The Norse Waterways of West Mainland Orkney, Scotland

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Abstract

Norse place-names for farms, individual landscape features and general landscape areas are ubiquitous throughout the Orkney Islands. These have an origin during the medieval period AD790-1350 when Orkney was ruled by Scandinavian earls. The oldest referenced maps for the parish of Harray (West Mainland, Orkney) suggests that in the past significant waterways crossed wetlands extending between the Loch of Harray and Houseby in an area associated with the earldom power base at Birsay. Subsequent drainage projects, changes in climate and sea level have since resulted in the loss of the waterways. An investigation of the wetlands using geophysical and geological analysis provided a reconstruction of the palaeo-environments. Comparison with place-names of significance allowed interpretation of possible routeways along navigable waters by shallow-draught Viking-Age vessels. The results allow for re-drawing the map of Norse Orkney and postulation of produce transfer corridors from estates in the south to the power centre at Birsay.

Key Words

Norse; Orkney; Viking; vessel; waterway; palaeo-environment

Introduction

The archipelago of Orkney lies 10km off the north coast of Scotland, UK (figure 1) and is known for its iconic Neolithic archaeology (Downes et al., 2005) but also for its Viking and Norse history (c. AD790-1350) (Crawford, 2013). The low-lying landscape of Orkney today is marked by shallow lochs interconnected by slow-flowing streams and rivers. Since last glacial maximum 26ka, the landscape has changed significantly with rising sea level inundating the land along the coast (Bates et al., 2012) and more recently through change resulting from agricultural practices that include extensive artificial drainage networks (Thomson, 2008). Artificial drainage has considerably modified the natural drainage channels which would have resulted in the possible loss of navigable waterways to shallow draft craft that were in common use during Viking and Norse periods. This paper summarises the investigation and reconstruction of the potential pre-drainage navigable waterways across West Mainland of Orkney using physical survey methods and compares the results to research on historic place names.

Background

The geology of Orkney is typified by bedrock consisting of mid-Devonian flagstones that for the most part occur as flat-lying units with minor structural deformation and no acute folding (Marshall et al., 2011). This results in a very gently undulating topography today across the investigation area. The bedrock grain size within the flagstone varies from coarse basal units to fine mudstones which readily fracture into blocks. The bedrock surface is typically highly weathered (fractured and broken) and is commonly overlain by glacial till, the result of ice retreat following the last glacial maximum (Hall et al., 2016). Unconsolidated sedimentary sequences above the till depend on geographic position with hollows in the glacial landscape filling up with lake deposits consisting of fine grey silty sands and surrounding landscapes with windblown sand a common feature of coastal locations. A landscape that once consisted of small lakes joined by shallow, gently flowing streams has been lost where water-logging has occurred to create wetlands. In turn, the wetlands have given rise to peat deposits that have built up over the last 15ka with significant growth over the last 5ka (Whittington et al., 2015; Bunting, 1994). Climate change, natural processes of siltation and modification of drainage networks for agricultural purposes have had substantial impact on the landscape since the Norse period (Viking Age and Late Norse Period, c. AD790-1350). An aspect of the landscape change that would have been of great significance is that of the possible loss of navigable waterways. The potential existence of a network of such navigable waterways in the West Mainland of Orkney was an idea originally developed by Barbara Crawford (Crawford 2006a; Crawford, 2006b). This has been further examined in recent research using historic place-names, archaeology, and topographic study (Sanmark, 2017; Crawford and Sanmark, 2016) to highlight an important gap in our knowledge of the past landscape of this part of Orkney.

After the initial Norse settlement, the Orkney Earldom was created possibly as early as the late 9th century AD and gradually integrated into the kingdom of Norway, where it remained until the islands were mortgaged to the Scottish kingdom in 1468. The fertile West Mainland of Orkney was a key area of power for the Norse Earls, and this is where several earldom power centres were located, such as the residence on the Brough of Birsay (figure 1), and a large number of other estates linked to the Earls. One of the most significant estates is Houseby, in the parish of Harray, now located next to Sabiston Loch (formerly Loch of Houseby). Houseby is derived from Old Norse *húsabær* and translates as 'farms with many houses/buildings'. Estates bearing the modern name huseby/husaby are found across the Viking homelands of Sweden, Norway and Denmark. Outside Scandinavia, Orkney is the only area where these farms have been identified.

Published research into the Huseby farms dates from the 1950s (Steinnes, 1955), and in 2016 an edited volume containing the Stand der Forschung was published (Christensen et al., 2016). According to the current scholarly consensus, the Huseby farms formed part of a royal system that was introduced across all three Scandinavian kingdoms, with the growth of kingship in the 11th century. At this time, existing farms were renamed Huseby to signal their special function, most likely as royal farms for the collection of taxes in kind (Christensen et al., 2016). These farms shared many traits and characteristics, which varied slightly between geographical areas. The most relevant characteristic for this project is the location of the Huseby estates in the landscape. In this respect, researchers have shown that the Huseby farms were frequently situated at the convergence of different communication routes, often where land and major water routes met (see e.g. chapters in Christensen et al., 2016). Above all, a location by significant water routes seems to have been common, which fits with the idea of these farms as collection points for renders and rents in kind. This is indeed the case in Orkney too, as five of the six identified Huseby farms are located on the coast, by important sea routes. The one exception is Houseby on the West Mainland, which is currently found c. 3 km from the Loch of Harray and thus not directly accessible by boat today. In view of the evidence already presented above, this is rather surprising.

