Evidence of Early Metalworking in Arctic Canada

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This paper examines new evidence related to an early (pre-Columbian) European presence in Arctic Canada. Artifacts from archaeological sites that had been assumed to relate to pre-Inuit indigenous occupations of the region in the centuries around A.D. 1000 have recently been recognized as having been manufactured using European technologies. We report here on the SEM-EDS analysis of a small stone vessel recovered from a site on Baffin Island. The interior of the vessel contains abundant traces of copper–tin alloy (bronze) as well as glass spherules similar to those associated with high-temperature processes. These results indicate that it had been used as a crucible. This artifact may represent the earliest evidence of high-temperature nonferrous metalworking in the New World north of Mesoamerica. © 2014 Wiley Periodicals, Inc.

INTRODUCTION

The Viking-age Norse established settlements on the southwestern coast of Greenland about A.D. 1000, and these continued to be occupied until the early 15th century. Although less than 400 km separated the Norse Greenlandic colonies from the coasts of Arctic Canada, and explorations to the west of Greenland are described in Icelandic sagas, surprisingly little is known of ventures to North America. The archaeological site at L'Anse aux Meadows in northern Newfoundland confirms saga accounts that the Norse established a short-lived station in Atlantic Canada at some time around A.D. 1000 (Ingstad, 1985; Linderoth Wallace, 2003, 2006). In Arctic Canada and northwestern Greenland a number of Norse artifacts have been found in the remains of early Inuit settlements dating to the 13th or 14th centuries, suggesting occasional contact with the Greenlandic Norse or the salvage of a Norse shipwreck by Inuit who had recently arrived in the area from their Alaskan homeland (Schledermann, 1980; McCullough, 1989). Until recently the Norse presence in the eastern North American Arctic and Subarctic was assumed to have been limited to brief and infrequent explorations (Jones, 1986; Linderoth Wallace, 2003).

The Norse gave the name "Helluland" to a mountainous tundra country to the west of Greenland, which can probably be identified with Baffin Island and adjacent regions of northern Labrador (Jones, 1986). During most of the period that the Norse Greenlandic colonies existed, this region was occupied by Dorset culture Paleo-Eskimos, a people who were genetically and culturally distinct from the Inuit, and who were more closely related to peoples whose descendants now occupy northeastern Siberia (Rasmussen et al., 2010). Recently, objects associated with a variety of European technologies have been recognized in collections from several Dorset sites in the Helluland region. The bulk of this material was found in collections that had been excavated from four sites: Nunguvik (PgHb-1) located near Pond Inlet on northern Baffin Island (Mary-Rousselière, 2002); Willows Island-4 (KeDe-14) in Frobisher Bay, eastern Baffin Island (Odess, 1998); three localities at Cape Tanfield (KdDq-9, KdDq-7–1, KdDq-7–3) on the south coast of Baffin Island (Maxwell, 1973, 1976); and Avayalik-1 (JaDb-10) in northern Labrador (Jordan, 1980). These four sites span a distance of approximately 1500 km from north to south (Figure 1). Each site has yielded several lengths of yarn or fine cordage spun from the fur of local animals, bar-shaped whetstones of a type used by the

Figure 1 Map showing location of the Nanook site and other sites mentioned in the text: (1) L'Anse aux Meadows, (2) Nunguvik, (3) Willows Island-4, (4) Cape Tanfield localities, (5) Avayalik-1.

Norse, and a variety of wooden objects including notched sticks closely resembling those used by the Norse as tallies (Sutherland, 2009).

One of the Cape Tanfield localities (Nanook, KdDq-9; Figure 1) contained the remains of a large structure with long straight walls of boulders and turf and a stone-edged drainage channel. Such features are not known to be associated with indigenous architecture in Arctic Canada, but do resemble those of Viking/Norse construction throughout the North Atlantic region, including Greenland (Roussel, 1941). The Nanook site was first investigated in the 1960s by Moreau Maxwell of Michigan State University (Maxwell, 1973, 1976). Maxwell identified Nanook as a Dorset Paleo-Eskimo site although he noted anomalies in the architectural remains, and obtained a series of radiocarbon dates ranging from 2460 ± 80 to 580 ± 80 ^{14}C yr B.P. (calibrated 1σ range 754 B.C. to 1367 A.D., using CALIB ^{14}C data set). Radiocarbon dates falling in the first millennium B.C. and early first millennium A.D. relate to early Paleo-Eskimo occupations, and many of the samples were compromised by the inclusion of materials from the marine reservoir or by problems of contamination related to a saturated permafrost milieu (McGhee, 2000). Further investigations were undertaken more recently by Sutherland (2009), revealing additional information on the structure, cultural remains, and complex stratigraphy indicating intermittent use over a considerable period of time. Notably, there is no evidence of use of the site by the Inuit who moved into the area during the 13th or 14th centuries and who remained the dominant occupants of the region to the present day.

