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Prehistoric Uses of Circumpolar Mineral Resources: Insights and Emerging Questions from Arctic Archaeology

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Abstract: Exploitation of the Arctic's abundant geological wealth it not just a modern phenomenon; humans have been targeting specific rocks and minerals in this region for thousands of years. Some of the earliest evidence comes from Northeast Siberia, where around 27,000 years ago, Arctic hunter-gatherers were already using stone to produce hunting tools and other resource-processing equipment. As human colonization of the circumpolar Arctic gathered pace during the Holocene (the last 12,000 or so years), use of rocks and mineral resources diversified away from the manufacturing of stone tools towards production of new kinds of cooking containers that were made from fired clay and carved soapstone. These new food-processing technologies appear to have played a central role in the growing human reliance on Arctic maritime ecosystems and were exchanged widely, as were other valued geological resources such as meteoric iron, copper and chert.
This paper aims to situate these prehistoric uses of Arctic geological resources within a long-term and fully circumpolar setting. We argue that any attempt to understand these early subsistence uses of rocks and minerals by Arctic hunter-gatherers eventually leads into a broader set of questions about how and why prehistoric peoples were innovating new technologies and developing effective survival strategies to cope the challenges and opportunities presented by dynamic Arctic climates and environments.
We therefore argue that in seeking to fully understand what motivated early exploitation of Arctic mineral we need to focus on the "*people behind the rocks*". More generally, we conclude that improved collaboration across Arctic Geosciences will enable these extended exploitation histories to be properly integrated into debates about the long-term role played by humans in the increasingly fragile Arctic environment.

Zusammenfassung: Die Ausnutzung der reichlich vorhandenen geologischen Reichtümer der Arktis ist nicht nur ein modernes Phänomen; seit Tausenden von Jahren haben es Menschen in dieser Region auf spezifische Gesteine und Mineralien abgesehen. Einige der frühesten Zeugnisse stammen aus dem Nordosten Sibiriens, wo vor rund 27.000 Jahren arktische Jäger und Sammler Gestein bereits dafür benutzten, um Jagdwerkzeuge und andere Gerätschaften zur Verarbeitung ihrer Beute herstellten. Als die menschliche Besiedlung der zirkumpolaren Arktis während des Holozäns (in den letzten 12.000 Jahren ungefähr) an Geschwindigkeit gewann, diversifizierte sich die Verwendung von Gestein und Mineralien weg von der Herstellung von Steinwerkzeugen hin zur Produktion neuer Arten von Kochbehältern, die aus gebranntem Ton oder geschnitztem Speckstein bestanden. Diese neuen Technologien zur Verarbeitung von Nahrungsmitteln spielten eine zentrale Rolle in der zunehmenden menschlichen Abhängigkeit vom arktischen maritimen Ökosystem und wurden weitverbreitet getauscht, ebenso wie andere hochgeschätzte geologische Ressourcen wie Meteoreisen, Kupfer und Chert (Hornstein).
In diesem Betrag soll diese prähistorische Nutzung der arktischen Georessourcen innerhalb eines langfristigen und gänzlich zirkumpolaren Rahmens dargestellt werden. Wir behaupten, dass jeder Versuch, diese frühe Verwendung von Gesteinen und Mineralien, die die Existenz arktischer Jäger und Sammler sicherte, schließlich zu einem breiteren Spektrum von Fragen darüber führt, wie und warum prähistorische Völker neuer Technologien mächtig wurden und wirksame Überlebensstrategien entwickelten, um die Herausforderungen und Chancen zu bewältigen, die die dynamischen arktischen Klimazonen und Umwelt darboten.
Wir behaupten, dass wir uns bei der Beantwortung der Frage, was diese frühe Ausnutzung von arktischen Bodenschätzen motiviert haben könnte, auf „die Menschen hinter den Steinen" konzentrieren müssen. Allgemeiner schlussfolgern wir, dass eine bessere Zusammenarbeit der arktischen Geowissenschaften ermöglichen wird, dass die erweiterte Geschichte des Rohstoffabbaus in die derzeitigen Debatten über die langfristige Rolle des Menschen in einer zunehmend fragilen arktischen Umwelt integriert wird.

INTRODUCTION

It is now clear that the modern Arctic is warming at an unprecedented speed, generating rapid environmental changes that threaten many forms of traditional livelihood in circumpolar indigenous communities. On the other hand, climate change is creating new opportunities for shorter international sea routes across the Arctic Ocean, as well improved access to earth resources that are in ever increasing demand from a growing global population that lives primarily in the world's lower latitudes. In fact, the media are now full of reports predicting a new rush for the Arctic's increasingly accessible mineral reserves, ranging from oil and gas, through to rare elements and precious metals.

But a sustained human presence in the Arctic environment is by no means a modern phenomenon, and nor is the targeted human use of circumpolar geological resources. In this paper, we aim to examine prehistoric uses of Arctic geological resources within a long-term perspective. Human uses of Arctic geological resources remain complex and historically-contingent phenomena, and were no doubt mediated by diverse cultural and social factors, even during these early phases of exploitation.

However, at a more general level, these prehistoric uses of geological resources would all have involved small-scale hunter-gatherer communities using rocks and minerals to manufacture tools and other equipment that could be used within their own survival strategies. In this sense, these earlier "subsistence" uses of geological resources provide a useful contrast to the increasingly "commercial" exploitation of Arctic mineral resources that emerged during later historical periods. Typically, this involved individuals, companies, states and empires located in (or originating from) regions further to the south undertaking journeys into the Arctic to map, extract and transport resources back to distant markets, where they could be sold for financial profit. Fledgling commercial uses of Arctic mineral resources start to emerge around 1500 (see: Kruse 2016).