There is however a body of toponymic evidence which suggests that Houseby was most likely situated by a waterway of some kind. Houseby is located by the small Sabiston Loch (the former Loch of Houseby), southwest of which is the township of Sabiston. This is documented as 'Sebustar' in 1492 (Thomson,1996) and translates as 'Sea Farm' (Old Norse *sae bolstaðir* as discussed in Marwick (1952). In *The Place-Names of Birsay*

Marwick (1970) also acknowledges that the term 'sae' in an inland location is a 'sea' term and can be referring to the Loch of Sabiston/Houseby. The first element is used in Norwegian place-names to refer to an inland 'sea' or 'arm of the sea'. Greenay, the township to the northwest of Sabiston Loch, is another significant name which may be translated as 'shallow waters'. There is also Swartland farm ('Black Land'), 1 km west of Sabiston, which is said to refer to the dark, mossy nature of the soil. Another significant place-name, also a potential indicator of water routes, is Knarston (Old Norse *knarrar staðir*). This name is derived from the word for a transport vessel (Old Norse *knörr*) and denotes a farm where these vessels were moored. These names, and their topographical situation, have been examined in Norway and are known to be significant for transport routes and connections with the sea or rivers. This is indeed the case with the other Knarston place-names in Orkney which are found on the island of Rousay and on the Bay of Scapa near Kirkwall on Mainland. The Rousay Knarston is located c. 4km south of the Huseby farm (named Husabae) which replicates the close proximity of Knarston and Huseby farms in Harray (Crawford, 2006a).

The topography around the West Mainland Houseby supports the idea that the water levels were more suitable for navigation during the Norse period. This is particularly clearly seen in the area west and southwest of Sabiston Loch, an area of low-lying marshy terrain, which on late 19th-century Ordnance Survey (OS) maps is marked as 'liable to floods' (Figure 2a). The watercourses in these areas have been heavily modified with drainage channels as marked on all current OS maps. In the Norse period the Loch of Stenness was connected to the Loch of Harray via a narrow channel to the south of Brodgar marked today by the large standing stone called the Watch Stone. If navigable routeways through connected shallow lochs and gently flowing streams extended north from Harray then Houseby, which is located far inland on modern maps, could instead be shown to have been situated by a major water route through Orkney's West Mainland. In this way, the role of Houseby and other Earldom farms in this area can be shown to have formed an integral part of the Earls' administrative arrangements. It is further possible that the connections through the landscape north of Harray may even have been modified during the Norse period in order to make navigation more practical. Such undertakings are known, for example with the massive Kanhave canal on the island of Samsø in Denmark, which seems to have been constructed in the 8th century. These waterways, including modified streams connecting shallow lochs were easily traversed using the typical, shallow draft (often less than 0.5m) *snekkja* type vessels used to navigate inland waters (Crumlin Pedersen 2010). The development of inland waterways, and canals, in the Western Isles is exemplified in Martin and Martin (2017) with reference to Skye and by Angus (2018) on South Uist, but these locations and the evidence for the use of the water routes are rather different from the West Mainland of Orkney where the landscape has subsequently been more heavily modified.

The place-name Warth may also be of significance in this context. This farm lies to the south and west of the Loch of Sabiston and the Loch of Banks, in a low-lying locality which contains an unusually high density of drainage ditches, one of which is called the Burn of Warth. West of it is the small Loch of Rosemire. Warth is derived from Old Norse *varða* ('beacon'), but the origin of the name has been seen as 'obscure' as it is in a low-lying location. It has the same origin as the Ward Hills in Orkney, where the beacon meaning is well understood (Marwick 1970; Clouston, 1931). However, there is evidence from Denmark that the same name (Danish *warth*) was used for a *vagttarne* ('watchtower') in low-lying locations on routes through the waterways, such as the Roskilde fjord. Ole Crumlin Pedersen has studied all such watchtowers in the different branches of the fjord waterways leading to Roskilde as a *varslingsystemer* ('defence system') and shows the interconnecting viewpoints (viewsheds) (Crumlin-Pedersen, 1978). This was part of a wide-ranging signal system established in many fjords in the 11th century (Crumlin-Pedersen, 2010).

The toponymic evidence for an appreciation of the use of the waterways in the West Mainland of Orkney is tied geographically to the earldom Centre in Birsay and the farm of Houseby. The Houseby (Old Norse *husaboe*r) farms are considered to be administrative centres for the estates of the kings and powerful followers of the kings in Scandinavia. The 'many houses' of the place-name would have been partly storehouses for the food renders collected in from the estates and stored for the use of the kings and their