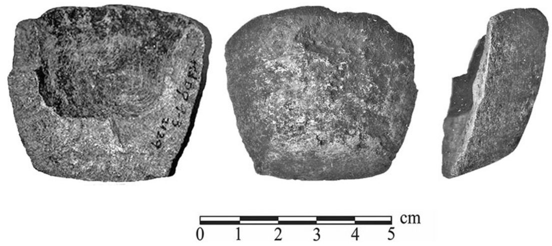

Figure 2 Three views of the broken crucible.

Among the specimens recovered by Maxwell in association with the unusual architectural remains was a small broken vessel carved from gray mafic metamorphic rock (catalog number: KdDq-9–3:2129, Canadian Museum of Civilization; Figure 2). The object is 48 mm tall and has a straight sloping base meeting the slightly convex lateral wall at an angle of approximately 140°. The base of the complete object may have been keel-shaped. The artifact appears to have been roughly circular in plan, with diameter expanding from >35 mm at the base to >48 mm at the rim. The base is 15 mm thick, with the walls tapering to a thickness of 6 mm at the rim. The exterior is smoothly finished, but portions of the interior are scarred by scratching or scraping. An irregular break cuts across roughly the center of the vessel, indicating that approximately half is missing.

METHODS

In assessing the nature of nonindigenous technologies recovered from the Helluland Dorset sites, scanning electron microscopy was used by the authors of this paper to determine if traces of smelted metals were present on the working surfaces of whetstones. The method was also applied to the small stone vessel described above.

The surface of the specimen was scanned using a Zeiss EVO 50 Scanning Electron Microscope (SEM) in environmental mode using a chamber pressure from 60 to 100 Pa. The instrument includes a backscattered electron detector, Everhart–Thornley secondary electron detector, and a variable pressure secondary electron detector. For chemical analysis, the Oxford Energy Dispersive Spectra (EDS) system was used in conjunction with the INCA X-sight series Si(Li) EDS Detector (resolution 127 eV) and INCA Energy 450 Microanalysis software. SEM settings included a standard working distance of 8.5 mm, high voltage (EHT) of 20 kV, and probe current of 1 nA. Image store resolution was 1024 × 768 pixels, and images were saved as tiff files.

RESULTS AND DISCUSSION

The EDS component of the SEM provides a qualitative nondestructive means of identifying the rock type used to manufacture the artifact. The major minerals, chlorite and albite, are associated with minor amounts of titanite, iron oxide, and rutile, and traces of chloritized biotite, apatite, allanite, and zircon. The very fine grain size (<0.5 mm) and abundance of "softer" chlorite facilitated carving of the vessel. Mineralogy is consistent with metamorphism or hydrothermal alteration of a mafic igneous rock (e.g., basalt/andesite) at relatively low temperature (350–450°C) and pressure (2–5 kbars) in the greenschist facies (low metamorphic grade). Precambrian metamorphic bedrock at the locality where the artifact was discovered is much higher metamorphic grade (upper amphibolite to lower granulite facies, >650°C, 6–8 kbars; (Jackson & Morgan, 1978; St-Onge, Wodicka, & Lucas, 2000). The closest potential source areas of comparable greenschist facies metamorphic rocks are located hundreds of kilometers away in north-central Baffin Island (Jackson & Berman, 2000), in northern Labrador (Morgan, 1975), and on the west (Escher & Pulvertaft, 1976) and southwest (Higgins & Bondesen, 1966) coast of Greenland. Irregular patches of the organic-rich material that formed the unconsolidated matrix in which the artifact was found are present on both worked and broken surfaces. This matrix contains silicate mineral grains of clastic origin (fine sand, silt), glass spherules, and remains of vegetation in addition to metallic grains.

An initial pass across 400 mm^2 (20 × 20 mm) of the inner surface of the vessel was done using the automated scan feature of the Oxford EDS system. The quality of this analysis was limited by the small size of the grains of interest (2–20 μm), the short counting times of the automated scan (about 1 second), and the restriction of the instrument's working distance caused by the curvature of the surface of the vessel. The automated scan identified 800 occurrences of copper and 161 of copper–tin.

