magnetized as a consequence of the breakdown of organic matter.[3] It does not usually positively identify wall foundations, unless such foundations contrast magnetically with the surrounding soil, for example fired bricks but walls can leave negative magnetic signatures. Both techniques were applied over the possible location of the abbey to best identify the stone elements expected of an ecclesiastical structure as well as any other associated features such as foundation trenches, enclosures and heaths or kilns.

The ecclesiastical complex is situated *c.* 3km east of the modern hamlet of Ardboe. In the early 20th century settlement was shifted 1.5km further inland by the construction of an RAF airbase after the outbreak of WWII. The ecclesiastical medieval core occupies a modest knoll on a small promontory on the western shores of Lough Neagh. The surrounding landscape is relatively flat and low laying with shallow drumlins forming 'islands' which are surrounded by open pasture (Figure 1). Situated below the 20m contour mark, the archaeological features at the core of the medieval ecclesiastical site are located on a modest ridge running north to south with a good aspect from the north clockwise to the east, over the lough, through to wetter lowlands to the west. A reduction of the lake levels since the mid-19th century have seen the shoreline recede over 80m to the east, reducing the pronounced nature of the promontory (Figure 2). The area targeted for survey (Figure 3) is a large field to the north-west of the ruined parish church (TYR 040:004) and high cross (TYR 040:003), and west of the ruins associated with the abbey (TYR 040:005).The field has an even ground surface sloping gently from a north – south ridge in its easternmost quarter towards lower,

[2] Clark, O. A. 1997, *Seeing beneath the soil* (New York), p 27.

[3] Aspinall, A., Gaffney, C., & Schmidt, A., 2009, *Magnetometry for* archaeologists, Alta Mira Press: Plymouth, pp 1–8.

waterlogged grounds to the west. The western third is libel to flooding. It was heavily waterlogged during the survey even though rainfall had been modest and the area was the focus of drainage works in the last couple of decades. Within the survey area there is little of topographic note. A townland boundary doglegs through the middle of the survey area the features on which it was laid out appear to be field ditches. Indeed in the in the First Edition County Series (Figure 21) it runs diagonally suggesting even these are relatively modern.

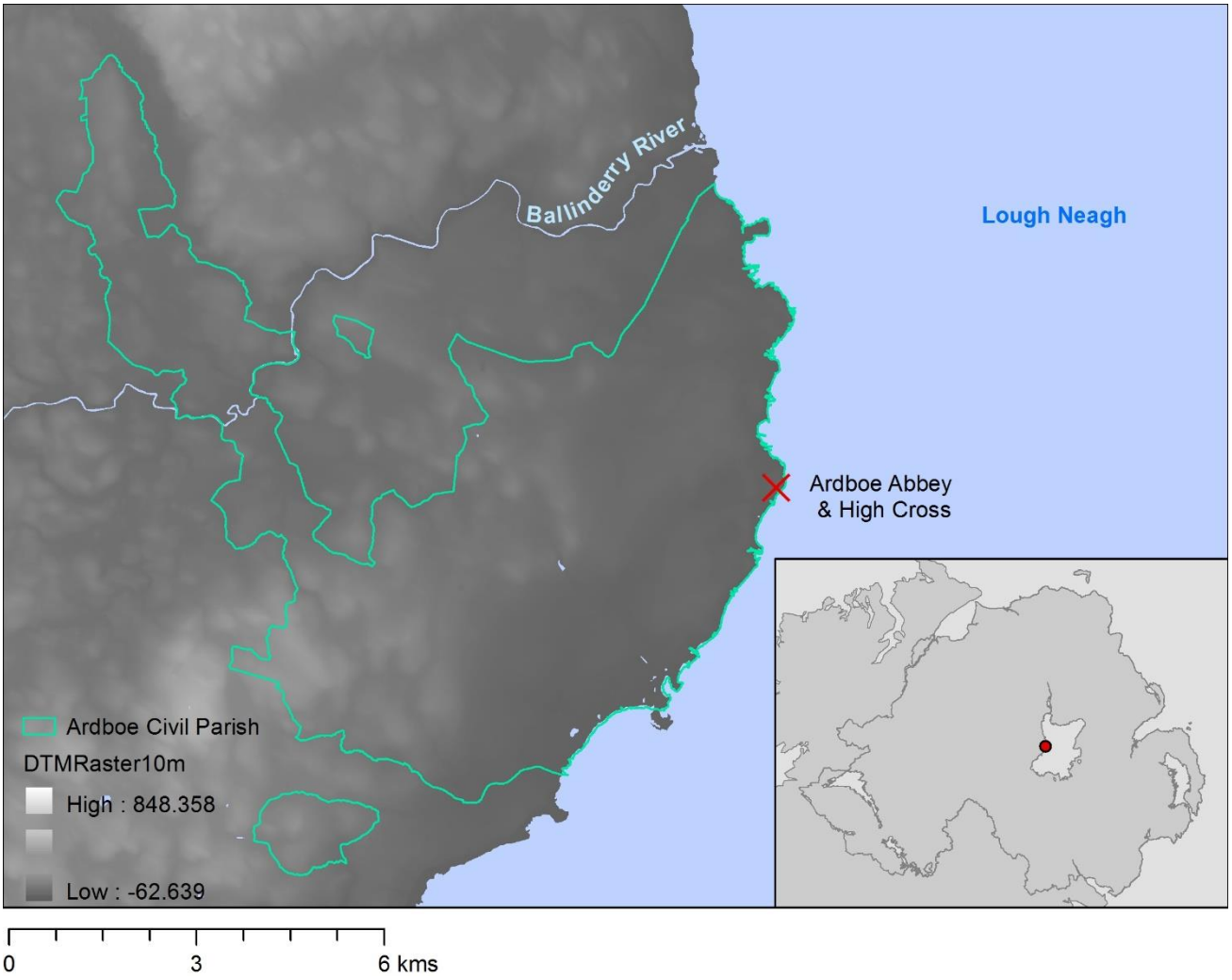

Figure 1 Location and landscape setting of the geophysical survey.*

Figure 2 The changing Lough Neagh shoreline at Ardboe: water levels were digitised off the historic maps (1883 – First Ed County Series OS; 1906 – Third Ed Country Series OS; 1975 – First Ed Irish Grid OS).

Historical & archaeological background

In the immediate vicinity of the survey area are a number of locations recorded on the Northern Ireland Sites & Monuments Record (NISMR). The remains of a small rectangular building (TYR 040:005), commonly called the Abbey, at the eastern limits of the survey area are believed to be the remnants of an ecclesiastical site. Land improvement works in the 1970s, to the east of the structure, revealed human remains and coarse pottery.[4] Situated *c.* 130m southwest of the possible abbey is a 10th-century High Cross (TYR 040:003). One of the tallest and finest decorated in Ulster this is a badly weathered sandstone cross. Just over *c.* 70 m east of Ardboe High Cross are the remains of a later church (TYR 040:004) and crowded graveyard. The ruins are probably 16th century but they may mark the location of an earlier parochial centre. Fragments of 14th-century moulded brackets and columns are incorporated into the ruins, thus suggesting a richly decorated

[4] NISMR TYR 040:005 [online] http://appsc.doeni.gov.uk/ambit/docs/TYR/TYR_040/TYR_040_005/Public/SM7-TYR-040-005-02.pdf. Accessed May 2017.

stone building was in the vicinity in the period, but later architectural features are absent.[5] The pre-Reformation church was appropriated by newly arrived plantation communities in the early 17th century. Eventually the Chancel widow was removed from this site and erected in a new Church of Ireland parish church, at Aghacolumb, in 1714 as the isolated location of the former building was inconvenient for 18th century parishioners.[6] The graveyard continues to be used for burials, predominately Roman Catholic, while many of the earlier headstones have been incorporated into modern grave plots, either through the assimilation of the memorialised within modern inscriptions or the physical relocation of these older headstones. Notable within the graveyard are two steep banks, now with modern graves inserted into them, which have been likened to bastions from 17th-century military fortifications.[7] The survey area targeted a large open field to the north and west of the upstanding stone structure (Figure 3).

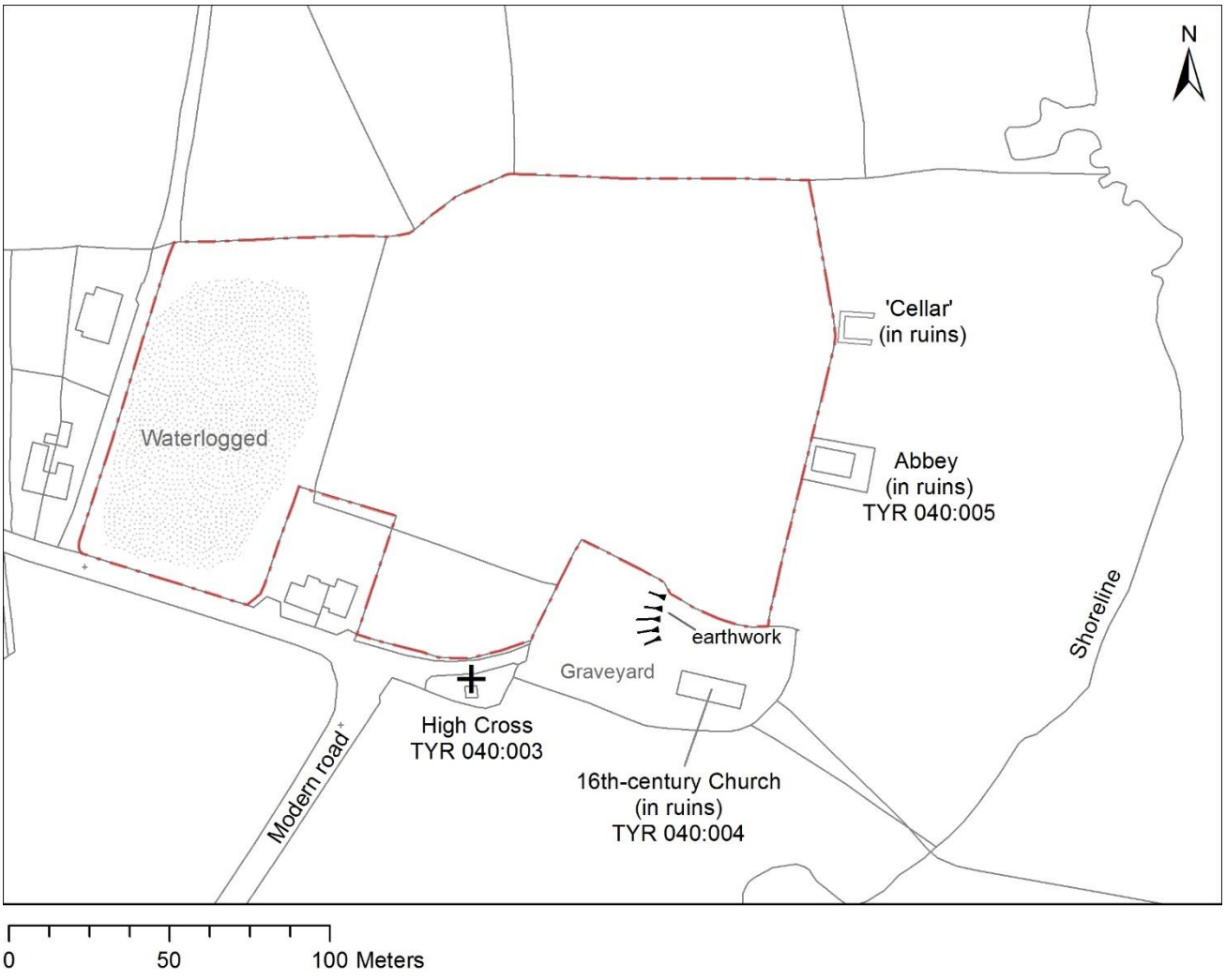

Figure 3 Location of survey in relation to known archaeological record, with the area surveyed outlined in red.

