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TOWARDS A FIRST CHRONOLOGY FOR THE MIDDLE SETTLEMENT OF NORSE GREENLAND: ^{14}C AND RELATED STUDIES OF ANIMAL BONE AND ENVIRONMENTAL MATERIAL

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ABSTRACT. The so-called Middle Settlement (*Mellembygden*) of Norse/Viking Greenland has received far less attention than either of its larger Eastern and Western counterparts. The Greenlandic Norse occupation is nominally taken to date between AD 985 and about AD 1450 and it is generally assumed that the Western Settlement was abandoned prior to the Eastern, but where the Middle Settlement fits into the pattern temporally has hitherto been completely unknown. This paper presents the first absolute dating evidence from the Middle Settlement. In addition to providing the results (^{14}C, δ^{13}C, δ^{15}N) of a radiocarbon dating and stable isotope measurement program from domesticated (*Bos*, *Ovis*/*Capra*) and wild (*Rangifer*) animal bone and cultural-environmental (coastal, possibly midden) samples, the paper also addresses some problems of ^{14}C estimation for the period of Norse occupation in Greenland. Investigations show a Medieval Scandinavian presence close to the start of the conventional *landnám* period (after AD 985) and with occupation continuing up to at least the 14th century AD. The start of this activity, found at 2 sites, bears comparison with various locations in both the Eastern and Western settlement areas. The terminal phase of activity in the Middle Settlement is represented at 1 site only, but despite this limitation, it shows that the Norse may have been present for most of the period that they occupied sites in both the Western and Eastern settlements. Caribou bone from separate contexts that also contained Thule Inuit material proves useful in indicating dates for a probable post-Norse Inuit presence. The position of age estimates on the calibration curve underscores the need to look critically at such evidence when making chronological inference during the Norse period owing to the existence of plateaus and wiggles. The inclusion of samples from both domesticated and wild fauna considered to be possibly modern, yet reported from archaeological assemblages, provides a warning to archaeozoologists to be especially vigilant when considering the potential non-contemporaneity of material.

INTRODUCTION

The Eastern (ON *Eystribyggð*) and Western settlements (ON *Vestribyggð*) are well-known foci of Norse/Viking colonization (Figure 1) and they continue to be investigated, archaeologically, historically, and environmentally (e.g. Ingstad 1966; Fitzhugh and Ward 2000; Edwards et al. 2008; Schofield and Edwards 2011; Massa et al. 2012). The Eastern Settlement is in the extreme south of Greenland, a sea journey of some 600 km from its "western" partner. The former was a more extensive area containing about 250–300 farms (what constitutes a farm can be difficult to determine and not all ruin groups were coeval). It had a more attractive climate for agriculture and it was closer to the sea lanes of Iceland and Europe (Dugmore et al. 2005). In contrast, the Western Settlement, consisting of around 60–90 farms, placed greater reliance on the hunting of both terrestrial and marine animals as a means of subsistence, though animal husbandry was still important (McGovern 1980).

The so-called Middle Settlement (a modern construct; Danish *Mellembygden*) is more enigmatic than either the Eastern or Western settlements. The area has received relatively little attention from scholars (cf. Ingstad 1966; Vebæk 1956; but see Fanøe 1873; Bruun 1918; Albrethsen and Arneborg 2004). Its Norse components consisted of at least 41 known sites, 20 of which have less than 5 ruins associated within them. In modern terms, it has an abandoned cryolite mine and a museum at Ivitt-

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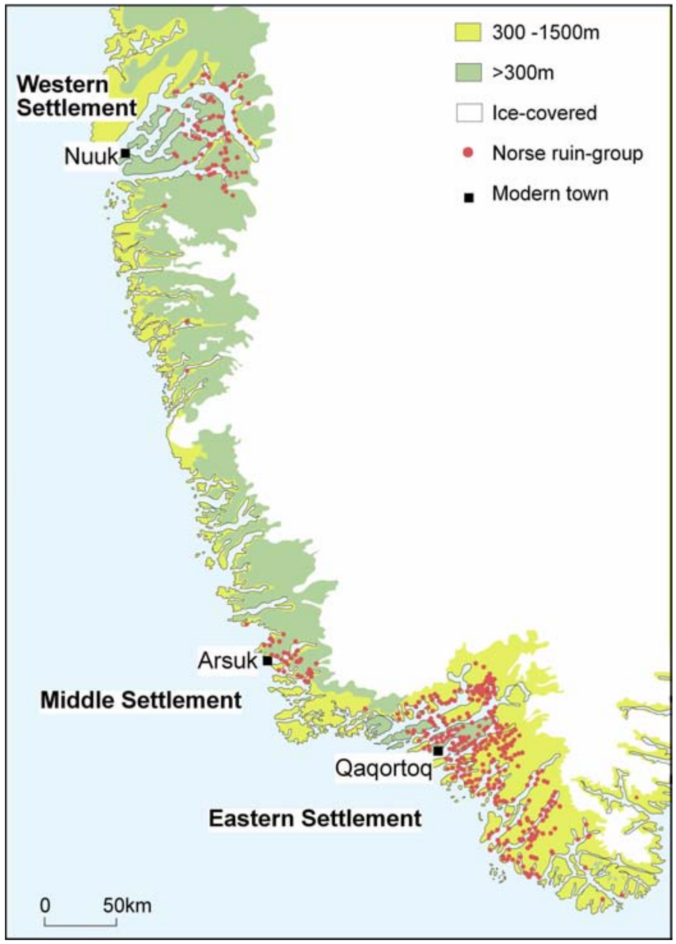

Figure 1 Map of southwest Greenland showing the location of the Norse Middle Settlement in relation to the Eastern and Western settlements.

uut, a former Danish naval base at Kangilinnguit (Grønnedal; closed 1 November 2012 and moved to Nuuk), and a settlement at Arsuk.

The Norse Middle settlement is generally seen as an extension of the Eastern Settlement (Vebæk 1956; Albrethsen and Arneborg 2004) from which it is physically separated, lying at around 135 nautical miles (250 km) from Qassiarsuk, the favored location for Erik the Red's farm estate of *Brattahlið* in the heart of the *Eystribyggð* (Edwards et al. 2010). Its proximity to the Eastern relative to the Western Settlement allows a claim of connectivity. Unlike both these areas, however, the ruin groups of the Middle Settlement are almost entirely located by the sea and fjord sides rather than being found both coastally and inland. It has no extensive farms, no known church, and the ruin groups tend to consist of small dwellings and a few sheep or goat pens, though byres are known (as at M15).

