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A Lateglacial archaeological site in the far north-west of Europe at Rubha Port an t-Seilich, Isle of Islay, western Scotland: Ahrensburgian-style artefacts, absolute dating and geoarchaeology

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ABSTRACT: The exact pattern, process and timing of the human re-colonization of northern Europe after the end of the last Ice Age remain controversial. Recent research has provided increasingly early dates for at least pioneer explorations of latitudes above 54°N in many regions, yet the far north-west of the European landmass, Scotland, has remained an unexplained exception to this pattern. Although the recently described Hamburgian artefacts from Howburn and an assemblage belonging to the arch-backed point complex from Kilmelfort Cave have established at least a sporadic human presence during earlier stages of the Lateglacial Interstadial, we currently lack evidence for Younger Dryas/Greenland Stadial 1 (GS-1) activity other than rare stray finds that have been claimed to be of Ahrensburgian affiliation but are difficult to interpret in isolation. We here report the discovery of chipped stone artefacts with technological and typological characteristics similar to those of the continental Ahrensburgian at a locality in western Scotland. A preliminary analysis of associated tephra, pollen and phytoliths, along with microstratigraphic analysis, suggest the artefacts represent one or more episodes of human activity that fall within the second half of GS-1 and the Preboreal period. © 2015 The Authors. *Journal of Quaternary Science* published by John Wiley & Sons, Ltd.

KEYWORDS: Ahrensburgian culture; Lateglacial; stratified sediments; tephra; western Scotland.

Introduction

While considerable progress has been made in documenting the Late Pleistocene colonization of Scandinavia, the dating and nature of the earliest settlement in the far north-west of Europe, notably Scotland (Fig. 1), has remained contentious. This is primarily because of a scarcity of evidence, especially that which might be located *in situ* and which might provide cultural, palaeoenvironmental and chronological information for human activity.

In this contribution we describe the discovery of chipped stone artefacts that are most likely of Lateglacial date at the site of Rubha Port an t-Seilich on the Isle of Islay, located off the west coast of Scotland. The artefacts are sealed within a sedimentary context that has the potential to provide palaeoenvironmental and chronological information in light of preliminary analyses of tephra, pollen, phytoliths, geochemistry and microstratigraphy. Unexcavated sediments provide the possibility of acquiring additional stone artefacts and further types of cultural material. The activity is tentatively attributed to the Ahrensburgian culture and to the late Younger Dryas–Preboreal. If these interpretations are correct, the evidence from Rubha Port an t-Seilich poses questions about the environmental transitions in western Scotland and the economic strategies of the Ahrensburgian, lending credence to the notion of a specific coastal, if not maritime, adaptation. With unexcavated and likely *in situ* evidence remaining, Rubha Port an t-Seilich provides an important opportunity to address such questions via future fieldwork and analysis of both sedimentary and archaeological data. To explain the potential significance of the site we initially provide a succinct overview of Lateglacial colonization in north-west Europe.

The Lateglacial colonization of north-west Europe

During the most severe stages of the Last Glacial Maximum the north-west European landmass, encompassing Britain, the Low Countries and Scandinavia, was locked in glacial ice and polar desert (Fig. 2). These landscapes became habitable by humans after *c.* 15.5k cal a BP*, following the down-wastage of the British and Scandinavian ice sheets and a rapid increase in temperature marking the beginning of the Lateglacial Interstadial [during the so-called Bølling warm stage that broadly coincides with the Greenland Interstadial 1e (GI-1e) climate oscillation] (Fig. 3). [*All radiocarbon dates are calibrated using the IntCal13 calibration curve (Reimer *et al.*, 2013) and are stated in terms of their 95% probability range.] With sea levels yet to rise, vast tracts of land were exposed across the Dogger Bank joining northern Britain to the Low Countries and southern Scandinavia (Coles, 1998; Gaffney *et al.*, 2007). People were drawn northwards from their Lateglacial refugia into these steppe–tundra landscapes, as evident by the suite of Lateglacial techno-complexes in north-west Europe: the shouldered point complex (SP), the arch-backed point complex (ABP) and the tanged point complex (TP). Each of these have more or less regionally circumscribed industrial variants, such as the Creswellian and the Havelte phase for the SP and the Bromme culture for the TP (Riede, 2014a; Riede and Tallaavaara, 2014; Wygal and Heidenreich, 2014) (Fig. 3).

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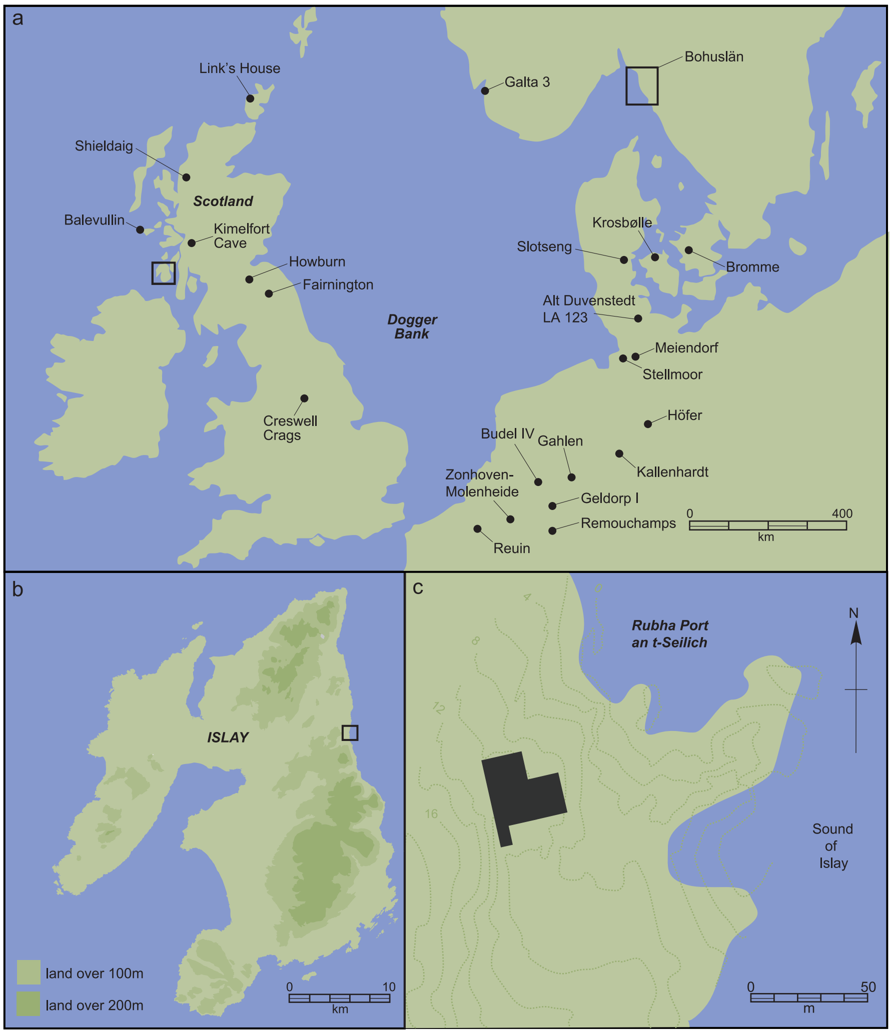

Figure 1. (a) Map of NW Europe showing sites and regions mentioned in the text; (b) the location of Rubha Port an t-Seilich, Isle of Islay; (c) area of archaeological evaluation on the coastal terrace at Rubha Port an t-Seilich.

The timing and extent of human activity within the now submerged Doggerland remains difficult to evaluate. Finds from the Last Termination remain conspicuously absent despite recent efforts to evaluate the current evidence and to produce new finds (Glørstad and Kvalø, 2012; Peeters and Momber, 2014). Evidence for the movement of raw materials restricted in their source origin to specific places within Doggerland, such as Baltic amber (Pettitt, 2008) and Heligoland flint (Beuker and Niekus, 2003; Beuker and Drenth, 2014; Clausen, 2014; Fries and Veil, 2014; Hartz and Segschneider, 2014; Nösler, 2014), suggest that humans did indeed venture, at least occasionally, into these vast low-lying plains during some phases of the Lateglacial. The rapid sea-level rise within GI-1e (cf. Deschamps *et al.*, 2012) may, however, have made these landscapes unpredictable, dangerous and thus unattractive despite the evident presence of large mammal game (Glimmerveen *et al.*, 2006).

A few Lateglacial sites in mainland Europe provide radiocarbon-dated evidence of human occupation at equivalent latitudes to Scotland. For instance, radiocarbon dates associated with Havelte phase assemblages from the Danish site of Slotseng, southern Jutland, record a human presence at *c.* 14.2k cal a BP (see Mortensen *et al.*, 2014) (Fig. 1). This timing suggests contemporaneity with the SP sites of the Hamburgian under the increasingly warm conditions of the Bølling Interstadial stage (Grimm and Weber, 2008) (Fig. 3). In neighbouring parts of the continent, ABP sites of the so-called Federmessergruppen produce dates that tend to fall into the intermediate and warmer stages of the Lateglacial Interstadial during the Allerød (see Riede and Edinborough, 2012 for a recent review).

The Bromme was a short-lived culture that succeeded the Federmessergruppen in southern Scandinavia. This was followed by the Ahrensburgian during the late stages of the Lateglacial Interstadial, sometime after the Intra Allerød Cold Phase (the IACP that broadly corresponds to GI-1b) and the Laacher See eruption (see Riede, 2008). A simple developmental sequence from the Bromme to the Ahrensburgian (Johansson, 2003) is challenged, however, by the late GI-1a/early Greenland Stadial 1 (GS-1) equivalent date (AAR-2246: 11 060 $\pm$ 110 ^{14}C a BP, δ^{13}C -26.9‰) on charcoal from a hearth associated with a likely Ahrensburgian assemblage at Alt Duvenstedt LA 123 in northern Germany (Kaiser and Clausen, 2005), as well as early dates for a small number of Ahrensburgian sites in the Benelux (e.g. Remouchamps, Budel IV, Geldorp I) (see Weber *et al.*, 2011 for details). Setting aside the similarity in projectile point morphology, flint technological analyses link the Ahrensburgian to the ABP (De Bie, 1999), perhaps suggesting its origin within the Federmessergruppen in the Benelux region, potentially signalled by sites such as Ruien 'Rosalinde' in the Belgian Scheldt valley (Crombé *et al.*, 2014).

The bulk of directly dated Ahrensburgian sites have produced radiocarbon dates that typically cluster in the latter stages of the Younger Dryas Stadial (broadly equating to GS-1) while others range well into the early Holocene (Weber *et al.*, 2011). Ahrensburgian-type assemblages are found around and north of the upland margins of central western Europe (Cziesla, 1992; Baales, 1996) and are generally associated with specialized reindeer hunting. This interpretation derives from the still impressive but not entirely unproblematic old excavations, such as Stellmoor and