[5] Roulston, W., 2002, 'An agreement to build a new church in Ardboe parish in 1710', in UJA, Vol. 61. P 149, Bigger, J. & Fennell, W. J., 1897, 'Ardboe, Co. Tyrone: Its cross and churches' in UJA, Vol. 4, No. 1, p 6.

[6] Bigger & Fennell, 'Ardboe, Co. Tyrone: Its cross and churches', pp 5 – 6.

[7] Paul Logue (Pers. Comm.) NISMR TYR 040:005 [online] http://appsc.doeni.gov.uk/ambit/docs/TYR/TYR_040/TYR_040_005/Public/SM7-TYR-040-005.pdf. Accessed May 2017.

Surprisingly little is known about the site at Ardboe with scant research on the site beyond art historical analysis of the high cross itself. The Gaelic chronicles have only two entries for the site from the 12th century. In 1103 the death of Murchada Ua Flaithecain, erenagh of Ardboe, while on pilgrimage to Armagh is recorded by both the Annals of Ulster[8] and the Annals of the Four Masters[9]. Erenaghs, an Anglicization of the Irish term *airchinnech*, were originally the heads of early Irish ecclesiastical communities who remained as tenants on Church lands even after the transfer of their estates to the Irish bishops during the 12th century.[10] Murchada is described as a, 'master of learning, liberality and poetry' which may indicate that Ardboe was also considered a seat of learning. Two generations later, in 1166, Ardboe was burned by members of neighbouring Gaelic families by, 'Ruaidhri, son of Mac Canni[11] and by the son of Cilla-Muire Uan Monrai[12] and by the Crotraighi[13]'. This indicates that Ardboe was functioning in an ecclesiastical role during the 12th century before emerging as a parochial centre as evidence by the 14th century architectural fragments.

The high cross itself most likely dates to the 10th century thus supplying a baseline date for an epoch phase of ecclesiastical activity at the complex. As discussed above the 'abbey' and 'cellar' have no early diagnostic architectural features, while fragmentary inclusions can date the church site to the 14th century at the earliest. High crosses are common at larger ecclesiastical sites with the Ardboe example being one of the most imposing and highly decorated of the Ulster crosses. The sandstone cross shows signs of weathering with well-meaning 19th-century repairs further threatening its structural integrity. Metal pins were inserted into the stone to secure the cross head and the shaft, and the shaft and the various elements of the plinth.[14] As ferrous metal corrodes the pins will erode and eventually destroy the surrounding stone. The cross has 22 carved panels depicting scenes from the Old and New testaments. It is difficult to say if the cross is in its original position. The relocation of this monument type is not uncommon.[15] There is no evidence for a round tower or founder's tomb which are common features for larger ecclesiastical sites, although Leslie does refer to the latter being present at Ardboe. The building referred to as the 'abbey' is aligned east to west measuring 12m east – west by 8m north – south with no evidence for internal features.

Leslie[16] refers to the establishment of Ardboe by a St. Colman at the close of the 6th century. He appears to calculate the foundation date by reference to the saint's genealogy. Given the abundance of St Colmans,

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[8] Hence forth *AU* Hennessy, W.M, and MacCarthy, B., (ed. and trans.) 4 vols (Dublin, 1887 – 1901).
[9] Henceforth *AFM* O'Donovan, ,J., (ed.and trans.) 7 vols (Dublin, 1851).
[10] Jefferies, H A 1999 'Erenaghs in pre-plantation Ulster: An early seventeenth-century account', in *Archivium Hibernicum* Vo. 53, p 16.
[11] Probably the '*c.cána* – the MacCanns on the south of Lough Neagh' Hogan, E. 1910 *Onomasticon Goedelicum*, [online] http://publish.ucc.ie/doi/locus.
[12] Possible the O'Morgans, a family who were in near south-east Lough Neagh during the medieval period. Morgan, B., [undated] [online] http://freepages.genealogy.rootsweb.ancestry.com/~muireagain/Ulster.htm.
[13] Family associated with the placename Cary in north Antrim, McSparron, C., [2015] 'Excavation at Doonmore, Co. Antrim: Data Structure Report No. 116' [online] www.heartoftheglens.org/cms/wp.../Doonmore-Community-Excavation-Report.doc, p 10.
[14] Linsay, C., [2010] 'An intergrated toolkit for the conservation of stone-built heritage' [Unpublished] submitted to NIEA.
[15] O'Sullivan, A., McCormick, F., Kerr, T. R., & Harney, L., 2014 *Early Medieval Ireland AD 400 – 1100: The evidence from archaeological excavations*, Dublin: Royal Irish Academy, p 166.
[16] Leslie, J. B., 1911 *Armagh clergy and parishes*, [online] https://archive.org/details/armaghclergypari00lesl, p 95.

nearly 130 names individuals across the island, and the sometimes fabricated nature of Irish genealogies this early date should perhaps be treated with caution. Neither is Ardboe readily identifiable as one of the seven churches founded by Patrick for the Uí Tuirtre, one of many tribal groupings that formed Airgialla, at the beginning of the Christian period.[17] Whatever the foundation of Ardboe, the complex itself would have been at the heart of a community. Human remains were discovered at the site in the 19th century and re-interred by the east wall of the 'abbey' ruin.[18] This is the same location that burials and coarse pottery were recovered from during land reclamation works in the 1970s.[19] Little exists above ground to give much sense of how that community was organised. Certainly the organisation of internal space was an important consideration with the church building its foci. Larger foundations display a concentric arrangement of degrees of sanctity usually associated with enclosing features such as walls, banks or ditches. As centres of active communities there would have been domestic buildings, either circular or rectangular made out of stone, wood or post-and-wattle.[20] Evidence for specialised craft-working, industrial activity and agriculture would also be expected.

The earthworks in Ardboe graveyard are associated with the fortification of the church by Hugh O'Neill's forces during the Nine Years War. At the end of the 16th century Hugh O'Neill started a prolonged military campaign against the Tudor Crown. O'Neill and his Gaelic confederates would eventually be defeated but only after a protracted, entrenched war which saw the province and civilian population left in a state of turmoil. An extract from the Bartlett map of South Ulster[21] depicts a fortified church, inscribed *Drum-bo*, under fire from English naval forces (Figure 4). The church, which is roofless, is identified by a cross on the west gable. It is located on a small promontory with a river emptying into the lough to the north. To the immediate south is the fort named *Forte Mountioie* (Brockagh) and to the south-southwest is *Clonogh* (Clonoe). Ardboe is situated on a promontory with the Ballinderry River running to the north. A wall with two oblique returns is positioned to the west of the ruin defending it from a land-based assault. Further inland is a roofless structure identified as *Ardro*. Curiously Ardboe is not recorded on a second Bartlett map (Figure 5),[22] which specifically deals with military fortifications on Lough Neagh, whereas *Bellgadara* (Ballinderry) and *Clanno* (Clonoe) are, as is a distinct promontory on which we would expect Ardboe to stand.

[17] Ó Doibhlin, É., 1971 'The deanery of Tulach Óg', in *Seanchais Ardmhacha: Journal of the Armagh Diocesan Historical Society*, Vol. 6, No. 1, p 149.

[18] Bigger & Fennell, 'Ardboe, Co. Tyrone: Its cross and churches', p 3.

[19] NISMR TYR 040:005 [online].

[20] O'Sullivan *et al.*, *Early medieval Ireland*, pp 168 – 173.

[21] Bartlett, R., *Map of the southern part of Ulster…* c. 1602-3 [National Archives: Kew, MPF 1/36].

[22] Bartlett, R., *Map of the forts in Lough Neagh area, and showing forts fortified by Tyrone.* c. 1602 [National Library of Ireland: Dublin, MS 2656 (19)].

Figure 4 Extract from the Bartlett map of South Ulster (National Archives; Kew MPF 1/36)

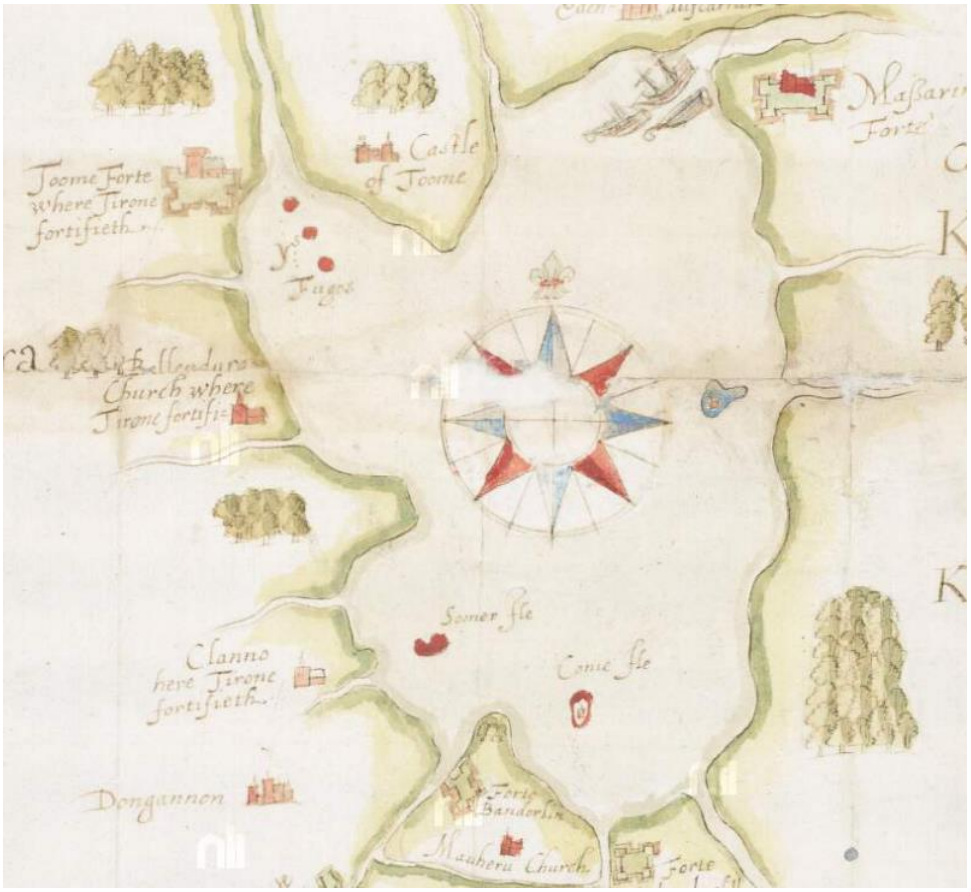

Figure 5 Extract from Bartlett Map of the forts in Lough Neagh area, (National Library of Ireland; Dublin MS 2656 (19)). Note the distinct promontory along the western shoreline of the lough where we would expect Ardboe church to be.