In contrast, we focus this paper on the earlier, subsistence-related exploitation of Arctic mineral resources. We trace out the earliest human exploitation of a diverse array of rocks, clays and minerals, using a series of case-studies to examine how different kinds of geological resources were used to make diverse tools and equipment that played important roles in Arctic survival and interaction strategies (Fig. 1). Evidence

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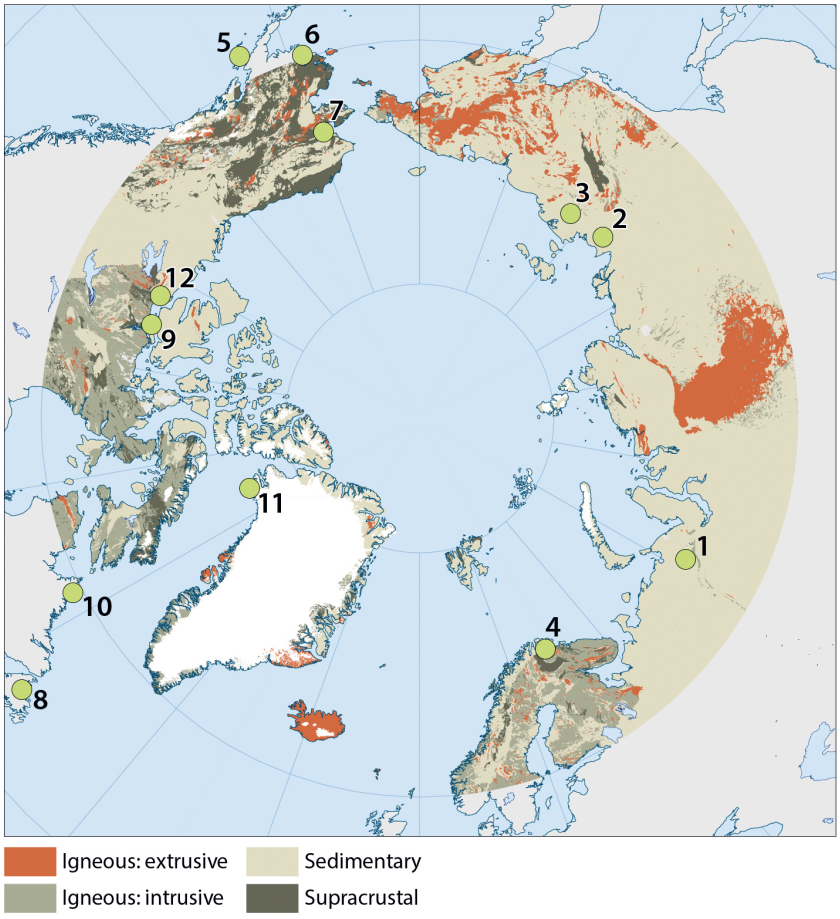

Fig. 1: Geological map of the Arctic with modern sea levels/coast lines and geographic locations of sites and case-studies mentioned in text. -1: Mamontovaya Kurya site; -2: Yana RHS; -3: Berelekh site; -4: Arctic Norway (early maritime adaptations); -5: Kodiak Island; -6: Nunalleq site; -7: Northwest Alaska; -8: Soapstone Quarry at Fleur de Lys; -9: Soapstone sources at Coronation Gulf; -10: Ramah Chert (source); -11: Meteoric iron source at Cape York; -12: Coppermine River (copper source).
Base map and geological features derived from Geol. Survey of Canada Map 2159A, Geol. Map of the Arctic. Drawn by Frits Steenhuisen, Arctic Centre, University of Groningen.

Abb. 1: Geologische Karte der Arktis mit heutigen Meeresspiegeln/Küstenlinien und den geografischen Standorten der im Text erwähnten Fallstudien. -1: Mamontovaya Kurya; -2: Yana RHS; -3: Berelech; -4: Arktisches Norwegen (frühe maritime Anpassungen); -5: Kodiak Insel; -6: Nunalleq; -7: Nordwestliches Alaska; -8: Speicksteinbruch bei Fleur de Lys; -9: Speicksteinvorkommen im Krönungs-Golf -10: Vorkommen von Ramah Chert; -11: Meteoritisches Eisenvorkommen bei Cape York; -12: Coppermine River (Kupfervorkommen).
Basiskarte und geologische Eigenschaften abgeleitet von: Geol. Surv. Canada Karte 2159A, Geol. Karte der Arktis. Bearbeitet von Frits Steenhuisen, Arktisches Zentrum der Universität Groningen.

for prehistoric uses of rocks and minerals comes from artefacts and tool-making debris that commonly survive in Arctic environments for many millennia. Arctic Archaeology focuses on excavating sites that contain this kind of evidence, and has developed into a highly specialized research field that has become adept at gleaning as much cultural information as possible from these surviving material remains.

Using an inter-disciplinary approach that integrates artefact analysis with palaeoecology, palaeoclimate research, chronology-building and geological sourcing studies, archaeologists are able to reconstruct human behaviours, and patterns of cultural diversity and change. These include tracing the emergence of new adaptive strategies, reconstructing the timing and direction of Arctic colonizations, and documenting the rise of regional interaction networks, as well as the climatic and ecological settings in which these events occurred. This means that in the end, researching the dynamic relationship between early hunter-gatherer populations and their prehistoric exploitation of Arctic mineral resources merely provides a productive entry point into a wide array of evidence that can be brought together to better understand the long-term roles played by humans in evolving Arctic environments.

However, while many of our case-studies are necessarily embedded within the general sweeps of circumpolar culture history, the goal here is not to not to provide "grand narrative" of Arctic prehistory (see Hoffecker 2005), which would clearly beyond the scope of this paper. Instead, we focus on exploring a particular range of human-geological relationships in order to illustrate some of the diverse ways in which harnessing the diverse mineral resources of the Arctic provided prehistoric cultures with important material opportunities and new technological potentials.

