Palaeoenvironmental investigations at two Norse farms near the margin of the Greenland Ice Sheet

Report to the Greenland National Museum and Archives on fieldwork undertaken in the Norse Western Settlement during August and September 2015

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Cover image: the dwelling at Umiivik (ruin group V15) on Kangersuneq fjord. (Photo by J.E.Schofield, August 2015).

"I went up to it, and from there beheld new country: Austmannadal. It was a narrow, wild valley, where a glacier river ran white, though a mist of green lay upon the hillsides to the west. Having scrambled down the steep slope I set off up the valley to see something of the old buildings. A drenching rain began to fall, and never stopped; yet there was this to be said for it: I was soon so soaking wet that I hadn't to trouble about keeping anything dry."

Helge Ingstad – *Land under the Pole Star* (1966: 280-281)

1 INTRODUCTION, AIMS AND OBJECTIVES

This report contains details of palaeoenvironmental fieldwork undertaken in the Western Settlement of Greenland by researchers from the Universities of Aberdeen and Liverpool, UK, during August-September 2015. Attention is centred upon two Norse farmsteads located very close to the margin of the Greenland Ice Sheet (GrIS); ruin group V53d, which is situated towards the head of Austmannadalen, and V15 at Umiivik, to the east of Kangersuneq (Fig. 1). Even today, these sites are considered to be remote and difficult to access without a helicopter. Reaching V53d requires a long (c. 20 km) trek inland from Sandnes (V51) over rough, steep and uneven ground, and often through dense willow and alder scrub, whilst V15 can only be arrived at (during the summer months, at least) by navigating the iceberg-choked Kangersuneq fjord in a small boat. Similar challenges were presumably faced by the Norse settlers, which makes the choice of these locations for sizeable farmsteads intriguing. In addition, during the period of Norse settlement – conventionally accepted as c. AD 1000-1350 for the Western Settlement (cf. Barlow et al. 1997) – both farms were possibly at risk of being significantly disrupted by events linked to the advance of tidewater glaciers in Kangersuneq, as temperatures declined into the 'Little Ice Age' (Grove 1988).

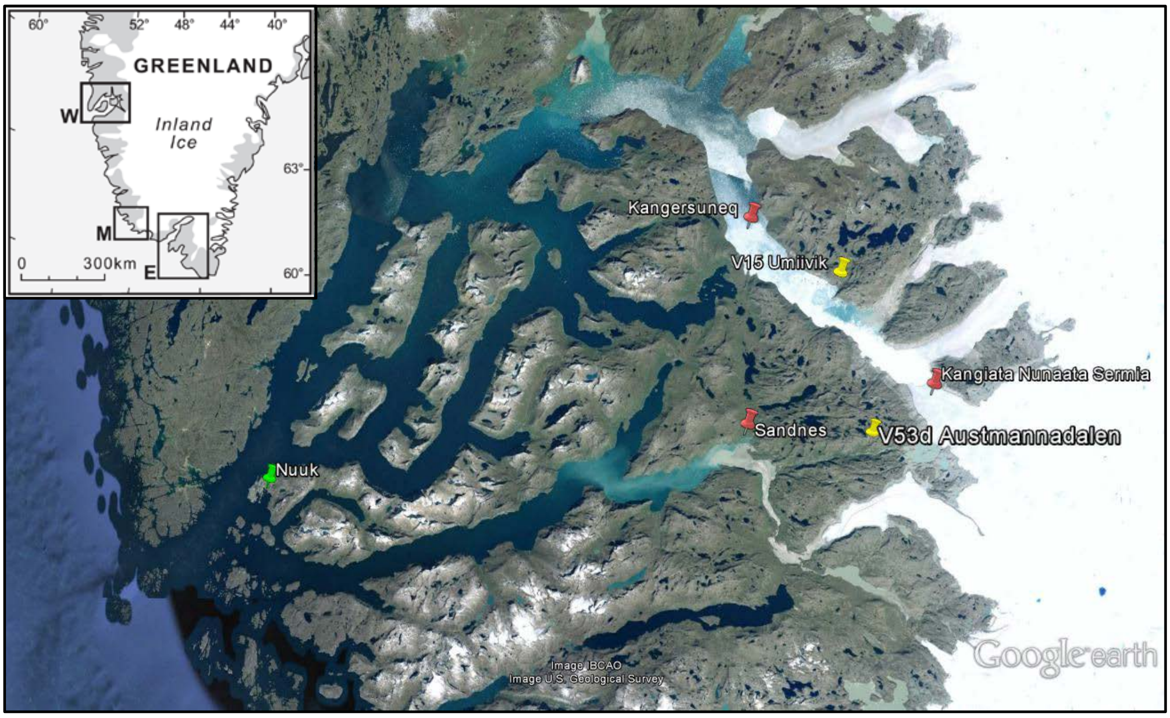

Figure 1: Main panel: *Google Earth* image of the Western Settlement of Greenland. The two field locations featured in this investigation are marked by yellow pins. Other places and landscape features mentioned in the text are labelled. *(Map Data: Google, IBCAO and U.S. Geological Survey)*. Inset: location of the Norse Settlements in Greenland. W = Western (this report); M = Middle; E = Eastern.