Description and interpretation of anomalies

In general the magnetic data was noisy (Figure 11). This is probably due to geology. The bedrock is Interbasaltic Formation – Bauxite-clay a mineral group which demonstrates great variation in composition. Igneous rock types, such as Basalt, can preclude magnetometer survey as the geological conditions which created them changed their thermoremanent character.[23] Where the technique can be applied the expected polarity of responses can be inverted with cut features displaying negative returns as the fill material has a lower magnetic susceptibility in contrast to the surrounding igneous rock.[24] Most of the magnetic anomalies were very subtle and while they can be viewed in a positive value plot (clipped to =>0nT) the mean average for the polygon areas were negative. The superficial geology is a Lacustrine Alluvium mix of clay, silt and sand changing to Diamicton till as you move back from the shoreline. The soil type is stagnosol which is typified by stagnating surface water in relatively flat, temperate conditions. The conditions result in a leaching of the mineral content of the soils which reduce the magnetic contrast between archaeological deposits and the surrounding soil matrix. The combination of the various geological elements, erratic magnetic interference and the low contrast character of archaeological features, do not create the best conditions for magnetic survey.

Unsurprisingly then, the electrical resistivity survey provided the best evidence for anomalies with a high archaeological potential. The electrical resistance data was collected using two probe spacings; 0.5m and 1m, as two sampling resolutions, 0.5m and 1m. The wider the probe spacing the deeper the signal will penetrate. However this does not necessarily increase the likelihood of identifying deeply buried discrete features as the wider spacings lose overall resolution as those features with smaller dimensions now make up a lower ratio of the entire sampled volume. The loss of resolution must be remembered when comparing data from the different probe spacings. More frequent sampling of the data is one way to increase resolution without effecting the individual reading resolution. A key area of the survey, over m_5/r_2 and m_4/r_3 (grid squares G5, G6 & F6), was targeted for higher resolution sampling. Sample readings were taken every 0.5m instead of every meter.

Finally, the field has been used for arable farming. A photograph supplied courtesy of Pat Grimes (Figure 28) clearly shows the area to the west of the abbey, where the bulk of the archaeological geophysical returns are located, under maize cultivation during the 1990s. This is also evident in the 2010 aerial photography of the survey area (Figure 26). The deep ploughing associated with arable farming is more likely to truncate and destroy archaeological features.

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[23] David, A., Linford, N., & Linford, P., 2008 *Geophysical Survey in Archaeological Field Evaluation*, p15. English Heritage [online]: http://content.historicengland.org.uk/images-books/publications/geophysical-survey-in-archaeological-field-evaluation/geophysics-guidelines.pdf.

[24] Bonsall, J, Gaffney, C & Armit, I 2014 'A decade of ground truthing: reappraising magnetometer prospection surveys on linear corridors in light of excavation evidence 2001–2010', in Kamermans, H, Gojda, M & Posluschny, A G (ed), A Sense of the Past: Studies in Current Archaeological Applications of Remote Sensing and Non-Invasive Prospection Methods (BAR International Ser 2588), p 8.

Table 1 Description and interpretation of magnetic anomalies (Figure 6).

MAGNETIC ANOMALIES		
CODE	**DESCRIPTION**	**INTERPRETATION**
m_1	Series of positive, low magnetic linear features criss-crossing a heavily waterlogged area. The longest stretch can be traced for *c.* 95m. They can be traced over an area of about 4,000m². On some occasions they follow the path of subtle higher resistance linears (r_11), identified in the electrical resistance dataset, which spatially behave in a similar manner in plan.	The farmer identified that area as having been the focus of drainage. The geophysical returns confirm higher resistance features (stone filled drainage trenches) with subtly positive magnetic returns (on this occasion possibly produced by changes in the soils magnetic susceptibility[25]).
m_2	Positive, low magnetic linear which can be mapped partially for a distance of *c.* 48m SW - NE from the field entrance towards the abbey remains. The southernmost portion of m_2 overlays r_5 a low resistance anomaly and appears to align with the resistivity anomaly r_12 and a breach in the linear r_1.	During fieldwork it was noted that this appears a natural approach route to the crown of the outcrop, which appears to correspond with the anomalies m_5 and r_2, from the modern gateway. Possible approach route to the crest of the rise. Maybe due to contemporary agricultural activity.
m_3	Subtle, magnetically positive linear running from the northern edge of the field boundary towards the south-southwest. Traceable for a distance of c 46m, c 2m wide. Runs parallel to, and to the east of, the northern third of r_1. It does not appear to overlap with r_1.	The high resistance returns associated with r_1 have been interpreted as an enclosing feature focussing on protecting the promontory from an inland attack coming from the west. The anomaly m_3 could trace the path of a cut feature which contains a fill with a greater magnetic susceptibility. It could have perhaps contained a palisade fence located on the inside of r_1 and adding a further defensive element.
m_4a & m_4b	Two irregular areas of subtlety, magnetically positive readings running roughly east to west in the north-western quarter of the survey area.	Notably these occur around the edges of the high resistance features identified as r_3. The subtle magnetic features could be due to microbial activity which enhanced the soils magnetic

[25] Gaffney, C., & Gater, J., 2003 *Revealing the buried past: Geophysics for archaeologists*, Tempus: London, pp 38 – 9.

	The northernmost portion, m_4a, can be traced for a distance of *c.* 39m with a width of *c.* 1.5m. Located *c.* 2m to the south of m_4a, and running parallel to it, is m_4b. It can be traced for a distance of *c*. 25m. Tapering towards the east from a max width of *c*. 5m at the west. The anomalies, m_4a & m_4b, overlay r_3a a high resistance feature with the easternmost linear arm of m_4a overlaying the southern edge of r_3b. When viewed in plan the returns from the two datasets give a greater sense of trapezoid anomaly being detected by m_4 and r_3a.	susceptibility as the stone impeded drainage establishing a moisture-rich environment suitable for decay or as magnetically more susceptible topsoil was leached into the rubble and silted around them.
m_5	Large irregular area of magnetically very subtle readings. The data is a mix of positive and negative returns with a mean value for the entire area of -7nT. However the anomaly is defined along its outer limits by a subtle band of positive readings. It measures c. 37m E – W, c. 27m N – S and is positioned *c.* 12m south of m_4. It appears to record the same anomaly identified through the high resistance returns plotted by r_2a & r_2b.	Similar to m_4 and possible created by the same conditions. Occurs around the edges of the high resistance feature identified as r_2.
m_6	Subtle, curvilinear magnetically positive feature traceable for a distance of c. 20m with a width of c. 2m. Located *c.* 9m southwest of m_5 and *c.* 16m north of m_7. Appears to align with a breach in r_1 which may be associated with m_2.	Corresponds with a higher resistance, r_13, feature in the same area with the same plan. The curvilinear plan suggests this could be archaeological in nature, possibly related to the activity that was occurring at m_7.
m_7a, m_7b, m_7c & m_7d.	A series of higher magnetic responses which form a serpentine plan anomaly characterised by a high positive (ranging from 8 – 21 nT) magnetic core and a negative (-40 nT) halo to the north. Starting in the west, m_7a, is a relatively short stretch of linear, running southwest to northeast, measuring *c*. 6.5m by *c*. 2m. It has a high positive mean (12.2 nT) but no halo of negative readings.	The serpentine plan is typical signature that one would expect for a souterrain. However curiously there are no high resistance anomalies in the electrical resistivity survey that suggest a stone structure. These appear to be absent from both electrical resistance probe spacing datasets suggesting it is not present to a depth of <=0.7m.

	At its southern limit is m_7b. An irregular arc which can be traced from the north-west to the south-east before gently turning towards the north-east. Traceable for a length of c. 16m, c. 2m wide. It has a lower positive mean (8.6nT) but does display a negative halo along it the northern edge of its western half. It leads up to m_7c. This element of m_7 forms a loose s-shape leading on from the eastern tip of m_7b. Moving from the south-west to the north-east before weaving south-east again and then turning towards the north-east. It contains the highest positive readings in its westernmost arm (>=100nT or over range) with a mean of 21 nT and a halo of negative readings around the western core. Traceable for a length of 15m, width c. 2m. Does not overlay with any distinct features on the electrical resistance dataset. The western tip of r_9 overlays generally with the eastern limit (r_7c). Interesting the path of m_7 does appear too correlated with a break in r_1.	A clear, well-defined, break in the high resistance anomaly r_1 indicates that m_7 cuts this feature but beyond this evidence of absence, it cannot be identified in the resistance data. Unless the returns are positive but weak and are masked by the surrounding high readings of r_1. Clipping at various min/max absolute values did not help identify any further resistance values. The magnetic returns for m_7 are also quite high – high enough be outside the instrument range (-100 – 100 nT) in places. Another explanation could be some form of industrial or agricultural activity using a kiln or furnace and an elongated flue. But again one would expect to see high resistance features present. The lack of resistance readings could be explained by the features being buried at a greater depth then the resistivity meter could penetrate, even using a 1m probe spacing. In this scenario it may be basalt lintels on a souterrain or the thermoremanent signature of a kiln or furnace that was strong enough to be read by the gradiometer but was buried deeply enough to be missed by the earth resistance meter. Souterrains are usually dated to the late-first millennia AD.[26]
m_8	Straight negative linear feature running north-north-west to south-south-east from the northern edge of the survey. Traceable for a distance of c. 62m, c. 2m wide. Appears to overlay with the subtle electrical resistance anomaly r_8.	The straight regular plan and negative readings suggest a wall. Corresponding returns, r_8, in the electrical resistance data but very subtle, not the type of high readings one would expect from a wall.
m_9	Irregular linear feature, modestly magnetic (mean 0.45 nT) running south-west to north-east. Located in the western portion of the survey area. Traceable for a distance of c. 17.5m, 2.5m wide.	Possible cut feature – may be an earlier drainage scheme then the latter 20th century episode associated with m_1 & r_11.

[26] O'Sullivan *et al.*, *Early medieval Ireland*, pp 66 – 68.

