The 'lost' islands of Cardigan Bay (Wales, UK): insights into the post-glacial evolution of some Celtic coasts of northwest Europe

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ABSTRACT

A 13th - 14th-century map held in the Bodleian Library (the Gough Map and the oldest map of Great Britain) shows two 'lost' islands in Cardigan Bay offshore west Wales (UK). This study investigates historical sources, alongside geological and bathymetric evidence, and proposes a model of post-glacial coastal evolution that provides an explanation for the 'lost' islands and a hypothetical framework for future research: (1) during the Pleistocene, Irish Sea ice occupied the area from the north and west, and Welsh ice from the east, (2) a landscape of unconsolidated Pleistocene deposits developed seaward of a relict pre-Quaternary cliffline with a land surface up to c. 30 m above present sea-level, (3) erosion proceeded along the lines of a template provided by a retreating shoreline affected by Holocene sea-level rise, shore-normal rivers, and surface run-off from the relict cliffline and interfluves, (4) dissection established islands occupying cores of the depositional landscape, and (5) continued down-wearing, marginal erosion and marine inundation(s) removed the two remaining islands by the 16th century. Literary evidence and folklore traditions provide support in that Cardigan Bay is associated with the 'lost' lowland of Cantre'r Gwaelod. The model offers potential for further understanding post-glacial evolution of similar lowlands along northwest European coastlines.

INTRODUCTION

Cardigan Bay (*Bae Ceredigion* in Welsh) is a large embayment in the St. George's Channel situated on the west coast of mid-Wales, United Kingdom (UK), bounded to the north by the Llŷn Peninsula and to the south by St. David's Head (Fig. 1). The geological history of Cardigan Bay and its present physical setting is provided by Tappin *et al.* (1994, and references therein) and associated geological maps (Institute of Geological Sciences 1982; British Geological Survey 1988, 1990). Only one significant island currently exists in Cardigan Bay, Bardsey Island (*Ynys Enlli*), located off the southern tip of the Llŷn Peninsula. However, the earliest map of Great Britain, known as the Gough Map, shows two additional islands in the central part of Cardigan Bay which no longer exist and have not been considered previously in terms of the post-glacial evolution of the coastline.

The aim of the present study is to consider these 'lost' islands and to examine the implications for understanding post-glacial coastal evolution of Cardigan Bay and elsewhere along the Celtic seaboard of northwest Europe. In addition to the coastline of Wales, the coasts of Scotland, Ireland, the Isle of Man, Cornwall, the Isles of Scilly, and Brittany in northwest France, are included in this group of northwest European Celtic coasts. They are generally characterised by exposure to the Atlantic Ocean and hard rock Palaeozoic geology that have combined to give rise to an overall peninsula-type morphology for each region, with widespread features of Pleistocene glacial and/or periglacial origin.

SOURCES

This investigation utilises a range of historical sources, fieldwalking, and available bathymetric and topographic information, coupled with a geomythological approach to draw upon evidence from medieval literature and from folklore.

Historical Sources

The two 'lost' islands of Cardigan Bay are shown on the Gough Map, which is the earliest known map of Great Britain (Pelham 1933; Parsons 1958; Skelton 1959). The historical map is held in the

Bodleian Library of the University of Oxford (*ms*. Gough Gen. Top. 16) and is so named after its previous owner, Richard Gough, who donated it to the library in 1809. For many years it hung on the wall in the Map Library of the Bodleian but its significance is such that a major project undertaken by the Gough Map Panel (Delano-Smith *et al.* 2017) has digitised it and made it available online for researchers to utilise (Linguistic Geographies Project 2021). The date of the map is debated with estimates ranging through the fourteenth and fifteenth centuries with *c*. 1360 often cited (e.g. Parsons 1958; Lilley *et al.* 2009), but with advocates for a later date around 1400 or later (e.g. Smallwood 2009). It has also been suggested that it is based on an earlier original estimated to date from around 1280 with the surviving version being a revised copy (Birkholz 2004, 2006).

The use of historical maps in general should be made with caution; however, in this case a level of reassurance is reasonably provided by specialist opinion. For example, Lloyd and Lilley (2009) state that "one of the attributes of the Gough Map ….. consistently remarked on by scholars is the apparent geographical truthfulness of its content, particularly the shape of the British coastline and islands …" (p. 29). Therefore, based on such academic views and notwithstanding early survey techniques and resultant cartographic distortions, the fundamental geographical features shown on the Gough Map might be considered reasonably secure. Nevertheless, the outline of Wales is strange in shape on the Gough Map and the current embayed configuration of Cardigan Bay is absent, a fact that Bower (2015) attributes to the poor combination of separate surveys used to construct the map. Nevertheless, the lack of curvature of Cardigan Bay on the Gough Map does not cast significant doubt in itself on the distinct occurrence of the two 'lost' islands depicted on the map offshore the Cardigan Bay coast.