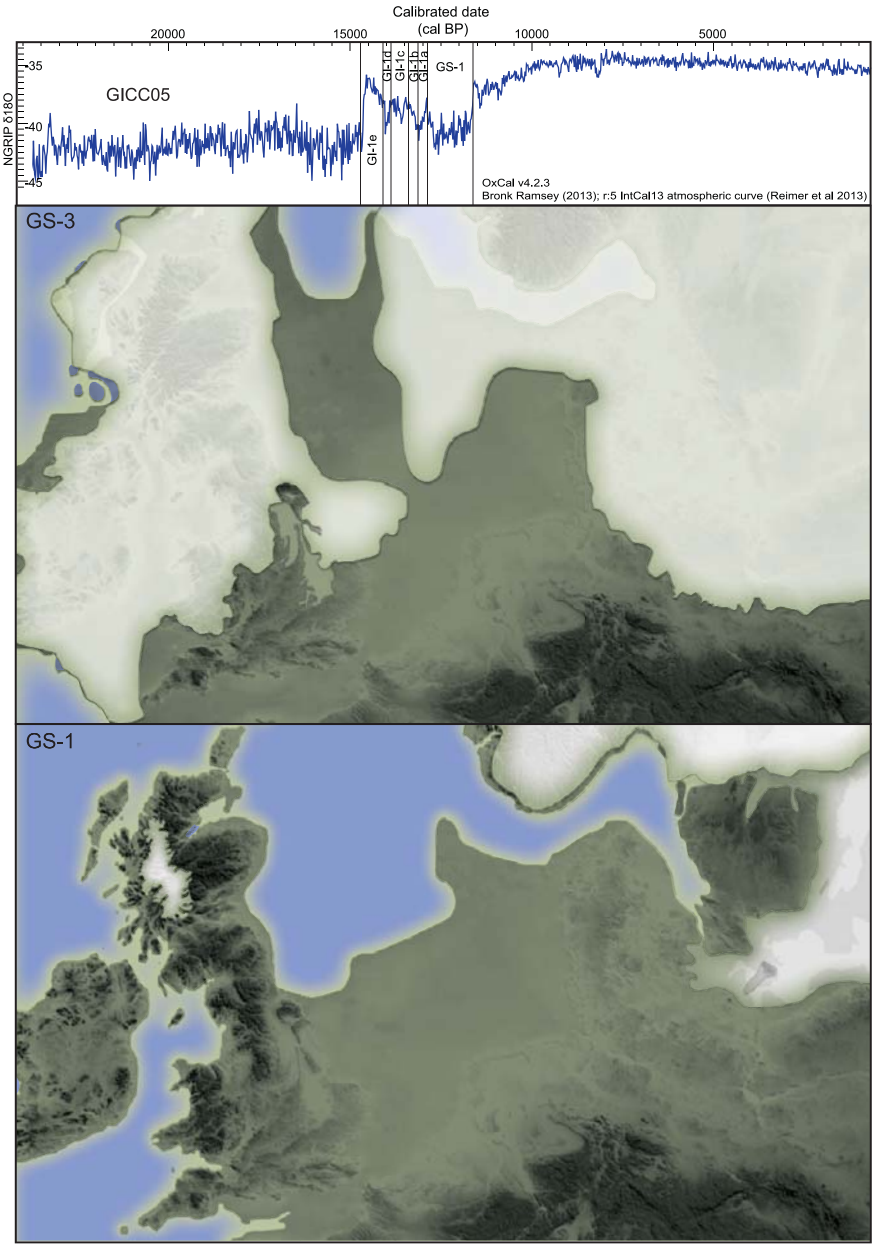

Figure 2. Ice extent and sea level at the Last Glacial Maximum (GS-3) and the Loch Lomond Stadial (GS-1) in NW Europe. Limits of ice sheets and Lateglacial sea levels re-drawn from Ballantyne (2004, his fig. 2.1), Bjartmann Bjerck (2008, his fig. 3.1) and Grimm (2011). GICC05 timeline follows Lowe *et al.* (2008).

Meiendorf north of Hamburg (Rust, 1937 1943), and the preferential presence of reindeer in northern Europe during the Younger Dryas (see Riede *et al.*, 2010; Sommer *et al.*, 2014). Yet, towards the latter stages of the Ahrensburgian – perhaps as early as GS-1 equivalent timing (see Schmitt, 2013a) – northern variants of this techno-complex began to appear, notably the so-called Hensbacka found in the Bohuslän region of south-west Sweden (Schmitt, 1994) and the Fosna of south-western Norway (Fuglestvedt, 2007).

Although conclusive faunal evidence is lacking, these hunter-gatherers were arguably attracted by the emerging availability of highly productive marine environments created by changing sea levels and the mixing of ocean and ice-lake currents (Schmitt *et al.*, 2009; Breivik, 2014). Sites of this possibly marine-orientated 'coastal Ahrensburgian' are most commonly located along island and skerry bays suitable for landing waterborne transport (Kindgren, 2002). Nevertheless, the complete absence of associated organic materials, relating to both the economy and the means of non-pedestrian transport, make the degree to which these hunter-gatherers were truly marine adapted (rather than being marine-orientated) a matter of contention (see, for instance, the polemic paper by Glørstad, 2013 and its attendant comments).

In light of such southern Scandinavian sites being situated within the same latitudes as Scotland and a significant Lateglacial presence in the Midlands of England, such as at Creswell Crags (Pettitt and White, 2012 their fig. 8.4), one might expect Scotland to yield comparable archaeological evidence. Until recently, however, it has failed to produce anything other than circumstantial evidence for hunter-gatherers before the Mesolithic period (Wicks and Mithen, 2014). The most significant evidence is the assemblage of stone artefacts bearing technological and typological attributes consistent with the Hamburgian culture, discovered during the course of field-walking at Howburn, Lanarkshire. This indicates that hunter-gatherers were at least making exploratory forays into the far north-west of Europe during the early stages of the Lateglacial Interstadial (Ballin *et al.*, 2010). Unfortunately, further fieldwork at Howburn was unable to find any *in situ* deposits of Pleistocene age and hence provide absolute dating or contextual information for the artefacts. Nevertheless, the Howburn assemblage suggests a

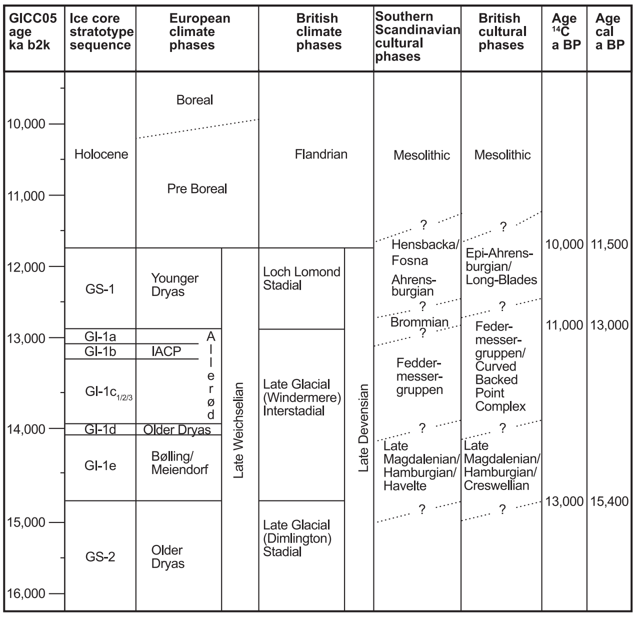

Figure 3. Climato-stratigraphic sub-divisions and Archaeological Cultural Units (ACU) at the Late Pleistocene-Early Holocene transition. GICC05 chronology redrawn from Lowe *et al.* (2008) and Tipping (2012). Lower and upper boundaries of Archaeological Cultural Units based on Riede and Edinborough (2012) and Pettitt and White (2012, Chapter 8).

hunter-gatherer presence in Scotland at around 14.2–14.3 ka by analogy with absolutely dated Havelte phase sites in Denmark, such as Slotseng and Krogsbølle (Riede, 2014b; Mortensen *et al.*, 2014).

Similar frustrations arise from the absence of absolute dating and contextual information for several cases of possible Late Pleistocene artefacts in Scotland. An isolated find of a Creswellian-type angle-backed piece from Fairnington, Roxburghshire (Saville, 2004 his fig. 10.23; Saville and Ballin, 2009 p. 40), suggests a human presence in the south-central lowlands of Scotland during the early Lateglacial Interstadial. Further north, an assemblage from Kilmelfort Cave, Argyll, attributed to the Federmessergruppen culture (Saville and Ballin, 2009), may reflect the movement of people from the south-east to the west coast of Scotland during intermediary stages (Allerød; equivalent to GI-1c/b) of the Lateglacial Interstadial. Several isolated finds of claimed Ahrensburgian-type points have been found on the north-west and north coasts of Scotland, with those from Balevullin, Isle of Tiree and Shieldaig, Wester Ross, constituting the most credible (Ballin and Saville, 2003). If correctly identified, their distribution might suggest a north-westerly movement of people during or soon after the Younger Dryas (referred to in Scotland as the Loch Lomond Stadial) (Fig. 3).

Until additional and more importantly *in situ* Pleistocene-dated remains are discovered in Scotland, the far north-west extent of the European landmass will remain an exception to the otherwise well-documented pattern of exploration by modern humans to the boundaries of their habitable world. We think it probable that such evidence has now been discovered at Rubha Port an t-Seilich (Mithen and Wicks, 2010 2013; Wicks and Mithen, 2014), on the Isle of Islay, western Scotland.

Rubha Port an t-Seilich: site discovery and fieldwork

Rubha Port an t-Seilich is located on the east coast of the Isle of Islay, western Scotland (grid reference: NR 43035 67449) (Fig. 1). This name, translated from the Gaelic as 'Point of the Hunting Port', refers to a small bay along the west coastline of the Sound of Islay that separates the Isles of Islay and Jura. The bay is sheltered to its south by a rocky outcrop that extends *c.* 50 m into the Sound. At *c.* 5 m above high water there is a level terrace, *c.* 60 × 100 m, before the land rises to *c.* 100 m OD. A mire community of *Scirpus–Erica* plant associations dominates the present-day vegetation surrounding the terrace, while a dense growth of bracken covers it during the warmer months with willow scrub woodland on the steep slopes and crevices leading to the shoreline. A mixed conifer and birch plantation situated *c.* 500 m to the north of the terrace surrounds a burn flowing into the Sound.

Pigs unearthed Mesolithic stone artefacts on the terrace when foraging in 2009. An initial site examination was undertaken in 2010 by test-pitting as part of the *East Islay Mesolithic Project* (Mithen and Wicks, 2010) (Figs 1 and 4). This identified stratified deposits with particularly high densities of Mesolithic chipped and coarse stone artefacts. These were associated with charred hazelnut shells, wood charcoal and fragmented animal bone, an initial examination of which has identified a predominance of red deer with roe deer, wild boar and low frequencies of fish bone.

Further examination of the site was undertaken in the summer of 2013 from a 30-m-long by 1.0-m-wide trench that bisected the terrace with the intention of establishing the stratigraphy of the Mesolithic deposits and retrieving samples of artefacts, ecofacts and material for accelerator mass spectrometry (AMS) radiocarbon dating (Mithen and Wicks, 2013) [Figs 4 and 5; for field sampling methods see supporting information (Appendix S1)]. This exposed a narrow wedge of sediment stratified below the earliest Mesolithic horizon that contained artefacts atypical of the Scottish Mesolithic.

Stratigraphy

The stratigraphy at Rubha Port an t-Seilich consists of four main horizons (Fig. 6):

1. An upper horizon of colluvium and soil (primarily Contexts 114 and 115) that is likely to have been cultivated in the 19th century when a nearby fisherman's house was occupied, and which now has a dense root mass from bracken.
2. A horizon (primarily Context 101) that contains stratified Mesolithic deposits, characterized by high densities of

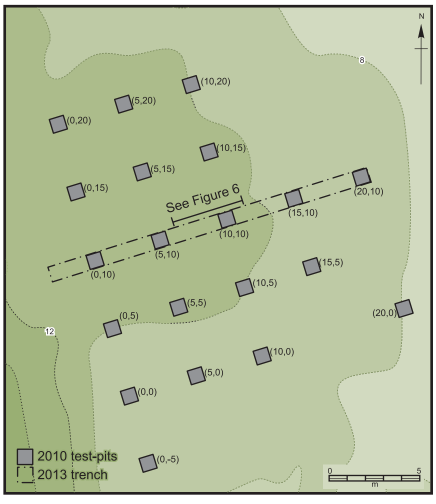

Figure 4. Plan of Rubha Port an t-Seilich showing 2010 test-pits and 2013 trench.

Figure 5. Photo of Rubha Port an t-Seilich, looking east across the Sound of Islay to the Isle of Jura, showing 2013 fieldwork on the terrace.