Starting points: earliest evidence for human exploitation of Arctic mineral resources

Exactly when did modern humans first start making use of Arctic mineral resources? Currently, the oldest known archaeological sites in the Arctic are the Mamontovaya Kurya site (Fig. 1-1), which lies on the Arctic Circle, and is located in the western foothills of the Polar Urals, and has been dated to around 34,000 years ago (Pavlov et al. 2001, Svendsen & Pavlov 2003), and the Yana Rhinoceros Horn Site (Yana RHS, Fig. 1-2).) (Pitulko et al. 2004). This is located even further north, at 71°, and is somewhat younger, being occupied around 27,000 years ago. Prior to the discovery of these two sites, the earliest widely accepted human presence in the Arctic had been the Berelekh site (Fig. 1-3), dated to about 13,000-14,000 years BP (Mochanov 1977, Pitulko 2011).

The Mamontovaya Kura and Yana sites are therefore an important starting point in Arctic history because they demonstrate that human populations were penetrating deep into northern environments even during colder Pleistocene times, and were surviving there by hunting mammoth, woolly rhino, reindeer, horse, wolf, birds and hares. But perhaps of

greater importance for this paper, it is clear that these early Arctic populations were making use of geological resources to maintain their hunting strategies; both sites contain stone tool assemblages. While Mamonovaya Kurya has only a handful of stone tools (Svendsen & Pavlov 2003), the Yana site has yielded a much larger collection (Pitulko et al. 2004), and so we focus on this particular assemblage.

The Yana site is actually a complex of six archaeological sites (Pitulko et al. 2004), and has provided rich insights into the subsistence strategies of the first hunter-gatherers to live so far above the Arctic Circle (Pitulko et al. 2004, Basilyan et al. 2011, Nikolskiy & Pitulko 2013). The community were producing complex, multi-component hunting tools; the diverse assemblage of artefacts recovered from the site includes numerous projectile points made from stone, as well as rare rhinoceros and mammoth bone foreshafts, which would have fitted the stone points onto wooden shafts (Pitulko et al. 2004). Other stone tools included choppers, chisels, scrapers for working skins, and a hammer stone (Pitulko et al 2004, 54; see Fig. 2).

Interestingly, the Yana hunter-gatherers appear to have been targeting a diverse suite of mineral resources to make these tools; during the 2001 and 2002 excavations, almost 400 artifacts of flinty slate were recovered, plus one object of granite, and six of quartz (Pitulko et al. 2004). Slate and granite occur naturally in the adjacent riverbed, probably indicating that local rock sources were used. However, the presence of quartz is particularly intriguing, because there are no local sources of this rock, and so the group must either have been visiting more distant geological sources during their seasonal migrations, or perhaps exchanging quartz pieces or finished tools with neighbouring bands (Pitulko et al. 2004).