A second historical source is Ptolemy's *Geographia*, collated CE 120–160, and the geographical references for coastal locations in Roman Britain that it lists (Strang 1997). Ptolemy's coordinates for places listed in Cardigan Bay have been corrected by North (1957) and may be used to establish historical positions for those locations to permit comparison. Some authors have produced maps of

Roman Britain based on Ptolemy's coordinates (e.g. Strang 1998) but as a few locations only are listed for Cardigan Bay, such an exercise connecting the points is of limited benefit locally.

A literature search and review for other relevant historical sources is undertaken using searchable online literature databases, such as the University of Oxford's Search Oxford Libraries Online (SOLO) service, and hard-copy sources in the collection of the Celtic Library of Jesus College, Oxford.

Physical Aspects

Bathymetric information for Cardigan Bay is obtained from the Marine Themes vector data (dated March 2018) based on the UK Hydrographic Offices authorised material, and topographic information is from the Ordnance Survey, both accessed through *Digimap*. Reconnaissance fieldwalking of sections of the Cardigan Bay coastline has been undertaken to supplement the published literature on, and gain an appreciation of, the region's geology and geomorphology. The fieldwalking was conducted through the period 2016 - 2020 on sites of interest, principally for familiarisation and to obtain photographs. Field observation is supplemented by examination of satellite imagery using *Google Earth Pro*.

Geomythological sources

Geomythology as a sub-discipline was formally defined by Vitaliano (1968), who stated that geomythology "seeks to find the real geologic event underlying a myth or legend to which it has given rise; thus … [helping to] … convert mythology back into history" (p. 5, see also Burbery 2021). A number of geological and geographical studies have included a geomythological dimension, such as Carson and Athens (2007), Cashman and Cronin (2008), Cashman and Giordano (2008), Piccardi *et al.* (2008), Rappenglück *et al.* (2010), Nunn (2014a, b, 2016), Walsh *et al.* (2017), Helm *et al.* (2019), Liritzis *et al.* (2019), Combey *et al.* (2020), Wilkie *et al.* (2020), Stewart (2021) along with a collection of papers published in a Geological Society of London Special Publication entitled *Myth and Geology*

(Piccardi and Masse 2007). The present study employs this approach to identify sources and extract coastal geomorphological information from medieval literary sources and modern folklore traditions to compare with other evidence.

RESULTS

Historical Sources

The Gough Map depicts two elliptically-shaped and featureless islands lying offshore the central part of coast of Cardigan Bay (Fig. 2). The long axis of the islands lies roughly parallel to the mainland coast. Settlements and rivers included on the map have been identified by the Linguistic Geographies Project (2021) and can be used to locate the islands more precisely. The southern island is shown to lie offshore the mainland between the river estuaries of the Afon Ystwyth in the south, close to the town of Aberystwyth, and the Afon Dyfi to the north, close to the town of Aberdovey. The northern island occurs offshore the mainland between the Dyfi and the Afon Mawddach, close to the town of Barmouth (see Fig. 3 for annotated and re-orientated version of Fig. 2).

Although no scale is given on the Gough Map, the distances between the rivers provide a guide to measurement. Using *Google Earth Pro*, the approximate present-day straight-line distance between the mouths of the Ystwyth and Dyfi is *c.* 14.4 km, and between the Dyfi and Mawddach *c.* 19.5 km. The dimensions of the offshore islands may be estimated in proportion to these respective two sets of measurements, so that the southern island measures approximately 6.6 x 3.8 km (*c.* 19.7 km^2) and the northern island 10.7 x 5.8 km (*c.* 48.7 km^2), and that the islands lie c. 3.5 - 4.0 km from the mainland shore. However, these measurements must be viewed with extreme caution given the poor areal accuracy of the Gough Map.

From a review of North (1957), it appears that it is generally accepted that Ptolemy provided positions for four locations in Cardigan Bay: the Llŷn Peninsula (*Canganorum promotorium*); one of the westernmost headlands in Pembrokeshire (*Octapitarum promontorium*); and the mouths of the

rivers Teifi (*Tuerobis fluvii ostia*) and Ystwyth (*Stucciae fluvii ostia*). North (1957) provides a correction to Ptolemy's coordinates, based on discrepancies between the latitude and longitude used, and concludes that the "mouth [of the Afon Teifi] ….. is in nearly the right position" (p. 173), being in a similar position to its present-day location, but that the mouth of the Afon Ystwyth "is about 8 miles [c. 13 km] out in the sea" (p. 174) from its present location. Furthermore, North (1957) speculates that if "the coast lay a little farther out than it does now, a very likely possibility, the rivers Ystwyth and Rheidol would have joined before reaching the sea and Ptolemy's *Stucciae fluvii ostia* may well have been the combined estuary of those two streams" (p. 174). North (1957) advises caution but concedes in general terms that "Ptolemy's information was not so inaccurate as might first appear" (p. 173) and that Ptolemy "often came nearer to the truth than we suppose" (p. 174), which provides a degree of reassurance that the corrected positions in Cardigan Bay might be used to evaluate other information.