The coastal location of farms in *Mellembygden* distinguishes it from the other settlement areas, though otherwise it has more in common topographically with the Western Settlement. Thus, the steepness of the mountains and hillslopes and their close proximity to the coast limits the availability

of agricultural land. This, and the shallowness of the soils, would have prohibited the development of good home fields (infields). On the other hand, while mean July summer temperatures of ~10 °C in Ivittuut (for the period 1931–56) are similar to those in Igaliku (1933–46) and Kapisillit (1939–59) in the Eastern and Western settlements, respectively, the January mean minima (–5 °C) for Ivittuut and Igaliku are somewhat higher than at Kapisillit (–10 °C) (Krogh 1982, 1986). Similarly, precipitation for the same periods is markedly variable with Ivittuut receiving ~1310 mm/yr, compared to 800 mm at Igaliku and 255 mm at Kapisillit. The Middle Settlement also experiences greater snowfall and more persistent snowcover than the other areas. If these climatic conditions followed similar patterns for the greater part of the period of Norse occupation, then the Middle Settlement would have been less suited to agriculture than the other areas. It is probable that the Middle Settlement was a relatively poor area and its occupants survived with some animal husbandry and the resources of the sea and rivers.

Unlike its better known counterparts, there has never been any attempt to establish a chronological framework for the Middle Settlement. It is generally assumed that the Western Settlement was abandoned prior to the Eastern (e.g. Barlow et al. 1997), but where the *Mellembygden* fits into the pattern is completely unknown. As Albrethsen and Arneborg (2004:19) noted, “we have no fixed point of reference for the time during which the Middle Settlement was occupied” beyond an allusion to a *Garðanesi* church in a *Miðfjörðum* in the *Flateyjarbók* (Halldórsson 1978) and a runic stone—perhaps part of a grave marker—from the island of Napasut. Vebæk (1952, 1987) took *Miðfjörðum* to refer to a location in the Middle Settlement. The *Flateyjarbók* is considered to have been written in Iceland around AD 1390, with its list of churches and bishops dating to after 1288 (when the last bishop of Greenland, Þórdur, cited therein was consecrated). The runic stone from Napasut (to which it was probably transported) is thought to date to after AD 1200 on the basis of its orthography (Stoklund 1994). The known Norse buildings in the Middle Settlement, many of which are overgrown and little investigated, do not seem to provide useful clues as to site chronologies.

This paper presents the first absolute dating evidence from the Middle Settlement. Apart from detailing the results of a radiocarbon dating program from domesticated animal bone and environmental samples, it also places these in the context of the wider Norse colonization of Greenland and addresses some problems of ^{14}C estimation for the period of Norse occupation.

SITES AND SAMPLE MATERIALS

Material for ^{14}C dating comes from putative domestic refuse (middens) associated with 3 sites that have been excavated or are currently experiencing coastal erosion. The excavations were carried out by Christian Vebæk in the 1940s and 1950s although never published. Some reports exist within the National Museum of Denmark (cf. Vebæk 1987) and resulting bone collections are held at the Zoological Museum of the University of Copenhagen. The sites are listed by both their Danish (M-) and Greenlandic (61 V1-) ruin-group designations; they are shown in Figure 2 and described in further detail below.

M10 (61 V1-II-512) Eqaluit, Kuunnaat Bay (61°11′47.56″N, 48°23′38.8″W)

This site is located on the narrow coastal strip and lower slopes beneath precipitous mountain sides to the northwest of Kuunnaat Bay. The ruin-group complex consists of a dwelling and 9 small animal pens. Coastal erosion at the back of the beach (Figure 3) revealed weakly developed Podzolic profiles, but to the south of the dwelling these overlie a black organic-rich horizon containing charcoal and herbaceous detritus. This deposit was near-continuous in section over a distance of approximately 50 m, and was of greatest thickness (~10 cm) adjacent to the dwelling. If not a midden, then

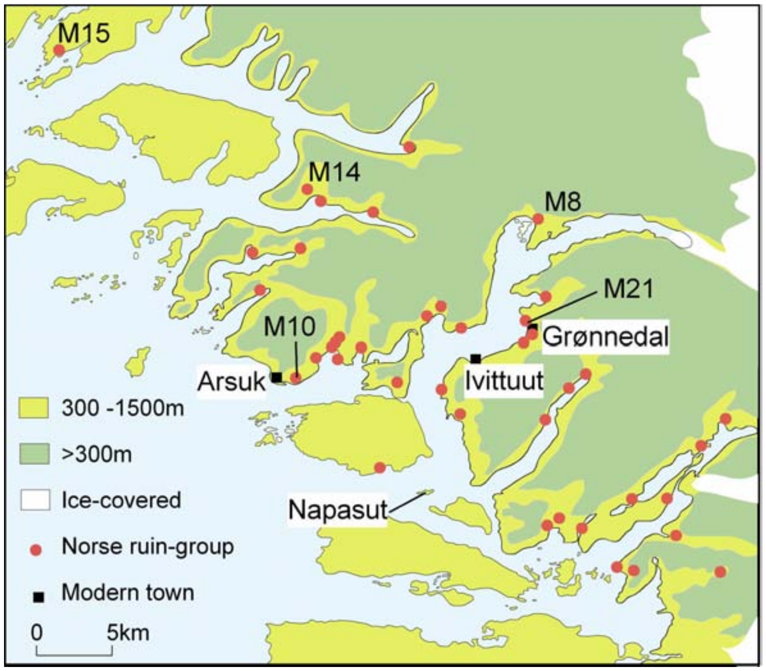

Figure 2 Map of the Middle Settlement showing the ruin-group locations (M-) from which data are presented in this study.

the material may represent a relict, artificially enhanced soil (Anthrosol) composed from materials such as domestic refuse, waste from byres, construction debris, and fuel residues, all of which were typically applied to Norse home-field soils to maintain and/or enhance fertility (cf. Golding et al. 2011). The extent of the material and the proximity to the dwelling are supportive of the notion that the two are probably related, even if the precise temporal connection is unknown. A profile (Figure 3) was cleaned and sampled in the field, and 2 samples of charcoal—a small fragment and a charred twig—were extracted for AMS ^{14}C dating following laboratory processing (discussed below).