	Does not correspond with any features identified in the electrical resistance survey.	
m_10	High magnetic dipolar anomaly. Positive core (=< 100 nT or over range) appears L-shaped with return to the west. Dimensions c. 3m N - S, 2m E - W. Displays distinctive halo of negative values. Located at the western limit of m_5 and possible associated with this feature.	The extreme returns would suggest that this is thermoremanent perhaps a kiln or hearth. Possible associated with a structure indicated by m_5 & r_2.
m_11	High magnetic dipolar anomaly. Positive core (=< 100 nT or over range) c. 2m E - W, 1.5m N - S. Displays distinctive halo of negative values.	This occurs in an area that we know has seen a lot of agricultural activity. It could be a buried ferrous object.

Figure 6 Diagram of magnetic anomalies identified.

Table 2 Description and interpretation of electrical resistance anomalies (Figure 7).

ELECTRICAL RESISTANCE ANOMALIES		
CODE	**DESCRIPTION**	**INTERPRETATION**
r_1	High resistance (mean 87.8 Ω-m) linear running south-south-east to north-north-west through the eastern third of the survey area for a distance of c. 126m, c. 9m at its widest. A portion of r_1 was captured in the high sample density survey. At this point both side of the feature are well defined and it measures *c.* 5m in width. Interpolating the route of r_1 indicates that it would have separated the promontory from the mainland enclosing the features within it. It also appears to align with the earthworks in the graveyard, previously interpreted as 17th-century military fortification. The magnetic anomaly m_3 delineates the eastern limit of its northern third. The feature, r_1, is breached in a number of places.	The ground surface is relatively flat although earthworks are visible in the graveyard and appear to align with r_1. Initially r_1 looks like a roadway. However it does not appear to connect any locations, instead if extended out beyond the limits of the survey area this feature would separate the promontory from the rest of the mainland (Figure 9). It is more likely that the anomaly r_1 may be an enclosing feature – the high returns suggest a cut feature with a high resistance fill, although the erosive effect of r_10 on the linear r_1 suggests that is was a bank which had been ploughed. It appears to separate the promontory from the mainland, protecting the interior from an inland attack coming from the west. The anomaly m_3 has been interpreted as a further defensive feature, perhaps a palisade trench.
r_2a & r_2b	A sub-trapezoid high resistance anomaly. Most of r_2 was targeted with a second higher resolution sampling density (0.5m as opposed to the previous 1m sampling density). The feature appears to be composed of two elements – this is evident in the 0.5m probe spacing, higher sampling raw data. And after HPF of all four datasets at various sampling and probe spacing densities. It is located to the centre of the eastern third of the survey area, *c.* 30m west of the 'cellar' and *c.* 36m north-west of the abbey. The total area of r_2 reduces on the wider probe spacing data which will penetrate deeper suggesting its external limits are shallow.	This feature is associated with some of the highest resistance readings of the entire dataset, on some occasions nearly four times greater than the mean for the raw dataset. It is possible that this is geological in nature. An arc of high resistance readings moving from a modern field boundary to the north clockwise through to the modern entrance is geological. High Pass Filtering (HPF) of the dataset effectively removed this anomaly. However HPF did not remove r_2, it does when dealing with the smaller sample area of the higher resolution sampling density (0.5m x 0.5/1m), when dealing with the larger 1m sampled data it remains.

	The main body of the feature is associated with r_2a an irregular high resistance (mean 101.6 Ω-m) anomaly. This appears as sub-triangular plan with an oblique return at its southern corner after HPF. It is *c*. 34m E - W, 16m N - S. Possible part of a larger feature associated with r_2b. Irregular high resistance (mean 81.4 Ω-m) anomaly located immediately (1m) north of r_2a. Sub-triangular plan with an oblique return at its northern corner. Measuring 10m N-S, 21m E - W. Possible part of a larger feature associated with r_2a. The area of r_2 is overlaid by m_5 a subtle positive magnetic feature.	This is because HPF supresses low frequency large scale anomalies. In the higher sampled dataset the anomaly made up a larger ratio of the over data and thus was filtered out like the geology in the 1m sampled data. Further r_2 correlates with a distinct magnetic anomaly, m_5, which traces a roughly similar area and plan. If this was the result of human action then it could the rubble scree from a stone structure or the remains of a paved area. .
r_3a & r_3b	Linear sausage-link like anomaly in the north-eastern corner of the survey area running roughly east to west. Appears to be formed from two features r_3a to the west and r_3b to the east. This was targeted, along with r_2, for a higher resolution (0.5m) sampling survey. Located *c.* 12 north of r_2. The westernmost anomaly, r_3a, is an irregular oblong-shape. Aligned roughly east to west with a short squared off-shoot at the north-east corner. The higher resolution sampling dataset appears to plot a trapezoid anomaly with angular returns to the west and possible wall footings enclosing an area of lower resistance. Measures *c*. 24m E - W, *c*. 6m wide. Aligns with r_3b and is partially overlaid by m_4b. To the east is r_3b positioned south-west to north-east aligning with the off-shoot of r_3a. It is oblong in form with measuring *c*. 13m SW - NE, 8m wide. In the higher resolution sampling density data if appears to have angular returns on its western end. The magnetic anomaly m_4a traces along its southern edge. Both r_3a & r_3b appear to align with r_4. .	The high resistance nature of the returns, two to three times the mean, and the linear plan are indicative of stone wall footings. Although an overall coherent plan is difficult to ascertain which suggests it has been heavily eroded. The magnetic feature m_4a does indicate changes in the susceptibility readings which could possible relate to r_3a although it appears to have less of a relationship with r_3b.
r_4	Trapezoid anomaly extending beyond the eastern limit of the survey area running south-west to north-east. Returns are weak compared to other elements in the dataset. Traceable for a distance of c. 16m SE - NW, c.	The readings are more subtle then r_3 but of interest due to its spatial relationship with the latter. The anomaly r_4 appears to align

	6m wide. Appears to align with r_3 with the linears associated with r_8 and m_8 separating it from the rest of the cluster.	with r_3b. It has a roughly trapezoid form although an overall plan is difficult to identify due to the sampling density. It is possible that r_4 once had a more defined relationship with r_3 but it has been detached by the linear feature associated with r_8 and m_8.
r_5	Low resistance linear anomaly running from the entrance to the field towards the north-east. Traceable for a distance of c. 33m, 3m wide. Corresponds with the position of westernmost third of m_2, a positive magnetic linear.	Probably due to the route being used to access the ridge from the modern field entrance, Repeated use of the route by wheeled vehicles may have encouraged waterlogging which will reduce the soils electrical resistivity and could change its magnetic susceptibility.
r_6	Pair of curvilinear low resistance anomalies seemingly bridged by a saddle to form an elongated H-shape. Located in the western half of the survey area on a flat plane. The anomaly runs roughly north to south for a total distance of c. 33m N-S, 8m wide.	A cut feature with a moisture-rich fill. The form of r_6, two concentric linears, suggests a human-made feature with a possible defensive focus. However the plan is more difficult to interpret. It appears only partially mapped but can be traced from the north-west to south-east before gently turning towards the south, almost diverging from the path of the large enclosing element associated with r_1.
r_7	Linear low resistance feature. Can be traced for a distance of c. 23m, c. 1.5m wide. Follows the path of a field boundary recorded by the 3rd Ed OS.	Historic field boundary – probably a ditch in-filled with moisture-rich fill.
r_8	Subtle linear feature running roughly running north-north-west to south-south-east from the northern edge of the survey. Gently veers south two thirds of the way along its length. Runs 22m parallel to the historic 1833 shoreline as recorded by the 1st Edition County Series Ordnance Survey. Traceable for a distance of c. 93m, c. 2m wide. Corresponds with the position of m_8.	An enclosing element which runs parallel to the old shoreline. It may have helped to internally divide the headland as defined by r_1. Could possibly have some stone footings, m_8, and may have detached r_4 from the rest of r_3.
r_9	Higher resistance linear running roughly east-north-east to west-south-west before curving towards the south-west at its mid-point. Traceable	Could follow in a similar vein to r_8. It is irregular in form, although linear, and is probably not a modern (post-1800) field boundary. No

	for a distance of c. 60m, c. 2m wide. Intersects with r_8 along its eastern quarter, leads up to m_7 at its westernmost limit.	boundaries are recorded by the historic County Series maps (FIG) of the area.
r_10	Series of subtle, higher resistance linears running north-east to south-west in the south-eastern quarter of the survey area. Run parallel to each other at a distance of *c.* 9m. Appear to be associated with breaches in r_1.	The linears identified as r_10 also correspond with warped erosions into the eastern edge of r_1. These may be plough marks. The area was used for arable farming and earthworks in the graveyard which align with r_1 suggest it could have been an extant feature.
r_11	Series of criss-crossing linear features with subtle resistance responses in a water-logged area with poor drainage. Corresponds with the position of m_1.	Modern drainage features.
r_12	Subtle low resistance linear running south-west to north-east for a distance of *c*. 22m. Appears to align with m_2, positive low magnetic linear, and possible a breach in r_1.	Possible extension of r_5. Does appear to align with a break in r_1 but this could be related to r_13 and coincidently.
r_13	Subtle curvilinear feature traceable for a distance of *c*. 13m. Appears to correspond with the position of m_6, subtle positive feature, could also be associated with a breach in r_1.	Its form and plan suggest that this is archaeological in nature. Probably a cut feature related with a fill that has a higher resistance and greater magnetic susceptibility then the surrounding soil.
r_14	Subtle higher resistance feature, possible extension of r_2a. Traceable for a distance of c. 13m.	Possible extension of r_2. Appears to be linear and could be a wall footing.

Figure 7 Diagram of earth resistivity anomalies.