Relevant historical sources are the 6th-century *De Excidio et Conquestu Britanniae* by Gildas and the 9th-century *Historia Brittonum* formerly attributed to Nennius (Giles 1841; Dumville 1975; Winterbottom 1978), Geoffrey of Monmouth's *De Gestis Britonum [Historia Regum Britanniae]* (Reeve and Wright 2007), medieval saga poetry and triads, the *Mabinogi*, and local antiquarian accounts, such as Meyrick's (1808) history of Cardiganshire. Some of these sources provide historical statements as well as reflecting literary and folkloric accounts, which nevertheless have geomythological value (see below), but caution must be exercised where the boundary between history, literature and tradition may have become blurred. For example, the subtitle of Meyrick's (1808) history is 'collected from the few remaining documents which have escaped the destructive ravages of time, as well as from actual observation', suggesting that some of the content is based on unspecified material that, if it ever existed, may now be lost, and, therefore, not all content may be corroborated by surviving sources. Relevant details from these sources are introduced below and in the Discussion section where appropriate.

Bathymetry

The inshore bathymetry of Cardigan Bay is shown in Fig. 4 and indicates water depths in excess of 30 m in the west generally shallowing eastwards towards the shore. There are four bathymetric features that are of interest. In southern Cardigan Bay a shore-parallel elongate bathymetric depression, known locally as the Trawling Grounds, extends for approximately 30 km from Aberystwyth south to Newquay and the mouth of the Teifi estuary at water depths in excess of 20 m. To the north, between Aberystwyth and the Dyfi estuary, a ridge-like submarine high (<10 m water depth) extends to approximately 12 km offshore, shallowing to less than 2 m water depth around the summit of the high. This submarine ridge is locally known as Sarn Cynfelin ('Cynfelin's Causeway') or, sometimes, Sarn Gynfelyn or Sarn Wallog. Between the Dyfi and Mawddach estuaries, a second ridge-like submarine high (<10 m water depth) extends approximately 8km offshore, again shallowing to less than 2 m water depth along the crest of the submarine ridge, which is known locally as Sarn y Bwch ('The Buck's Causeway'). A third submarine high (<10 m water depth) occurs north of the Mawddach estuary, known locally as Sarn Badrig ('Patrick's Causeway'). The crest of the Sarn Badrig ridge is in water shallow enough for it to be exposed at low tide, extending over 20 km offshore.

Quaternary Geology

The desk-based geological review indicates that Cardigan Bay comprises unconsolidated Quaternary deposits underlain by Palaeozoic and Mesozoic basement rocks (Tappin *et al.* 1994). The majority of the Quaternary deposits are associated with the Pleistocene glaciation of the region, including a widespread *c.* 30 m-thick lodgement till assigned to the Upper Till of the Cardigan Bay Formation, and various facies assigned to the Western Irish Sea Formation, of which the Sarnau Facies characterises the geology of the Sarns. The Sarnau Facies is a diamicton that comprises gravel, cobbles and boulders in a clay matrix and has been interpreted variously as remnants of median moraines of piedmont glaciers issuing from the Welsh mainland valleys (Garrard and Dobson 1974;

Garrard 1977) or as remnants of late-glacial sandur deposits (Tappin *et al.* 1994). The facies is 50 m thick in a borehole north of the Mawddach estuary.

Subsequent to Tappin *et al.* (1994), Bowen *et al.* (1999) established the St. Asaph Formation to include the 'Irish Sea till' and the Elenid and Meirion formations to include till from glaciers sourced from upland mid- and northwest Wales respectively. North of Aberystwyth, the Welsh till extends 10 - 12 km seaward of the present-day coast (Garrard 1977), offshore the Ystwyth-Dyfi and Dyfi-Mawddach coastal sections, and beyond that the Irish Sea till occurs. In southern Cardigan Bay, however, the Irish Sea ice over-rode the present-day coast to deposit till approximately 10 km inland and at altitudes up to approximately 250 m above present sea level (*e.g.* British Geological Survey 2006).

Field exposures of the Irish Sea till and associated Pleistocene deposits that remain along the present-day coast include *c.* 20 m-high cliffs at Newquay and Cwm Silio, and *c.* 30 m-high cliffs at Mwnt, Afon Cwinten, and south of Aberystwyth (Williams 1927; Rijsdijk and McCarroll 2001; see Fig. 5). Furthermore, Williams (1927) describes a number of coastal 'platforms' or terraces underlain by these Pleistocene deposits that extend up to *c.* 1 km inland from the present-day coast, approximately to the 30 m contour, and are backed by relict cliffs representing a pre-glacial coastline (Fig. 6). Therefore, these depositional terraces occupy palaeo-embayments of a former coastline. The geomorphology of the present-day coastline in these areas typically comprises eroding cliffs of Pleistocene deposits fronted by coarse-clastic storm beaches associated seaward with sand terraces and gravel-lag deposits as may be seen along the coast south of Aberystwyth, for example (Fig. 6).