M15 (61 V1-II-522) Tissaluk (61°22′40.94″N, 48°50′01.44″W)

This ruin group is found on the western side of a bay in Tissaluup Ilua and consists of 6 structures including a dwelling ("house 1") and a "shed/barn complex" ("house 2") (Vebæk 1956; Albrethsen and Arneborg 2004; Figure 4). Eroding coastal sections revealed thin peaty soils or peaty podzols. All profiles appeared to be natural with no obvious signs of cultural amendment. The large amount of stone and rockfall debris at the site, if extant at the time of Norse occupation, does not suggest that the site had much agricultural promise. Nevertheless, the 2 ruins are not insubstantial and a relatively small amount of animal bone (249 fragments dominated [*n* = 201] by seal, a single cattle [*Bos taurus*] bone, and 2 caribou [reindeer; *Rangifer tarandus*] bones; McGovern 1985) was collected by Vebæk during a partial excavation of ruins 1 and 2. We were able to obtain a *Bos* metatarsus and 2 *Rangifer* bones for dating from Vebæk's collection. Vebæk (1987) noted that Inuit material (e.g. stone knives and steatite lamps) was also found at the site and that this seemed to suggest usage after the Norse had vacated the area (there was a progressive southerly migration of Inuit people of the Thule culture from northwest Greenland during the 13th–14th centuries AD; McGhee 1984).

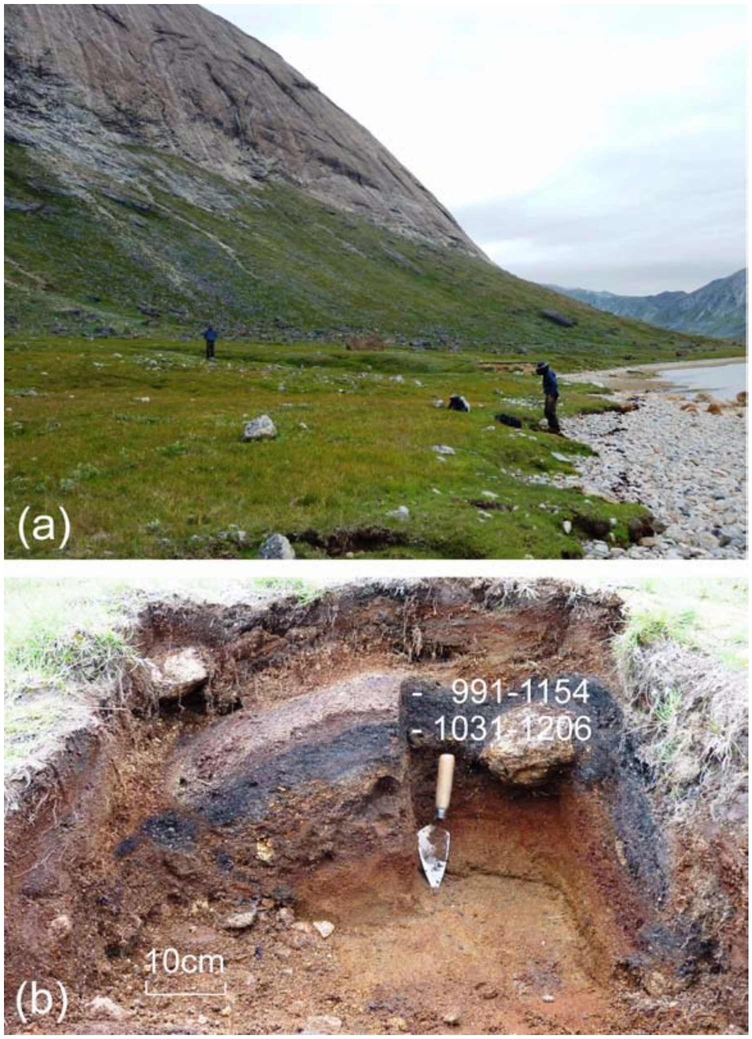

Figure 3 M10 (61 V1-II-512) Eqaluit, Kuunnnaat Bay: (a) The person on the right is standing beside the eroding coastal section and the person on the left is standing in the centre of the dwelling; (b) eroded section at the back of the beach showing the organic/midden horizon and location of the 2 ^{14}C samples and their calibrated age ranges (cal AD, 2σ).

M21 (61 V1-II-506) Grønnedal (61°14′17.64″N, 48°06′12.55″W)

The main part of this ruin group is located on a south-facing hillslope to the north of the former Danish naval base in Arsuk Fjord. The land surface is highly irregular, stony and covered in dense *Salix glauca* scrub (Figure 5). Nine rather indistinct structures have been observed at the site (Albrethsen and Arneborg 2004). A midden was found south of ruin 1 during a trial excavation by Vebæk in 1954. Vebæk's map and report are not comprehensive, but 42 fragments of identifiable bone were collected including 21 seal, 8 *Bos*, 8 *Rangifer*, and 5 *Ovis/Capra* (sheep/goat; McGovern 1985). Nine bones (2 *Bos*, 3 *Rangifer*, and 4 *Ovis/Capra*) from a variety of contexts were made available to us from Vebæk's collection. Of particular interest was that a small proportion of the assemblage seemed to be fresher than the rest, with a lighter color and less abraded surface texture (though this

Figure 4 M15 (61 V1-II-522) Tissaluk, house 1

Figure 5 M21 (61 V1-II-506) Grønnedal. The site is much obscured by willow (*Salix*) scrub; the marker post in the foreground indicates the location of a dwelling (ruin 3).

would not of necessity be diagnostic of age, depending on rapidity of burial or soil conditions), including a sample that bore a likely saw-cut face (Figure 6). It seemed possible that some of the material could be more recent than the bulk of probable Norse age bone. Consequently, of the 9 samples obtained for ^{14}C dating, we intentionally included 3 (2 *Ovis/Capra* and 1 *Rangifer*; SUERC-38629, -38630, -38631) suspect "modern" samples.