The main objective of our fieldwork was to locate and sample organic sediments (e.g. peat) and soil profiles occurring in close proximity to the ruins at V15 and V53d. These samples would be returned to the UK for laboratory investigation (pollen analysis and ^{14}C dating) with the aim of revealing information about landscape and vegetation change, and land-use activity – particularly the character and intensity of farming – in the areas immediately around the former farmsteads during the period that these were occupied (*cf.* Edwards et al. 2008; Schofield & Edwards 2011; Ledger et al. 2014). It was anticipated that should suitable samples be obtained, their analysis might also contribute to the wider debate surrounding the timing of Norse settlement in Greenland by potentially establishing precise dates for *landnám* and abandonment at two relatively large Western Settlement farms.

This research forms part of a larger 3-year project (2015-2018) funded by the Leverhulme Trust – entitled *Calving glaciers: long-term validation and evidence (CALVE)* – that seeks to reconstruct the advance and retreat cycle of the Kangiata Nunaata Sermia (KNS) tidewater glacier at the head of Kangersuneq over the last c. 1000 cal. yr. In this report, we present details of the samples that were collected, and our observations on the sites under investigation. The results from 'rangefinder' radiocarbon dating of selected materials/profiles are also included, allowing some tentative preliminary conclusions to be made regarding the probable timing of occupation of the farms featured in our investigation.

2 AUSTMANNADALEN: RUIN GROUP V53d (64V2-III-518)

2.1 Background and archaeological context

Ruin group V53d is situated in Austmannadalen, approximately 13 km east and inland of Nansen's tent place (*Nansens teltplads*), and ~10 km west of KNS glacier (64º13'35" N, 49º49'11" W; Fig. 2). The farm is not located immediately adjacent to Kuussuaq – the river running the length of Austmannadalen. Rather, it can be found on slightly elevated slopes (~220 m a.s.l.) around 1 km north of the river, beside a tributary that feeds into the main river channel and which presumably provided the Norse settlers with their fresh water. The ruins represent the remains of a 'centralized farm' in which most of the buildings – the living quarters, byres, barn, storerooms, and a postulated bath-house – are all drawn together into a single unit (Roussell 1941). The site was excavated in 1937 by Aage Roussell. The dig unearthed ~150 objects including a carved wooden crucifix and an iron hunting spear. Much of the area around the ruins is covered by willow scrub, and this has begun to encroach upon, and obscure what remains of the buildings (Fig. 3). This was not the case at the time of the excavation in 1937; a photograph appearing in Roussell (1941: Fig.111, p.181) clearly shows the area around the house to be grassy and clear of shrubs.

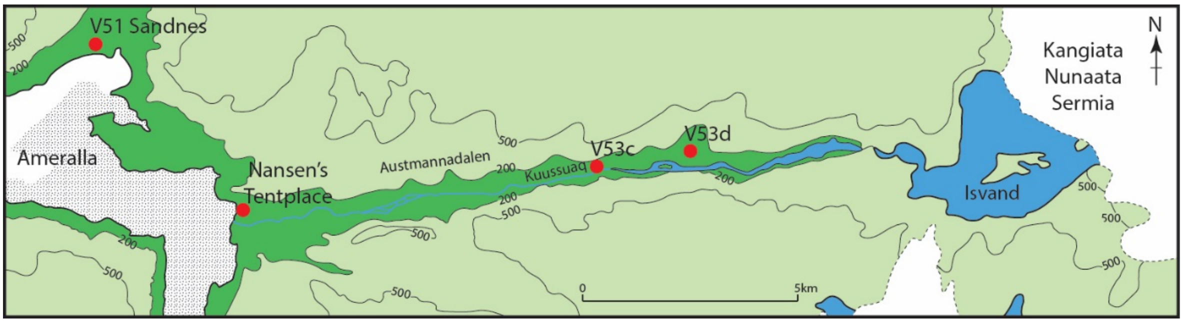

Figure 2: Location of ruin group V53d in Austmannadalen. Other places and landscape features mentioned in the text are labelled. Isvand is depicted as this appears on the 1:250 000 Nuuk/Gobthåb map sheet (Tage Schjøtt 2003) prior to drainage of the lake in 2009. The stippling in Ameralla depicts the silted-up area at the head of the fjord that is not navigable by boat. Dark green shading indicates land generally below 200 m a.s.l. (contours in metres).

A little-discussed feature of Norse settlement in Austmannadalen are potential impacts that may have arisen from the routing of glacial meltwater down the valley. The advance position/size of KNS determines whether meltwater from the glacier is directed into Kangersuneq fjord, or down Austmannadalen and into Ameralla fjord via the ice-damned lake (IDL) known as Isvand (Uukkaasup Tasia) (Fig. 2). For much of the past ~250 years, drainage has been into Ameralla fjord, yet by the first decade of the 21st century, rising temperatures had caused KNS to retreat to a position where Isvand had emptied and tapping of the glacier discharge through Austmannadalen had been 'switched off' (Weidick and Citterio 2011). The details surrounding the pattern of drainage before the 18th century are uncertain, but as KNS advanced during the period of cooler temperatures leading into and through the Little Ice Age, this would have led to meltwater routing down Austmannadalen being 'switched on' at some, as yet unspecified, time in the past. If this occurred during the period of Norse settlement, then it might have presented significant challenges to access and movement through the valley; for example, through flooding, the accumulation of silt on the valley floor and at the river mouth, and increased difficulty in fording the river.