The infill of the submarine channel marked by the Trawling Grounds depression is characterised by the Mud Facies of the Western Irish Sea Formation of Tappin *et al.* (1994), which spans the end of the Pleistocene extending into the Holocene. Garrard (1977) and Haynes *et al.* (1977) report a radiocarbon date (Birm. 400) from a peat sample collected in the Trawling Grounds northeast of Newquay. The sample came from c. 2.5 m downcore in a water depth of c. 16 m near the base of the

Mud Facies, approximately 0.5 m above the junction with underlying glacial till. The sample yielded a date of 8740 ± 110 BP (9539-10, 154 cal BP; calibrated using OxCal with IntCal20 (Reimer *et al.* 2020) at 95.4% probability) and a palaeoenvironmental study of the core indicates that the Trawling Grounds channel was under estuarine conditions at this time due to postglacial sea-level rise (Haynes *et al.* 1977). Garrard (1977) interprets the Trawling Grounds channel as being initially formed by early post-glacial rivers in the southern part of Cardigan Bay being diverted to the south as the route to the west was blocked by retreating Irish Sea ice.

Estuarine deposits are also recorded from the Dyfi estuary and at Tywyn where Holocene silts and clays began to be deposited approximately 8000 yrs BP (Cave and Hains 1986; Pratt *et al.* 1995). During sea-level lowstands rivers cut channels in the underlying bedrock which became infilled and flooded during postglacial sea-level rise (e.g. Blundell *et al.* 1969). Estuarine deposition continued until the mid-Holocene when increased sedimentation and a decrease in the rate of sea-level rise resulted in the terrestrialisation of the intertidal surfaces and the growth of trees, preserved as a 'submerged forest', which by 4700 yrs BP had developed into ombrogenous mires that accumulated peat, such as Borth Bog on the southern bank of the Dyfi estuary (Cave and Hains 1986). A submerged forest also occurs between Aberystwyth and the Dyfi estuary in a valley at Clarach (Heyworth *et al.* 1985) and is dated to 5404 yrs BP (6196 - 6281 yrs BP). The submerged forest at Clarach occurs within a >10 m depositional sequence that remained predominantly terrestrial throughout; however, diatom evidence indicates increased marine influence at this site from 2560 ± 80 BP (2366 - 2783 cal BP).

Geomythology

The scholarly monograph *Celtic Folklore* (1901) by Sir John Rhŷs, former Jesus Professor of Celtic and Principal of Jesus College, Oxford, is an important early secondary source of information regarding legends and traditions in the Cardigan Bay area and elsewhere along the Celtic coastline of northwest Europe. Some of the previously mentioned historical works also present local legends and

traditions (*e.g.* Meyrick 1808; North 1957; Reeve and Wright 2007) that make useful contributions. Of particular geomythological interest are legends regarding now 'lost' coastal lowland landscapes, not only in Cardigan Bay but also associated with Cornwall, Brittany, and elsewhere.

According to Welsh folkloric traditions (see below), a 'lost' landscape, often regarded as a submerged landscape locally, once occupied what is now Cardigan Bay and is variously referred to as Cantre'r Gwaelod (the 'Lowland Hundred' or 'Lowland of the Depth', a 'cantref' being the intermediate administrative division of medieval Wales) or Maes Gwyddno ('The Plain of Gwyddno'). In the 17th century, antiquarian Robert Vaughan, in his 'Survey of Merioneth' (National Library of Wales ms. 472B), considered Sarn Badrig to be the remains of the defensive wall of Cantre'r Gwaelod (North 1957, p. 153). J. E. Lloyd tentatively suggested that the Cantre'r Gwaelod story involves 'reminiscences handed down through many generations of the effects — at times, perhaps, startling — of this gradual subsidence [in Cardigan Bay] attested by geology' (Lloyd 1911 vol. 1, p. 5). Bromwich (1950 p. 227, 231) is more circumspect, suggesting that it is an attempt to explain the observed geological formations in Cardigan Bay, rather than a direct recollection of inundation events.