'hirdmen' (military followers). In Orkney the *husaboe*r farms would have functioned similarly for the earls and their retinues. We can therefore understand the Houseby farm on the Loch of Sabiston as a collection point for the food renders gathered in from the estates in the West Mainland (a very fertile part of the earldom) and that these estates may be the farms with the *staðir* endings (see Crawford, 2006a). One important purpose of the navigable waterways would be to enable the tenants and hirdmen to transport the heavy loads of provender (grain in particular) to the Houseby farm for distribution to the earldom power centre in Birsay (or further afield). That meant the further area of shallow lochs (Loch of Banks) could be used for navigating shallow vessels north from Houseby to the portage at Twatt and over to the Loch of Boardhouse which is in the western part of the earldom estates in Birsay (Crawford, 2006a). Another important reason for navigable waterways is of course general communication across the West Mainland, as travelling across water was far more efficient than overland on rough and muddy paths,

Methodology

Prior to field investigation of the site a background mapping exercise was conducted of all available georeferenced maps from the National Map Library of Scotland. These included Mckenzie's coastal charts of 1750, James Dorret's 1750 land maps, those of Crawford (2006a) and the series of UK Ordnance Survey (OS) 19th century maps (Figure 2). Together with recent aerial photography surveys using both drone acquisition and online images from Google Earth these allowed a targeting of potential infilled stream and lochs for further investigation.

Field work consisted of both geophysical remote sensing and collecting ground truth information using targeted coring. The ground geophysical methods adopted was direct current electrical resistivity tomography using an ABEM SAS4000 Terrameter (see supplementary data for more information) as this has proven successful in identifying palaeo-channels in other similar landscapes (Bates and Bates, 2016). The geophysics was acquired to image the subsurface geologic units including unconsolidated sediments and bedrock geology with the specific aim of exploring for natural channels beneath the present day modified (by drainage) surface. The geophysical lines were placed at key locations where channels were predicted from hydrographic stream models but where little surface manifestation of the streams was apparent. This was particularly the case at the upland end of the steam network near Tufta (Twatt) to the north of the Loch of Banks. The ground-based geophysical survey was supported by acquisition of additional high-resolution imagery and digital terrain models using an airborne drone. The drone was deployed using automated mapping programmes (PIx4D) flying at a height of 80m to give a ground resolution of 2cm.

Hydrographic modelling was performed using high resolution digital terrain or elevation models (DTMs) at 5m resolution downloaded from the OS through Digimap services and supplemented by very high-resolution (10cm resolution) topographic information acquired using drone mapping. The combined DTMs were then analysed as raster maps using ArcMAP v.10.7 (ESRI ltd.) with a methodology for producing stream flow analysis following the work of Tarboton et al. (1991). Final stream models were produced by initially filling the landscape elevations to calculate flow direction, flow accumulation and flow order based on methods originally developed by Strahler (1957). In addition a model analysis of the DTM was conducted to evaluate line-of-sight across the landscape from strategic localities such as the farms, elevated ground near bends of river, topographic saddles and neck points such as those where the stream channels flow between sub-valleys. Line-of-sight analysis calculates the intervisibility between different points on a landscape surface, that is what can and cannot be seen from any given position.

Ground truth coring was conducted using a standard Eijkelkamp 2.54cm diameter open hand gouge auger with sampling in the soft sediments down to over 2m depth. The core material was recorded in the field and sub-samples preserved at key intervals in the sections for further laboratory analysis. Location information and high-resolution topographic details of each field site were recorded using a Trimble ground-based GNSS and also with airborne imagery and topographic mapping using drones (see supplementary data for specifications).

Laboratory study included the assessment of selected samples for their contained microfossils. Samples were prepared using standard laboratory techniques (detailed in the supplementary materials) and included drying, fractionation, sieving and examination. A detailed recording of the microfossil species was undertaken and is presented as semi-quantitative indications of abundance. Dating of a key core interval from the area was achieved using AMS C14 analysis of plant remains undertaken by Beta Analytical laboratories, Florida.

Results

Figure 2 shows the 1750 maps by James Dorret and McKenzie together with the 1830 OS map for West Mainland Orkney. While the 1750 maps give the indication of natural drainage to the north, west and east of the Loch of Harray, already by first edition OS maps of 1880 these have been extensively altered by agricultural drainage. Figure 3a shows the results of stream modelling of the DTM (figure 1) and figure 3b indicates the wetland areas that would have been prone to flooding prior to artificial drainage. The gentle slopes and relatively flat lying nature of the terrain is clear from this analysis (figure 3c) with angle of slope dominantly less than 5 degree. The main drainage axis gradient, that is the slope angle along the streams show slopes for the most part of less than 1 degree. To illustrate this two pertinent transects have been drawn across the landscape along the main stream channel from the Loch of Harray through the Loch of Banks over to the Loch of Boardhouse and down to Birsay and along the eastern branch of the stream network from the Loch of Harray up to the Loch of Sabiston. The profiles along these transects are shown (with vertical exaggeration) in Figures 4a and 4b.