Figure 6 Possible saw-cut *Ovis/Capra* tibia (SUERC-38631) from House 1–2, site M21. External diameter of top is 2.0 cm.

ISOTOPE MEASUREMENTS

Bone samples were prepared for ^{14}C dating and stable isotope measurement (δ^{13}C and δ^{15}N) by extraction of collagen following a modified Longin (1971) method. After cleaning of the sample surface with a Dremmel® fitted with an abrading disk, the bone was lightly crushed and immersed in 1M HCl until dissolution of the bone phosphate was complete. The phosphate and organic contaminants were removed by filtration, after which the residue was heated gently to solubilize the collagen. Finally, the solution was filtered and collagen recovered by freeze-drying.

Measurements of sample %C and %N were made on a Costech elemental analyzer (EA) (Milan, Italy), which was fitted with a zero-blank autosampler. δ^{13}C and δ^{15}N measurements were made on a ThermoFinnigan Delta V Advantage continuous-flow isotope ratio mass spectrometer (Thermo-Finnigan GmbH, Bremen, Germany), which was linked to the EA via a ConFlo IV. Each sample run included a mix of samples, laboratory standards, and blanks, with precision better than ±0.2‰ (1σ) for δ^{13}C and better than ±0.3‰ (1σ) for δ^{15}N. The isotope values are reported as per mil (‰) deviations from the VPDB and AIR international standards for δ^{13}C and δ^{15}N, respectively.

For ^{14}C measurements, CO_2 was obtained from collagen via combustion in evacuated sealed quartz tubes containing copper oxide and silver foil, following the method of Vandeputte et al. (1996). The sample CO_2 was purified cryogenically and an aliquot taken for off-line δ^{13}C determination on a VG SIRA 10 isotope ratio mass spectrometer, using NBS 22 (oil) and NBS 19 (marble) as standards. A

3-mL aliquot of the CO_2 was converted to graphite by the method of Slota et al. (1987) for ^{14}C measurement by accelerator mass spectrometry (AMS). Sample $^{14}C/^{13}C$ ratios were measured with carbon in the +1 charge state on the SUERC SSAMS at 245 keV.

Charcoal contained within the organic-rich layer at M10 was extracted for AMS dating following disaggregation of the sample matrix in weak (2%) NaOH and sieving through a 175-µm mesh to remove fine material. Ten samples were examined, spaced at contiguous 1-cm intervals through the deposit, and sample residues caught on the sieve were inspected under an Olympus microscope (×8–30 magnification). Small fragments of charcoal of varying size (all <5 mm diameter) were found in each sample. A single piece of charcoal from the center of the deposit—one of the larger fragments— and a charred twig from the top of the layer were selected for ^{14}C dating. The samples were unfortunately considered to be too small and fragile to attempt species identification using standard thin-sectioning procedures (cf. Schweingruber 1978), although in the case of the charred twig anything other than a local origin for the macrofossil appears highly unlikely.

The samples and their contexts are shown in Table 1. Calibration of ^{14}C dates was performed using the IntCal09 calibration curve (Reimer et al. 2009) within the program CALIB Rev 6.0.2 (Stuiver and Reimer 1993). OxCal v 4.1 (Bronk Ramsey 2009) was used to produce multiplots allowing visual comparison of the probability distributions for the calibrated dates. Calibrated age ranges are presented at the 2σ confidence level.

Table 1 Samples and dating information from animal bone and environmental samples from the Norse Middle Settlement of Greenland.

Lab code (SUERC-)	Site	Context	Material/species	^{14}C age BP	δ^{13}C (‰ VPDB)	δ^{15}N (‰)	C/N	cal AD (2σ)	Median probability cal AD
34395	M10	19–20 cm	Charred twig	985 ± 30	–27.1			991–1154	1047
34396	M10	22–23 cm	Charcoal	915 ± 30	–27.0			1031–1206	1103
38641	M15	House 1	*Bos*, metatarsus	915 ± 30	–20.6	3.9	3.2	1031–1206	1103
38642	M15	House 2	*Rangifer*, scapula	420 ± 30	–17.8	1.4	3.3	1426–1618	1459
38646	M15	House 1	*Rangifer*, humerus	330 ± 30	–17.5	2.6	3.2	1477–1643	1561
38629	M21	House 5–6	*Rangifer*, os sacrum	320 ± 30	–17.1	2.4	3.3	1482–1646	1562
38630	M21	House 1–2	*Ovis/Capra*, pelvis	230 ± 30	–18.6	9.1	3.3	1530–1955	1738
38631	M21	House 1–2	*Ovis/Capra*, tibia	265 ± 30	–11.7	5.5	3.3	1516–1953	1640
38632	M21	House 8	*Ovis/Capra*, metatarsus	635 ± 30	–19.9	5.5	3.3	1285–1339	1351
38636	M21	House 8	*Ovis/Capra*, radius	600 ± 30	–20.3	5.6	3.3	1297–1409	1346
38637	M21	House 8	*Bos*, femur	650 ± 30	–20.4	5.5	3.3	1280–1343	1350
38638	M21	House 8	*Bos*, phalanx 1	665 ± 30	–20.8	5.2	3.3	1276–1392	1317
38639	M21	House 8	*Rangifer*, humerus	670 ± 30	–17.4	2.9	3.3	1274–1391	1309
38640	M21	House 8	*Rangifer*, calcaneus	655 ± 30	–18.1	1.2	3.3	1278–1394	1348