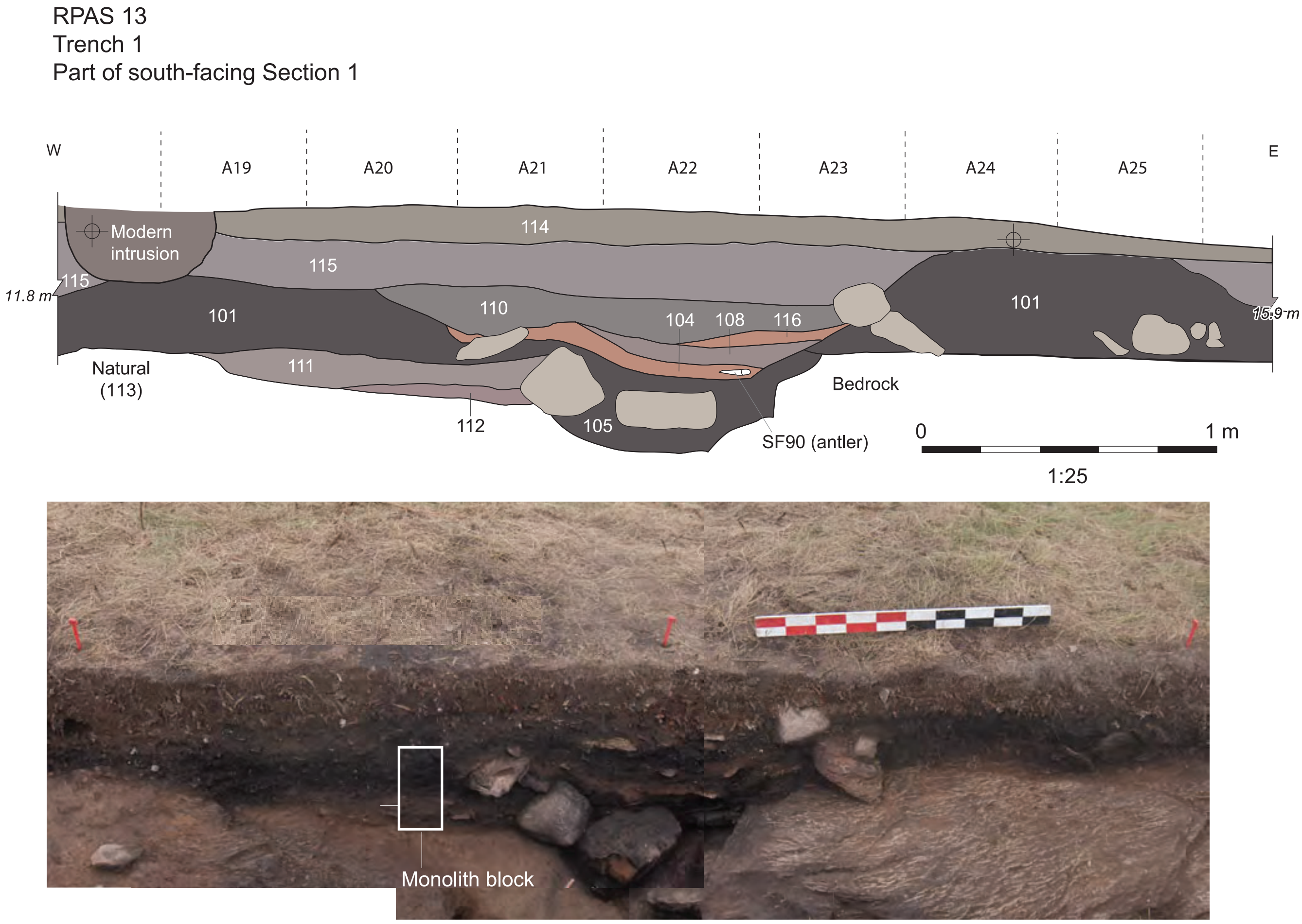

Figure 6. South facing section of Trench 1 between grid squares A19 and A25 showing the substantial hearth-like structure.

Table 1. AMS radiocarbon dates from single-entity fragments of charred hazelnut shell (HNS). a) ^{14}C dates obtained from Mesolithic horizons sampled during the 2010 test-pit survey; b) ^{14}C dates obtained from the base of (101) during the 2013 trench excavation.

						Posterior density estimate (cal a BP)	
Lab. ref.	Test pit	Context	Sample	Age (^{14}C a BP)	$\delta^{13}C$ (‰)	68.2% probability	95.4% probability
(a) From Mesolithic horizons							
Beta-288425	(0,15)	Mesolithic horizon	HNS	7010 ± 50	−23.4	7940–7820	7960–7750
Beta-288424	(0,10)	Mesolithic horizon	HNS	7540 ± 40	−24.3	8400–8340	8420–8210
Beta-288428	(10,5)	Mesolithic horizon	HNS	7660 ± 40	−21.6	8520–8400	8540–8390
Beta-288423	(0,5)	Mesolithic horizon	HNS	7820 ± 40	−25.0	8640–8550	8730–8470
Beta-288426	(5/0)	Mesolithic horizon	HNS	8230 ± 40	−25.1	9260–9120	9300–9030
Beta-288427	(5,15)	Mesolithic horizon	HNS	8240 ± 40	−24.8	9270–9120	9310–9030
(b) From base of (101)							
Beta-363963	–	Grid square A20	HNS	7640 ± 30	−24.6	8450–8390	8520–8380
Beta-363965	–	Grid square A20	HNS	7690 ± 40	−24.7	8520–8420	8560–8400
Beta-363964	–	Grid square A20	HNS	7790 ± 40	−26.0	8610–8520	8640–8450

HNS, charred hazelnut shell.

chipped and coarse stone artefacts, charred hazelnut shells, fragmented animal bone and antler, and with features including a fire-place and pit. Six single entity samples of charred hazelnut shell fragments taken from this horizon when exposed within the 2010 test pits returned AMS radiocarbon dates that when calibrated range between 9.3 and 7.8k cal a BP (Beta-288423 to Beta-288428) (Table 1a).

3. Horizons (Contexts 111 and 112) within a 1-m-long section of the trench between site grid squares A19 and A22 (Fig. 6) that are stratified below the base of the Mesolithic deposits (Context 101) and above a culturally sterile deposit (Context 113) and degrading bedrock. Contexts 111 and 112 comprise of a narrow wedge of coarse-grained sediment (from here on referred to as Context 111/2) that extended a few centimetres into the trench from the south-facing section, having a maximum thickness of 20 cm and containing chipped stone artefacts.
4. Bedrock consisting of degrading diamictite (Context 113) and outcrops of harder sandstone and quartzite. At one location bedrock boulders were used to contain a fireplace (Fig. 6).

A 35 × 15 × 15-cm monolith of sediment encompassing the base of (101), all of (111/2) and the upper levels of the underlying natural (113) was removed from the section within site grid square A20 (Figs 6 and 7). Samples were extracted from this block for AMS dating, tephrochronology and geoarchaeological analysis, the samples being referred to by their height above the base of the monolith block.

Chipped stone artefacts

Sixty-five chipped stone artefacts were recovered from the narrow wedge of sediment (*c.* 20 litres) comprising Context 111/2, a sample of which is illustrated in Fig. 8 (Table 2). Fifty-five of these artefacts were meticulously hand-picked during the excavation, while a further 10 artefacts were recovered from the wet sieve residue (2-mm aperture) of one further litre of sediment recovered during collection of the monolith block. We compare the (111/2) assemblage with an assemblage coming from square A20 of horizon (101). This assemblage ($n = 2067$) was entirely recovered from the wet-sieve residue of the 56 litres of sediment that had been contained within that square (Fig. 9; Table 2).

Figure 10 compares the size of artefacts within the hand-picked and wet-sieved components of the (111/2) assemblage. The former includes artefacts almost as small as the smallest of those recovered by wet sieving. As such we are confident that the (111/2) assemblage as a whole provides a representative sample of the chipped stone artefacts buried in Context 111/2. We are also confident that it can be meaningfully compared with the entirely wet-sieved assemblage of (101), although a higher frequency of the fine fraction within that assemblage should still be expected.

All the (111/2) artefacts are on flint while (101) also has a quartz component (<5%). Evidence from partially worked cores and cortex on artefacts from (101) indicate that flint and quartz beach pebbles had provided the primary source of raw material, with a possible use of vein quartz, an exposure of which is adjacent to the site at the shoreline. While flint beach pebbles may have also been the raw material source for (111/2), some of its artefacts would have required exceptionally large pebbles, those beyond 80 mm in diameter, which have rarely (<5%) been recovered from modern beach surveys within the region (see Marshall, 2000 p. 84, his figs 3.2.12 and 3.2.14).

Context 111/2 has a higher proportion of blades (as defined by Ballin, 2000 p. 11) to flakes than (101), these being 36.4 and 10.6%, respectively (Table 2). As Fig. 11 illustrates, the blades from (111/2) are relatively large, this assemblage having the six longest blades within the two assemblages. Table 3 lists technological differences between (111/2) and (101) with regard to attributes that are prone to be associated with Lateglacial rather than Mesolithic technology: the regularity of blades, signs of soft-hammer use, the presence of opposed platforms and facetted bulbs. Fourteen of the 18 whole blades within (111/2) have at least one of these attributes, all of which are less frequent within the (101) assemblage. In contrast, there is no sign of bipolar technology within (111/2). While this is relatively rare in northern Ahrensburgian assemblages (Hartz, 1987), bipolar technology is a pervasive feature of the Mesolithic in western Scotland and present on 20% of the cores from (101). Moreover, the lack of microburin technique in the (111/2) assemblage echoes the Ahrensburgian from Belgium and the Netherlands (Vermeersch, 2011). No correlation was found between the size of blades in the (111/2) assemblage and the presence of the technological attributes listed in Table 3. As such, there is no evidence to suggest that the smaller elements of (111/2) may have been intrusive from the overlying Mesolithic levels.

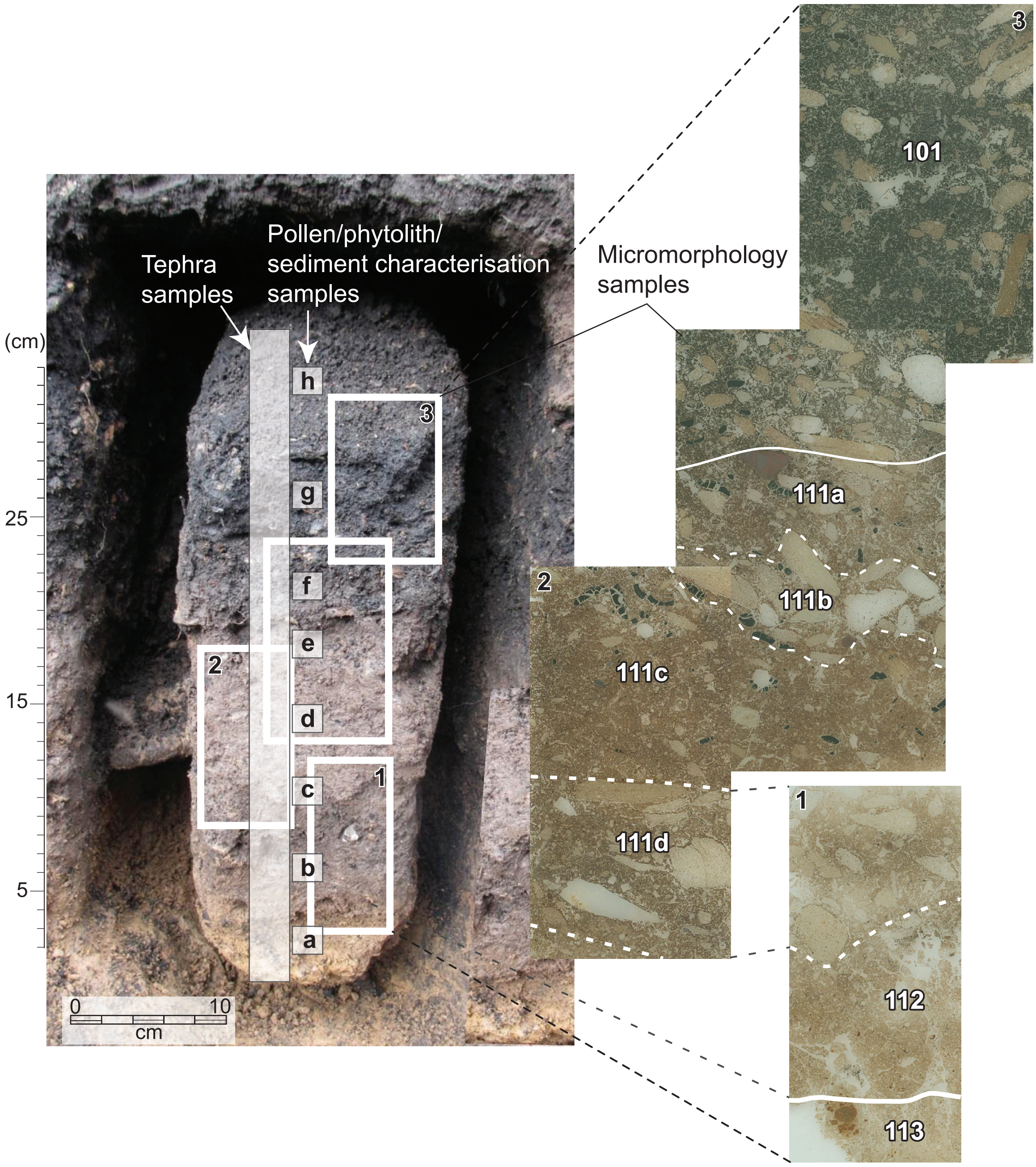

Figure 7. Monolith block removed from the south face of Trench 1 showing sampling for microstratigraphy and geoarchaeological analysis, along with microstratigraphic horizons 111a–d identified in thin section.

Context 111/2 has a higher proportion of tools within its assemblage than (101), 52.3 and 7.0%, respectively, of tools being defined as either retouched artefacts or those displaying use-wear (Table 4). The (101) tool assemblage contains microliths, predominately scalene triangles and lunates, as well as microburins and notched and snapped bladelets. Notches, truncations and marginally retouched pieces are present, along with several knives and an artefact with invasive retouch. The (111/2) tools are largely on blades (53%), with 85% of all blades having been retouched. The assemblage contains a high frequency of marginally retouched tools (41%) with small, nibbly, retouch defined by the presence of at least three regular overlapping removals.