Figure 3: View southeast over ruin group V53d, Austmannadalen. The remains of the dwelling are visible as the low mound partly covered by willow bushes in the centre of the photograph.

2.2 Sampling locations and methods

The ruins at V53d overlook a mire – an area of sedge-rich wet ground containing small pools – that is traversed by the stream (Fig. 3). This was investigated using an Eijkelkamp gouge auger (2.5 cm diameter chamber) on the supposition that it might yield a significant depth of peat for laboratory analysis. A transect comprising ~20 boreholes at ~5 m spacing was run across the mire. In addition, two soil test pits measuring ~1x1 m^2 were excavated within the willow scrub approximately 50 m west of the dwelling (64º13'37'' N, 49º49'16'' W) in the hope that these might reveal peat and/or cultural soil profiles. Similar soil pits were also dug within a basin mire situated several hundred metres northeast and elevated above V53d (64º13'46" N, 49º48'37" W; ~320 m a.s.l.), and from the floodplain of the main river valley, approximately 2 km southwest of the farm (64º13'05" N, 49º50'48" W; ~180 m a.s.l.). These locations were explored with the intention of gathering samples that might provide information about environmental changes in the wider catchment area around the farm.

Samples were collected from the locations outlined above by inserting monolith tins into the cleaned faces of the soil pits. These tins were wrapped in polythene bags, sealed, and shipped back to the University of Aberdeen where they were placed in cold storage (4ºC). Preliminary laboratory analysis of the samples has begun with measurement of the organic content through loss-on-ignition (LOI) following combustion in a furnace at 550ºC for three hours, and the broad determination of the absolute ages of profiles using a series of radiocarbon 'rangefinder' dates. Terrestrial plant macrofossils such as mosses, seeds, leaves, charcoal, etc. typically provide the most reliable materials for AMS ^{14}C dating in this environment (cf. Edwards et al. 2008; Blockley et al. 2015), and these were selected where possible. Samples were soaked with weak 10% NaOH to disaggregate the sediment prior to sieving (500 μm mesh). Macrofossils suitable for AMS were then picked from sieve residues using fine forceps and stored in distilled water in glass vials. ^{14}C dating of the humic acid fraction of 1 cm^3 bulk sediment samples was undertaken as an alternative in cases where suitable macrofossils for AMS could not be found. Measurements were performed at the ^{14}CHRONO Centre, University of Belfast.

2.3 Results, interpretation and discussion

2.3.1 Samples from the area immediately around the farm

The borehole transect across the mire in front of the ruins revealed up to ~30 cm of organic-rich sands – probably colluvial in origin – resting above a thin (~10-20 cm) sandy peat on top of a solid (bedrock) base. The total depth of sediment across the mire is shallow –typically less than 40 cm – and the deposit appears unpromising from a palaeoenvironmental perspective; the high minerogenic content of the peat suggests significant potential for large numbers of reworked secondary microfossils to be contained in the deposit. For these reasons, laboratory samples were not collected from this area.

The soil pits under the willow scrub proved to be more promising. The stratigraphy here comprises a fibrous and humus-rich modern root mat (O horizon) extending from the surface to a depth of ~7 cm. This is developed above a medium brown organic-rich layer (Ap horizon; ~30 cm thickness) of variable minerogenic content (LOI ~20-60%) containing flecks of charcoal and occasional narrow sandy stripes. The striping, where present, is most frequent towards the bottom of the unit. The organic deposit rests upon a fine yellowish-grey sand (BC horizon) that is iron-stained (oxidised) in places. This sand was proven to a depth of at least 70 cm. The contact between the sand and the overlying organics is irregular. In one soil pit (AMDa; Fig. 4), a narrow black band was revealed – possibly composed of fine charcoal particles; this will need to be confirmed in the laboratory – that delimits a sharp boundary separating the basal minerogenic (BC) and overlying organic (Ap) horizons. Yet in some places this contact in blurred and appears to have been disturbed/mixed, possibly as a result of cryoturbation. In the second, closely adjacent soil pit (AMDb; Fig. 4), the black band is absent, but the sediment division is still very sharp.

In appearance, the organic-rich (Ap) layer revealed in the soil pits at V53d resembles anthrosols (i.e. anthropogenically-created or enhanced soils) that have been found at several other Norse farms in Greenland, such as Ø47 Igaliku/*Garðar* (Buckland et al. 2009), Ø65 Atikilleq (Ledger et al. 2015), and Ø221 Sandhavn (Golding et al. 2011, 2015). This indicates that a homefield is likely to have been present in the area between the stream and the dwelling. If the dark band at the base of soil pit AMDa is indeed charcoal, then it is tempting to attribute this to *landnám*, with clearance of the area for the homefield being achieved through burning of the vegetation cover (cf. Iversen 1934; Fredskild 1988). Stratigraphic evidence from the second soil pit (AMDb), however, suggests a different mode of clearance; in this case, the sharp contact between the anthrosol and basal sediments, and the absence of an apparent burnt layer, suggests that the turf may have been cut/stripped here (probably for use as building material) before the anthrosol was laid down.