In recent folklore, Gwyddno is presented as the ruler of Cantre'r Gwaelod and the inundation is the result of the negligence of the drunken gatekeeper, Seithiennin, while, in medieval versions of the tale, Seithiennin is the focus, probably the lowland's/island's king, and Gwyddno is mentioned only indirectly in the name Maes Gwyddno. A tradition that seems to go back to triads, possibly forged by Iolo Morgannwg in the 19th century, portrays Gwyddno as King of Ceredigion in the 5th and 6th centuries (North 1957 p. 152-3). Gwyddno is also linked to the mythological figure of Taliesin in *Ystoria Taliesin*, a tale attested from the 16th century. Here, Gwyddno's castle is located specifically in Aberystwyth (in most versions of the tale) or somewhat further north, between the Ystwyth and the Dyfi (in Llywelyn Siôn's version of the same tale, Cwrtmawr ms. 20) (Ford 1975, p.

453; Wood 1980). A number of 15th-century genealogies claim descent to Gwyddno through his son Elffin.

The folkloric traditions build on earlier traditions that find literary form in a number of medieval Welsh sources (Bromwich 2014, p. 391-392). Elffin is mentioned in a number of poems of the Gogynfeirdd (Poets of the Princes). Porth Wyddno 'Gwyddno's Harbour' is mentioned in a medieval Welsh triad (Bromwich 2014, p. 246) as being in the north (of Britain); and Gwyddno is listed as one of Gwŷr y Gogledd 'the Men of the North', and a descendent of Dyfnwal Hen (Bromwich 2014, p. 256). Thus, an early tradition links him with the Old North (today's southern Scotland). Whether his name was associated with the submersion of Cantre'r Gwaelod in the Old North or only after he became known in Wales is unclear. Evidence of place names links him both to Ceredigion and the Conwy estuary: places named Cored Wyddno 'Gwyddno's weir' are found both in Aberconwy and in Ceredigion, and there is a stream called Gwenwyn meirch Gwyddno in Arfon (Williams 1957, p. 5; Bromwich 2014, p. 392).

The fate of Cantre'r Gwaelod itself is mentioned in a poem in the Black Book of Carmarthen (mid-13th century), the first stanza of which is given here in Rachel Bromwich's interpretation and translation:

Seithenhin sawde allan
ac edrychuirde varanres
mor maes guitnev ry toes.

'Stand forth, Seithenhin,
and look upon the fury of the sea;
it has covered Maes Gwyddneu.' (Bromwich 1950, p. 217)

As noted above, Gwyddno is here not the ruler of Cantre'r Gwaelod, as in the later folkloric tradition, and appears only in the name of the land inundated. A similar presentation is found in *Bonedd y Saint*, a list of genealogies of saints first redacted in the 12th century, in which a number of saints are listed as sons of 'Seithennin Vrenhin o Vaes Gwydno a oresgynnvs mor ev tir' ('Seithennin king of Maes Gwyddno, whose land the sea overran') (Wade-Evans 1944, p. 322).

The tale of Cantre'r Gwaelod suggests the lowland was suddenly inundated and overwhelmed by a flood which Meyrick (1808) asserts occurred in CE 520, although he provides no evidence to support this date.

Similar legends also exist of other 'lost' landscapes elsewhere. In Brittany, King Gradlon (or Grallon) is said to have ruled the city of Ys, the sudden inundation of which is referred to in the Breton Life of St. Gwenôlé (Widmer and Jørgensen 2011). This report goes back to the Latin life of the saint (*Vita Sancti Winwaloei*, de Smedt 1888), believed to have been composed 860 - 884 (see also Bromwich 1950, pp, 232-241; Piriou 1992; Poulin 2009, p. 396-445). Taken at face value, the inundation would be contemporaneous with Gwenôlé himself, that is, in the late 5th or early 6th century. Other examples come from southwest England, where Lyonesse is claimed to have existed around the Isles of Scilly and the southern coast of Cornwall; and in north Wales, where it is also claimed that Llys Helig ('Helig's Court') suffered an inundation in the 5th or 6th century. A Latin triad interspersed among genealogical material in Exeter Cathedral Library ms. 3514 (late-13th century) lists the kingdom of Helig son of Glannog among the three realms that the sea destroyed, placing it between Ceredigion and Bardsey towards Aberdyfi (Aberdovey), in the north of Cardigan Bay (Jones 1948; Bromwich 2014, p. lxxiv-lxxv). The location of this kingdom in Cardigan Bay rather than off the north coast of Wales has been suggested to reflect the earlier tradition (North 1940), bringing it and the tale of Cantre'r Gwaelod closer together. Indeed, it has been suggested that they were originally one and the same (Bromwich 1950, p. 231).