Figure 5 shows the results of coring along a transect across the lowest part of the landscape near to the Loch of Harray. Appendix A contains the logs of individual cores. Eighteen cores were acquired through the sequence that showed peat at the surface underlain by silty sands, grey silts and boulder clay. Refusal of the core was typically at the bedrock surface within 1m of the present day landscape surface apart from at the centre of the transect near to the Burn of Hackland where the river has cut a channel over 2m deep into the landscape and infilled the sides with sand and soft muds (Figures 6a and 6b). No sediments interpreted as lake or pond sediments were found in this transect and running water (river) sediments were not found. Microfossil analysis of the organic deposits showed plant debris, megaspores and insect remains together with the crustacea cladocerans and ephippia. A single freshwater ostracod species was recognised, namely, *Cypria ophtalmica.*

Further to the north a second investigation of the main channel was made to the west of Tounga and to the east of Warth Farm. At this point the river is crossed by a shallow ford and a small stone footbridge of indeterminate age. The river-cut bank sections to the west and east of the burn were logged and elevations measured for the heights of bedrock surface (Figure 7a). The section to the west showed almost no glacial till on top of the bedrock surface (Figure 7b) however the section to the east showed a typical thickness of approximately 1m of till (see photo, Figure 7c). It was noted that the bedrock surface is approximately 1.5m higher on the west. This evidence implies that the cutting in which the modern river lies predates the deposition of the till and is part of the antecedent topography. As such this step in the bedrock topography of the landscape would imply that in this low-lying environment river has probably occupied this location throughout the Holocene period. The situation of this bluff or cut bank area might be significant for a look out-guiding place in the landscape as it sits on a wide bend in the palaeo- and present river setting.

A further core transect was taken across the northern end of the Loch of Banks and extended up the gentle hill slope to the east of the loch (Figures 8a and 8b). This transect exhibits a deeper sequence of sediments than that at Dounby. The sequence here thins to the east and eventually is absent up-slope onto the agricultural land. At the centre of the transect the wetland gradually transitions into the Loch of Banks where the peat is underlain by a grey clay on top of a base of silt and stone typical of the till sequence above weathered bedrock seen throughout the islands. Two dates have been obtained from the main body of peat (Table 1) from borehole 5/14 (Figure 8a). The lowermost date at the base of the peat ($6840^{+}/_{-}30$ B.P.) provides a *terminus*

ante quem for the transformation of open water conditions towards the development of the reed dominated swamp. Analysis of the microfossils in BH4 identified two types of cold/cool ostracod indicator species, namely *Candona candida* and *Cytherissa lacustris* within the grey clays beneath the at 1.4 to 1.5m depth. In BH5/14 a further indicator species (*Limnocythere suessenbornensis)* was identified along with a wider range of cool climate indicator species. *L. suessenbornensis* is a species that is commonly found in late Pleistocene sequences but known to have become extinct by the Holocene suggesting that the freshwater lake was silted up prior to be onset of the Holocene.

The results of the direct current ERT survey conducted along a line located to intersect any possible enhanced or cut channel through the higher ground between the Loch of Banks and the Loch of Boardhouse is shown in Figure 9. Infilled channels should be manifest by different resistivity than the surrounding soils and bedrock. Apparent resistivity variation was recorded between less than 10 ohm.m and over 100 ohm.m. The zones of low resistivity were coincident with modern field drains at each end of the line but no clear channel feature was observed in the section.

The results from using ArcGIS to analyse the topographic significance of the landscapes by conducting a visibility analysis (line of sight) from the top of the bank near to Warth Farm are shown in Figure 10. It is interesting to note that down-valley and across the Loch of Harray there is clear line of sight to the Watch Stone located at the necking of the Brodgar peninsula where the Loch of Stennes and Loch of Harray meet.

Discussion

Analysis of maps, interpretation of current aerial photographs and modelling using GIS of the low-lying landscapes north of the Loch of Harray suggest that prior to the improvements in drainage a network of channels interlinked a series of shallow lochs. Peat sequences would have started to form in the islands subsequent to Last Glacial Maximum with extensive peat growth after approximately 5000 B.P. as the climate deteriorated (Whittington et al., 2015). The date on the base of the peat sequence ($6840^{+}/_{-}30$ B.P.) and date on the upper part of the main peat body ($2320^{+}/_{-}30$ B.P.) suggest a gap of perhaps 4000yrs might exist between infilling of the lake basin and development of the reed swamp. The continuity of deposits from the top of the sequence to present day imply that conditions have not changed significantly since the Iron Age apart from where agricultural drainage has taken place but that over time these lochs have become wetlands infilled with silt eventually leaving only the larger Loch of Sabiston and Loch of Banks as open water bodies today.

Analysis of the DTM gave insight to the possible locations of most streams across the area apart from to the north of the Loch of Banks. Here no indication of further channels was evident from either the model or high-resolution air photography. At this location the geophysics did not show any obvious signatures of cut channels beneath the modern agriculture topsoil profile either. This result suggests that if the channels did extend this far then the infilling material would have to be of the same electrical values as the surrounding material. At this location the topography rises to a maximum elevation of just under 20m, that is approximately 7m higher than the Loch of Banks. The stream channel gradients throughout the area do not exceed 1 degree. Due to the size of watersheds and gradient of streams these were likely of shallow depth but could still have provided transport routes for shallow draft vessels. If portage was necessary in the shallowest parts then this could have been easily achieved as has been established elsewhere in Scotland (Martin and Martin, 2018). It is mentioned in many sagas where kings, such as Olaf Haraldsson and Sverre Sigurdsson, are said to have moved their fleets considerable distances and even across mountain passes (Larsson, 2007). Gunilla Larsson, who has recreated a number of Viking Age ships with boat builders and also sailed them, has shown how frequent portages were used. She has also demonstrated that the ships and boats were light enough to be pulled on rollers over rather large distances, even up inclines (Larsson 2007 pers. comm. 2019).