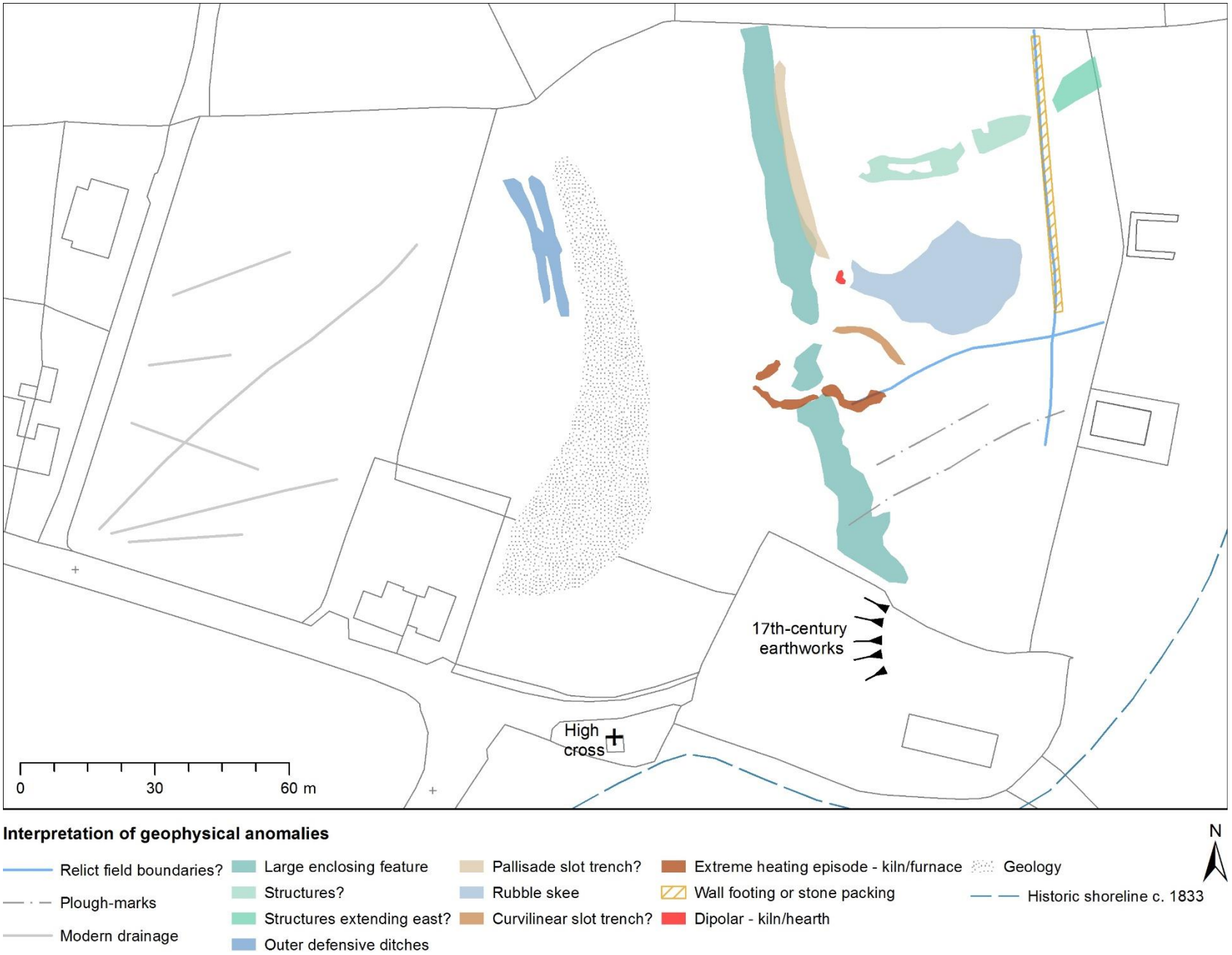

Figure 8 Diagram of interpreted anomalies for both magnetic gradiometer and electrical resistance survey data.

Discussion

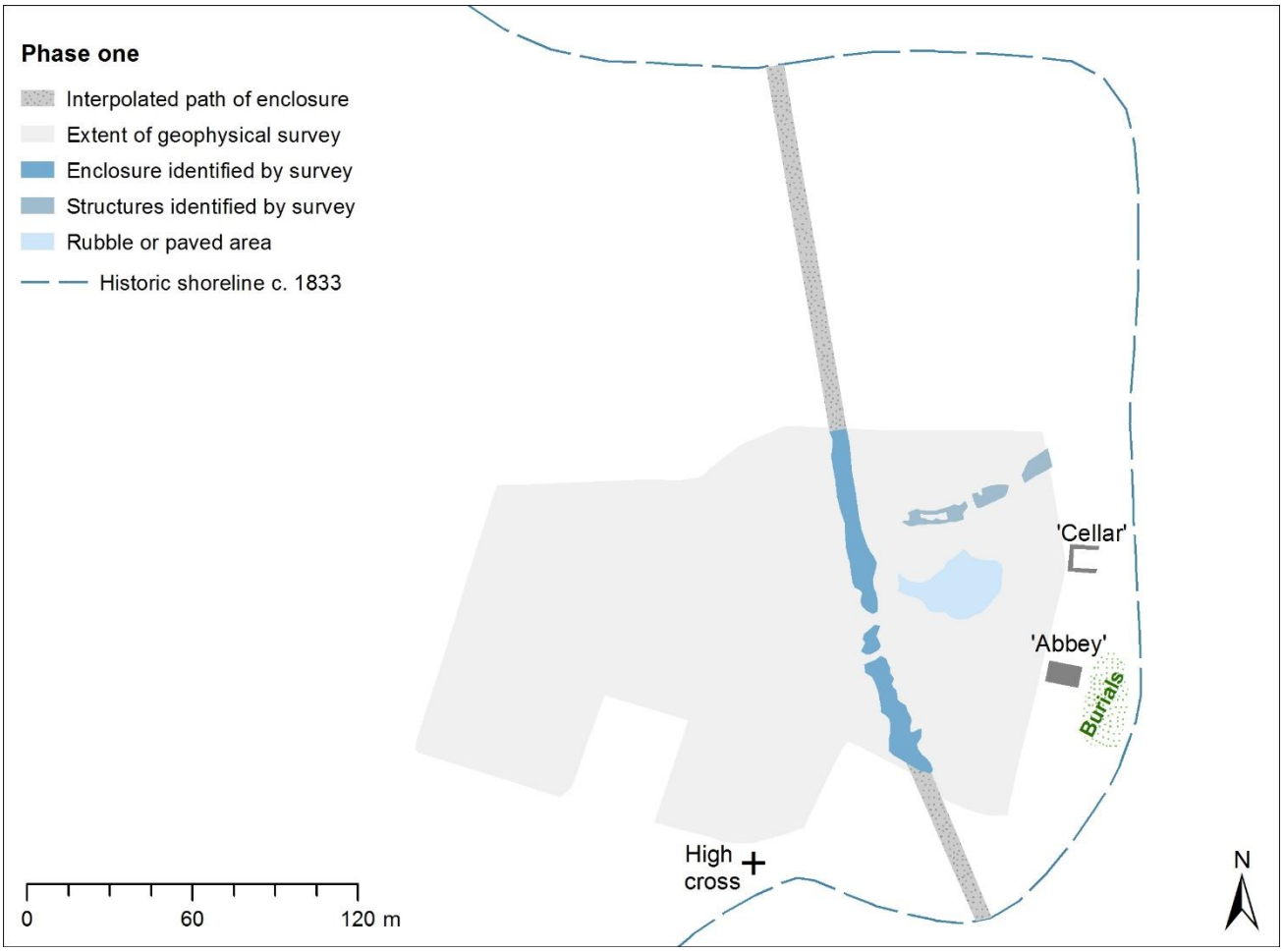

Figure 9 Enclosing the headland.

The geophysical survey data captured at Ardboe indicates a complex, multi-period use of the headland. It significantly aids our understanding of the site, establishing a meaningful research agenda. The historical record, and the surviving architectural fabric, can tell us something about the development of the site and provide a narrative around which the geophysical data can be contextualised. They indicate that Ardboe was an important ecclesiastical centre around the 10th century AD when the statuesque, richly decorated high cross was commissioned. This may also be the period from which the structures called the 'abbey' and 'cellar' date, thus suggesting that settlement focussed on the north – south ridge of the headland. The ecclesiastical centre continued in some form, presumably continuously, until the 12th century when an attack by neighbouring Gaelic Irish families appear to mark a downturn in its fortunes. It functioned as a parochial centre during the 14th century with architectural fragments evidence of an episode of rebuilding during this period. By the early 17th century it is depicted as a ruin by Bartlett and was fortified by O'Neill during the Nine Years War. With the fall of Gaelic hegemony in Ulster the arriving settlers appropriated the pre-Reformation parochial centre, rebuilding the church and monumentalising burials with stone grave-markers which was rapidly adopted, and adapted by the Gaelic Irish. In the early 17th century the Church of Ireland congregation moved to Aghacolumb bringing the 16th century chancel window with them. The Roman Catholic congregation continued to use the burial ground with the typical proliferation of funerary markers

form the 18th century onwards. In the later 20th century the trackway which lead south towards the modern hamlet of Ardboe was tarmacked and the lough water levels dropped.

The geophysical survey has identified a significant, high resistance, linear enclosing feature (r_1), running north – south, which if interpolated out would have cut off the headland from the mainland (Figure 7, Figure 8 & Figure 9). The form that this enclosing feature took is difficult to ascertain. Although the ground surface in the survey area is relatively flat significant earthworks, which align with the southern limit of the geophysical anomaly, are present in the graveyard. These have previously been interpreted as military fortifications constructed by O'Neill in the early 17th century. Bartlett's depiction of the fortified Ardboe church (Figure 4) illustrates a linear defence protecting the position from land attack. It is not improbable to suggest that O'Neill's forces simple reinforced, or utilised the fabric of, earthworks that already existed. The high resistance readings suggest that this was an earthen bank, perhaps with a high composition of stone or gravel. The loss of the extant earthworks in the survey area, to the north of the graveyard, was probably the result of agricultural activity as evidenced by plough marks in the survey data (r_10). The enclosure may have been further defend by an internal palisade. If correct, then it would have enclosed the headland, an area of *c.* 2 Ha. It is possible that the double ditched linear to the west (r_6) relates to the enclosing of the promontory, although it may also be part of the 16th-century military landscape. The area to the far west of the survey area is heavily waterlogged and would have further hampered any approach from the west onto the headland or a position near the church.

Within the enclosure there appears to have been a number of stone structures. These are already alluded to by the presence of the 'abbey' and 'cellar', however it is not possible to say if these various elements were contemporary nor how they relate to the 10th-century high cross. A linear arrangement of long, narrow anomalies (r_3 & r_4) with evidence from wall footings run roughly east – west from the shoreline towards the centre of the headland. To the south is an irregular are of very high resistance readings (r_2) which could be rubble scree or perhaps a paved area. Both collections of features have a magnetic signature. To the west of the scree is a magnetic dipolar which may be a hearth or kiln, but could also be a buried ferrous object. There appears to be no evidence for the type of concentric, circular enclosing features one would expect of an early ecclesiastical site.

At a later date it appears that some irregular linear features were laid out internally dividing the headland, possibly field boundaries but not modern, one of these (r_8 & m_8) may cut through the linear arrangement of east – west structures. It follows the path of the historic shoreline, running parallel to it. The other (r_9) appears to respect the position of the large bank. It is unclear if the activity that relates to m_7, a highly magnetised serpentine linear, occurs before or after this internal division. The serpentine linear clearly cuts r_1 and is therefore younger then the initial enclosing episode. Its strong magnetic returns indicate the use of extreme heat possibly due to industrial, craft or agricultural activity. The linear plan is reminiscent of the flues from a kiln or furnace. It may be several kilns, the returns for which have bleed together to give the impression of one whole. The curvilinear feature identified by m_6 & r_13 could be part of this episode. Its regular form indicates that it is human-made and it appears to correlate in plan with the position, at least, of the highly magnetic serpentine anomaly. Perhaps it was a temporary structure erected to shelter whatever activity was occurring around the possible furnace or kiln.