DISCUSSION OF RESULTS

General Observations on Reliability

The OxCal plots of the full data set (Figure 7; cf. Table 1) show that 9 ^{14}C dating estimates fit totally or substantially within the nominal period of Norse settlement (cal AD 985–1450; Arneborg 1996; Seaver 2010; see discussion in Edwards et al. 2011), while a tenth date (SUERC-38642) does so partly. The suspicion that 3 samples from site M21 might be modern, or perhaps non-contemporaneous with the group of bones that had a more aged aspect, would appear to be borne out by the ^{14}C estimates on 2 *Ovis/Capra* samples (both from house 1–2), which range from cal AD 1516–1953

and 1530–1955. The former (SUERC-38631) has a highly unusual $\delta^{13}C$ value of –11.7‰ and a $\delta^{15}N$ value of 5.5‰. Re-analysis of the collagen produced values of –12.0‰ and 5.6‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively, indicating that the analyses were not in error. The $\delta^{13}C$ value is much heavier than could be accounted for by consumption of C_3 plants, although there are sheep on North Ronaldsay (the northernmost of the Scottish Orkney Islands) that are known to feed on a range of green, red, and brown macroalgae. $\delta^{13}C$ values for seaweed species collected in Scotland and England have been demonstrated to range from 18.5‰ to 13.1‰ (Raven et al. 2002), differing significantly from terrestrial C_3 plants. Similarly, in southwest Iceland, seaweed $\delta^{13}C$ values varied between –24.1 ± 1.5‰ and –13.9 ± 1.1‰ while $\delta^{15}N$ values ranged between 3.7 ± 0.7‰ and 6.6 ± 1.2‰ (Steinarsdóttir et al. 2009). These values would require that this particular animal subsisted almost entirely on seaweed, although there is no evidence from isotope data that sheep consumed seaweed during the period of Norse occupation from either the Eastern (average $\delta^{13}C$ = –19.8 ± 0.5‰) or Western (average $\delta^{13}C$ = –19.8 ± 0.3‰) settlements (Nelson et al. 2012a; cf. Balasse et al. 2009), nor are banks of seaweed generally available on foreshores in Greenland and there is no likelihood that sheep were confined to shore grazing.

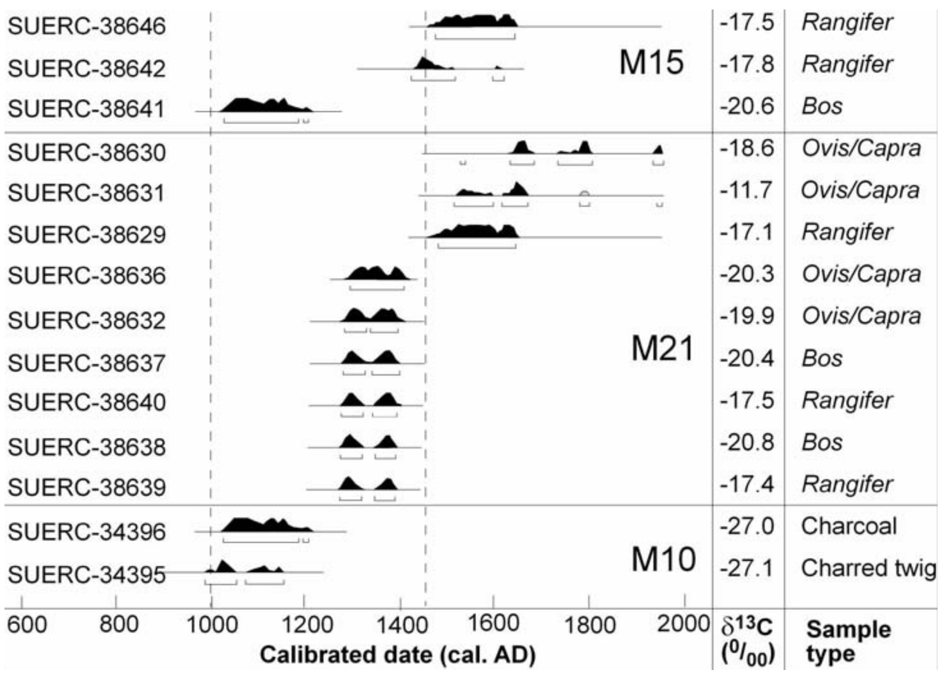

Figure 7 OxCal multiplot of calibrated age estimates on all material from M10, M15, and M21. Calibrations were performed using the terrestrial (IntCal09) calibration curve. The dashed vertical lines represent the nominal start and end dates for Norse settlement in Greenland (AD 985 and 1450).

Sample SUERC-38630 (cal AD 1530–1955) has a $\delta^{13}C$ value of –18.6‰, which denotes a significant non-terrestrial component. The $\delta^{15}N$ value of 9.1‰ is also unusual for a terrestrial herbivore (average values of 3.7 ± 0.8‰ and 4.1 ± 0.8‰ were obtained for the Eastern and Western settlements, respectively [Nelson et al. 2012a]). Repeat measurement on the collagen gave values of –18.5‰ for $\delta^{13}C$ and 8.9‰ for $\delta^{15}N$, which are entirely consistent with the original data. Again, the data for this animal could be consistent with seaweed consumption. The ages are close to modern and if there was a marine reservoir effect to take into consideration, this would reduce the ^{14}C ages further.

If samples SUERC-38630 and -38631 are indeed “modern,” and assuming that they do not come from imported carcasses/joints, then there is the remote possibility that these animals were fed on imported grain derived from C_4 plants, such as maize or millet. This would bolster the argument that these samples are modern, or at least relatively recent, and not from Norse or free-ranging animals. There is, however, no evidence for any such importations, nor for such economic practices in Grønnedal during the post-Norse period.

The third posited “modern” sample (SUERC-38629), from a *Rangifer* os sacrum recovered from house 5–6, dates to an earlier period of cal AD 1482–1646, but it is certainly younger than the suite of 6 samples from house 8, which have statistically indistinguishable dates falling across the range cal AD 1274 (SUERC-38369) to AD 1409 (SUERC-38636).

The δ^{13}C values for the animal bone, other than for “modern” sample SUERC-38631 and probably SUERC-38630, would seem to be within or close to the ranges for these animals when fed on a known or inferred terrestrial diet (cf. Coltrain et al. 2004; Coltrain 2009). The values for *Rangifer* (here –17.1 to –18.1‰) are a little higher than a previous study (at –19 to –20‰) (Drucker et al. 2011), but close to those from the Western and Eastern settlements (average –18.2 ± 0.4‰, range from –17.3 to –18.8‰; Nelson et al. 2012b). The enhanced values when compared to domesticates may indicate more extensive grazing on lichen by caribou. There seems little justification in applying a marine reservoir age correction to the bone material (cf. Arneborg et al. 1999).