The line of sight calculation (Figure 10) provides further insight to the possibility of navigation paths where there is clear line of sight from Warth to the Watch Stone at the southern end of Loch of Harray. This visibility

could perhaps represent something similar to the 'defence system' identified along the Roskilde Fjord, based on the *warth/vord* and *bavne* (beacon) names (Crumlin Pedersen 2010). The Watch Stone is interesting in this context, although the name is likely to be Victorian, it seems plausible that it may have been used for navigation purposes. There are a number of other Neolithic standing stones that seem to have served this function (Tom Muir, pers. comm. 2019) and even if the Watch Stone is of Neolithic date, it could have been used for this same purpose in the Norse period.

The place-names and existing landscape features support an investigation through a maritime lens. Moving north from the Loch of Stennes, Tufta in Skaebrae township is located where according to the OS map (Figure 2c), drainage ditches for the watery area of Orr Shun run into Harray Loch. There is also a second Tufta/Tufter, between Twatt and Boardhouse Loch (Marwick, 1970). Marwick derives these names from Old Norse *tupt* pl. *tuptir* 'an old house or building site', i.e. the usual meaning in Orcadian names. In Scandinavia, however, a link has been postulated between the place-name and the word *tofte* ('rowers seat' or 'thwart'), so that the farm may have been obliged to provide one rower for the *leidang* ship (the coastal defence levy) (Porsmose 1987 and Ole Crumlin Pedersen, pers. comm 2008). It is moreover interesting that in Hordaland in western Norway a connection exists between *tofte* and *snekkja/skipa,* two different names for longships, and Stylegar also cites *skipreidetufti*, in which the term is linked with the *skipreide* district which had to provide a 'fully equipped ship to the levy fleet' (Stylegar 2003, 10, 13). This points to Old Norse *tupt,* pl. *tuptir* being used of boathouse foundations, which could suggest that the 'Tufta' name in these two locations in Skeabrae and Twatt may indicate places where boats were drawn up and housed. In addition, the name Orr Shun itself is suggestive of water, as it could be translated as 'Grouse Tarn', from Old Norse *orri* and *tjörn* (Heggstad et al., 1975).

The location of Warth, to west of the Loch of Sabiston and the Loch of Banks, and on a raised part of the landscape in prominent view for considerable distance is likely to have been part of signal arrangements, (if not defensive) in the waterway system between Dounby and Twatt. It may be very relevant that the Warth farm is located at the narrowing of the channel indicated on Figure 9, which is where a track goes across the putative waterway to the mill situated at the outflow from Loch of Sabiston. Line of site analysis shows that this point is visible from far to the south across the Loch of Harray to a farm named Wart near the Brig of Waith. This location is exactly where a warning beacon or signal would prove helpful to seamen navigating the narrow, and shallow channel between the Loch of Stenness and the open waters of the Bay of Ireland. Previous surveys in the Loch of Stenness and Bay of Ireland to the south of the Brig of Waith show that this channel would have been open and navigable from at least 4ka (Bates et al., 2016). According to Clouston (1933), Wart is a 'shore name' and he suggests that it indicates 'an ancient mustering place for the local levies'. Joining these locations along the line-of-sight presents a marked routeway following open water in the Bay of Ireland, through the Brig of Waith, across the Loch of Stenness navigating via the Watchstone and Wart into the loch of Harray and then on up through the proposed stream channel network into the heart of the island (Figure 10). Such a route would have sign made easier travel through Mainland

The farm called Wattle on the north banks of Boardhouse Loch, has a name of great significance derived from Old Norse *veizla* (a technical term for food renders to a lord, and the name one of the Orkney scats, i.e. wattle). Marwick notes that this had possibly been a farm 'with the obligation of providing provender for the Norse earls when resident in Birsay' (Marwick 1970) and it may have been located in this position for the collection of food obligations from the surrounding estates in Birsay and Harray for transmission to the Earldom seat on the Brough of Birsay (Crawford 2006a). If this was indeed the case then food collection to a central place here and then transfer of this along the watery route from Dounby to Twatt and across Boardhouse Loch as indicated on Figure 10 would have been an easily achievable activity. Further, by collection and perhaps storage in this sheltered and protected inland location might have been highly desirable before transfer to the more open location on the coast. If so, it represents a vitally important part of the Earldom organization of food supplies.

At present we have no absolute dating of when this network of waterways was open along its full extent as a natural feature or one that was maintained as a navigable route. The date for peat in the Loch of Banks indicates that parts of the system were filling up since the Iron Age however maintaining navigable pathways could have still been possible for much longer. The persistence of Old Norse water-related names for farms and the connection between Birsay and these would suggest an ease of communication thus implying that the waterways were in use at that time. While no stone structures or channelled bedrock have so far been identified in the system as is the case for Rubh an Dunain, Skye (Martin and Martin, 2018) the small gorge-like connection between Birsay and the Loch of Boardhouse is intriguing as it would then provide a complete pathway through the interior of the island. The persistence of the network is also of debate but they could have extended to post-medieval period as has been reported at Caisteal Ormacleit, South Uist (Angus, 2018).