Figure 4: Cultural soil profiles at V53d (left panel – AMDa; right panel – AMDb).

Lab code	Profile	Depth (cm)	Material	^{14}C age (yr BP)	cal AD range (95.4% confidence)
UBA-31333	AMDa	14-15	Charcoal and *Montia fontana* seeds	645 ± 46	1278-1401
UBA-31334	AMDa	31-33	Charcoal and *Carex* seeds	1101 ± 49	777-1022
UBA-31335	AMD2	10-11	*Sphagnum* sect. *Acutifolia*	183 ± 34	1650-1950
UBA-31336	AMD2	29-30	*Sphagnum* sect. *Acutifolia*	1443 ± 30	566-653
UBA-31337	RIVA5	20.5-21.0	*Betula nana* leaf	*1.0121 ± 0.0037	1955-1957
UBA-32286	RIVA5	47-48	~1 cm^3 bulk organic-rich sediment (humic acid fraction)	463 ± 41	1398-1615
UBA-31338	RIVA5	57-58	~1 cm^3 bulk organic-rich sediment (humic acid fraction)	972 ± 43	992-1160

Table 1: Radiocarbon dates on samples collected from Austmannadalen. Calibration was performed using Calib v.7.0 software (Stuiver & Reimer 1993) and the IntCal13 calibration curve (Reimer et al. 2013). UBA-31337 returned a 'modern' (post-AD 1950) result. This date was calibrated using CALIbomb software and the Northern Hemisphere Zone 1 post-bomb calibration dataset (Reimer et al. 2004). * indicates fraction modern ($F^{14}C$).

Two ^{14}C dates are available for the anthrosol from soil pit AMDa (Table 1). A sample comprising bulked charcoal fragments and *Carex* (sedge) seeds taken towards the base of the deposit (31-33 cm) returned a date of 1101±49 ^{14}C yr BP (UBA-31334). The calibrated range (AD 777-1022; 95.4% probability) encompasses the conventional timing of first settlement in Greenland and, if accurate, suggests that the farm was established during the early stages of the colonisation process (i.e. within no more than three decades of the arrival of the first settlers in Greenland). A second ^{14}C sample consisting of bulked charcoal fragments and seeds of *Montia fontana* (blinks) – a plant considered to be a Norse apophyte in Greenland (Fredskild 1988; Edwards et al. 2011) – was extracted near the top of the anthrosol (14-15 cm). This provided an uncalibrated age of 645±46 ^{14}C yr BP (UBA-31333). The calendar age range for this sample (AD 1278-1401; 95.4%) indicates that it probably dates to the 14th century AD, denoting a likely end-of-settlement date for the farm that is in broad agreement with the conventional wisdom that the Western Settlement was abandoned by ~AD 1350.

2.3.2 Samples from the basin mire

Exploration of the basin above V53d (Fig. 5) revealed a brown fibrous peat extending to a maximum depth of ~40 cm. This peat contains a significant inorganic component (LOI varies between ~5-60%), and thin sandy stripes are occasionally visible with the peat that indicate the episodic inwash of material eroded from the surrounding slopes and delivered onto the mire surface. The peat rests upon a base of fine yellow sand. A sample was collected from one of the deeper pockets of peat revealed during augering.

Figure 5: Mire near V53d. A peat monolith was collected from the centre of the basin (note person for scale).

Two radiocarbon 'rangefinders' are available for the profile (Table 1). Both measurements were made on the leaves and stems of bog mosses (*Sphagnum* section *Acutifolia*). The lower of the two dates (UBA-31336; 29-30 cm) returned a result of 1443±30 ^{14}C yr BP (AD 566-653; 95.4%). The upper measurement (UBA-31335; 10-11 cm) is 183±34 ^{14}C yr BP (AD 1650-1950; 95.4%). The rangefinders indicate that the peat is likely to contain an uninterrupted environmental record that encompasses the Norse occupation at V53d and the Western Settlement in general. It also holds the potential to provide information relating to the environmental 'baseline' leading up to *landnám*, and the post-abandonment (landscape recovery) phase. Pollen analysis and a further programme of ^{14}C dating will be conducted on this profile in due course.

2.3.3 Samples from the main valley floor

A series of five soil pits (RIVA1-5) were placed at regular intervals (10 m spacing) across the valley floor immediately north of the river (Kuussuaq), at a location approximately equidistant (2 km) from ruin groups V53c and V53d (Fig. 6). The soil pits revealed ~10 cm of black humus-rich topsoil developed above ~45 cm thickness of fine grey-brown sandy silt, resting on a compressed black and well-humified peat (Fig. 7). The peat unit extends to a depth of at least 70 cm, but its full thickness could not be established as frozen ground prevented deeper excavation.