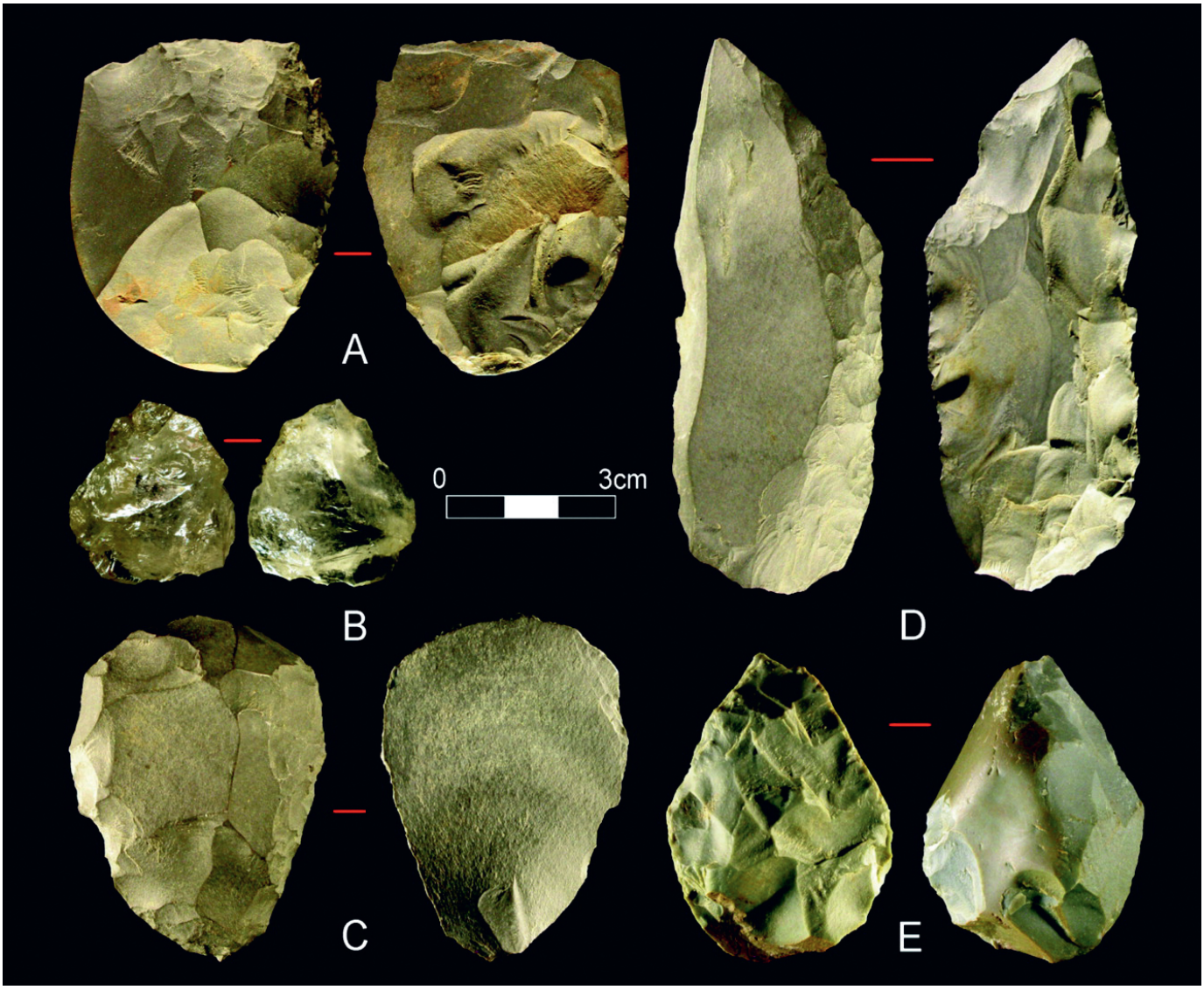

Fig. 2: Stone artifacts from Yana RHS (for location see Fig. 1-2). A: a side scraper with bifacially retouched working edge; B: worked piece of quartz crystal; C: end scraper; D: pointed tool; E: A side scraper with bifacially retouched working edge. Material: A, C, and D, siliceous slate; B, quartz crystal, E, chert. Source: originally published in Science (Pitulko et al 2004); reproduced with permission.

Abb. 2: Steinartefakte aus Yana RHS (Standort siehe Abb. 1-2). A: beidflächig retuschierter Schaber; B: bearbeitetes Stück Quarzkristall; C: Kratzer; D: spitzförmiges Werkzeug; E: beidflächig retuschierter Schaber. Material A, C, und D: Kieselschiefer; B: Quarzkristall; E: Hornstein. Quelle: Science (Pitulko et al 2004); mit Erlaubnis wiedergegeben.

Of course, modern humans and their hominin ancestors had been making stone tools for millions of years in the warmer latitudes of the globe (Hoffecker 2005; Robinson 2014), that is, long before hunter-gatherers were occupying the Mamontovaya Kurya and Yana sites. However, the activities recorded at these two high-latitude sites are an important threshold for Arctic Geosciences because they mark not only the material traces of some of the first modern human communities to penetrate this far north of the Arctic Circle, but also highlight that in one way or another, the capacity of humans to settle and survive in these Arctic environments has always been based on the ability to exploit Polar mineral resources. In other words, hunting has always been central to Arctic survival, but so too was effective use of geological resources to produce essential stone tools and other equipment. In the following millennia, stone-made artefacts went on to perform fundamentally important roles in the survival strategies of all prehistoric Arctic cultures (Hoffecker 2005).

UNDERSTANDING CIRCUMPOLAR LITHIC TRADITIONS

Lithics (i.e. finished stone tools, waste production flakes, rock cores and even discards) are in fact the most ubiquitous of all prehistoric archaeological finds in the Arctic. This is due to two main factors. First, stone suitable for tool production was widely available across circumpolar environments. For example, chert is an easily-worked rock, and tools made from this material have been found throughout the Arctic (e.g. Lazenby 1980, Mull 1995, Milne et al. 2011); the geological characteristics of slate mean that it could easily be modified into effective cutting and piercing tools, and the rock can be found in a number of areas, ranging from Alaska (e.g. Brooks et al. 1906) through to Arctic Fennoscandia (Engelstad 1985).

Second, tools and equipment made from mineral resources tend to survive longer than objects made from perishable organic materials. Some archaeological sites include evidence about the range of economic resources being exploited (e.g. in the form of bones, plants and other materials deposited in waste dumps). But only in very rare instances (e.g. where archaeological deposits are deeply frozen) do archaeologists gain insights into the complete range of equipment made and used by prehistoric populations. Commonly, these "full" Arctic survival kits would have included warm clothing, complex hunting and fishing equipment, shelters, boats and sledges, and perhaps nets, cordage and bags, as well as elaborate ornaments and other ritual equipment. In general, however, hardly any of this additional evidence survives into the archaeological record – stone tools and their associated production waste often form the main source of evidence for reconstructing the strategies and behaviours of past Arctic populations.

Despite these inherent challenges, much can still be learned through careful analysis of these lithic materials. Stone sources were used in very particular ways by different populations living in different places and periods, and stone-working skills would have been passed on between generations as enduring cultural traditions. Studying the composition of these lithic traditions can shed light on many aspects of past human behaviour. For example, at the most basic level, the recovery of stone tools signifies that people once occupied a particular location. By relative or absolute dating techniques (e.g. radiocarbon dating), archaeologists can then begin to build up a clearer picture of not only *where* people were, but *when* they were there.

Working at this kind of site-based scale, archaeologists can also assess lithic tool kit diversity and complexity building up a picture of what types of tools were being used by past peoples and for what purposes they were employed. For example, a typical Arctic hunter-gatherer lithic tool-kit might include diverse projectile points for hunting, scrapers for working skins into clothing, as well as choppers, smaller blades and burins for the further processing of meat, bones and other materials into food and equipment. The careful study of the changing composition of lithic tool-kits can not only provide important insights into how Arctic peoples were organizing their daily activities, but can also demonstrate the extent to which particular tool traditions were being passed on, adjusted or abandoned, from one generation to the next.

Working at larger geographic scales, archaeologists can also reconstruct the extent to which specific tool-making traditions were being shared between groups, and how these traditions evolved over time. For example, the chaîne opératoire of particular tool traditions (i.e. the specific sequence of steps and decisions involved in production and use of implements) appears to have varied significantly over time and space; this is because individuals and their communities were able to employ specific raw-materials, create and maintain their tools in distinctive ways, use them for particular purposes, and even discard them according to different kinds of cultural logic (Sørensen 2006).

Thus, by meticulously tracing similarities and differences in the chaîne opératoire of particular tool-making techniques, archaeologists reconstruct patterns of cultural change over time and space, for example, identifying where one particular "cultural tradition" might have originated, expanded or been replaced. This kind of reconstruction provides broad-scale insights into the existence of cultural groups and boundaries, sequences of technological innovation, as well as the expansion of populations into new areas, or the dispersal of new ideas through existing social networks (Sørensen 2006). In turn, these sequences of diversity and change in lithic traditions can be linked to shifts in past climates and environments, or to adjustments in hunting and settlement patterns, if additional evidence is also available.