Conclusion

It is proposed that in the Norse period there was a network of waterways that crossed the West Mainland making it possible to cut through using a *snekkja* type vessel. It can be envisaged that vessels entered the Loch of Stennes via the Brig of Waith, and then moved into the Loch of Harray south of the Ness of Brodgar with possible navigation provided by the Watch Stone. Navigation through to the Loch of Harray was provided by beacons at Warth and from the northern point of Harray, it could have been possible that boats would be hauled up to the current lochs of Sabiston and Banks. Furthermore, even though no evidence of a channel exists beyond the northern tip of the Loch of Banks it is still within possibility that haulage to the Loch of Boardhouse was within the capabilities of Norse boat crews at the time as accomplished elsewhere (Larsson 2007, 163). Once in the Loch of Boardhouse, a stream leads from the northern end close to Wattle northwest to the Earl seat at Birsay. This potential thoroughfare through the West Mainland of Orkney has significance for the interpretation of the farm names in this area and may well explain the location of the *staðir* farms around the lochs, originally Earldom farms which were probably granted out to members of the Earl's retinue (Crawford, 2006a). It significantly changes how we think about the transfer of goods and people in the west Mainland of Orkney during the Viking Age and the Late Norse period.

Geolocation information

The study was conducted north of the Loch of Harray over to Birsay on west Orkney mainland, Orkney, Scotland.

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Declaration of Interest

The authors declare no conflict of interest

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Figures

Figure 1 – Location map (inset) and present day topography overlaid on OS 1830 map of West Mainland, Orkney with farms and areas discussed in text. (Backdrop mapping British National Grid)

Figure 2 – a) Wetland map of west Mainland Orkney after Crawford (2006a), b) James Dorret map, 1870 (https://maps.nls.uk/view/74400614), c) McKenzie map,1870 (https://maps.nls.uk/coasts/chart/4145) d) OS 1880 Map of West Mainland, Orkney. Reproduced with permission of the National Library of Scotland.

Figure 3 – a) Present day topography and modelled stream channels with geophysics (DC Resistivity refers to ERT transect) and core (Auger) locations, b) modelled streams and wetlands identified in OS 1830 maps, c) topographic slope with modelled streams. (Backdrop mapping British National Grid)

Figure 4 – a) Transect from Loch of Harray through to Birsay along main watercourse, b) profile from loch of Harray to Loch of Sabiston

Figure 5 – a) Core transect near Dounby and the Loch of Harray

Figure 6 – a) Bridge at centre of Dounby transect showing piers founded on bedrock, b) stream channel cut into bedrock

Figure 7 – a) Cross section through stratigraphy at Tounga foot bridge near Warth, b) photograph of ford and Tounga foot bridge near Warth Farm, c) west bank of burn of Warth showing bedrock cut section (trowel for scale 20cm)

Figure 8 – a) Core transect through Loch of Banks

Figure 9 – a) Transect showing results of the electrical resistivity tomography inversion acquired in a northwest to southeast direction across the saddle between the loch of Banks and the Loch of Broadhouse to the south of Twatt

Figure 10 – Visibility analysis (line of sight) from Warth showing potential Viking Route. (Backdrop mapping British National Grid)

Table 1. 14C dates from Twatt BH 5/14.

Borehole	**Laboratory code**	**Depth down borehole**	**Material**	**δ13C ($^0/_{00}$)**	**Conventional radiocarbon age (BP)**	**Calibrated range cal B.C.**
Twatt BH5/14	Beta-540087	0.42-0.44m	Peat, plant material	-27.5	2320+/-30 B.P.	430-355 (89.9%) 290-235 (5.5%)
Twatt BH5/14	Beta-540086	0.77-0.79m	Peat, plant material	-26.8	6840+/-30 B.P.	5785-5660 (95.4%)

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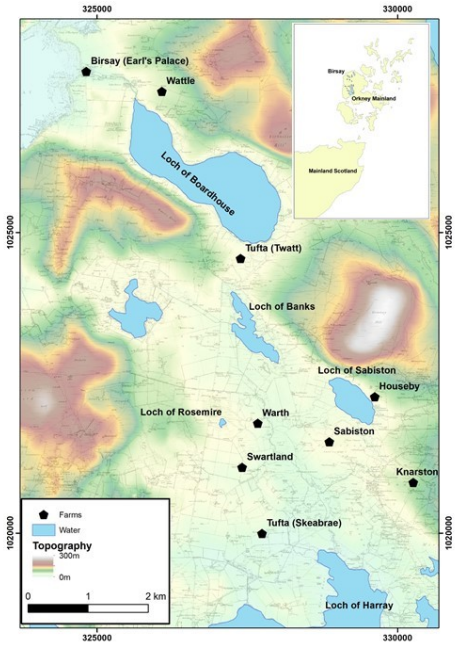

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a)