Recommendations

1. A micro-topography of the survey area would greatly aid the interpretation of the geophysical data gathered to date and any future commissions. This could easily be captured using UVA flown SfM photogrammetry when vegetation is low or with a discrete Terrestrial Laser Scan survey. It must include the topography of the graveyard earthworks and the relict shoreline.
2. The data gathered to date suggests that the geophysical survey is incomplete. If the entire headland was protected by a possible bank with internal palisade, associated with r_1 & m_3, then additional survey should capture this. The additional survey should include both electrical resistance and magnetic gradiometery.
3. This survey should also be able to identify if there is any more evidence for settlement activity within the interior of the enclosure. Identification of wall footings may aid our understanding of the plan which the settlement took and perhaps establish if it was related to the ecclesiastical activity indicated by the high cross by diagnostic plans.
4. On completion of the additional survey works targeted excavation should be considered. Key excavation targets would be the large enclosing bank, the linear east – west aligned structures and the highly magnetised serpentine linear feature.

Acknowledgements

Thank-you to Grace McAlister, Ruth Logue & Ruaíri Ó Baoil, Centre for Archaeological Fieldwork, Queen's University Belfast, who carried out the fieldwork for this survey. Thank-you also to Liam Campbell, Lough Neagh Landscape Partnership, for his support throughout the project and Dermot Quinn for giving us access to his land.

Appendix one: Georeferenced geophysical survey grid

Figure 10 Irish National Grid coordinates for geophysical survey grid (30m x 30m) baselines. *

Appendix two: Raw geophysical survey plots

Magnetic Gradiometery Data

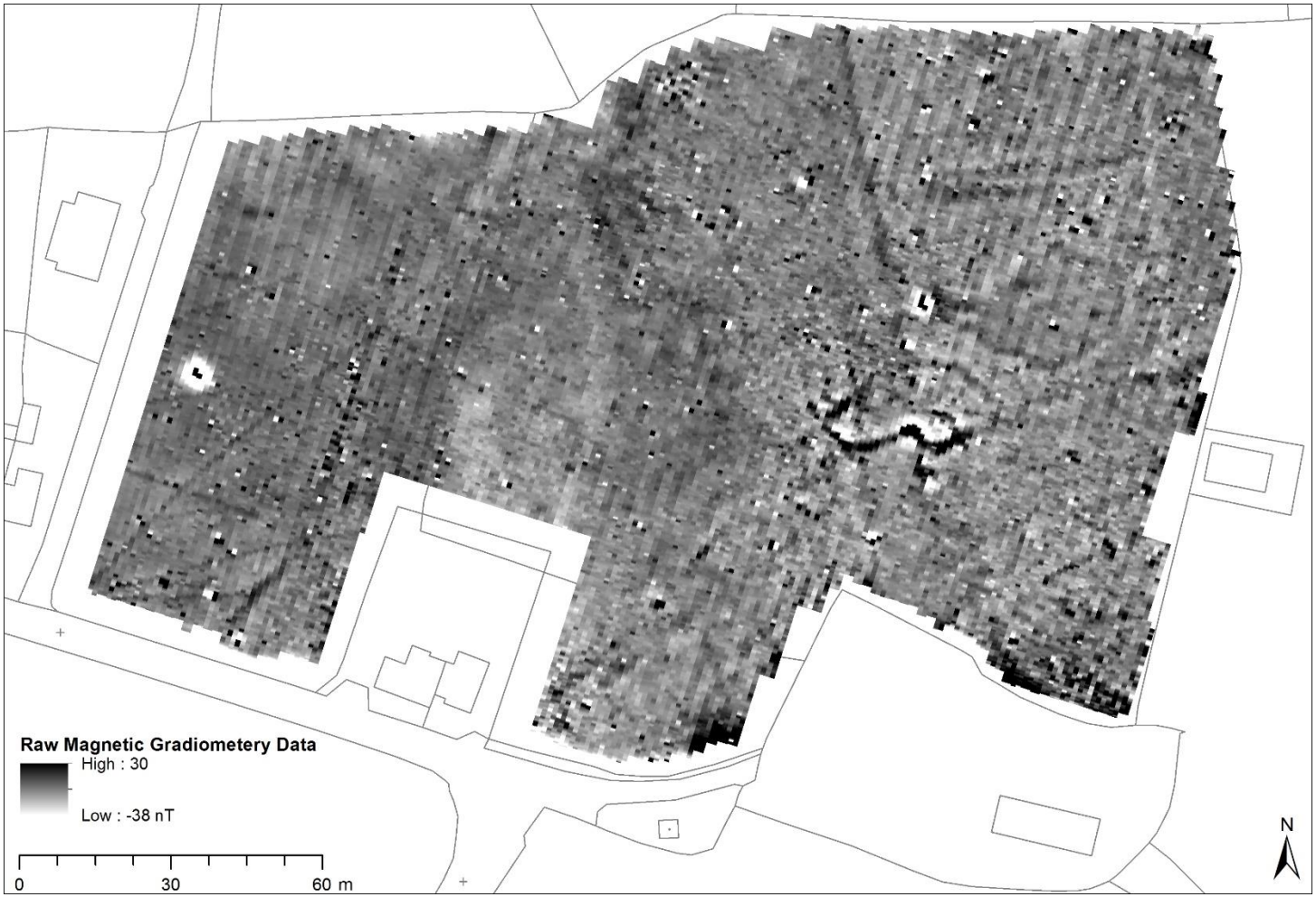

Figure 11 Greyscale plot of raw magnetic data. Clipped to +/- 3 Std. Dev with some area of magnetic peaking removed. Statistics: Mean: -7.42 nT, Std Dev.: 6.83.*

Electrical Resistance Data (1m sampling density)

Figure 12 Greyscale plot of raw resistivity data sampled at 1m gathered with 0.5m probe spacing. Data despiked and converted from resistance readings (Ω) to resistivity (Ω-m). Statistics: Mean: 39.75 Ω-m, Std Dev.: 19.51.*

Figure 13 Greyscale plot of raw resistivity data sampled at 1m gathered with 1m probe spacing.* Despiked and converted from resistance readings (Ω) to resistivity (Ω-m). Statistics: Mean: 34.9 Ω-m, Std Dev.: 18.57.*

Electrical Resistance Data (0.5m sampling density)

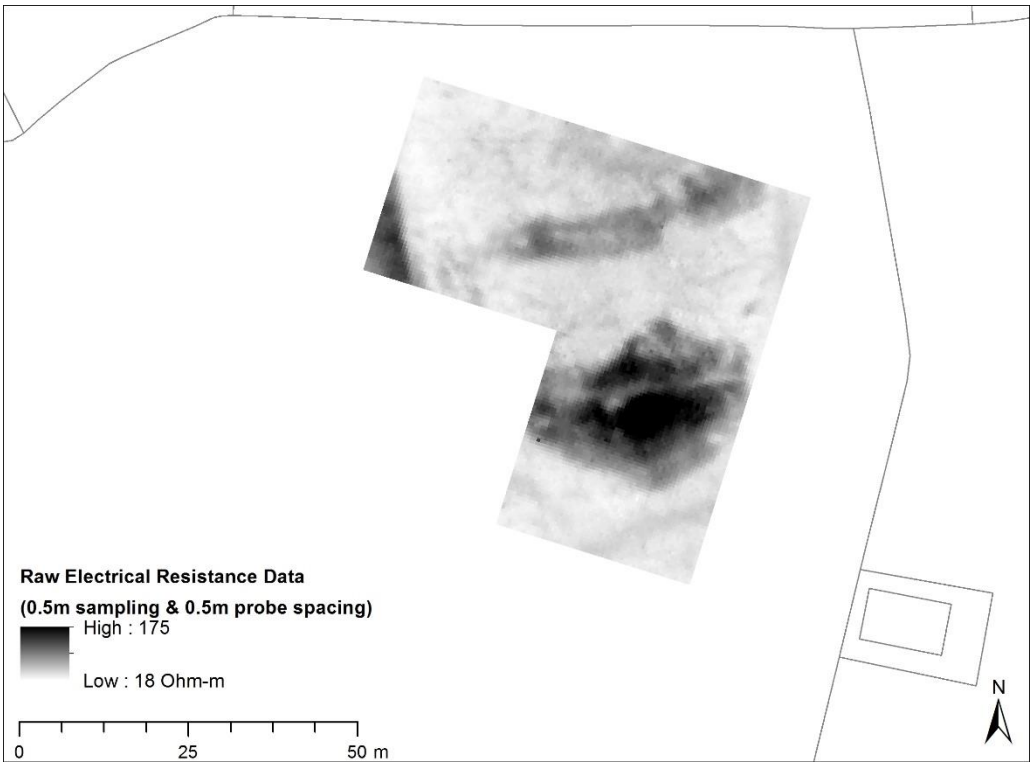

Figure 14 Greyscale plot of raw data sampled at 0.5m gathered with 0.5m probe spacing * Despiked and converted from resistance readings (Ω) to resistivity (Ω-m). Statistics: Mean: 48.38 Ω-m, Std Dev.: 28.36.*

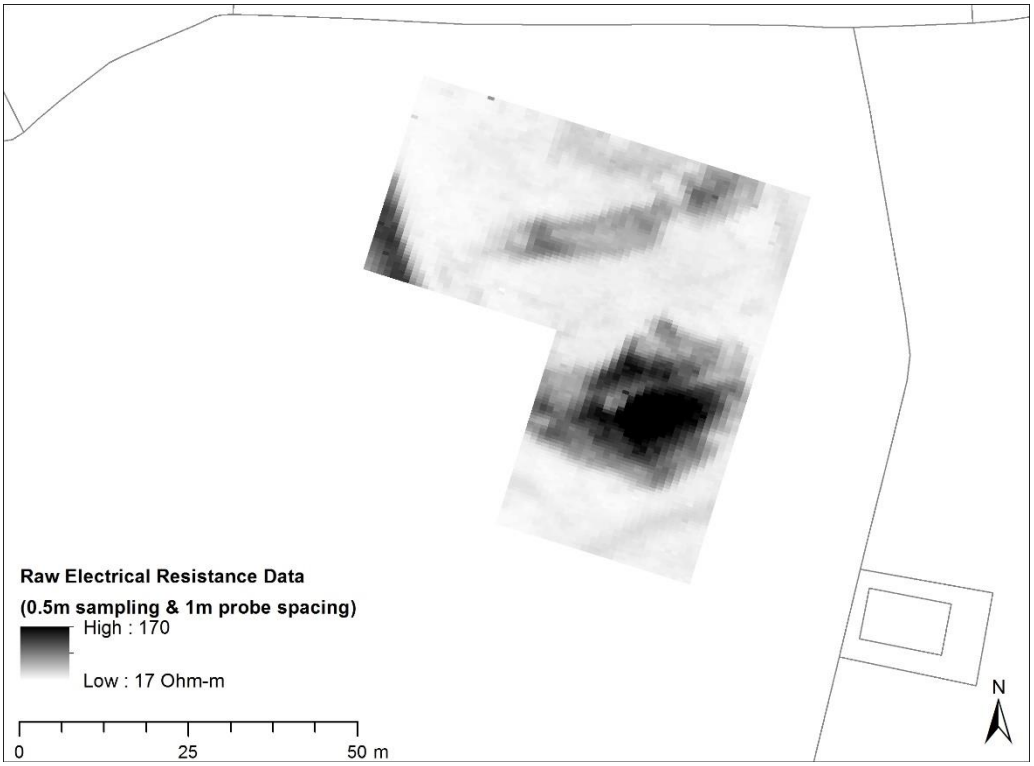

Figure 15 Greyscale plot of raw data sampled at 0.5m gathered with 1m probe spacing * Despiked and converted from resistance readings (Ω) to resistivity (Ω-m). Statistics: Mean: 39.67 Ω-m, Std Dev.: 27.77.*