Most famously, in *Branwen,* the second branch of the medieval Welsh *Mabinogi* tales, when Bendigeidfran, king of the Island of Britain, leads his forces across from Wales to Ireland (although not on their return), the intervening sea consists merely of two navigable rivers, called Lli and Archan: "Bendigeiduran, a'r yniuer a dywedyssam ni, a hwylyssant parth ac Iwerdon, ac nyt oed uawr y weilgi yna: y ueis yd aeth ef. Nyt oed namyn dwy auon: Lli ac Archan y gelwit. A guedy hynny yd amlawys y weilgi, pan oreskynwys y weilgi y tyrnassoed" (*Branwen*, ed. Thomson 1986 lines 252-256) ('Bendigeidfran and the army we mentioned sailed towards Ireland, and the sea was not wide then; Bendigeidfran waded across. There were only two rivers, called the Lli and the Archan. Later the sea spread out when it flooded the kingdoms', trans. Davies 2007, p.28; see also Rhŷs 1901, p. 386; Sims-Williams 2010, p. 192-196).

DISCUSSION

The 13th-14th-century Gough Map provides cartographic evidence for the existence of two 'lost' offshore islands located in Cardigan Bay. Considering the geological setting, any such islands are likely to have comprised unconsolidated Pleistocene deposits that were susceptible to lateral erosion. It is also likely that the geomorphology of island coasts, at least on the exposed seaward sides, would be analogous to present-day coastal settings in Cardigan Bay with eroding cliffs of unconsolidated deposits fronted by coarse-clastic storm beaches, sand terraces and gravel-lag deposits. The recession of the cliffs would have resulted in the areal reduction of the islands with marine action in the surf zone further eroding the exposed surface of the Pleistocene deposits. Indeed, Garrard (1977) recognised that such erosion across the region resulted in "a thin but extensive cover of lag gravel, resting on a distinct plane of marine erosion" (p. 91). The more sheltered, landward-facing, leeside, island coasts may have been different in character and supported depositional landforms comprising more fine-grained sediments.

Bathymetrically, the two islands depicted on the Gough Map appear to be located approximately coincident with Sarn Cynfelin, between the Ystwyth and Dyfi estuaries, and Sarn y Bwch, between

the Dyfi and Mawddach estuaries, suggesting that the coarse clasts of these sarns may have 'anchored' the islands resulting in significant gravel lag accumulations following erosion of the diamicton's finer-grained matrix. Furthermore, the height of the land surface of the islands may be estimated if the altitude of the 20 - 30 m-high cliffs of Pleistocene deposits that remain along the Cardigan Bay coast is extrapolated westward. This approach suggests the land surface height of the islands in the areas of the two sarns might have been up to 15 - 25 m above sea-level in areas enclosed by the present-day 5 m isobath or 10 - 20 m in waters enclosed by the 10 m isobath. However, due to surface lowering, through simultaneous weathering and erosion of the unconsolidated sediments, it is likely that the altitude was lower than these maximum estimates.

It appears that the erosion of the two islands was completed by the mid-16th century, as the islands do not appear on later maps, such as Thomas Butler's *Mape of Ynglonnd* dated to 1547 - 1554 (Birkholz 2006). Therefore, the disappearance of the two 'lost' islands may represent a stage in the gradual planation and removal from Cardigan Bay of the top decametres of unconsolidated Quaternary deposits due to marine action operating on the Holocene sea-level high-stand, a process that has not yet been fully completed, as substantial areas of Quaternary deposits remain as terraces and exposed in cliffs along the Cardigan Bay coast as observed in the field seaward of the relict pre-glacial coastline (e.g. Fig. 6).

Historical, literary and geomythological evidence might suggest that the two 'lost' islands were remnants of a larger area of lowland formerly occupying Cardigan Bay. Ptolemy's coordinates place the mouth of the Afon Ystwyth in the 2nd century CE c. 10 - 15 km to the west of its present position (North 1957), approximately coincident with the 10 m isobath, and south of Sarn Cynfelin roughly along the line of longitude of its westernmost tip. This suggests that the coastline at this time was seaward of the western shores of the 'lost' islands. Furthermore, the tale of Cantre'r Gwaelod might suggest that the lowland, or at least part of it, continued to be inhabited up until the 5th-6th centuries.

A number of authors have considered the legend of Cantre'r Gwaelod to represent a folk memory of gradual landscape submergence through rising sea levels during the Holocene marine transgression (e.g. Matthews 1993; Kavanagh and Bates, 2019; Nunn *et al.* 2021). However, the association of this memory with a sudden inundation tends to contradict this view. Elsewhere, coastal submergence due to gradual post-glacial sea-level rise is represented in traditions, such as in Australian Aboriginal myths, that either recall "how two landmasses, now separated by a water gap, were once joined" or "how people once crossed a water gap (by wading or swimming) from one landmass to another, a feat that would be impossible today" (Nunn 2016, p. 397). In Wales, the *Mabinogi* description of Bendigeidfran's crossing to Ireland, with only two navigable rivers lying in between, aligns well with the second of these tradition types involving gradual sea-level rise, but the sudden inundation of Cantre'r Gwaelod does not align with a sea-level rise explanation for its demise and instead evokes a more rapid event or series of events.