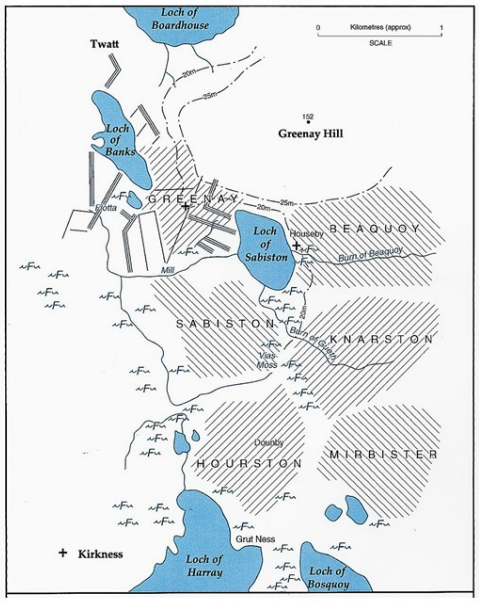

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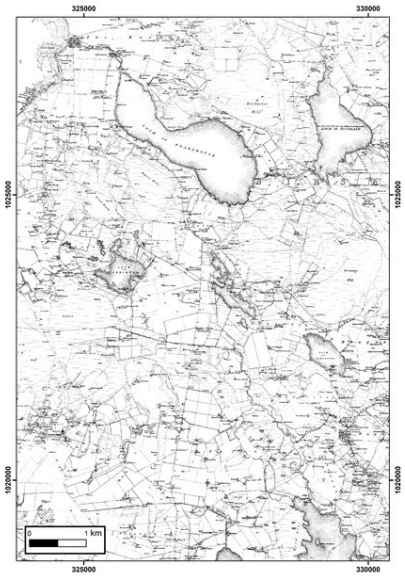
Figure 2 c) McKenzie map,1870 (https://maps.nls.uk/coasts/chart/4145) d) OS 1830 Map of West Mainland, Orkney. Reproduced with permission of the National Library of Scotland.

c)

d)



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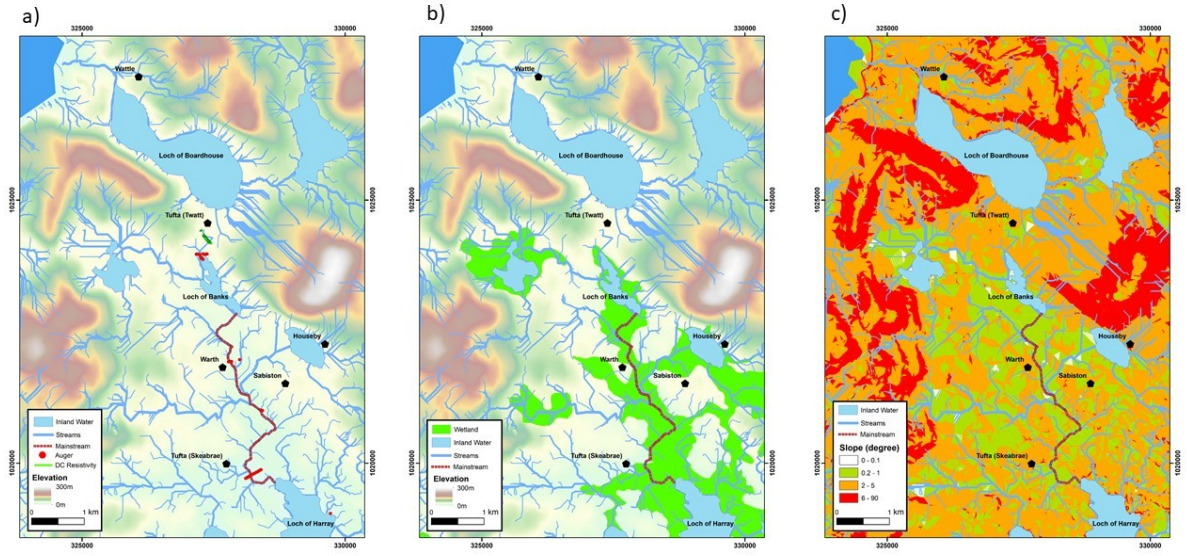

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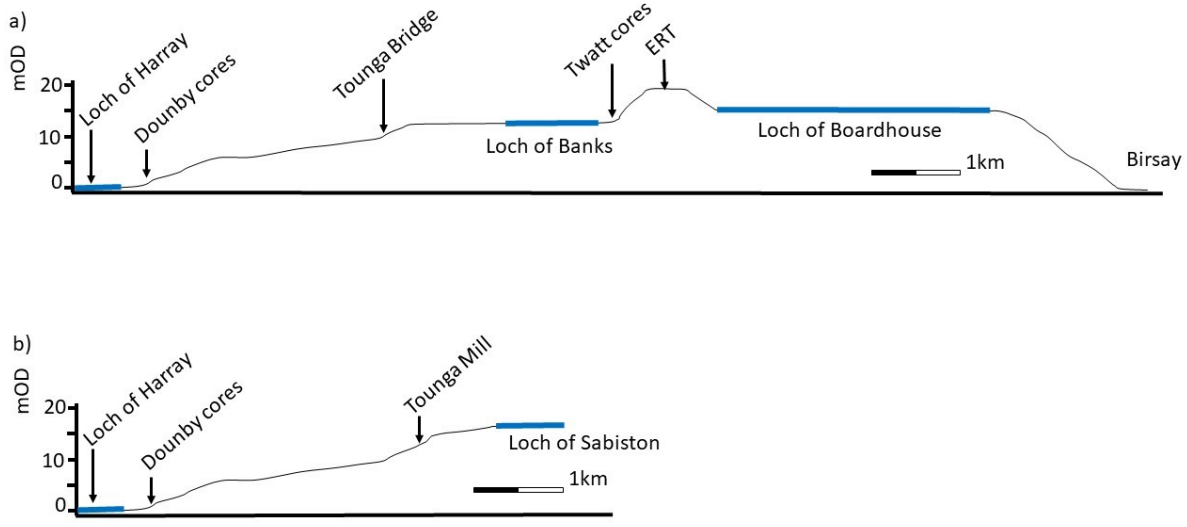