Context 111/2 entirely lacks microliths and microburins. This is unlikely to be a consequence of collection bias in light of the relatively high frequency of tools within the assemblage and the dimensions of artefacts recovered (Fig. 10), which include pieces smaller than the average microlith from Context 101 (length 13 mm, width 4 mm). Context 111/2 contains various truncations on bladelets, which are dissimilar in form and considerably larger than the microliths from (101). Context 111/2 also contains two asymmetrical points of a type unknown in the Scottish Mesolithic, each formed by a truncation and lateral backing. In addition, there are two tools with steeply angled truncations and fine retouch forming a tip opposite the truncation that are not dissimilar from what is at times termed single-edged points (e.g. Kindgren, 2002). For such a small assemblage there is a large range of other tools, including a backed piece, a scraper and two burins. There are five unretouched artefacts that appear to have visible sign of use, although it is not easy to distinguish this from post-depositional damage.

In summary, the (111/2) and (101) assemblages are quite distinct with regard to both technology and typology. The (101) assemblage is consistent with the Mesolithic of western Scotland, although notable for its high frequency of microliths. The (111/2) assemblage is quite different, lacking Mesolithic attributes and having a significant presence of

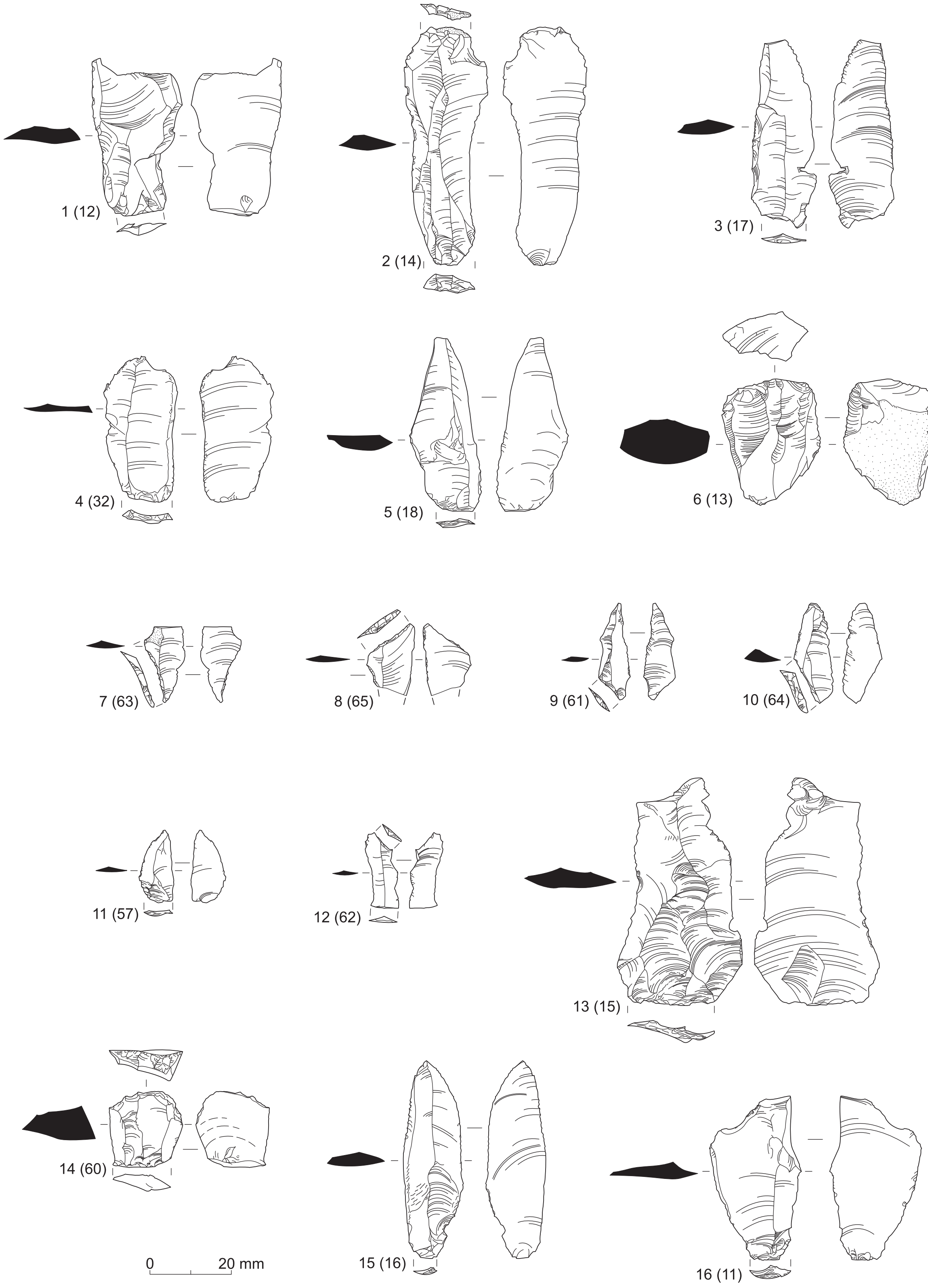

Figure 8. Chipped stone artefacts from grid square A20, Context 111/2: 1–4, marginally retouched pieces; 5, blade; 6, platform core; 7–8, asymmetrical points; 9–10, angled truncations; 11–12, truncations; 13, backed blade; 14, endscraper; 15, notch; 16, marginally retouched piece.

those associated with Lateglacial technology, although the two steeply angled truncations are similar to the obliquely blunted points found within the Early Mesolithic in England. Although we remain cautious because of the small sample size of (111/2), we note that this assemblage lacks culturally diagnostic artefacts, such as shouldered points or arch backed points, to suggest a Lateglacial Interstadial source. While it also lacks the fully diagnostic diminutive tanged points of the Ahrensburgian, we note the considerable extent of morphological, typological and technological variability in the Ahrensburgian (see, for instance Buck Pedersen, 2009 and Weber *et al.*, 2011).

Assemblages of clear Ahrensburgian affinity but which are lacking in tanged points are known from elsewhere, such as from Höfer in northern Germany (Veil, 1987). More importantly, microlithic elements and oblique truncations on blades known as Zonhoven points are a recurring and at times dominant feature in many Ahrensburgian assemblages, including Stellmoor (Rust, 1943), Gahlen (Richter, 1981) and Kallenhardt (Baales, 1996) in Germany, the eponymous site of Zonhoven-Molenheide (Vermeersch, 2013), Remouchamps (Dewez *et al.*, 1974) and many others in Belgium (cf. Gob, 1991; Vermeersch, 2011), as well as coastal Ahrensburgian assemblages such as Tosskärr in Bohuslän, Sweden (Kindgren, 2002), and Galta 3 in south-western Norway (Prøsch-Danielsen and Høgestøl, 1995).

Both the blade and the tool repertoire from Rubha Port an t-Seilich can be readily paralleled with elements from these key Ahrensburgian assemblages, as illustrated by a sample of tool types shown in Fig. 12. In particular we note that the asymmetrical point [artefact no. 8 (65) in Fig. 8] bears a striking resemblance to the obliquely retouched (Zonhoven) points shown in Fig. 12. Other artefacts with angled truncations, such as artefact nos. 9 (61) and 10 (64), are also possible examples of single-edged points. It is possible that the broken asymmetrical point [artefact no. 7 (63)] could be an Ahrensburgian point.

Taken as a whole, we suggest that the (111/2) assemblage finds its greatest technological and typological affinity with the continental variant of the Ahrensburgian from north-west Europe. In suggesting this linkage we remain keenly aware of the small size of the assemblage, which may explain the absence of diagnostic artefacts, whether they are shouldered, arch backed points or tanged points. As such, linking the Rubha Port an t-Seilich (111/2) assemblage to the Ahrensburgian on the lithic evidence alone is a working hypothesis and requires further evaluation by absolute dating and biostratigraphic markers.

Absolute dating

AMS radiocarbon dating

Three pieces of charred hazelnut shell were extracted for AMS dating at the base of (101) between 23 and 25 cm from the base of the monolith block (Beta-363 963 to Beta-363 965) (Figs 7 and 14; Table 1b). Their AMS dates form two pairs of statistically consistent dates (shown on Fig. 13) suggesting that they could derive from two separate depositional episodes or from a series of events occurring in close succession centred on 8.52 and 8.47k cal a BP. Posterior density estimates for the calibrated AMS dates provided in Table 1b were obtained using a single-phase Bayesian chronological model (Bronk Ramsey, 2009) (see Appendix S1 for details of Bayesian methods used). This model produced a lower boundary estimate for the start of the formation of Context 101 of 9.05–8.42k cal a BP (95.4% probability) (Fig. 14), falling coherently within the range of Mesolithic dates obtained from Mesolithic horizons sampled during the 2010 test-pit survey (Table 1a). The sieved residue of the 1-litre sample of (111/2), collected when removing the monolith block, was inspected for wood charcoal and charred hazelnut. Only microscopic fragments were detected, these being deemed unsuitable for AMS dating because of their size and liability for re-deposition by bioturbation from overlying sediments.

Tephrochronology

The following provides an initial study of tephra located within the sediments at Rubha Port an t-Seilich. This study was designed to identify a preliminary tephrochronology based on the limited data available from the monolith block so that a tephrochronological framework could be established to encompass the chipped stone artefacts. If the preliminary tephrochronology appeared of potential interest a more substantial analysis would be of value involving in-field sampling for tephra.

A 35-cm sequence of sediment slices, 1 cm^3 in volume, was sub-sampled contiguously from the base to the top of the front facing surface of the monolith block for tephrochronology (Fig. 7). An initial analysis for the presence and then extraction of tephra was undertaken at a low resolution by combining those from each successive 5-cm interval and using the methods described by Lane *et al.* (2014) (see summary of methods used in Appendix S1). Having identified where the high concentrations of tephra were located, 20 samples were then analysed at 1-cm resolution from 5 to 25 cm height, which also covered the key archaeological units 111–112 (Fig. 13) (see Appendix S2 for tephra count data).

The three highest concentrations of tephra shards were selected for chemical characterization, these being present in the upper boundary of Context 112 at 9–10 cm (tephra code: RPAS_9-10cm 9206), in Context 111 at 14–15 cm (tephra code RPAS_14-15 cm 9211) and at the interface with Context 101 at 21–22 cm (tephra code RPAS_21-22cm 9218) above the base of the monolith (Fig. 13). While such peak concentrations are often taken to represent the specific occurrence of volcanic events, with the lower-density samples of tephra in their overlying samples representing the re-working of tephra within the site (Lane *et al.*, 2014 p. 48), caution must be applied to the Rubha Port an t-Seilich samples because of the relatively low density of tephra shards in levels containing peaks in tephra (Housley and Gamble, 2014) and the presence of tephra in every 1-cm sample from 8 to 25 cm. The limited number of analyses for geochemical data (six for RPAS_21-22cm 9218, five for RPAS_9-10cm 9206 and 11 for RPAS_14-15cm 9211) reflects the preliminary nature of this study and the availability of appropriate shards within each horizon.

The Rubha Port an t-Seilich tephra layers are compared with published reference data for widespread Icelandic tephra layers dated to the Lateglacial to Early Holocene (Figs 15 and 16). As illustrated in Fig. 15, the tephra layers RPAS_9-10cm (9206) and RPAS_21-22cm (9218) have geochemical affinities with four different ashes all from Katla and which are chemically indistinguishable (Matthews *et al.*, 2011 p. 251; Lane *et al.*, 2012a p. 97): the Suðuroy Ash, dated to 8.31–7.86k cal a BP (Wastegård, 2002); AF555 at 11.79–11.20k cal a BP (Matthews *et al.*, 2011); the rhyolitic phase of the Vedde Ash at 12.24–12.00k cal a BP (Mangerud *et al.*, 1984; Rasmussen *et al.*, 2006) and the Dimna Ash dated to at least 15.6–15.1k cal a BP (Koren *et al.*, 2008).

Tephra RPAS_14-15cm (9211) lacks a strong geochemical affinity with any one particular ash (Fig. 16). It is distinct from the Katla tephras but has some similarity to the Borrobol (~14.1k cal a BP) (Bronk Ramsey *et al.*, 2014) and Hasseldalen (early Holocene), the former having previously been identified in Scotland (Matthews *et al.*, 2011). Some elements of RPAS_14-15cm (9211) also have geochemical affinities to the early Holocene L274 tephra, identified by Lind and Wastegård (2011; E. Lind pers. comm.) on the Faroes – the L274 tephra itself being a mixture of several eruptions.

For the interpretation of the Katla-type tephra layers, RPAS_21-22cm (9218) and RPAS_9-10cm (9206), we note two observations. First, RPAS_21-22cm (9218) and RPAS_9-10cm (9206) are different tephra layers: they are separated by 12 cm of relatively undisturbed sediment that contains RPAS_14-15cm (9211), which is a non-Katla tephra(s) (Fig. 17). The most reasonable interpretation of RPAS_14-

Table 2. Context 111/2 and Context 101: chipped stone assemblage composition.