Lithic-studies in action

At broader spatio-temporal scales, analysis of circumpolar lithic traditions has been indispensable for understanding the earliest human movements into northern latitudes, as well as subsequent migrations and dispersals (for an overview, see Hoffecker 2005, 96-134). For example, lithic evidence has long been central for understanding the first peopling of the New World (Kornfield & Politis 2014, Goebel et al. 2003, Goebel & Buvit 2011), and also the resettlement of Arctic Europe after the last Ice Age (Riede 2014, Bjerck 2008, 2009). Human movements into the North American Arctic and Greenland came later; even by 7,000 BP much of this area

was uninhabited due to the persistence of large glaciers, which were slowly retreating (Hoffecker 2005, 128). However, by around 4500 BP small pioneering groups had moved from Arctic Canada into northern Greenland (Grønnow & Sørensen 2006). By this point, diverse bands of Arctic-adapted hunter-gatherers were now living across the circumpolar North, having completed an enormous colonisation event, and one in which they had relied heavily on stone tool-making traditions – and therefore *Arctic geological resources* – every step of the way.

Lithic technologies have also provided important insights into later patterns of cultural continuity and change. For example, archaeological sites located from Alaska to Greenland, and dating to around 4500 BP, were found to have very similar stone tool kits tools, characterized by small, chipped micro-blades, end- and side-blades, scrapers, and burins (Knuth 1954, McGhee 1980). These similarities have been used to argue that the people occupying the North American Arctic were all maintaining a broadly similar lithic tradition, and that this "Arctic Small Tool" tradition (ASTt) formed a major Palaeoeskimo cultural horizon, which had expanded out from Alaska in the west, and eventually entered Greenland in the east. Archaeologists have also used the same evidence to identify more subtle cultural boundaries within the wider ASTt (Grønnow & Sørensen 2006).

Interestingly, around 1000 BP a completely different culture emerged in the Bering Strait and spread rapidly from Alaska out into the eastern Arctic and eventually Greenland. Although they followed closely in the footsteps of the Palaeoeskimo ASTt migrations, they brought with them a different tool-kit, and appear to have completely replaced the earlier population. These new arrivals were the Neoeskimo Thule, and form the direct biological, cultural and linguistic ancestors of the modern Inuit indigenous peoples. They were marine mammal hunters with a preference for ground slate and metals over chipped stone – both of which were used to make ulus, knives, and harpoon endblades among other tools (Fitzhugh 1975a, 366, McGhee 1980). In this sense, the North American Arctic was subject to two major prehistoric colonisation events, each involving different populations who maintained contrasting cultural traditions, and exploited the Arctic's geological resources in their own unique ways.

Mapping general shifts in lithic traditions can also provide insights into important economic transformations that were playing out across the Arctic. One good example of this is the rise of slate tool complexes, which appear to have been linked to the rise of specialised Arctic maritime adaptations (Fitzhugh 1975a, 1975b), which eventually dominated the Far North (Hoffecker 2005, 119). Interestingly, and unlike the ethnographically documented Inuit cultures who relied heavily on marine resources, many of the first people to settle in the Arctic appear to have had broader-based subsistence strategies, including hunting of terrestrial game. Some of the earliest evidence for specialised Arctic maritime economies appear in the fjord landscapes of northern Norway prior to 7,000 years ago, and were well established by the Late Stone Age, around 7,000 to 2,000 BP, for example, in locations such as the Varangerfjord (Hoffecker 2005, 121-2; Engelstad 1985; Fig. 1-4). Due to later settlement, harsher conditions, and a range of other factors, specialist maritime adaptations emerged somewhat later in the North American Arctic (Hoffecker 2005, 128-40, Ackerman 1998).

Regardless of the specific timing and location, the rise of thriving maritime economies across the Arctic meant that local communities needed new equipment to both hunt and process maritime resources (Fitzhugh 1975b), and this may have contributed to the growing use of slate sources across the Arctic (Hoffecker 2005, 123, Fitzhugh 1975a; Møllenhus 1975, Engelstad 1985). Flat pieces of slate can easily be shaped into long blades that are ideal for slicing and scraping; they can also be easily re-sharpened to maintain their cutting edge. For example, Fitzhugh (1975a, 376-377) argues that slate would have been ideal for harpoon heads, but especially for use in intensive processing operations, which would have included slicing, butchering and blubber-cutting tasks for large sea mammals (seals, walrus, whale), as well as the routine cleaning and fileting of fish that were now being seasonally harvested on a large and relatively predictable basis. In contrast, chipped stone tools are poorly suited for these kinds of slicing activities; they are generally smaller, less good at slicing, and much harder to re-sharpen. Interestingly then, the growing use of slate across the Arctic must have had independent regional origins, and suggests that the useful properties of this rock for new kinds of task were being widely recognized.

ARCTIC CONTAINER TECHNOLOGIES: FIRED CLAY VESSELS (POTTERY)

Turning away from lithic technology for the time being, we now focus on investigating how another kind of mineral resource came to be widely used by prehistoric hunter-gatherers of the Arctic: clay. Although a universal definition of *clay* does not exist (Bergaya & Lagaly 2006, 3), the term usually refers to small-grained soils which often contain phyllosilicate minerals and organic matter, are generally plastic when unaltered, and harden when dried or fired (Guggenheim & Martin 1995). These latter features made clay an ideal raw material for creating a range of cultural objects. In fact, prehistoric hunter-gatherers have been procuring and manipulating clay for upwards of 30,000 years. The oldest examples of this practice come in the form of fired clay figurines from Upper Palaeolithic sites in Europe, including Dolní Věstonice in the Czech Republic (Zimmerman & Huxtable 1971, and see: Jordan & Zvelebil 2009, Hommel 2014 for overviews of early ceramic traditions).