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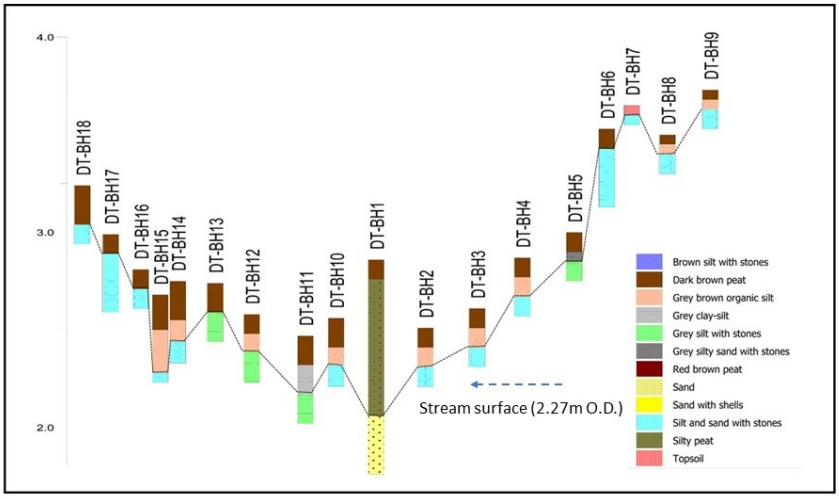

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a)

b)

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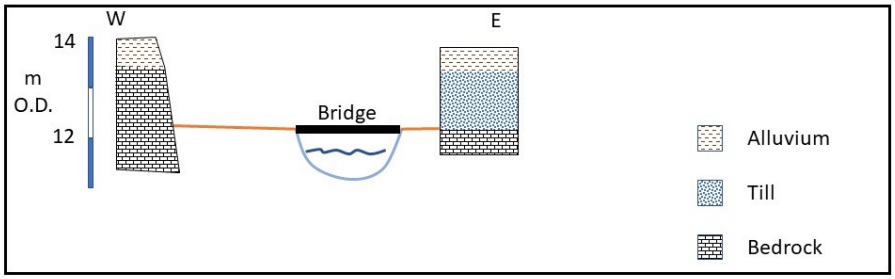

b)

c)

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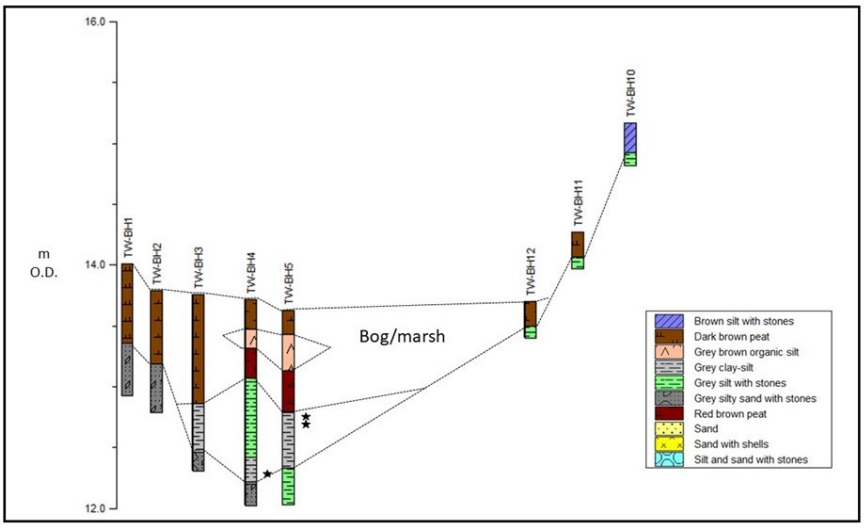
a)



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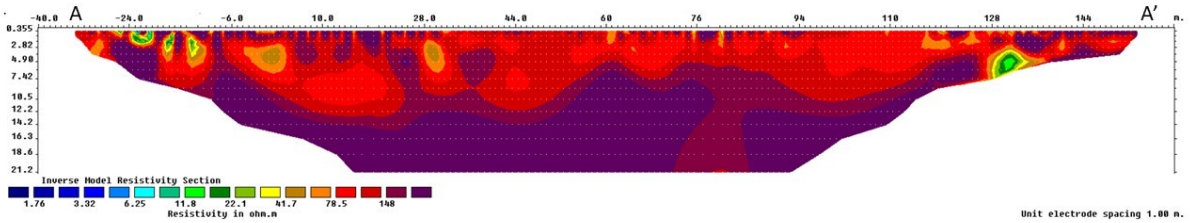

Figure 10 Visibility analysis (line of sight) from Warth showing potential Viking Route. (Backdrop mapping British National Grid)