	Site grid square A20								
		Context 101					Context 111/2		
	Quartz	Flint	Other	Total	Hand picked		Wet-sieved		
Flakes	54	961	4	1019	49.3%	28	50.9%	7	70.0%
Blades	5	214	0	219	10.6%	20	36.4%	1	10.0%
Spalls	0	9	1	10	0.5%	3	5.5%	0	0.0%
Microburins	0	9	0	9	0.4%	0	0.0%	0	0.0%
Core trimming elements	0	20	0	20	1.0%	0	0.0%	1	10.0%
Indeterminate artefacts	18	507	0	525	25.4%	3	5.5%	1	10.0%
Small fraction $\leq$3 mm	7	227	0	234	11.3%	0	0.0%	0	0.0%
Cores	3	27	1	31	1.5%	1	1.8%	0	0.0%
TOTAL	87	1974	1	2067	100.0%	55	100.0%	10	100.0%

15cm (9211) is that this is an amalgam of ashes from more than one volcanic eruption occurring early in the onset of the Holocene. Second, RPAS_21-22cm (9218) is close to the sampling location with ^{14}C posterior density estimates ranging from 8.64 to 8.38k cal a BP (base of Context 101; Table 1b). While falling short of providing an exact date match, a close correlation in timing suggests it most likely represents the Suðuroy event dating, such as it, does to 8.31–7.87k cal a BP (Wastegård, 2002).

Noting these observations, the lowermost tephra RPAS_9-10cm (9206) is most reasonably interpreted as one of the three older Katla-type tephra layers: either the terminal Younger Dryas AF555 tephra, dating to 11.58–11.34k cal a BP (Matthews *et al.*, 2011; Bronk Ramsey *et al.*, 2014), the widespread mid Younger Dryas Vedde Ash dating to 12.24–12.00k cal a BP (Rasmussen *et al.*, 2006), or the Interstadial Dimna Ash dating to at least 15.6–15.1k cal a BP (Koren *et al.*, 2008). Although we are unable to separate these on geochemical grounds, we favour an assignment to the Vedde Ash for two reasons. First, because this is the most widespread tephra from Katla having been found at several bog sites in Scotland and as far south as Central Europe (Lane *et al.*, 2012a). Second, because the closest match of the technology and typology of the (111/2) assemblage is the Ahrensburgian, which would sit most comfortably within the latter half of GS-1 and hence be most compatible with an immediately underlying ash dating to the second half of the 13th millennium cal BP. We fully acknowledge, however, that the small size of the assemblage makes such cultural affiliation uncertain and that the basal ash (RPAS_9-10cm 9206) might represent either the Dimna or the AF555 tephra. All we can say with confidence is that the artefacts are of a Lateglacial–Early Holocene transition age and are distinct from the Mesolithic narrow-blade industry that is known to be established by *c.* 10.3k cal a BP in western Scotland (Wicks and Mithen, 2014).

Geoarchaeological analysis

A geoarchaeological analysis was undertaken to provide information about the depositional and post-depositional histories of (101) and (111/2) in terms of: (i) physical and

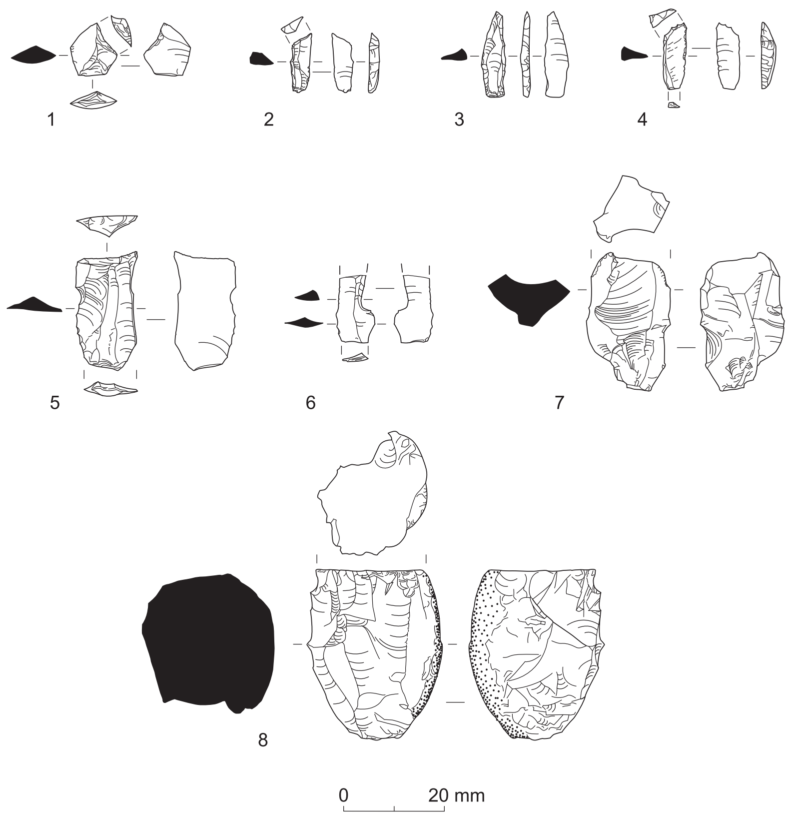

Figure 9. Chipped stone artefacts from grid square A20, Context 101: 1, microburin; 2–4, microliths; 5, truncation; 6, notched and snapped bladelet; 7, bipolar core; 8, platform core.

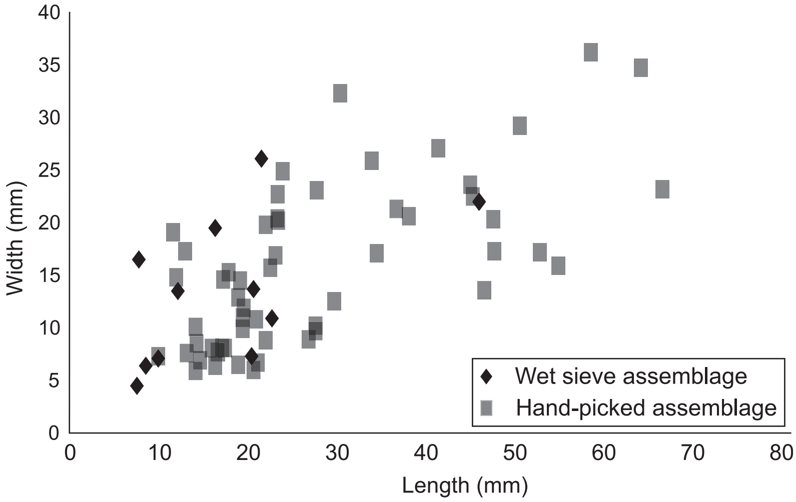

Figure 10. Size comparison of artefacts within the (111/2) and (101) assemblages.

geochemical characterization of the sediments in which the artefacts were contained; (ii) palaeoenvironmental indicators using pollen and phytoliths; and (iii) microstratigraphy.

Eight sediment sub-samples in slices 1 cm thick were taken from the monolith, one from Context 113 (sub-sample [a]), four from Context 111/2 (sub-samples [b], [c], [d] and [e]) and three from Context 101 (sub-samples [f], [g] and [h]) (Fig. 7). These were sampled to provide sediment for loss on ignition, magnetic susceptibility, particle size analysis, portable X-ray fluorescence (pXRF), X-ray diffraction (XRD), pollen and phytolith analysis. Three sub-samples were taken for micromorphological analysis (sub-samples 1, 2 and 3) (Fig. 7); the central sub-sample was cut into two facing slabs with a 2.5-cm overlap providing four slides. Analytical methods are summarized in Appendix S1, while detailed descriptions and a complete set of results are reported elsewhere (Banerjea *et al.*, 2014).

Physical properties and geochemistry of sediments

The integrated results of lithostratigraphic, organic matter content, magnetic susceptibility and particle size analysis are summarized in Fig. 13, while the results from XRD and pXRF analyses are provided in Tables 5 and 6, respectively. These indicate that the sediment has a consistent composition throughout the profile with subtle but important variations between (111) and (101). XRD analysis (Table 5) indicates a similar mineral composition throughout the profile, with a limited number of identified minerals, notably quartz (44–76%), muscovite (9–46%) and albite (8–24%). Changes in lithostratigraphy and colour occur, together with an increase in organic matter, clay content and a peak in magnetic susceptibility values at the top of Context 111.

A gradual up-profile increase in organic matter content and mass-specific magnetic susceptibility, as well as peaks in Mn, Ca (sub-sample [h]) and Sr (sub-sample [g]), may indicate increasing inputs of charred and burned debris from hearths (Dalan and Banerjee, 1998; Rosendahl *et al.*, 2014), along with the breakdown of organic matter (Bartlett, 1988), ashes and bone. Increasing values such as these could also reflect an acceleration in natural soil-forming processes (Rosendahl *et al.*, 2014 p. 22). The elemental enrichments could have derived from anthropogenic activities, such as food preparation and deposition of hearth ashes, or arisen as by-products of post-depositional chemical weathering. A higher sand content (31.05%) in sub-sample [g] may reflect an increase in wind-blown sand accumulation.

In Context 111, sub-sample [f] gave the highest magnetic susceptibility measurements, probably reflecting relatively high levels of tephra, charred material and ferruginous charcoal fragments. Magnetic susceptibility shows a gradual increase throughout (111) reflecting the higher frequencies of carbonized material in the upper levels. A notably low sand content in the mid-levels of Context 111 (16.86%; sub-sample [d]) may reflect a decrease in wind-blown sand accumulation.

Micromorphology has shown that the lower part of the sequence (from 3 to 18 cm from the base of the monolith) has

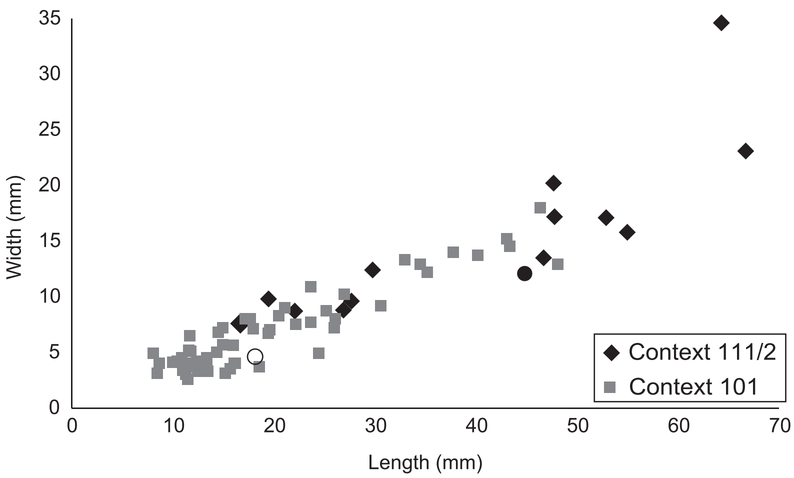

Figure 11. Size of comparison of blades within the (111/2) and (101) assemblages. Average blade dimensions indicated by a solid circle (111/2) and hollow circle (101).

Table 3. Context 111/2 and Context 101: Lateglacial and Mesolithic technological attributes.

		Site grid square A20	
		Context 101	Context 111/2
Regularity of blades*		69%	94%
Opposed blade technology*		11%	33%
Use of soft hammer†	Flat bulb	25%	43%
	Lipped butt	4%	36%
Platform faceting*		0%	14%

*Percentage of all blades.
†Context 111/2 = percentage of all blades; Context 101 = percentage of 42 complete blades.

undergone significant chemical weathering, which is evident by biotite within rock fragments, iron translocation, iron nodules, manganese nodules and vivianite neomineral formation. This corresponds to notable elemental peaks of P which were detected in Context 112 (sub-samples [b] and [c]), and Fe in sub-sample [c] (Table 6). Chemical weathering may have resulted in the leaching of elements into Context 113. Relatively high elemental concentrations of P and K (Table 6) towards the base of the sequence in sub-sample [a] suggest that some leaching may have occurred.

Palaeoenvironmental indicators: pollen and phytoliths

A rapid pollen assessment (see Appendix S3) of sediment contained in the monolith indicated that pollen preservation is extremely poor, with all the eight pollen samples yielding insufficient numbers of pollen grains to obtain statistically reliable pollen counts. Only 10 pollen grains were observed, seven of which were severely corroded and/or broken (Fig. 13). Prolonged exposure of pollen and spore surfaces to oxygenated environments is likely to have corroded the outer surfaces of individual grains, while grain breakage could have resulted from the translocation of inorganic minerals (Tipping, 1995).