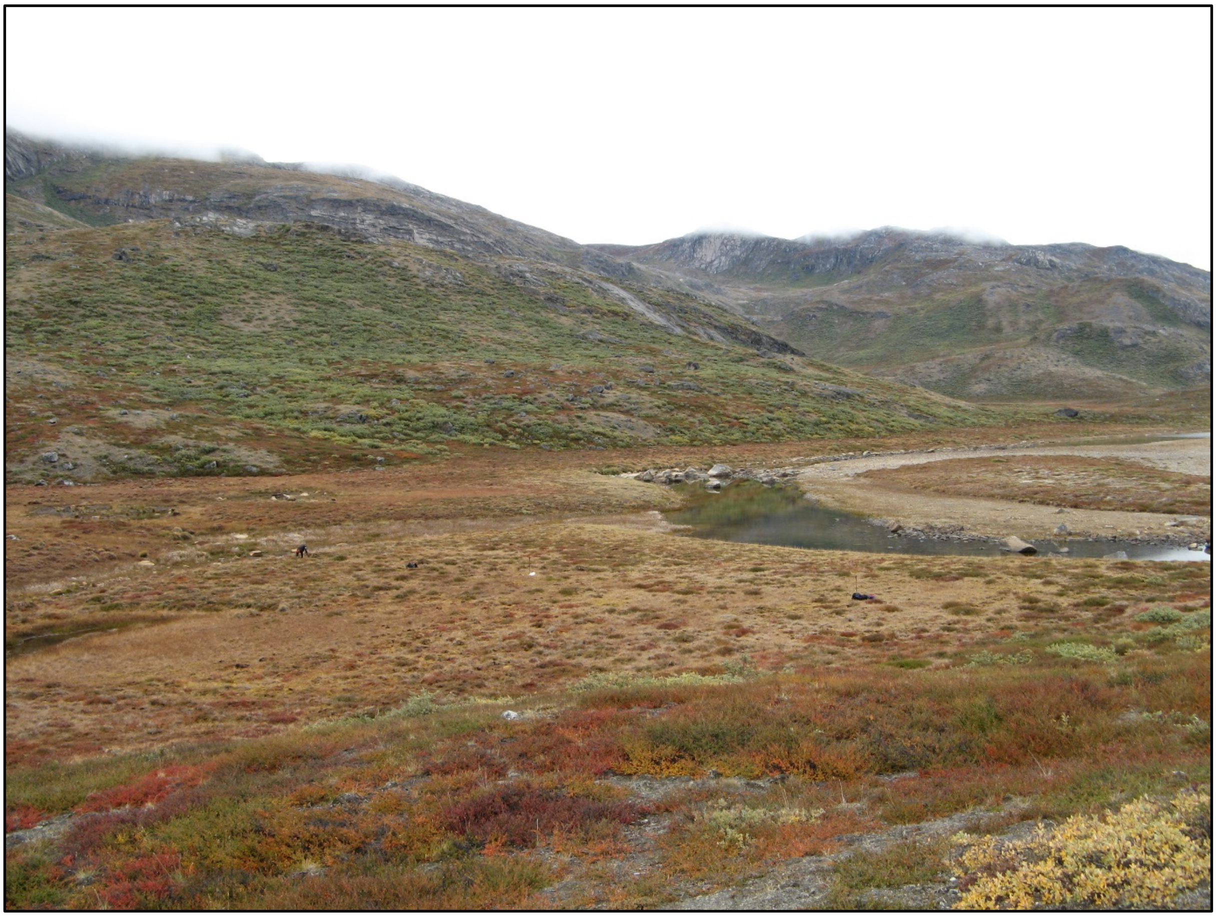

Figure 6: View northeast across the floodplain of Austmannadalen at a location around 2 km southwest of V53d. The channel of the river (Kuussuaq) flowing down the valley is visible on the right of the picture. Fine-grained alluvial sediments resting on peat were discovered in soil pits excavated on the low ground in the centre of the photograph.

The silt unit probably represents alluvium deposited during spring and early summer flooding at the time that sediment-laden glacial meltwater from KNS was directed down the valley (see Section 2.1). The silt contains two distinct, narrow, black organic bands. These seemingly represent palaeosols, i.e. buried fossil soils, similar to the contemporary soil profile but compressed by the weight of overlying sediment. These palaeosols may reflect brief periods in the past when flooding from the river was halted (locally, at least), thereby allowing soil formation to proceed. Reduced flooding might have occurred, for example, had the river been more deeply-incising its channel, or if its course had altered.

Three radiocarbon dates are available for the profile (Table 1); one from towards the top of the peat bed (~57-58 cm; UBA-31338), one from the lower palaeosol (~47-48 cm; UBA-32286), and one from the upper palaeosol (~20.5-21.0 cm; UBA-31337). The result returned for the top of the peat (972±43 ^{14}C yr BP; cal AD 992-1160 [95.4%])) provides a limiting (oldest) age for the peat-silt contact, and (by inference) an earliest date for when the tapping of glacial meltwater down Austmannadalen was initiated. This event appears to have occurred during either the 11th or early 12th century AD, i.e. most probably during a c. 150 cal. yr period after *landnám* at V53d (see Section 2.3.1). This event was therefore probably witnessed by the Norse settlers in this area. The calibrated radiocarbon dates on the lower palaeosol (cal AD 1398-1615) and the upper palaeosol (cal AD 1955-57) indicate subsequent periods when soil formation recommenced.