During subsequent analytical sessions, 57 copper-bearing metallic particles were analyzed manually using longer counting periods; all are copper–tin alloys (bronze) with copper predominant (~90–95%) over tin (~5–10%, Figure 3). In cases where the metal particle is smaller than the electron beam and excitation volume, elements attributed to the minerals comprising the rock from which the vessel was carved appear in the spectra. Clusters and individual particles of bismuth (1–3 μm) are quite common. One particle of lead and a number of glass spherules of variable size (<2–8 μm) and composition (Si, Si-Al, Si-Ca-Ti) are present (Figure 4). Similar to a component of fly ash, which is typically formed at temperatures of 1100–1400°C (Bech & Feuerborn, 2011), such spherules occur at temperatures high enough to melt rock-forming minerals. Along with metallic particles, spherules occur on the broken edge of the vessel as well as on the intact interior surface.

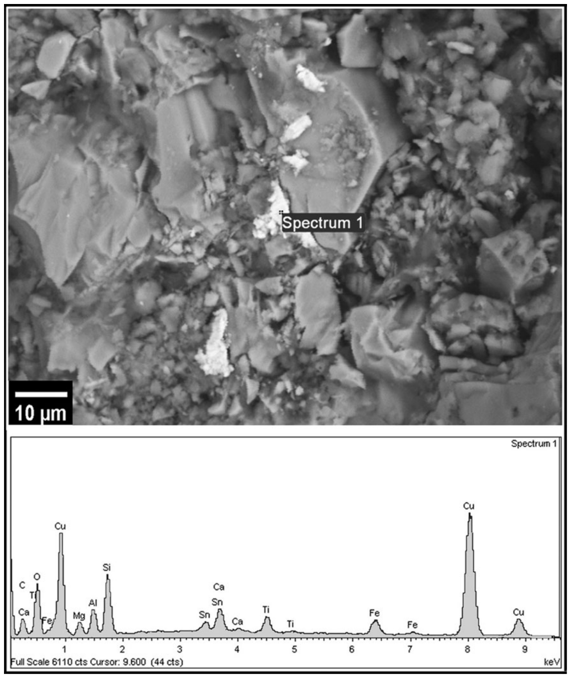

Figure 3 Backscattered SEM electron image and spectrum for a Cu–Sn particle on the surface of the crucible. Individual particles within the linear array are shreds of copper–tin alloy that appear to be caught on the edges of a titanite grain or between titanite and adjacent chlorite.

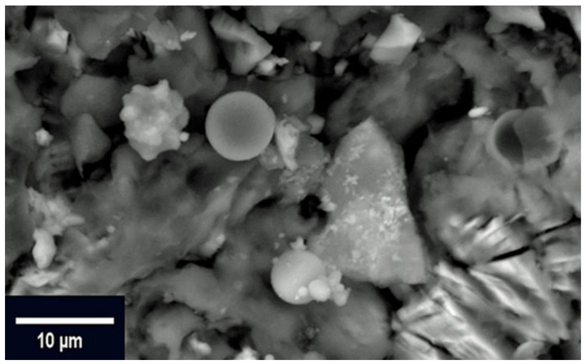

Figure 4 Backscattered SEM electron image of glass spherules on the surface of the crucible interior.

Copper–tin alloy occurs in crevices between mineral grains, on angular corners of relatively hard albite, within as well as on top of patches of organic-rich matrix, and on both the interior surface and broken edge of the vessel. This variety of settings, together with the "shredded" aspect of individual particles and the presence of glass spherules that are similar to those associated with high-temperature processes, are consistent with the use and breakage of the vessel in an environment where metalworking occurred. One or more small amounts of tin and copper or copper–tin alloy appear to have been melted, probably for the casting of small bronze objects. The broken condition of the crucible would suggest that it was used at the site. The specimen was recovered from an area that also yielded pieces of spun cordage, bar-shaped whetstones bearing traces of smelted metals on the working surfaces, and other specimens related to early European technologies that are consistent with a Norse presence. SEM-EDS analysis of soil matrix from the Nanook site also produced evidence of smelted metal particles.

Small ceramic crucibles were employed in nonferrous metalworking throughout the Norse world (Bayley, 1992; Bayley & Rehren, 2007). We are aware of only one stone crucible, which was recovered from a Viking Age context in Rogaland, Norway (catalog S3335c, Museum of Archaeology, University of Stavanger). Small crucibles with circular plan and either flat or conical bases have been recovered from Early Mediaeval sites in the British Isles including one stone specimen from Garranes in Ireland (Edwards, 1999). The presence of bronze traces in the crucible from Baffin Island is notable, as brass (copper–zinc alloy) is more characteristic of finds from Scandinavia. In a recent study of bronze artifacts from a Viking/Mediaeval site in Iceland, it is argued that the presence of tin and absence of zinc may indicate links with the British Isles, a tin-rich region (Wärmländer et al., 2010).

CONCLUSIONS

The crucible from the Nanook site provides new evidence of an early (pre-Columbian) European presence in the Canadian Arctic. It may also represent the earliest evidence of high-temperature nonferrous metalworking in the New World north of Mesoamerica.

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