Had there been no doubts about the antiquity of samples SUERC-38629, -38630, and -38631, the marine offset issue would have been investigated further. These samples, however, cannot convincingly contribute to the question of Norse chronology, and they receive no additional discussion in this section, although they are presented without reservoir age corrections in Table 1 and Figure 7.

^{14}C measurements on charred plant material from M10 resulted in age estimates that are inverted (i.e. the upper sample, SUERC-34395, provided the older ^{14}C date), although a chi-squared (χ^2) test demonstrates that these dates are statistically indistinguishable (Table 2). It would be useful if further exploration of this site and its ecofactual content could take place. The age estimates are fully consistent with Norse settlement dates from elsewhere and provide confidence in the association between the sample materials and local Scandinavian occupation as opposed, conceivably, to earlier burning or hunting activities. Any Thule Inuit presence is assumed to have taken place at a later stage (cf. Golding et al. 2011).

Table 2 Chi-squared tests for ^{14}C ages of samples derived from related contexts. Tests were performed in CALIB Rev 6.0.2 and demonstrate that samples within each context are statistically the same (95% confidence level).

Context	Test statistic (T)	χ^2 statistic (0.05)	Degrees of freedom
M10 midden/anthrosol	2.72	3.84	1
M21 House 8	3.63	11.1	5
M21 House 1–2	0.68	3.84	1

Chronology

The considerations aired above leave 9 dates that might usefully contribute to the question of the chronology of the Middle Settlement and these are displayed in Figures 7 and 8. In addition, there are 2 dates on *Rangifer* (SUERC-38642, -38646) that partially straddle the cal AD 1450 nominal “end date” for the Eastern Settlement. *Rangifer tarandus* is not a domesticate, and any consideration of the significance of caribou bone for inclusion in the construction of a chronology would need to

acknowledge that its presence in cultural contexts—unless bearing signs of butchery and/or securely stratified with other cultural material—is not definitive. There is always the possibility, of course, that non-contemporaneous bone may become incorporated into older deposits by trampling. However, of considerable interest is the fact that site M15, from which *Rangifer* bone was recovered, contains Thule Inuit artifacts (see above; Vebæk 1956, 1987). The 2 dates on caribou bone—cal AD 1426–1618 and cal AD 1477–1643—may not date the end of Norse settlement at the site, but perhaps do suggest date ranges for an Inuit presence.

There is no need to doubt the integrity of the *Rangifer* bone from house 8 at M21 as cultural ecofacts; the dates are statistically indistinguishable from those of *Bos* and *Ovis/Capra* from the same context (Table 2), which provides additional confidence.

The 9 dates (Figure 8) separate into 2 distinct clusters. An earlier group comprises the M15 *Bos* metatarsus and charred material from the possible midden at M10 (the latter two are statistically indistinguishable at the 95% confidence level; Table 2). The date on *Bos* (SUERC-38641) is precisely the same as that on charcoal (cal AD 1031–1206; SUERC-34396).

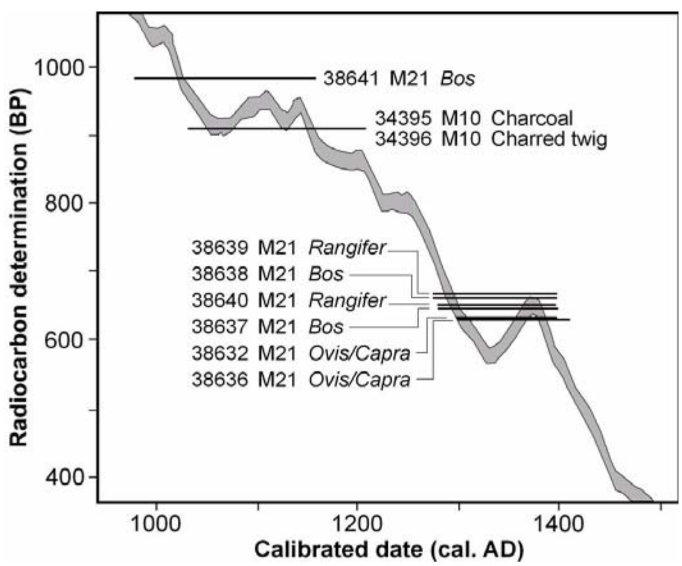

Figure 8 OxCal plot of ^{14}C calibration curve and selected ^{14}C age range estimates (2σ). Note that the shape of the IntCal09 calibration curve creates broad calendar date ranges for most of the results; see text for further details.

The later cluster comprises material solely from house 8, at M21. The *Bos*, *Ovis/Capra*, and *Rangifer* bone produces a statistically indistinguishable age grouping (Tables 1 and 2) with a collective range of cal AD 1274–1409. Even if it was posited that the material represents a contemporaneous assemblage, which would produce a pooled mean age estimate of cal AD 1289–1388, the bimodal distribution (Figure 7) still severely limits the interpretative power of the data (cal AD 1289–1313 [40%] and 1356–1388 [60%]). The dates suggest that House 8 was almost certainly still occupied in the 14th century.

The superimposition of the calibrated probability distributions on the ^{14}C calibration curve (Figure 8) raises the critical issue of confidence. The earlier cluster is located on a ^{14}C "plateau" (albeit one

including a "wiggle"), while the later cluster straddles a ^{14}C wiggle. It is evident, therefore, that the concordance between the dates within each cluster may be an artifact of the calibration—and ultimately of the variations in atmospheric ^{14}C production. By the same token, the fact that the later cluster dates are at least possibly from the same sample context may mean that its dating agreements are a factor of animal mortality occurring more or less at the same time. The variations in the calibration curve for these time periods do not allow greater precision in determining the start or end dates for the age clusters.