In support of a sudden inundation event or events, the only 6th-century historical source, that of the British monk Gildas, in his *De excidio et conquestu Britanniae,* records the pleas of the Britons in the face of barbarian invaders in the following way: "repellunt barbari ad mare, repellit mare ad barbaros; inter haec duo genera funerum aut iugulamur aut mergimur" ("the barbarians push us back to the sea, the sea pushes us back to the barbarians; between these two kinds of death, we are either drowned or slaughtered" (Winterbottom 1978. p. 23-24); "the barbarians drive us to the sea; the sea throws us back on the barbarians: thus two modes of death await us, we are either slain or drowned" (Giles 1841, p. 32). While this may simply mean that the Britons were caught between the sea and the attackers, it might also imply that both were seen as equally hostile as a result of a significant marine event or events at this period causing loss of life. This event is usually dated to CE 446 (Thompson 1979, p. 214; see also Sims-Williams 1983, p. 5-15).

Whether such an inundation(s) was due to storm surge or tsunami is not possible to discern but an interesting account (the legend of Aber Llyn Lliwan) included in the 9th-century *Historia*

Brittonum, and repeated by Geoffrey of Monmouth (Reeve and Wright 2007), recounts a marine phenomenon linked to the 5th or 6th century that describes unusual tidal conditions and a mountainous wave in the Severn Estuary along the south Wales coast (Rhŷs 1901). Evans *et al.* (2008) have suggested that this refers to a specific site where whirlpools occur near the coast; however, it may also be describing a tsunami event and, moreover, Bryant and Haslett (2007) and Haslett and Bryant (2007) present historic and physical evidence indicative of historic tsunami events in south and north Wales respectively. It is clear that this question requires further investigation in the future.

Taken together, the cartographic, historical, physical and geomythological evidence conspire to provide a preliminary framework for the post-glacial evolution of Cardigan Bay, developing a hypothesis that may be tested through future research:

1. During the Late Glacial, Cardigan Bay was occupied from the north and west by Irish Sea ice and Welsh ice from the east. In southern Cardigan Bay, the Irish Sea ice deposited glacial till approximately 10 km inland of the present-day coastline up to 250 m above present sea-level. In the northern part of Cardigan Bay Welsh ice extended *c.* 10-12 km west of the present coastline. The Welsh ice deposited significant accumulations of coarse clasts, including those that comprise the present-day sarns of Cardigan Bay.

2. Unconsolidated Pleistocene deposits, including glacial till, were deposited across Cardigan Bay seaward of a relict pre-glacial coastline producing a depositional subglacial landscape. Remaining cliffs of unconsolidated deposits that occur along the modern coastline suggest a surface altitude of up to 30 m above present sea-level for these unconsolidated deposits.

3. The post-glacial erosion of the unconsolidated Pleistocene deposits may have followed a template provided by land drainage and Holocene sea-level rise. Initial retreat of the Irish Sea ice, from the present shoreline of southern Cardigan Bay, forced emerging rivers, such as the Afon Teifi and Aeron, to flow southwards excavating the Trawling Grounds channel.

More northerly rivers, such as the Afon Ystwyth, Dyfi, and Mawddach flowed westward as the Welsh ice retreated eastwards from its confluence with Irish Sea ice. Once Irish Sea ice had fully retreated to the west and north, the Holocene transgression would begin to act on the western margin of the deposits and establish estuarine conditions in the coastal river valleys. Run-off from upland bedrock areas between the rivers is likely, in places, to have removed material fronting the relict pre-glacial cliffline.

4. As erosion progressed, the landscape would become dissected by westward flowing rivers eroding laterally to widen their valleys, coastal erosion and eastward retreat of the western margin, and erosion and north-south removal of materials from the foot of the inter-river upland bedrock areas, perhaps eventually connecting southwards with the Trawling Grounds channel. This process might have resulted in the formation of islands in the cores of these dissected areas, such as the two 'lost' islands depicted on the Gough Map positioned between the lines of rivers.

5. Marine inundation(s) and continued down-wearing of the interfluves and marginal erosion removed the two remaining islands by the 16th century and the process continues in eroding and removing areas along the present-day coast underlain by unconsolidated Pleistocene deposits.

Through this process, the river valleys, including the Trawling Grounds channel, became submerged landscapes, preserving post-glacial deposits in palaeochannel infills. However, islands of unconsolidated Pleistocene deposits forming the inter-river areas were not submerged but removed through lateral erosion to produce a plane of combined fluvial and marine erosion constituting a stratigraphic unconformity between underlying Pleistocene deposits and overlying modern seabed sediments.