While interpretations of the pollen assemblage are hampered by low pollen frequencies and poor preservation, rapid assessment has shown that the pollen assemblage surviving in Context 111/2 (sub-samples [a]–[e]) consists of shrub and herb taxa that are capable of withstanding relatively cool and open conditions (see Fig. 13 and Appendix S3 for the range of pollen taxa counted). In particular, pollen of Poaceae and Cyperaceae suggest at least a patchy mosaic of grassland and wetter ground, respectively, nearby. The appearance of *Calluna vulgaris* in an upper level (sub-sample [e]) of (111/2) could signal the development of heathland during the early Holocene, although all these records could equally represent a regional component of the pollen rain from long-distant sources. The absence of arboreal pollen taxa throughout the profile is not inconsistent with the open habitats encountered in records from similarly exposed coastal locations during the Lateglacial and across the transition to the Holocene in western Scotland (e.g. Lowe and Walker, 1986; Walker and Lowe, 1990; for a recent review of Scottish Lateglacial – early Holocene vegetation history see ScARF, 2012).

The results of the single cell phytolith counts are summarized in Fig. 13 (methods summarized in Appendix S1; for a full report see Banerjea *et al.*, 2014). The results indicate a moderate concentration of phytoliths, in an overall reasonable, but variable, state of preservation. All samples are dominated by monocotyledon (grass) phytoliths (>90%). Low frequencies of dicotyledonous phytoliths cannot be further classified into plant part, some of these possibly deriving from woody shrub and tree taxa. The phytolith results are consistent with those from pollen analysis by indicating a landscape dominated by wild grasses, with some trees/shrubs in the area.

Table 4. Context 111/2 and Context 101: tool assemblage.

	Site grid square A20			
	Context 101		Context 111/2	
Angled truncations	0	0.0%	2	5.9%
Asymmetrical points	0	0.0%	2	5.9%
Awls	1	0.7%	0	0.0%
Backed blade	0	0.0%	1	2.9%
Burins	0	0.0%	2	5.9%
Marginally retouched	26	18.1%	14	41.2%
Microliths	65	45.1%	0	0.0%
Notches	12	8.3%	2	5.9%
Scrapers	0	0.0%	1	2.9%
Truncations	16	11.1%	3	8.8%
Used pieces	12	8.3%	5	14.7%
Other	5	3.5%	0	0.0%
Fragments	7	4.9%	2	5.9%
TOTAL	144	100.0%	34	100.0%

Microstratigraphy

Microstratigraphic analysis divided the monolith block into seven units (Fig. 7) (methods summarized in Appendix S1; for a full report see Banerjea *et al.*, 2014). The lowermost, Unit 113, corresponds to archaeological Context 113. This was confirmed as the natural geology by the dominance of geological inclusions (quartz, biotite hornfels and metamorphic rocks). The unit lacks anthropogenic detritus other than rare charcoal fragments within void spaces reworked from overlying units. Immediately above this, Unit 112 corresponded to Context 112 (containing sub-sample [b]). This contained iron and manganese nodules and ferruginous rootlets in voids, but lacked any signs of anthropogenic activity.

Context 111 was shown to consist of four units. The lowest unit, Unit 111d, was a compacted sandy clay loam lacking sedimentation, with rounded gravel-sized inclusions forming a distinct surface. It was not possible to determine whether this surface has been anthropogenically constructed or derived from a natural event, such as storm action. The inclusions are predominantly unorientated, unrelated, random and unreferred; however, the rounded gravel-sized metamorphic rock fragments are locally orientated and clustered, referred to each other, or orientated parallel to the basal boundary. The inclusions are predominantly geological (80%) with some fragments (0.2–4.0 mm) of angular-shaped flints (5–10%). One larger flint artefact, 2 cm, was located at the base of Unit 111d.

It is possible that the overlying unit, Unit 111c, represents an 'active floor (or surface) zone', (Gé *et al.*, 1993 p. 155) formed by the simultaneous actions of disaggregation, compaction and addition of sedimentary materials. The embedded related distribution indicates compaction, which may result from trampling, biological reworking and/or burial (Matthews, 1995; Retallack, 2001 p. 13; French, 2003; Banerjea *et al.*, 2015). Dusty impure clay coatings occur

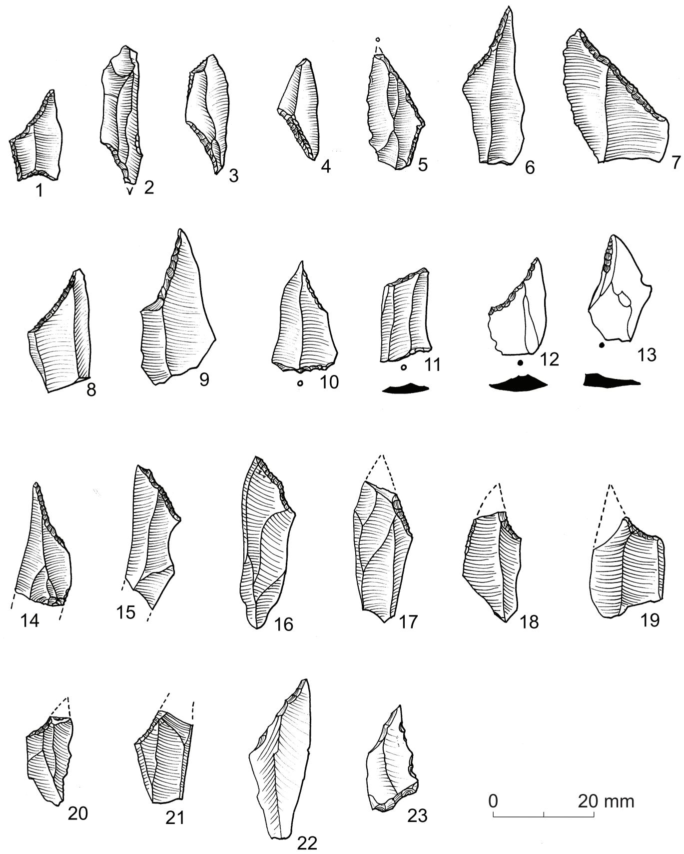

Figure 12. Ahrensburgian artefacts from selected sites in NW Europe. Obliquely retouched (Zonhoven) points and point fragments: 1–4, Kallenhardt (Baales, 1996); 5, Karstein (Baales, 1996); 6–7, Stellmoor (Rust, 1943); 8–10, Hofer (Veil, 1987); 11–13, Gahlen (Richter, 1981); 14–21, Deimern (Taute, 1968); 22–23, Galta 3 (Prøsch-Danielsen and Høgestøl, 1995). Redrawn at 1 : 1 scale.

which may indicate turbulent hydraulic conditions (Courty *et al.*, 1989) but in archaeological contexts can indicate processes such as trampling and dumping (Goldberg and Macphail, 2006; Shillito and Ryan, 2013, p. 691).

In comparison with Unit 111d, Unit 111c had a higher frequency of anthropogenic detritus of angular-shaped flints, charred wood and fragments of charred shells (probably hazelnut). The inclusions are unorientated, unrelated, randomly distributed and unreferred, which indicates haphazard deposition (Matthews, 1995; Shillito and Ryan, 2013; Banerjea *et al.*, 2015) and perhaps rotation because of reworking.

Unit 111b had similar properties to Unit 111d, constituting a second surface within archaeological Context 111, although it contained fragments of wood charcoal and shell (probably hazelnut). Such anthropogenic debris was at lower frequencies than in Unit 111c and had probably been trampled into the surface. The overlying unit, Unit 111a, had similar properties to Unit 111c.

The uppermost unit, Unit 101, corresponded to the base of archaeological Context 101. Soil development arising from chemical and biological weathering is evident in this unit based on a moderate to strongly developed fine crumb structure, chambers in the microstructure resulting from mesofaunal burrows, the breakdown of organic matter resulting in the occurrence of amorphous organic matter and organic staining. Plant tissue with organic staining within void spaces is evidence of decayed root material. Anthropogenic inclusions include poorly preserved and moderately burned bone fragments (0.25–1.0 mm), charred wood fragments (0.2–3.0 mm), fragments of charred shells (probably hazelnut), and angular-shaped flint fragments and amorphous charred organic matter.

The basal boundary of Unit 101 is different from the rest of the unit because its metamorphic rock fragments are moderately to strongly orientated and referred parallel to the basal boundary. These rock fragments may be the remains of a reworked constructed surface, similar to that in Units 111b and 111d. As a whole, therefore, Unit 101 may be the remains of a surface and its overlying occupation debris, which have been reworked by soil-forming processes.

With regard to post-depositional processes, all the units showed evidence of bioturbation. Fragments of ferruginous rootlets were visible within void spaces and mesofauna burrows had moved sediment, including fragments of charcoal, into the lowermost unit (Unit 113) from those above; it remains unclear whether the wood charcoal and hazelnut shell fragments in Units 111a–111d were *in situ* within those horizons or had been similarly moved down from (101). Despite bioturbation, however, stratigraphic integrity has been preserved to the extent that it is still possible to see the sequence of surfaces, interspersed with occupation debris, in Units 111a–d. It is unlikely that the 2-cm flint artefact at the base of Unit 111d could have been re-deposited from above. Pedogenesis has reworked Unit 101, so that it is not possible to conclusively determine if it had actually been two units, a surface and overlying occupation. We anticipate that further post-depositional insights will be gained by the acquisition of additional geochemical data as part of a wider intra-site tephra study.

Data synthesis

The technological and typological characteristics of the (111/2) chipped stone assemblage suggest a Lateglacial date.

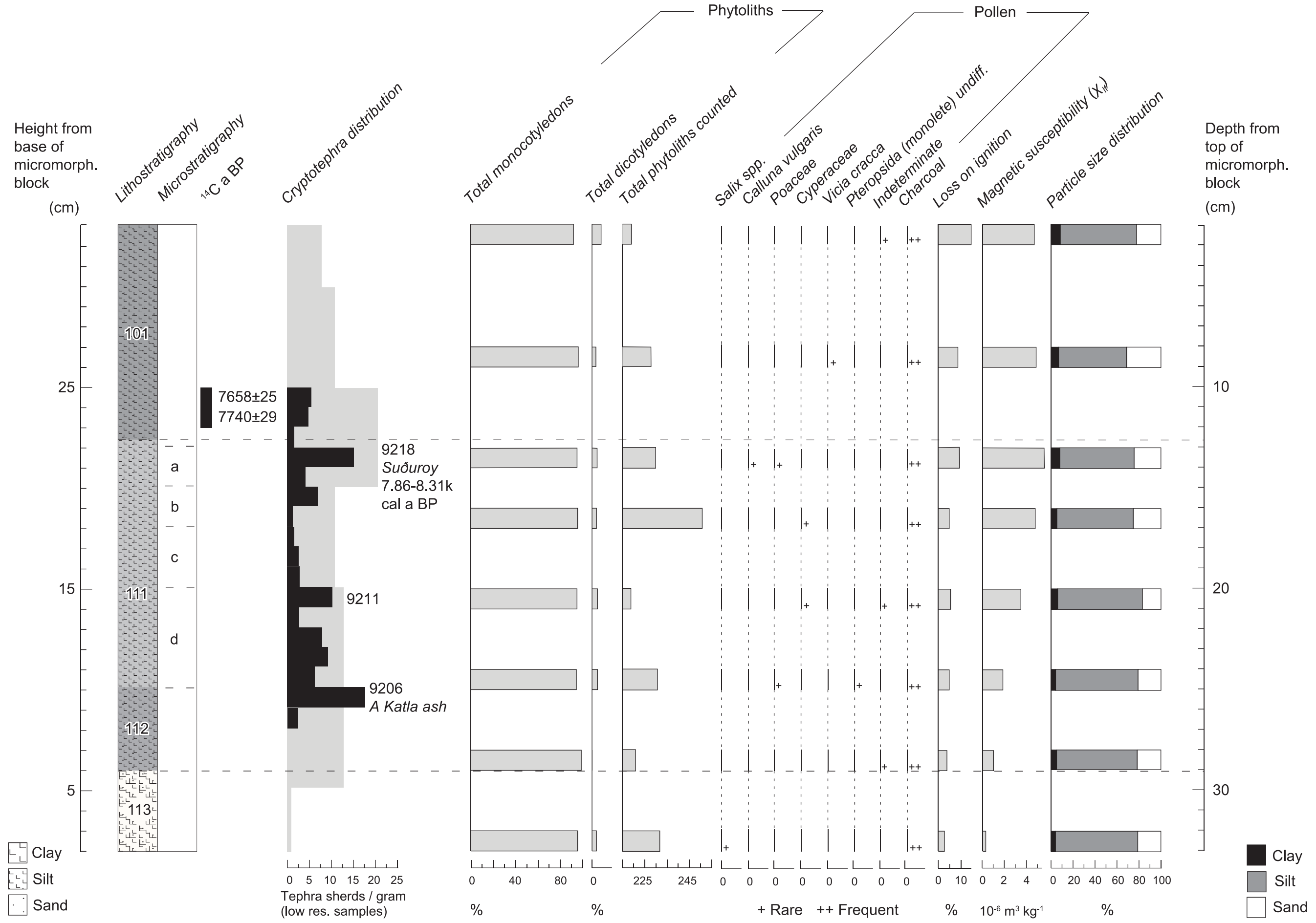

Figure 13. Litho- and microstratigraphy, R_Combine AMS dates (7740 ± 29 BP derived from Beta-353964 and Beta-363965, χ^2-test: d.f. = 1, T = 3.1 [5% 3.8]; 7658 ± 25 BP derived from Beta−363965 and Beta−363963, χ^2-test: d.f. = 1, T = 1.0 [5% 3.8]), cryptotephra distribution, phytolith assemblage, pollen assemblage, loss-on-ignition, magnetic susceptibility and particle size distributions from the Rubha Port an t-Seilich monolith block. The Katla ash could derive from either the Dimna Ash (15.6–15.1k cal a BP), the Vedde Ash (12.24–12.00k cal a BP) or the AF555 Ash (11.58–11.34k cal a BP).