The practice of using fired clay to make ceramic *containers* – i.e. pottery – emerged somewhat later, around 20,000 years ago, in China (Wu et al. 2012), though it wasn't until many millennia later that the practice was eventually adopted in the Arctic (for an overview of the global spread of pottery, see: Hommel 2014; and in Afro-Eurasia, see: Jordan & Zvelebil 2009, Silva et al 2013). In the European Arctic, early pottery traditions appear around 6500 years ago (Skandfer 2005, 2009), in northern Siberia by around 5000 years ago (Kuzmin & Orlova 2000), and in the New World Arctic, by around 3000 years ago (Giddings & Anderson 1986) where the tradition persisted until historic times (Frink 2009).

Unlike stone tools, which had been a vital survival technology even during the earliest settlement of Arctic regions

by hunter-gatherers (see earlier), pottery was a technology that had been adopted into the region much later on. This raises important questions about strategic motivations – in other words, where Arctic hunter-gatherers had no choice about whether to use lithic implements to hunt animals and process resources into food and clothing, they very much did have a choice about whether to make and use pottery.

The vital role played by cultural choice is evidenced by the long delay between the initial peopling of the Arctic and the much later adoption of pottery. For example, Palae-Eskimo groups had settled across much of the North American Arctic by around 5000 years ago, yet pottery was not used in the region until some 2000 years later. Likewise, some Arctic hunter-gatherer groups went on to use pottery extensively, while others never did. Even more interestingly, there are also several instances where pottery-making traditions had rather interrupted histories: in some areas of Arctic Norway (Fig. 1-4), including the Varangerfjord, early pottery traditions were first adopted and maintained for a few generations, then dropped out of use, only to be taken up again a few centuries later (Skandfer 2009).

All these patterns of delayed adoption, variable uptake and intermittent usage appear to suggest that pottery technologies held a rather "fragile" position within the prehistoric societies of the Arctic, and this serves to highlight an even greater puzzle: how was it that ceramic containers ever came to be used in such harsh environments in the first place? Clearly, nowhere on earth is *less* conducive to making pottery than the Arctic. This is because pottery manufacture involves a long sequence of production steps, from sourcing moist clay and gathering supplies of fuel, through to fully drying out the vessels and then firing them at sufficiently high temperatures. Many features of Arctic environments can make each and every one of these practical steps extremely challenging; clay sources are frozen for most of the year; fuel can be hard to find in the barren tundra; properly drying and firing the vessels is very difficult, especially in coastal locations in the frequently cool and foggy summer months.

Finally, completing the complex pottery production sequence requires people to stay in one place and invest their time and energy. But this may also have been problematic; humans were able to remain in the Arctic because they were able to deploy flexible survival strategies that often involved frequent moves between resource locations. They may simply not have been able to stay long enough in one location to maintain a commitment to a long-term pottery tradition. Conversely, they may have been settled in particular locations for longer periods to target seasonal resources, such as fish runs and animal migrations, but then these intense harvesting efforts may have been difficult to combine with the extra duties associated with pottery production. And once on the move again, groups may also have been reluctant to carry the heavy, breakable cooking pots with them (see: Jordan & Zvelebil 2009, for a wider discussion). Arctic pottery then, is a very curious technology. Knowing the multiple obstacles faced by Arctic potters, even the simple presence of ceramic sherds in circumpolar archaeological sites raises many interesting questions about strategic choices and Arctic survival strategies. So how and why did exploitation of clay become so widespread in Arctic prehistory?

Insights into the Function of Arctic Pottery

At the most basic level then, Arctic pottery must have fulfilled some kind of important function. Unfortunately, questions about the precise function of Arctic pottery have been difficult to answer because direct evidence has been difficult to obtain; archaeologists have typically relied either on assumptions or drawn on more circumstantial evidence. However, a series of important new insights are now starting to converge; all highlight the close apparent associations between pottery adoption and the rise of Arctic maritime economies.

In general, it seems that the wider uptake of pottery technology into the Arctic may have coincided with an increasing reliance on maritime resources, including salmon runs and sealing, but especially the hunting of larger sea mammals such as whales and walrus (Dumond 1975, 2000). Pottery adoption therefore appears to be caught up in one of the most important cultural developments in Arctic prehistory – the emergence of thriving coastal economies that in many areas supported substantial populations who lived for much of the year in permanent villages. These communities also exhibited many traits associated with hunter-gatherer "complexity", that is, production of reliable economic surplus; seasonal storage of this surplus; concentration of socio-political within individuals and linages, and in some cases, persistent inter-group raiding and warfare (Hoffecker 2005, 134-39). It seems reasonable to suggest that pottery technologies were able to occupy some kind of important functional niche within these emerging maritime economies, and indirect evidence frequently highlights the link between a commitment to pottery traditions and processing of marine resources. For example, Kodiak Island (Fig. 1-5) was occupied by diverse foraging communities, but not all maintained pottery traditions. Those that did make pottery lived close to the primary marine mammal migration routes upon which the communities relied for hunting (Knecht 1995).

More direct insights into Arctic pottery function are now emerging, facilitated primarily by advances in biomolecular (gas chromatography-mass spectrometry) and isotopic (gas chromatography-combustion-isotope ratio mass spectrometry) methods used by archaeological scientists. These have created exciting new opportunities for studying the function of prehistoric containers (Evershed 1993, Evershed et al. 1994, Craig et al. 2013); this is because organic residues derived from vessel use are commonly preserved within the clay matrix and on the surface of pottery sherds (Fig. 3). These new methods characterize the residues, enabling vessel function to be established with a growing degree of precision.