Figure 7: Sediment profile RIVA5 from the floodplain in Austmannadalen, showing fine-grained alluvium (grey silts) resting on a compressed bed of peat. Narrow organic bands within the silt probably represent palaeosols (buried soils).

3 UMIIVIK: RUIN GROUP V15 (64V2-III-549)

3.1 Background and archaeological context

Ruin group V15 represents the remains of a relatively large Norse farm located at Umiivik (64º26’48” N, 49º53’34” W) on the east side of Kangersuneq fjord, approximately 20 km northwest of the snout of KNS (Fig. 8). The site was excavated in 1932 by Aage Roussell. On-site structures include a dwelling house with 34 m frontage facing the fjord, storehouses, a byre sufficient to accommodate at least 15 cows, sheep sheds and folds (Roussell 1941). These are set back approximately 30-40 m from the coastline (Fig. 9). The farm is situated a few hundred metres from a steep, narrow but strong-flowing river that would have provided the settlers with ample fresh water.

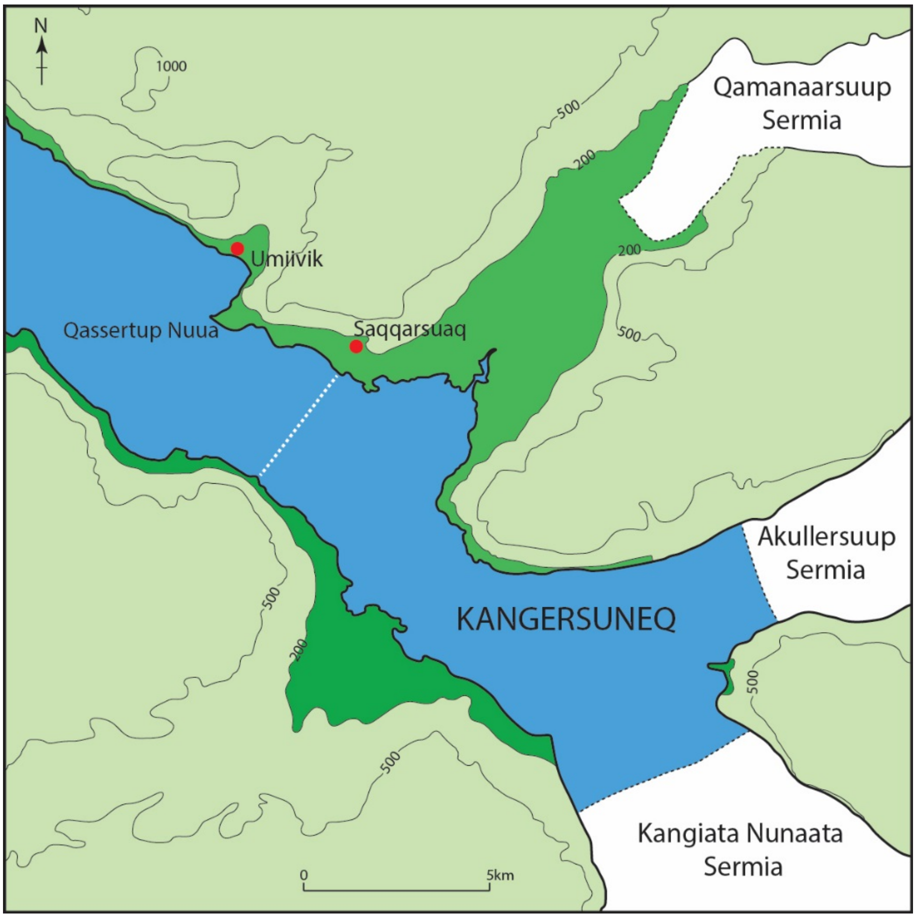

Figure 8: Location of the Norse ruins at Umiivik (V15) and Saqqarsuaq (V16) relative to Kangersuneq and the glaciers that feed/drain into this fjord. The dashed white line indicates the likely approximate advance position of the snout of the tidewater glacier during the late 13th century AD (see text for explanation). Dark green shading indicates land below 200 m a.s.l. (contours in metres).

A trimline scoured on the rocky promontory at Qassertup Nuua, less than 2 km southwest of Umiivik – noted by Roussell (1941), and still clearly visible today (Fig. 10) – is evidence that the site came very close to being overridden by ice during the last (Little Ice Age) advance of the Greenland Ice Sheet. It has been suggested that ice may have enveloped and partly destroyed the ruins of a neighbouring farm at Saqqarsuaq (V16) around 4 km southeast of Umiivik (Giesecke 1910; Bruun 1917); Roussell (1941) observed that the trimline there is positioned around 85 m below the farm buildings. Whether ice ever threatened to engulf the farms at V15 and V16 at the time they were occupied is, as yet, unclear. Nevertheless, the people living in this area would presumably have had to contend with the hazards posed to shipping through the calving of icebergs into the fjord. The fjord is currently choked with icebergs during the summer months, making its navigation difficult even in a small boat. The situation may, however, have been much different during the late Medieval period, as lower temperatures would have resulted in rates of calving being much reduced relative to today.