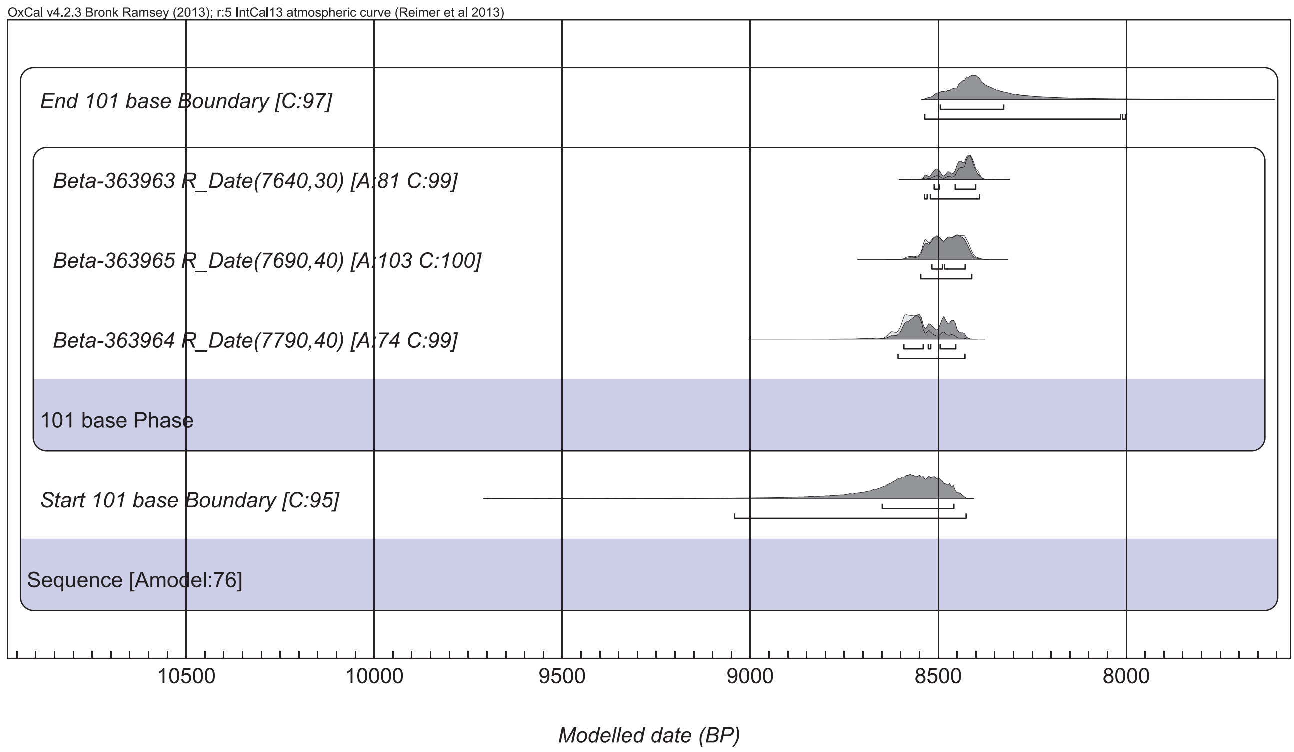

Figure 14. OxCal plot showing the chronological model for radiocarbon dates obtained from the base of the Mesolithic horizon (101) coincident with site grid square A20.

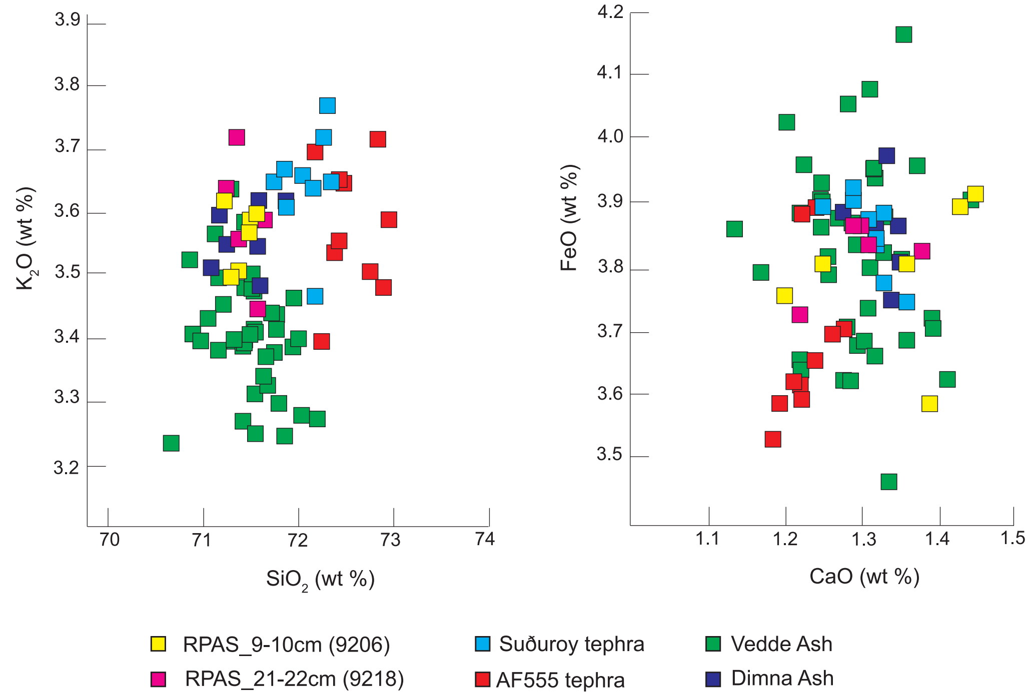

Figure 15. Elemental bi-plots for cryptotephras RPAS_9-10cm (9206) and RPAS_21-22cm (9218) compared with Lateglacial and Early Holocene tephra layers attributed to the Katla volcano (Dimna Ash: Koren *et al.*, 2008; Vedde ash: Lane *et al.*, 2012a; AF555: Matthews *et al.*, 2011; Suðuroy tephra: Wastegård, 2002). All data normalized to water-free totals. See Appendix S2 for full compositional data tables.

Although no definitively culturally diagnostic artefacts are present, the closest affinity is with the Ahrensburgian techno-complex as known from across north-west Europe and southern Scandinavia. This techno-complex currently lacks a precise chronology but is generally attributed to the second half of the Younger Dryas and the Preboreal (Weber *et al.*, 2011). As such, this is consistent with the AMS dating and preliminary tephrochronology from Rubha Port an t-Seilich. Although the precise depths of the (111/2) artefacts were not recorded, a large fragment of chipped stone was recovered from the block at a depth of 11–10 cm, immediately above the RPAS_9-10cm (9206) tephra that is attributed to either the Vedde Ash at 12.24–12.00k cal a BP or the AF555 Ash at 11.79–11.20 cal a BP. The (111/2) artefacts were sealed below a horizon post-dating 9.05k cal a BP as indicated by both Bayesian AMS modelling and tephra (RPAS_21-22cm 9218). Attribution of the (111/2) artefacts to the late Younger Dryas–Preboreal is also consistent with the palaeoenvironmental evidence. That from pollen suggests open conditions supporting areas of grassland possibly with heath and wet

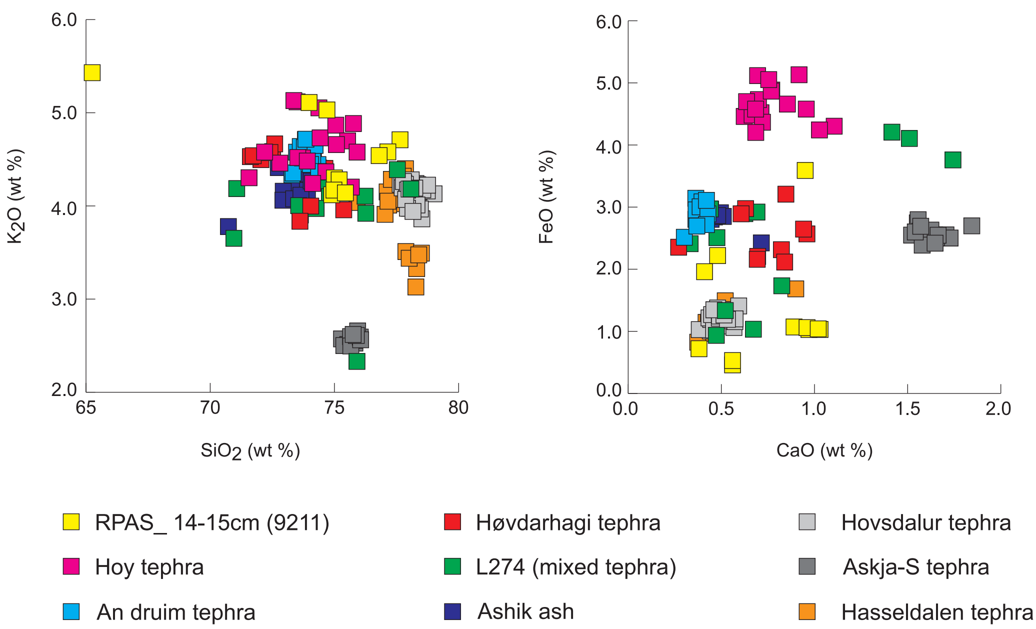

Figure 16. Elemental bi-plots for cryptotephra RPAS_14-15cm (9211) compared with Early Holocene Icelandic cryptotephra layers found in Northern Europe showing some compositional similarity (Hasseldalen and Askja-S tephras: Lane *et al.*, 2012b; Hovsdalur tephra: Wastegård, 2002; L-275 and Høverhagi tephra: Lind and Wastegård, 2011; Ashik ash: Pyne-O'Donnell, 2007; An Druim: Ranner *et al.*, 2005). All data normalized to water-free totals. See Appendix S2 for full compositional data tables.

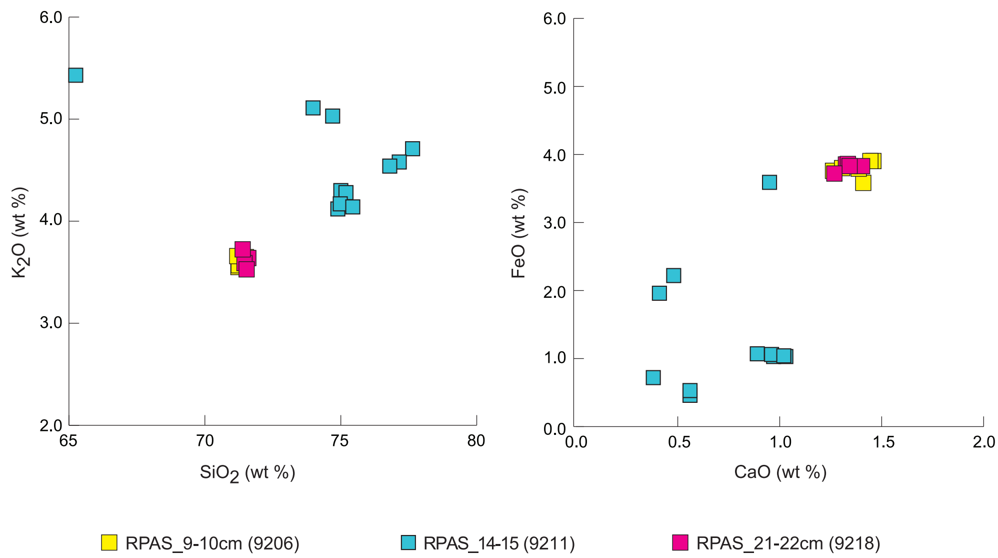

Figure 17. Elemental bi-plots for cryptotephras RPAS_9-10cm (9206), RPAS_14-15cm (9211) and RPAS_21-22cm (9218). All data normalized to water-free totals. See Appendix S2 for full compositional data tables.

ground nearby, this being corroborated by the phytolith evidence that indicates a landscape dominated by wild grasses, albeit with some trees/shrubs in the area.