Accepting the calibration problems, what can be said about the dates of Norse presence in the Middle Settlement? Firstly, there may have been Scandinavian occupation of the Middle Settlement near-contemporaneous with its AD 985 beginning (*landnám* period) in the heart of the Eastern Settlement at least. It is clear, however, that the age range for the earliest Middle Settlement midden sample at M10 (SUERC-34395, cal AD 991–1154, median probability cal AD 1047; Table 1) essentially places the age estimate after the earliest date (cal AD 830–1030; Table 3) seen in *Brattahlið*/ Qassiarsuk (sample AAR-1275 from Tjodhilde's Church; Arneborg et al. 1999), or, indeed any dates for *landnám* discernible in environmental samples (cf. Edwards et al. 2008). Secondly, settlement may conceivably have persisted until the final quarter of the 14th century AD or beyond (latest age range for M21, house 8, of cal AD 1297–1409 [SUERC-38636], with median probability cal AD 1346). In that respect, it would be no different than has been inferred from various sites from the Eastern and Western settlements (cf. Ø111 Herjolfsnes and Ø149 Narsarsuaq [Arneborg et al. 1999]; V48 Niaqussat and V51 Nipáatsoq [McGovern et al. 1983]; Figure 9). In order to contextualize these further, Figure 10 shows the 9 Middle Settlement dates plotted along with suites of ^{14}C dates (oldest and youngest samples where more than 2 dates were available) from Eastern and Western Settlement sites (Table 3). Their correspondence with these sequences make it clear that the Middle Settlement could well have participated fully within the Norse social and economic life of southwestern Greenland. To some extent, such suppositions may be too "generous" in that the real time

Table 3 Samples and dating information of selected human and animal bone and other material from the Norse Eastern (Ø-) and Western (V-) settlements of Greenland. Data from McGovern et al. (1983) and Arneborg et al. (1998, 1999).

Lab code	Site	Context	Material/species	^{14}C age BP	$\delta^{13}C$ (‰ VPDB)	% Marine diet	cal AD (2σ)	Median probability cal AD
AAR-1289	Ø111	Grave	Cloth	480 ± 43	–22.3		1320–1490	1430
AAR-2201	Ø111	Grave	Cloth ("Burgundy cap")	685 ± 40	–22.6		1260–1390	1301
AAR-1263	Ø149	Grave	Human (m, 25–30)	845 ± 50	–15.9	60	1290–1510	1406
AAR-1265	Ø149	Grave	Human (f, 35–40)	886 ± 48	–16.3	55	1280–1440	1360
AAR-1441	Ø66	Grave	Human (f, 25–30)	880 ± 55	–15.8	61	1280–1480	1384
AAR-1442	Ø66	Grave	Human (m, 30–35)	890 ± 45	–17.3	44	1250–1420	1329
AAR-1438	Ø47	Grave	Human (f, adult)	880 ± 90	–17.6	40	1160–1440	1316
AAR-1437	Ø47	Grave	Human (m, 30–35)	1030 ± 65	–16.8	50	1050–1390	1235
AAR-1276	Ø29a	Grave	Human (m, 50–55)	1025 ± 50	–18.0	35	1050–1270	1181
AAR-1275	Ø29a	Grave	Human (m, >35)	1229 ± 41	–18.5	29	830–1030	950
AAR-3394	GUS	Floor	*Bos taurus*	845 ± 60	–20.8		1040–1270	1183
AAR-3682	GUS	Floor	Wool	965 ± 45	–22.1		990–1170	1089
K-3060	V54	Midden	*Salix* charcoal	750 ± 70			1050–1400	1255
K-3058	V54	Midden	*Salix* charcoal	950 ± 70			910–1250	1096
AAR-1144	V51	Grave	Human (f, 20–25)	865 ± 40	–15.2	68	1300–1540	1426
AAR-1143	V51	Grave	Human (m, 35–40)	1030 ± 45	–14.8	73	1230–1440	1337
K-3203	V48	Midden	Terrestrial animal	610 ± 50			1290–1410	1348
K-3063	V48	Midden	*Salix* twigs	960 ±75			900–1220	1089

range for settlement may have been more narrowly constrained at either or both ends of the spectrum. Such a possibility applies to all other studies, though regrettably, few of these seem to consider the implications of ^{14}C correction and the shape of the calibration curve (though see Arneborg et al. 1999; Edwards 2012).

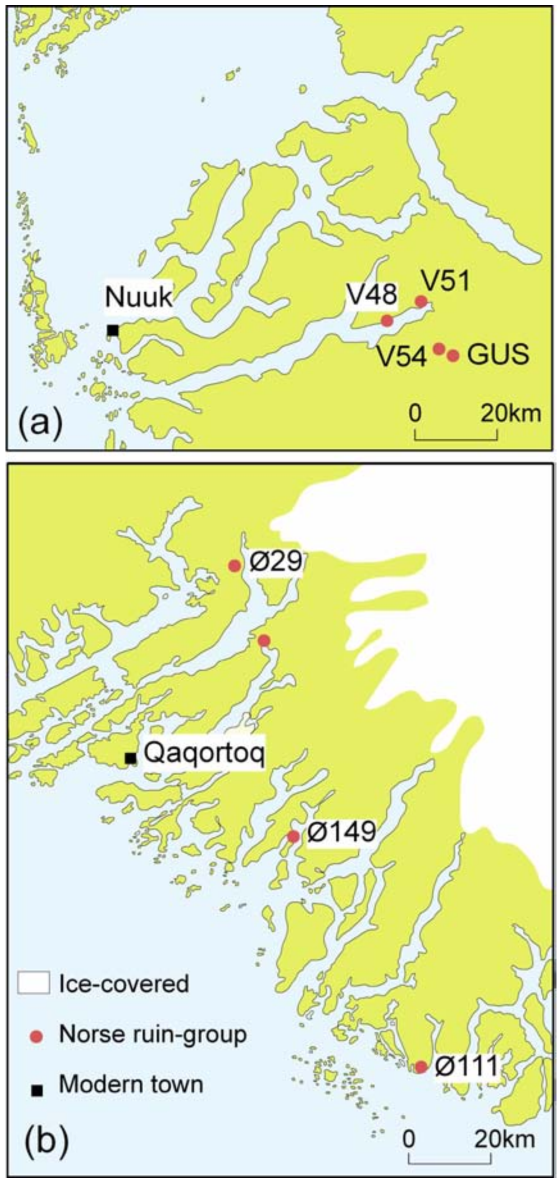

Figure 9 Ruin-group locations in (a) the Western Settlement and (b) the Eastern Settlement.

The percentage of marine diet is calculated by linear interpolation between the end-point values, –12.5.‰ (100% marine) and –21.0‰ (100% terrestrial), with an uncertainty of 10% in the percentage value.