Figure 9: View south over ruin group V15 at Umiivik. The remains of the dwelling house, a postulated storehouse, and a byre are visible from left to right, set in line and parallel to the coast.

3.2 Sampling locations and methods

The area immediately around the ruins at V15 is well-drained and very dry, and there are no mires or small waterbodies (ponds, lakes) close to the site that offer obvious potential to yield deep organic sediment profiles suitable for palaeoenvironmental analysis. A gentle herb-covered slope that is largely clear of stones is apparent between the ruins and the edge of the fjord. It was postulated that this could mark the former position of the homefield. If so, it was considered possible that an anthrosol might be present in this location, the analysis of which might provide a means of establishing the age of the farm.

An Eijkelkamp gouge auger was used to run two transects measuring ~65 m (borehole spacing of 5 m) through the postulated homefield area. These transects were set back at distances of 5 m and 10 m parallel to the coastline. Two soil test pits (coded UM11 and UM25; each ~1x1 m^2) were also excavated at locations along the transect where the soil profile was deepest, with monoliths collected from the open face of one of these (UM25). Two 'rangefinders' were selected from the profile for AMS ^{14}C dating. These were processed in the same fashion as described above (see Section 2.2).

At the outset to the project, it had been intended to conduct palaeoenvironmental fieldwork around ruin group V16. The high density of icebergs within the fjord, however, meant that access by boat south of Umiivik proved impossible. Yet by traveling light and carrying minimal kit and equipment, two members of the field team were able to walk into the valley occupied by Qamanaarsup Sermia (QS), ~3 km east of Saqqarsuaq and ~7 km southeast of Umiivik (Fig. 8). A sample for AMS radiocarbon dating was collected from the glacier foreland (64º25'21" N, 49º 44'4" W). The material submitted for ^{14}C measurement – a piece of bark (species unknown) – was extracted from the top of a peat bed capped by fine minerogenic sediments (sands and silts) and exposed in section towards the mouth of the valley. The peat represents a terrestrial land surface that appears to have been buried by sediment deposited in an ice-damned lake. This lake would have formed as ice advanced up Kangersuneq and blocked the exit to the valley, resulting in meltwater from QS collecting behind the barrier. The ^{14}C sample provides an earliest date for the onset of formation of the ice-damned lake, and by inference, gives an indication of the timing of when the ice front was encroaching upon V16.

3.3 Results, interpretation and discussion

The auger survey of the postulated homefield area revealed a tripartite sequence. From the surface to a depth of ~10 cm, a medium brown fibrous organic A horizon (*c.* 20-45 % LOI) is apparent. This grades into a more minerogenic (<20% LOI) and paler greyish-brown eluviated E horizon. Collectively, these are suggestive of a soil profile in the early stages of podsolization. Below this is a dark brown organic-rich silt (c. 12-15% LOI) containing occasional small pebbles and fragments of charcoal. In character and appearance, this resembles an anthrosol (see Section 2.3.1). This unit (Ap horizon) extends to a maximum depth of c. 40 cm and rests upon a base of fine pale grey sand (BC horizon). The contact between the anthrosol and the basal sand is typically irregular. For example, in profile UM11 (Fig. 11) the two units appear to be highly mixed where they meet, possibly as a result of cryoturbation. The extent of mixing is less apparent in UM25 (Fig. 11), and for this reason it was this profile that was selected for sampling.

Figure 10: View southeast over Kangersuneq towards Umiivik (V15). The rocky promontory at Qassertup Nuua (extreme right of photograph) exhibits a trimline, providing evidence that tidewater glaciers in the fjord were formerly more advanced than their current positions.

Two radiocarbon dates have been measured on the anthrosol (Table 2); one towards the base (UBA-31332; 32-34 cm) and another towards the top of the deposit (UBA-31331; 10-12 cm). The results both fall within the conventionally-recognised period of Norse settlement in Greenland, but are reversed. The deeper (stratigraphically-lower) sample – comprising *Montia fontana* seeds – is late 13th or 14th century AD (674±42 ^{14}C yr BP; cal AD 1265-1395 [95.4%]). The sample towards the top of the profile – *Montia fontana* seeds and charcoal fragments – dates to the mid-13th century AD (767±22 ^{14}C yr BP; cal AD 1223-1278 [95.4%]). We can only speculate as to why the reversal is apparent. It may be a consequence of the nature of the deposit (i.e. if it is highly mixed throughout, as the contact between the anthrosol and the basal sand might suggest), or due to differences in the material that was dated. The uppermost ^{14}C date (UBA-31331) would not have been sufficiently heavy for analysis if only the *Montia* seeds had been submitted for dating. It is possible that the addition of charcoal fragments to 'bulk up' this sample could have introduced an 'old carbon' error if one or more of these fragments was burnt driftwood, or represented an inherently older part of the plant (i.e. the trunk/main stem of a tree/shrub, as opposed to branch or twig). Further radiocarbon dates will be required on this profile to establish which (if either) of the dates reported here is accurate. At present, however, the two radiocarbon dates we have for this site cannot be used to establish precise dates for *landnám* or the abandonment of this farm.