Appendix three: Processed geophysical survey plots

Magnetic Gradiometery Data

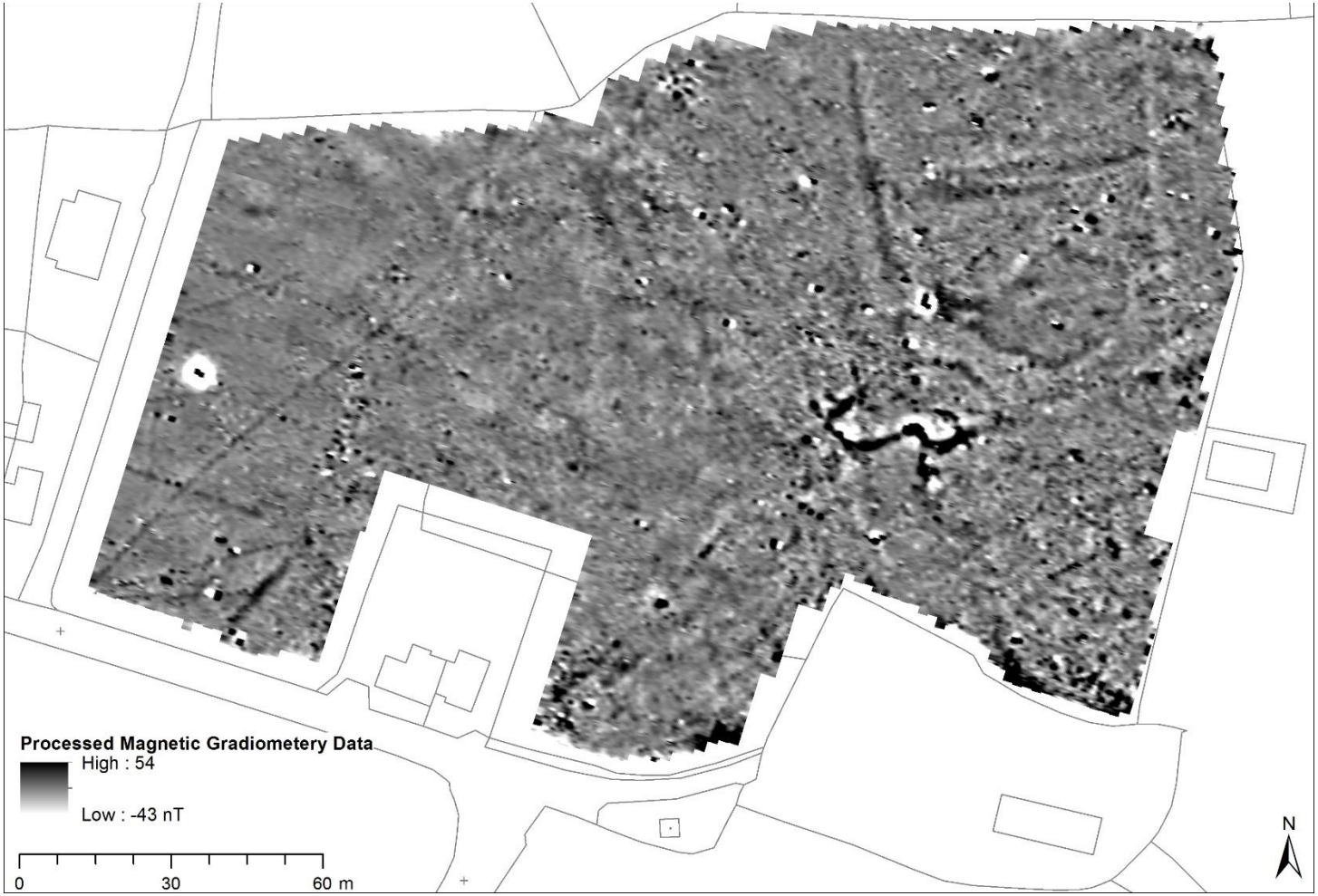

Figure 16 Greyscale plot of processed magnetic data. ZMT applied, despiked and sin(x)/x interpolation on y-axis (x2) & x-axis. Statistics: Mean: 0.20 nT, Std Dev: 5.32.*

Electrical Resistance Data (1m sampling density)

Figure 17 Greyscale plot of processed electrical resistance data sampled at 1m gathered with 0.5m probe spacing. HPF (Uniform weighting applied on the x- and y-axis), Sin(x)/x interpolation on x-axis (x2) and y-axis. Statistics: Mean: -0.09 Ω-m, Std Dev: 8.13.*

Figure 18 Greyscale plot of processed electrical resistance data sampled at 1m gathered with 1m probe spacing. HPF (Uniform weighting applied on the x- and y-axis), and sin(x)/x interpolation on x- and y-axis. Statistics: Mean: -0.07 Ω-m, Std Dev: 10.08.*

Electrical Resistance Data (0.5m sampling density)

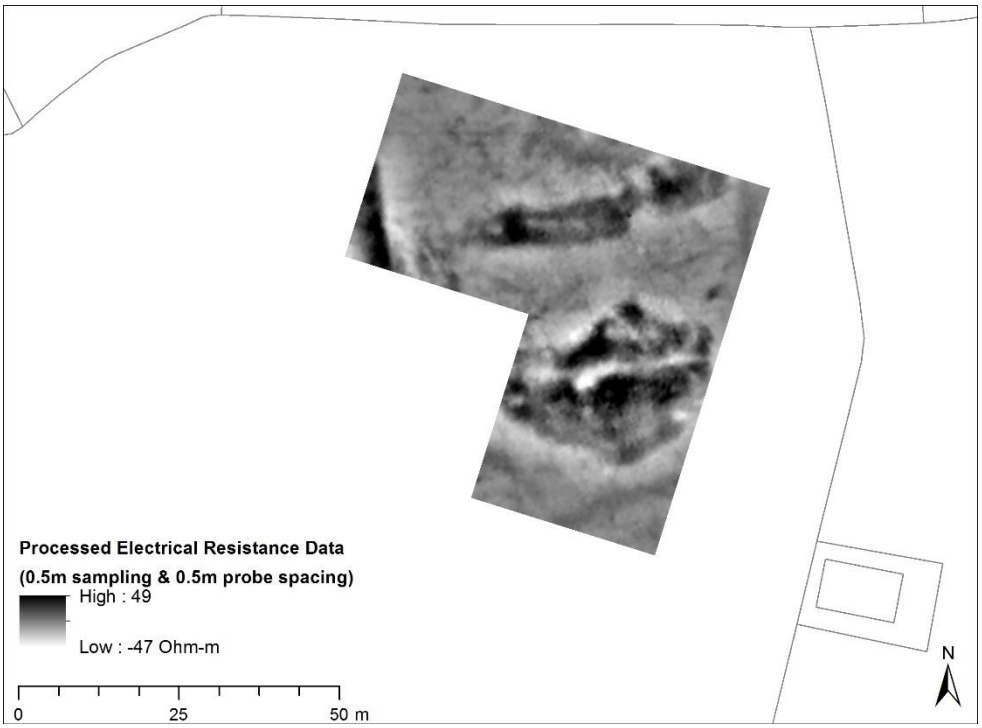

Figure 19 Greyscale plot of processed electrical resistance data sampled at 0.5m gathered with 0.5m probe spacing. HPF (Uniform weighting applied on the x- and y-axis), despiked and sin(x)/x interpolation on x- and y-axis. Statistics: Mean: -0.15 Ω-m, Std Dev: 10.52.*

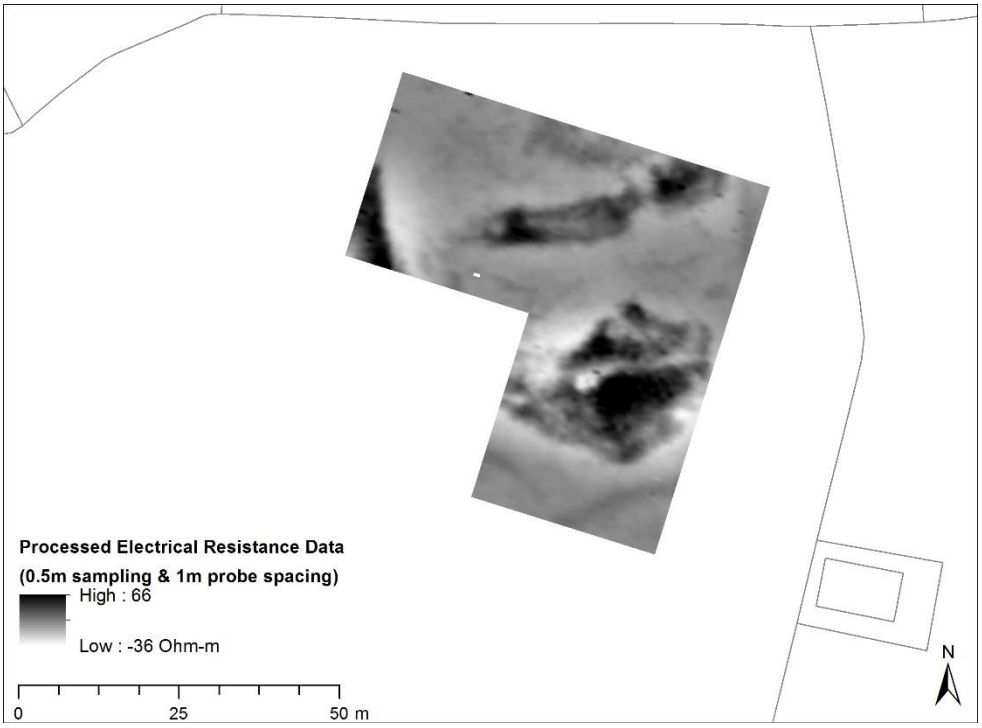

Figure 20 Greyscale plot of processed electrical resistance data sampled at 0.5m gathered with 1m probe spacing. HPF (Uniform weighting applied on the x- and y-axis), and sin(x)/x interpolation on x- and y-axis (x2). Statistics: Mean: -0.06 Ω-m, Std Dev: 13.37.*