To date, however, these approaches have seen only limited application to the study of Arctic container technologies. For example, Solazzo & Erhardt (2007) examined the fatty acid composition of samples extracted from pottery sherds recovered from archaeological sites across the North American Arctic, including surface crusts and absorbed residues. Interestingly, all the results indicated that the vessels had been used to process aquatic resources; a follow-up study of protein from one of those sherds confirmed the presence of residues consistent with processing of pinnipeds or cetaceans (Solazzo et al. 2008).

Fig. 3: Example of a pottery sherd of fired clay recovered from the Thule-era Neoeskimo site at Nunalleq, Alaska (for location see Fig. 1-6). Organic residues can be seen flaking away at the top of the sherd and indicated that the vessel had been used for processing of aquatic resources (photo: Thomas F. G. Farrell).

Abb. 3: Beispiel für eine Keramikscherbe aus gebranntem Ton geborgen aus der Thule-Ära Neoeskimo Stätte von Nunalleq, Alaska (Standort siehe Abb. 1-6). Organische Rückstände, die vom oberen Rand der Scherbe abplatzen, weisen darauf hin, dass der Behälter für die Verarbeitung von aquatischen Ressourcen verwendet wurde (Foto: Thomas F. G. Farrell).

More recently, a study by Farrell et al. (2014) also demonstrated that use of pottery at the Thule-era site at Nunalleq (Fig. 1-6), Alaska, was consistently associated with processing aquatic resources. What made this study particularly insightful was the fact that during the three hundred years in which the site had been occupied, the community had been practising a broad-based subsistence strategy involving exploitation of caribou and other terrestrial plant and animal resources. In contrast, pottery use had been highly specialized, focusing only on the processing of aquatic resources. While these results are certainly interesting, much more work still needs to be done throughout Arctic prehistory to better understand what motivated the use of pottery at different times and places, and in relation to specific socio-economic contexts, environmental factors and changing climatic conditions.

Technological Choices and Pottery Exchange Networks

In contrast to what appears to be a general association between Arctic pottery and the processing of aquatic resources, one equally intriguing feature of Arctic pottery is the persistent variability in shapes, design features and raw materials that were used in its production. Archaeologists have long been interested in documenting stylistic diversity in pottery traditions and have linked it to many factors. One older assumption was that stylistic differences simply represent separate group identities: different communities do things in different ways, and so by carefully mapping patterns of diversity and change in pottery traits, archaeologists could reconstruct historical relationships between different cultural groups (e.g. Oswalt 1955). As with the study of changing lithic traditions (see earlier), this approach provided a useful way of building culture histories across the Arctic. For example, and as noted above, one of the most important cultural transitions in Arctic prehistory is at the Palaeoeskimo-Neoeskimo succession. Interestingly, this is also reflected by a dramatic shift in pottery styles: thin-walled, relatively well-fired, and check-stamped pottery is replaced by a suite of new traditions, generally defined by thick-walled, relatively poorly-fired, and mostly undecorated pottery. And even within particular cultural periods, more subtle stylistic differences in pottery – as with the curvilinear decorations typical of northern Alaska Neoeskimo groups – provide a useful way to distinguish cultural boundaries between co-existing cultural or ethnic groups (De Laguna 1940).

More recent research is starting to explore how this stylistic diversity is generated by human agency, that is, through cultural strategies and human decision-making processes. In addition to basic decisions about vessel shapes and sizes, Harry et al. (2009) provide a useful summary of some of the wide range of choices made in other areas of pottery production, including: (a) *the temper*, which could be either organic (marine mammal oil or blood, fish oil, grass, feathers, animal hair), inorganic (pebbles, crushed stone, sand), or a mixture of both; (b) *vessel forming techniques*, which might involve modeling a single lump of clay or combining separate slabs or coils, or a combination of all three; (c) *surface finishing and decorating*, which might involve slipping, scraping, impressing or other techniques; (d) *drying/firing techniques*, with some pottery being fired at high or lower temperatures, or simply sun-baked. These insights emphasize the role of choice and enduring tradition; pottery could be made in a wide array of different ways, even in the Arctic.

What factors might inform these production choices? At a certain level, some options would certainly have been constrained by external factors like geography and resource availability at the time of manufacture. For example, variations in the temper of Early Northern Comb Ware pottery in Finnmark, Arctic Norway, has been attributed to geographic availability of local raw materials (Skandfer 2009); pottery recovered from the eastern Arctic, where fuel resources are in short supply, are often reported as "… poorly fired, friable vessels …" (Schledermann & McCullough 1980, 837). In some choices then, Arctic potters may have been left without a wide range of alternative options, and could have been forced to make compromises.

But if some stylistic differences were certainly governed by external factors, others would have been affected by social and cultural factors, including the ways in which particular craft skills and traditions were inherited, maintained and shared between generations and across social interaction networks. In seeking to move away from a traditional emphasis on identifying bounded cultural groups and sharp cultural boundaries, Skandfer's (2009) analysis of Early Northern Comb Ware pottery also reveals a subtle range of stylistic similarities and differences across the region, which she, in turn, interprets as reflecting varying levels of kinship relations and social learning networks (Skandfer 2009). In other words, these technological and decorative choices had become embedded within the wider reproduction of sociocultural life in this part of the Arctic, and had become entangled in the negotiation and solidification of prehistoric cultural identities.

Other recent work has highlighted the important role played by strategic choices within Arctic pottery-making traditions. Late prehistoric Thule-era pottery found in the Bering Strait and across parts of the North American Arctic has often been regarded as being rather crude and simplistic. HARRY et al. (2009, 33) have noted that "… *these Arctic cooking pots break nearly every engineering rule about how a ceramic cooking pot should be constructed* …"; unusual design features include thick and porous walls, flat bottoms, and straight walls – all traits that would have limited heat conduction and induced thermal stress during heating (FRINK & HARRY 2008, HARRY & FRINK 2009). However, by drawing on experimental research and local ethnographic records, they were able to demonstrate that these vessels were far from crude, but had instead been carefully designed to compliment several other cultural strategies, including deliberate parboiling of foodstuffs to maximise nutritional content, and minimising fuel consumption so that housing would not be damaged by use of large cooking fires (FRINK & HARRY 2008, HARRY & FRINK 2009).