The mean rate of removal of the depositional landscape in the period between the recording of Ptolemy's coordinates and the drafting of the Gough Map is estimated to be c. 10 m/yr if marine

erosion only of the coastline was responsible for retreat of the shore back to the approximate position of the present-day coast. However, a dissection model with combined marine and fluvial erosion would require a lower mean removal rate of c. 5 m/yr to erode towards the core of remnant islands within a dissected landscape, a rate that might be accelerated due to gradually deepening water adjacent to the coast bringing higher energy waves to the shore and occasional high-magnitude marine inundation(s). Although the current rate of erosion along the Cardigan Bay coast is estimated to be up to *c.* 1 m/yr (West Wales Shoreline Management Plan Consultation 2011), coastlines on the more protected coast of eastern England, with cliffs comprising similarly unconsolidated Pleistocene sediments, have retreated *c.* 5.5 km since Roman times (*c.* 2.75 m/yr) along the Yorkshire coast (Sistermans and Nieuwenhuis 2013) and rapid cliff erosion of up to *c.* 6 m/yr in Suffolk (May 2003).

Across the North Sea in the German Bight, historical cartographic evidence indicates that the island of Heligoland has experienced a major reduction in size (Hebbeln *et al.* 2003) from 60 km in length in CE 800 to 25 km in 1300 and 1.5 km in the 20th century (Bryant 2005). Presently, the island's shoreline has retreated to a resistant core of Mesozoic rocks (Kelletat 1992) but is surrounded on the seafloor by a basement of Pleistocene sediments (Wunderlich 1980) indicating that the material removed through historic coastal erosion comprised unconsolidated deposits. Indeed, Hebbeln *et al.* (2003) attribute very high historic sedimentation rates in the nearby Helgoland mud area to the disintegration of the island.

Elsewhere in the North Atlantic, the exposed shore of Nova Scotia in Canada has experienced rapid erosion of cliffs in unconsolidated Pleistocene deposits, such as drumlins, with recent measured rates of 5.4 m/yr, and perhaps up to 7.6 m/yr, on the western inlet of Chezzettcook Inlet (Shaw *et al.* 1993), and *c.* 8.33 m/yr through a six-year period at Cap la Ronde on Isle Madame (Force 2013). Furthermore, an island mapped offshore Nova Scotia in the eighteenth century, Fish Isle, has subsequently been removed though erosion and is "now represented only by intertidal boulder

shoals" (Force 2013, p. 37), which shows a similarity to the 'lost' islands of Cardigan Bay where the Sarns, and/or associated gravel lag deposits, may be considered to be analogous to the 'boulder shoals'.

Taken together, the rates of historical erosion proposed for the 'lost' islands of Cardigan Bay are entirely plausible within the context of other coasts where unconsolidated Pleistocene deposits are exposed in coastal cliffs and occur within a high-energy wave environment. Moreover, the geological and geomorphological similarity between Cardigan Bay and other areas along the northwest European coast, such as the Celtic coasts of Brittany and Cornwall, along with similar geomythological evidence, might suggest marine and fluvial dissection and erosion of 'lost' landscapes underlain by unconsolidated Pleistocene deposits provides a credible model to further investigate coastal evolution in these regions.

CONCLUSION

This study has investigated the significance of two 'lost' islands located in Cardigan Bay as shown on the 13th-14th-century Gough Map. Drawing upon historical, literary and folklore sources, and geological and bathymetric evidence, the existence of the 'lost' islands is considered plausible and offers a possible insight into the post-glacial coastal evolution of Cardigan Bay. A preliminary post-glacial coastal evolution model is presented that provides an integrated hypothetical framework upon which further research may be undertaken to test its validity and to offer refinements with the potential to offer new insights into the post-glacial evolution of lowland areas of the northwest European coastline. The model is also consistent with traditions that associate lost landscapes with these coastal areas, such as Cantre'r Gwaelod supposedly situated in Cardigan Bay.

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Figure Captions

Figure 1. Location of Cardigan Bay and places mentioned in the text (reproduced under Google Earth's terms of use).

Figure 2. Extract of the Gough Map showing Wales and the two 'lost' islands of Cardigan Bay in the bottom-centre of the image (note the map is orientated with East at the top; reproduced with permission of the Bodleian Library, Oxford).

Figure 3. Re-orientated and annotated version of the Gough Map shown in Figure 2 (reproduced with permission of the Bodleian Library, Oxford).

Figure 4. Bathymetry of Cardigan Bay with major submarine features and rivers marked (reproduced under Digimap's terms of use).

Figure 5. Field examples of coastal cliffs in unconsolidated Pleistocene deposits of Cardigan Bay, (a) Newquay (underlain to the right by Lower Palaeozoic basement), (b) Mwnt, and (c) Cwm Silio.

Figure 6. A view southward along the coast of Cardigan Bay south of Aberystwyth, between the villages of Llanrhystud and Llanon (seen in the middle distance), showing cliffs eroding into a coastal terrace comprising unconsolidated Pleistocene deposits backed landward by a pre-glacial relict cliffline; the foreshore comprises a gravel lag deposit and sand terraces with a coarse clastic storm beach fronting the eroding cliff.