Appendix four: Historical mapping

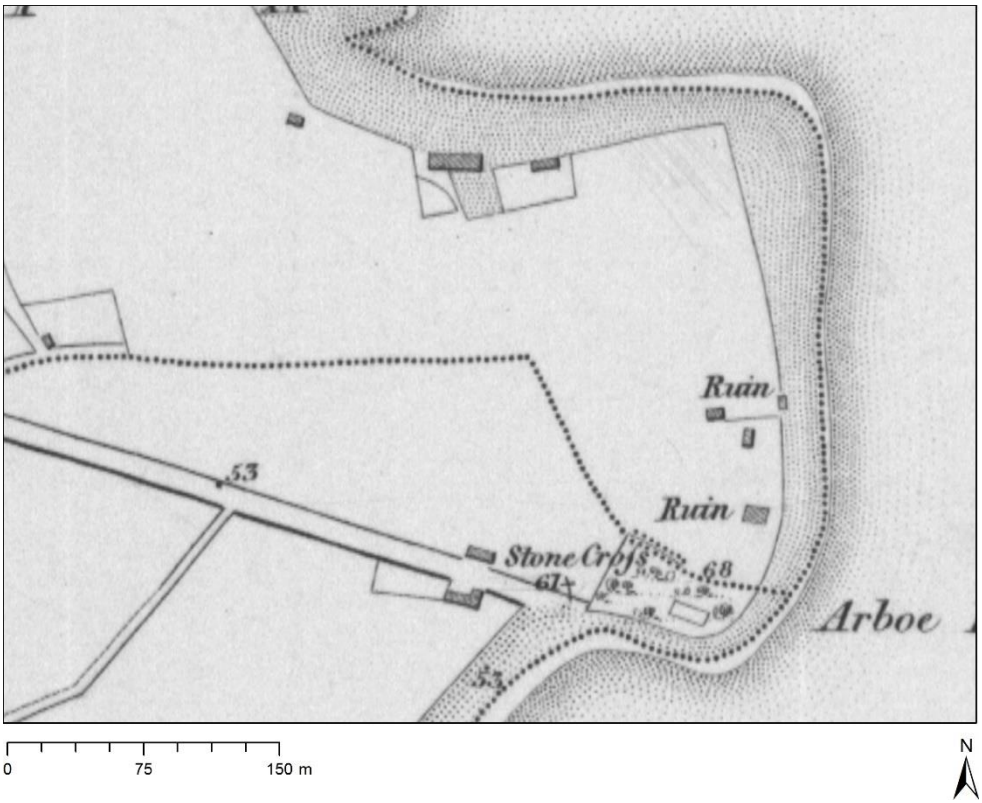

Figure 21 Ardboe headland as depicted by the First Edition Ordnance Survey County Series map, *c.* 1833.*

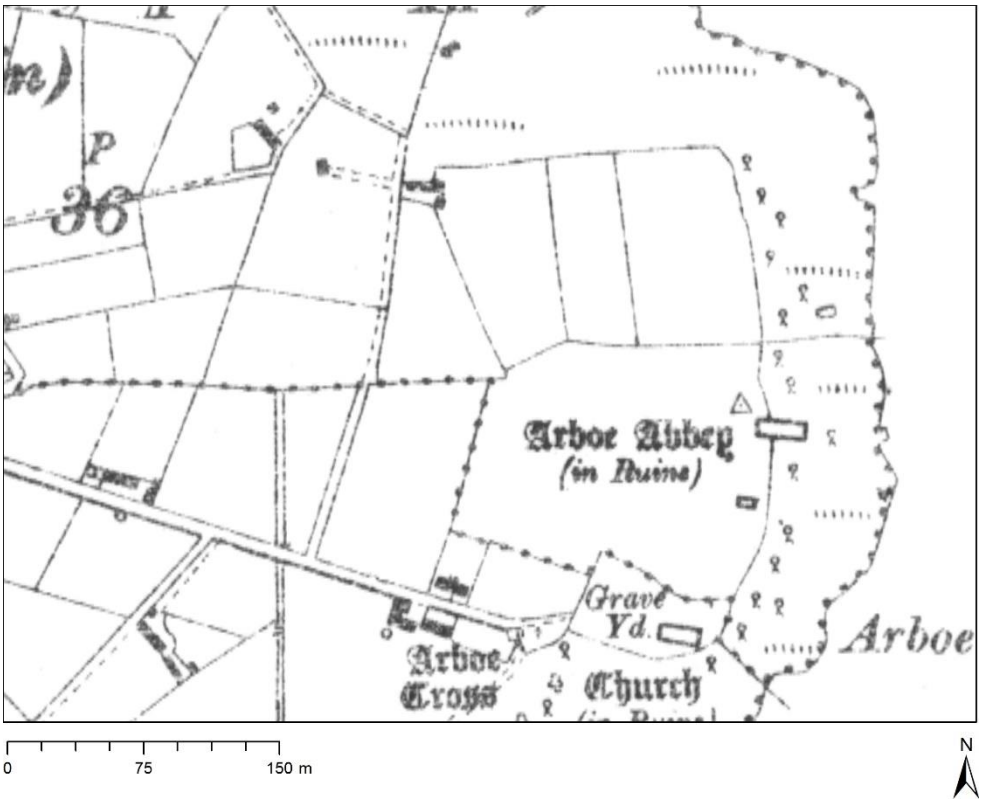

Figure 22 Ardboe headland as depicted by the Third Edition Ordnance Survey County Series map, *c.* 1905*

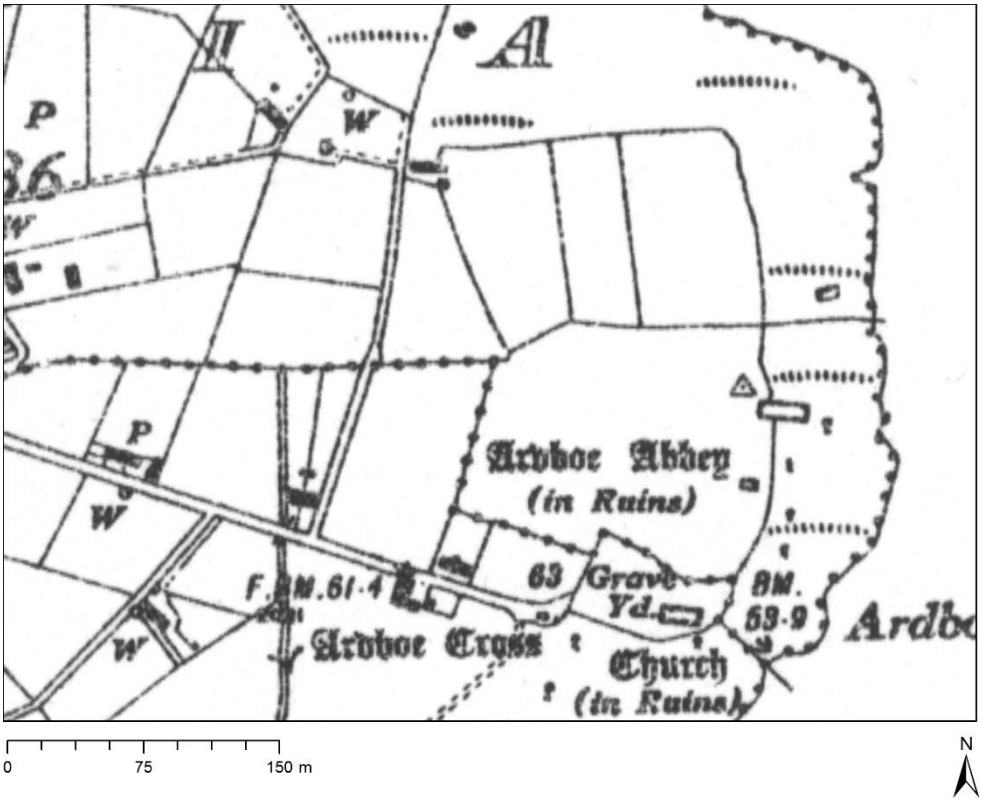

Figure 23 Ardboe headland as depicted by the Fourth Edition Ordnance Survey County Series map, *c.* 1935.*

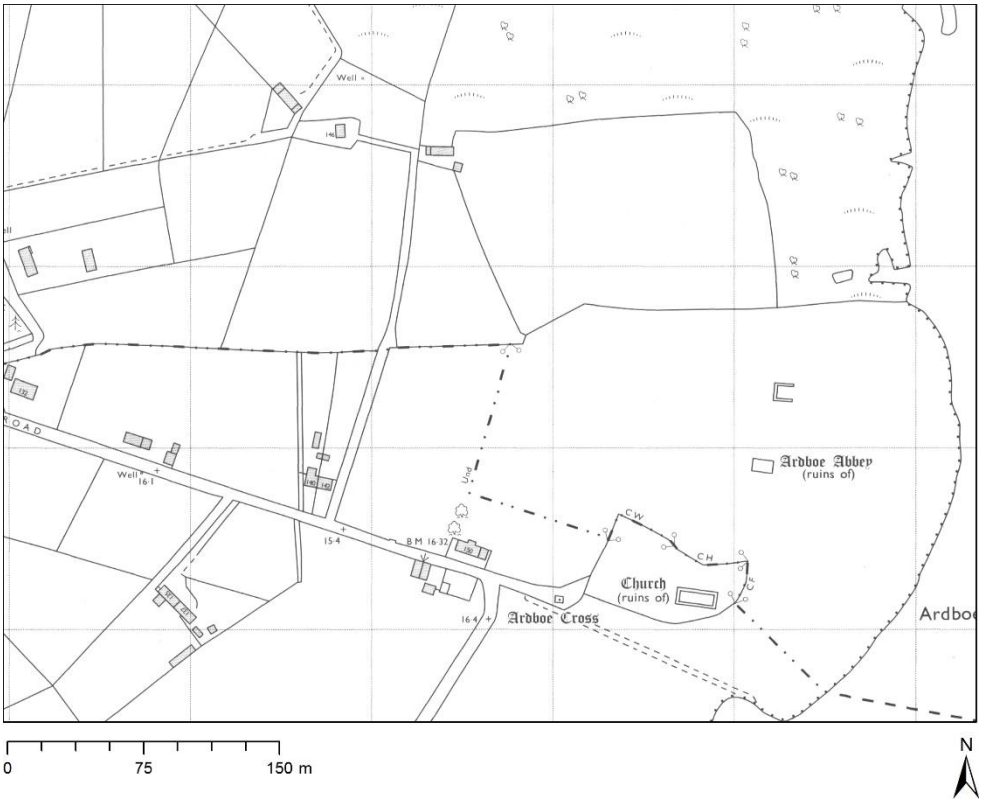

Figure 24 Ardboe headland as depicted by the First Edition Ordnance Survey National Grid Series map, *c.* 1975

Appendix five: Aerial imagery

Figure 25 Ardboe headland as captured by 2006 ortho-rectified aerial photography.*

Figure 26 Ardboe headland as captured by 2010 ortho-rectified aerial photography.*

Figure 27 Ardboe headland as captured by 2014 ortho-rectified aerial photography.*

Figure 28 The abbey with lands to the right under maize cultivation *c.* 1990s. Courtesy of Pat Grimes.