Although interpretative uncertainties remain with each individual source of evidence, when placed together they provide a compelling case that the artefacts from Context 111/2 should be attributed to the Lateglacial–Early Holocene transition and may represent the first Ahrensburgian site in Scotland and the most north-westerly presence of this Lateglacial culture. Moreover, the geoarchaeological analysis indicates that artefacts within Context 111/2 have received a limited degree of bioturbation and have the potential to be related to microstratigraphy within that horizon. The often subtle variations in sediment characteristics and geochemical composition between samples taken from (111) and (112) might derive from either environmental change occurring at

Table 5. Quantitative results of the bulk and clay mineralogy XRD.

Sample	Depth (cm)	Quartz (%)	Illite/mica (muscovite) (%)	Albite (%)	Expandable (%)	Kaolinite & chlorite
h	31–32	55	21	13	11	Trace
g	26–27	44	46	10	Trace	Trace
f	21–22	76	14	8	2	Trace
e	18–19	76	9	12	3	Trace
d	14–15	47	23	24	6	Trace
c	10–11	66	16	13	5	Trace
b	6–7	62	20	10	8	Trace
a	2–3	71	12	9	8	Trace

Table 6. Results of the pXRF analysis. Data expressed as parts per million: (a) trace elements; (b) major elements.

(a) Trace elements	Sample and depth (cm)		P	Si	Ba	Nb	Zr	Sr	Rb	As	Pb	Zn	Cu
	h	31–32	13 627.93	92 050.04	442.27	<LOD	120.49	500.73	28.64	<LOD	10.69	47.77	171.76
	g	26–27	14 060.84	111 885.1	344.01	8.62	141.19	836.34	28.04	<LOD	7.83	66.85	120.71
	f	21–22	9928.03	114 490.5	243.98	<LOD	122.83	474.89	23.9	<LOD	7.42	53.08	93.6
	e	18–19	11 312.14	136 598.4	367.02	10.24	131.63	466.35	32.82	<LOD	<LOD	85.58	103.27
	d	14–15	10 504.61	148 269.1	616.69	10.2	199.42	381.27	41.4	<LOD	<LOD	73.14	72.52
	c	10–11	16 574.01	138 002.3	537.66	10.27	177.2	485.71	36.98	<LOD	<LOD	54.01	<LOD
	b	6–7	16 551.76	142 334.3	623.29	11.09	200.72	398.12	34.84	16.44	<LOD	36.47	<LOD
	a	2–3	14 260.28	173 832.9	531.67	12.72	226.12	331.5	31.86	<LOD	<LOD	40.06	<LOD

(b) Major elements	Sample and depth (cm)		Fe	Mn	Cr	V	Ti	Ca	K	Al	Cl	S
	h	31–32	40 826.45	263.94	105.31	365.14	2338.4	1630.56	11 602.55	23 823.08	317.84	722.14
	g	26–27	39 548.13	<LOD	104.44	381.27	2601.55	1381.06	13 523.7	23 391.31	220.12	611.93
	f	21–22	33 624.56	<LOD	95.68	325.46	2281.02	1615.82	13 306.17	20 617.2	289.81	473.05
	e	18–19	40 354.41	<LOD	141.11	361.48	2779.82	1371.77	15 978.57	27 687.08	284.27	376.72
	d	14–15	43 320.88	<LOD	99.3	398.04	3191.98	475.45	23 422.5	33 229.64	166.6	<LOD
	c	10–11	53 513.88	<LOD	152.26	429.64	3154.33	633.24	20 793.36	32 024.71	201.18	<LOD
	b	6–7	47 292.72	<LOD	140.67	370.19	3285.9	692.32	20 918.43	29 092.71	<LOD	<LOD
	a	2–3	38 243.68	<LOD	103.95	333.18	3134.49	433.16	22 262.35	35 137.54	175.36	<LOD

Nb LOD = 3 ppm, As LOD = 5 ppm, Pb LOD = 10 ppm, Cu LOD = 15 ppm, Mn LOD = 65 ppm, Cl LOD = 80 ppm, S LOD = 90 ppm.

the transition from the Lateglacial to the Early Holocene or from anthropogenic impacts.

Discussion

Although we have tentatively attributed the artefacts from Rubha Port an t-Seilich to the Ahrensburgian we use that term cautiously. We recognize that this term remains chronologically ill-defined and encompasses considerable variability in technology and economic activities. Nevertheless, the Ahrensburgian provides the most likely techno-complex in which to place the (111/2) assemblage. If correct, the site would lend credence to the possibility that the tanged points from Shieldaig and Balevullin also belong to the Ahrensburgian.

If our interpretation is correct, Rubha Port an t-Seilich represents the most north-westerly known occurrence of Ahrensburgian activity, although this would be further extended if the interpretation of the tanged points from Shieldaig and Tiree (Ballin and Saville, 2003) and of that found at Link's House on Orkney (Woodward, 2008) are also accepted. Interestingly, Vermeersch (2011) has shown on the basis of the available radiocarbon record for the Ahrensburgian that there is a marked increase in the number of dated sites outside of the Benelux region in the second half of GS-1 and after the Vedde Ash, which also provides a clear *terminus post quem* for the oldest human occupation at Rubha Port an t-Seilich. Perhaps this site represents the north-westernmost outpost of this expansion around the Pleistocene–Holocene boundary.

The relative paucity of Lateglacial evidence from the interior of northern England, Wales or Ireland (see Pettitt and White, 2012, their figs 8.4, 8.15 and 8.17) might suggest that the Ahrensburgian hunter-gatherers who arrived in Scotland came directly from the east, either crossing Doggerland or travelling around its northern margin, rather than from the south. During the Loch Lomond Stadial extensive ice fields in the western Highlands would have limited the movement of people across the mainland of Scotland, whereas the coastlines of western Scotland remained ice free (Ballantyne, 2004). Furthermore, studies of glacio-marine sediments have shown sea level was *c.* 5 m lower than at present within the study region during the Loch Lomond Stadial (Dawson and Dawson, 2000). As such, it is highly probable that the Isle of Islay remained cut off from the mainland due to the deep channel that separates it from Jura and the mainland (McConnell *et al.*, 2013). Unhindered access could therefore have only been gained by people using boats probably coming from the north.

With regard to the environments these pioneer hunter-gatherers encountered, western Scotland would not have been altogether inhospitable despite the cold tundra conditions of the Loch Lomond Stadial having brought about an overall reduction in hunter-gatherer activity in Britain (Pettitt and White, 2012 p. 495). Deglaciation records from the Rannoch Moor region of western Scotland indicate that despite winter sea surface temperatures falling by as much as 6 °C below present-day during this stadial (Ballantyne, 2007), seasonality was greatly amplified, raising summer temperatures possibly as a function of a more continental climate in the North Atlantic (Bromley *et al.*, 2014). This could have provided opportunities for seasonal incursions into the region, especially during the last few centuries of the Pleistocene. Decreased sea-ice occurrences, reduced wind strength and generally higher temperatures are all elements that would make marine ventures less risky and thus more demographically viable for the small populations operating along the northern European margins.

Regional pollen records show that extensive grasslands would have formed a mosaic with dwarf communities of birch and willow scrub over thin minerogenic soils almost everywhere in western Scotland during the Loch Lomond Stadial (Edwards and Whittington, 1994 2003; ScARF, 2012), providing attractive browsing for grazing mammals. Recent biogeographical studies show that Britain's mammal community was similar to or indeed richer than those of southern parts of Scandinavia, the Netherlands and Belgium from Lateglacial Interstadial times (Montgomery *et al.*, 2014). Ahrensburgian sites in northern England have produced cut-marked remains of horse and reindeer such as Sewell's Cave in North Yorkshire (Lord *et al.*, 2007) and Flixton II in the Vale of Pickering (Conneller, 2007). Such evidence is consistent with that showing the importance of these large mammals at Ahrensburgian sites on the continent (Bratlund, 1996; Baales, 1999).

It may also be conjectured that cool-tolerant freshwater and marine fauna, along with wildfowl, as known from Lateglacial palaeontological sites in southern Scandinavia, are likely to have been present at similar mid-latitude locations in western Scotland (e.g. Brinch Petersen, 2009). Indeed, the location of Rubha Port an t-Seilich, on the relatively sheltered coast of an island off the west coast of Scotland, and the site's specific topographic characteristics that provide suitable mooring for small boats, lends credence to the notion of a specific coastal adaptation within the Ahrensburgian. There is circumstantial evidence for hunting from boats at sites such as Stellmoor (see Tromnau, 1987; Weber, 2012), although the degree to which these weak lines of evidence attest to a fully marine adaptation rather than an incipient marine-orientated adaptation is debatable.

Rubha Port an t-Seilich could only have been reached by boat and those arriving in the late Younger Dryas–Preboreal may have long been familiar with marine mammals, a supposition based on the interpretation of barbed points found in association with Ahrensburgian techno-complexes on the continent that have been interpreted as tools for seal-hunting (Cziesla, 2007). The absence of such points from Rubha Port an t-Seilich might be a consequence of the small sample size of the assemblage. Likewise, the assemblage lacks flake axes, which are a distinguishing feature of the coastal Ahrensburgian found in western Sweden and south-western Norway. These artefacts may have served as blubber-knives and were thus possibly related to the exploitation of marine mammals and umiak-like boat technology (Schmitt, 2013b).

Although, following Kindgren (2002) the position of Rubha Port an t-Seilich would initially appear to support the notion of an Ahrensburgian coastal adaptation, we note that the fauna currently analysed from the site's Mesolithic horizons suggests a predominance of terrestrial hunting of large mammals, including red deer, roe deer and wild boar. Also, a default characteristic of site location within the islands of western Scotland is that they can never be far from the coast and hence using site location by itself to argue for a coastal or marine adaptation is problematic.

Conclusions

The archaeological, tephra and geoarchaeological evidence from Rubha Port an t-Seilich indicates that Lateglacial hunter-gatherers arrived possibly by boat at this location in western Scotland most likely in the late Younger Dryas–Preboreal period. The high percentage of retouched tools within the chipped stone assemblage could indicate that a primary toolkit was brought to the site, some of this being subsequently abandoned after a relatively short period of activity (cf. Richter, 1990).

Any additional interpretation of the Lateglacial activity at Rubha Port an t-Seilich must await further excavation to recover a larger sample of evidence. The opportunity to do so is one of the most important aspects of this discovery. In this key regard, Rubha Port an t-Seilich contrasts with Howburn where no *in situ* remains have survived and with Shieldaig and Balevullin where the artefacts are stray finds with no provenance. The site also contrasts with coastal Ahrensburgian sites in Sweden and Norway that rarely if ever allow absolute dating other than via shorelines. The potential of future excavation at Rubha Port an t-Seilich is especially promising because of the rich overlying Mesolithic deposits that do contain faunal remains.

The Mesolithic deposits have already indicated several chronologically distinct activity events suggesting that Rubha Port an t-Seilich was used on a recurrent basis (Wicks and Mithen, 2014). This is not surprising in light of the local topography that provides ease of access by small boats and the availability of resources from terrestrial, coastal and marine environments. Moreover, the Sound of Islay provides access not only to the relatively large islands of Islay and Jura but is a key route-way to the smaller Hebridean islands to the north, also known to have been utilized during the Mesolithic, such as Oronsay, Colonsay and Coll, as well as Tiree, from where a claimed Ahrensburgian point has been recovered. In this regard, it may not be surprising that Rubha Port an t-Seilich appears to have been selected on at least one occasion in the Lateglacial. The area investigated at Rubha Port an t-Seilich remains small, but because of the attractiveness of the location, the number of Lateglacial activity events that are ultimately revealed by full excavation might provide a gauge for the overall scale of Lateglacial activity in this region, as the site appears to do for the Mesolithic.

In conclusion, the discovery of the Rubha Port an t-Seilich site leads us to strongly question Finlayson's (1999) long-held assertion that the search for the Lateglacial pioneer occupation of Scotland is a futile endeavour. We do agree with him, however, that establishing the degree to which economic and mobility strategies were or became adapted to coastal and marine environs is critical for better understanding the timing, patterns, processes and motivations for such dispersal pulses. The likely discovery of Lateglacial activity at Rubha Port an t-Seilich provides an opportunity to undertake further fieldwork and laboratory analysis to contribute towards that understanding.

Supporting Information

Additional supporting information can be found in the online version of this article:

Appendix S1. Methods.

Appendix S2. Tephra counts and EMPA tables.

Appendix S3. Rapid pollen assessment: Rubha Port an t-Seilich, Islay (Site Code: RPAS13/T1).

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Abbreviations. ABP, arch-backed point complex; AMS, accelerator mass spectrometry; GI, Greenland Interstadial; GS, Greenland Stadial; pXRF, portable X-ray fluorescence; SP, shouldered point complex; TP, tanged point complex; XRD, X-ray diffraction.

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