Neither the bone from sites M15 and M21, nor the environmental samples from site M10, can be proven to date contexts judged to represent the beginning or end of their particular ruin groups. This would also apply to most archaeological excavations because of spatial and temporal uncertainties surrounding sites of past human activity. The best hope for this may lie in the proxy evidence obtained from adjacent off-site environmental cores, provided that they are sufficiently sensitive in recording anthropogenic landscape impacts and that they contain no hiatuses. Mire deposits obtained from sites M8 (61 V1-II-508) Bjørnedal and M14 (61 V1-II-519) Kuannit (Figure 1) may eventually provide such data.

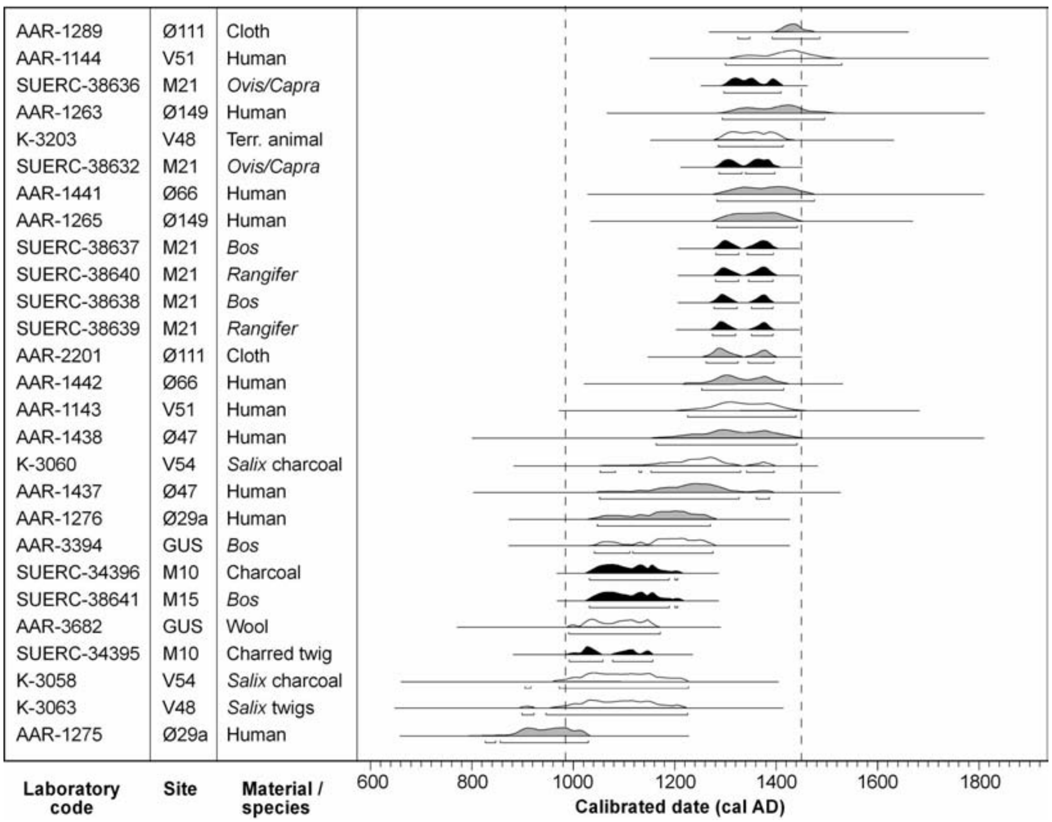

Figure 10 OxCal multiplot displaying the probability distributions (2σ) for selected ^{14}C samples from the Eastern (gray silhouettes), Middle (black silhouettes), and Western (white silhouettes) settlements. Fully terrestrial samples were calibrated in OxCal v 4.1 using the IntCal09 curve (Reimer et al. 2009); calibrations on human bone were calibrated using the Marine09 curve (*ibid*) and corrected to allow for the contribution to marine diet (cf. Arneborg et al. 1999). A regional marine reservoir correction ΔR of 129 ± 84 was applied to the latter calibrations (the value for Nuuk from the Marine Reservoir Database 2012) given that the data set includes samples from the Western Settlement and that the whole study region falls under the influence of the West Greenland Current. For details of sites, samples, and dates, see Tables 1 and 3. Abbreviations: GUS, Gården Under Sandet; M, Middle Settlement; Ø, Eastern Settlement; V, Western Settlement; terr., terrestrial. The dashed vertical lines represent the nominal start and end dates for Norse settlement in Greenland (AD 985 and 1450).

CONCLUSIONS

The ^{14}C material presented in this paper has provided the first absolute chronological evidence for Norse activity from the area of the Middle Settlement of Greenland. It may indicate a Medieval Scandinavian presence from close to the start of the conventional *landnám* period (after AD 985),

although probably a little later than this, and up to perhaps the last quarter of the 14th century AD. The earliest evidence for human activity, found at 2 sites, bears comparison with both the Eastern and Western Settlement areas. The terminal phase of activity in the Middle Settlement is represented by 1 site only, but despite this limitation, it shows that the Norse may have been present for most of the period that they occupied sites in both the Western and Eastern Settlement areas, though the latest dates in both territories extend beyond those from M 21.

The dated caribou bone at M15, when considered along with the finds of Thule Inuit artifacts, may not be very meaningful in providing a *terminus ante quem* for Norse occupation of the site, but they are useful in indicating a date for an Inuit presence. Further south at Sandhavn, there was inferred Norse-indigenous contemporaneity for an even earlier period (cal AD 1220–1290; Golding et al. 2011).

The constraints of the ^{14}C method are well known (cf. Walker 2005), but for Norse studies within the North Atlantic area at least, insufficient notice is taken of the existence of inconvenient plateaus or wiggles in the calibration curve. This has been shown forcefully for the Middle Settlement dates (Figure 8), but can equally be seen elsewhere (Arneborg et al. 1999; Edwards 2012).

The inclusion of samples (from both domesticated and wild fauna) considered to be possibly modern—or non-contemporaneous—is supported by the ^{14}C dating. We would not envisage this to represent a ubiquitous problem (though cf. Schulting et al. 2011), but it does provide a warning to archaeozoologists to be especially vigilant when considering the antiquity of archived material that might find its way into ostensibly subfossil bone assemblages.

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