Figure 11: Cultural soil profiles at Umiivik (V15). Left panel – UM11; right panel – UM25.

Lab code	Sample	Depth (cm)	Material	14C age (yr BP)	cal yr AD (95.4% confidence)
UBA-31331	UM25	10-12	Charcoal and *Montia fontana* seeds	767 ± 22	1223-1278
UBA-31332	UM25	32-34	*Montia fontana* seeds	674 ± 42	1265-1395
UBA-31339	QS-15-10	n/a	Bark (species unknown)	800 ± 29	1186-1275

Table 2: Radiocarbon dates on samples collected from Umiivik (UM25) and near Qamanaarsuup Sermia (QS-15-10). Calibration was performed using Calib v.7.0 software (Stuiver & Reimer 1993) and the IntCal13 calibration curve (Reimer et al. 2013).

The radiocarbon date taken from the top of the peat bed in the valley occupied by Qamanaarsuup Sermia returned an age estimate of 800±29 ^{14}C yr BP (UBA-31339; cal AD 1186-1275 [95.4%]). This suggests that the ice-damned lake – represented by the lacustrine sediments overlying the peat – had begun to form in this valley possibly as early as the late 13th century AD. In turn, this implies that ice had extended up Kangersuneq to a position that was probably very close to V16 (i.e. within 1-2 km) during the late stages of the Norse occupation of the Western Settlement (Fig. 8).

4 CONCLUSIONS

- Two soil test pits excavated in the vicinity of the ruins of V53d in Austmannadalen have revealed an anthrosol representative of a former homefield in an area now covered by dense willow scrub between the dwelling and the stream. Radiocarbon dates from the base and top of the anthrosol indicate that it is likely that this deposit began to accumulate in the first few decades of the 11th century AD (i.e. at, or very shortly after, the AD 985 *landnám* in Greenland), and that it ceased forming some time during the 14th century AD (i.e. in accord with the conventional wisdom that the abandonment of the Western Settlement had concluded by ~AD 1350).

- A peat profile collected from a basin overlooking V53d incorporates sediment encompassing the period of Norse settlement in Greenland, and offers the potential – through pollen analysis combined with ^{14}C dating – to further refine the dates for Norse settlement in Austmannadalen, and provide details about human impacts arising from *landnám* and land-use in this region.

- A sequence of alluvial silts deposited upon a bed of peat was revealed in five soil pits excavated beside the main channel of the river (Kuussuaq) in Austmannadalen, around 2 km southwest of V53d. The silts appear indicative of regular flooding of the valley floor with fine sediment-laden glacial meltwater derived from the Kangiata Nunata Sermia (KNS) glacier. This meltwater was routed down Austmannadalen into Ameralla fjord via the ice-damned lake, Isvand.

- A radiocarbon date immediately below the peat-silt contact (described above) suggests that the tapping of meltwater down Austmannadalen was 'switched on' during either the 11th or early 12th century AD. This would have resulted in a significant increase in the volume of water – and suspended sediment – flowing down the main channel of the river. Given its timing, this change seems likely to have been observed and experienced by the Norse settlers living at V53d and the other farms within the valley. At this stage we can only speculate on what impact (if any) this had upon the settlers in the valley. Certainly, the heavily sediment-laden water would not have been potable, and regular flooding might have hindered access into and through the valley by: (i) making the river more difficult to ford, thereby possibly cutting-off access to rangeland grazing areas south of the river; and (ii) contributing to silting-up at the head of Ameralla fjord, making navigation through this reach increasingly difficult.

- Systematic augering and test-pitting of soils at Umiivik has revealed an anthrosol containing characteristic 'indicators' of Norse settlement (e.g. charcoal and *Montia fontana* seeds) between the ruins of the Norse farm (V15) and the coastline. The anthrosol appears to be highly mixed (cryoturbated), at least towards its base. Possibly as a consequence of this, the ages of 'rangefinder' radiocarbon dates taken from the base and top of the anthrosol are reversed. It has therefore not yet been possible to establish precise dates for *landnám* and abandonment of the farm on the basis of the age of this anthropogenic deposit, although the ^{14}C dates do suggest that people were resident at the site during (at least) the 13th century AD as ice rapidly advanced up Kangersuneq fjord.

Acknowledgements

This research was financed by the Leverhulme Trust in connection with the project entitled, *Calving glaciers: long term validation and evidence* (CALVE). Bo Albrechtsen and the Greenland National Museum and Archives (NKA), Nuuk, are thanked for arranging permits to conduct fieldwork. We are grateful to the CALVE 'marine team' (Nick Kamenos, Kate Schoenrock and Lukasz Stachnik) for assisting with logistics and transport between field bases.

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