If Arctic pottery production required substantial investments of time and skill, then to what extent were the potentially valuable finished vessels exchanged between different communities, and how far did they move from production sites? Archaeologists can reconstruct geographic patterns in pottery production, use and final deposition because there is enormous variety in clay sources. Clays may either be a geological deposit (known as sedimentary clay), or the weathering product of a parent rock (known as residual clay) (BERGAYA & LAGALY 2006, 8), and because of the enormous potential variability in parent rocks and clay formation processes, the composition of one clay may be very different compared to any other. In northern Alaska alone, ANDERSON (2011) identified distinctive glacial, fluvial, lacustrine, shoreline, and residual clay deposits, with each source possesses a unique chemical "signature". This diversity in sources helps archaeologists understand where the clays used in pottery originated from.

Although ceramic exchange networks have seen widespread attention in other parts of the globe, there has been only limited research on Arctic pottery, though recent case-studies highlight. Recent studies, however, highlight the potentials of this kind of research. For example, there was widespread pottery usage across the Bering Strait region during the Neoeskimo period, which also saw increasing sedentism, growing social complexity, and the rise of inter-continental exchange networks (ANDERSON et al. 2011). Additionally, ethnographic data and modern surveys have shown that clay sources in this region are not particular widespread; moreover, some clays were considered to be of higher quality than others, and only certain individuals would have been considered experts in pottery manufacture, all of which raises the likelihood of pottery exchange between groups (FRINK 2009, ANDERSON 2011).

To investigate the extent to which pottery had been exchanged between communities, ANDERSON et al. (2011) performed chemical analyses (neutron activation analysis, NAA) of pottery sherds recovered from a series of archaeological sites in northwest Alaska. They identified three macrogroups in the clays being used, and while most of these groupings appear to have been closely related to geographic factors (i.e. local groups used local clay sources), several sites also had pottery from all three chemical macrogroups, suggesting movement of pottery between increasingly sedentary groups (ANDERSON et al. 2011). Although these results are somewhat preliminary, they raise further questions about the potential role of pottery within Arctic exchange networks, and the extent to which particular clay sources and potters' skills could become valuable prehistoric commodities.

EXPLOITATION OF SOAPSTONE: A RIVAL MATERIAL TO CLAY?

As we explored above, stone had obvious value to all Arctic peoples, but the place of pottery within Arctic lifeways had always been somewhat more precarious. This was especially the case in the North American Arctic, where clay-made containers faced a direct technological "rival": *soapstone*. As Palaeoeskimo groups moved eastwards across North America about 4500 years ago, they found themselves within the vast geological region known as the Canadian Shield, an area characterized by exposed igneous and metamorphic rocks. One of the rocks that can be sourced in some parts of this area is soapstone (steatite), a relatively soft rock composed primarily of talc. These features meant that soapstone could be easily carved into a range of useful forms.

Soapstone went on to become the material of choice for cooking vessels and blubber lamps in a vast area stretching from the High Arctic through to Newfoundland (Fig. 4). The scale of soapstone use by these communities is not only evidenced by the abundance of soapstone artefacts at archaeological sites, but also highlighted by quarry sites like Fleur de Lys in Newfoundland (Fig. 1-8), where the outlines of countless vessels can still be seen carved in the soapstone outcrops (ERWIN 2001).

The curious relationship between "rival" clay and soapstone container technologies becomes even more interesting during the Thule Inuit (Neoeskimo) migrations into the eastern North America Arctic around 1000 years ago. Originating from the Bering Strait region, these later groups had already been using clay to make their pots and lamps for some 500 years. However, clay sources are much less frequent in the Canadian Shield, plus the lack of driftwood in the High Arctic, may also have meant that there was a shortage of fuel for firing pottery. In addition, fragile pottery may also be less suitable for frequent transport that more durable soapstone vessels (ARNOLD & STIMMEL 1983); soapstone also withstands thermal stress and retains heat more effectively than pottery (FRINK et al. (2012). Given this combination of factors, it should come as no surprise that the Thule Inuit almost completely abandoned their ancestral pottery traditions during this eastern stage of their dispersal.

But interestingly, some lingering knowledge of pottery making traditions must have persisted within migrating Thule Inuit communities as ceramics have been found at several early Neoeskimo in the Canadian High Arctic, and even as far east as Greenland (SCHLEDERMANN & MCCULLOUGH 1980). It even co-occurs with soapstone at a number of sites in the Coronation Gulf (Fig. 1-9), even where soapstone sources are located quite near (e.g. MORRISON 1991). Also, a sherd of

Fig. 4: Example of a complete Dorset Palaeoeskimo soapstone vessel recovered from Port au Choix archaeological site, Newfoundland (photo: Patricia Wells; reproduced with permission).

Abb. 4: Beispiel für einen vollständigen Specksteinbehälter der Dorset Palaeoeskimo geborgen aus der archäologischen Ausgrabung von Port au Choix, Neufundland (Foto: Patricia Wells, mit Erlaubnis wiedergegeben).

pottery that had originally been manufactured in Alaska was later recovered on Ellesmere Island in the eastern Canadian Arctic, suggesting at least some *ultra* long-range movement of finished pottery across Arctic landscapes (Schledermann & McCullough 1980, McCullough 1989). In general then, the fact that pottery traditions were able to "hang on" within Thule Inuit communities even after they had left Alaska may indicate that ceramic containers possessed some kind of enduring sociocultural significance, despite the many practical and functional advantages exhibited by soapstone vessels.

Despite this enduring cultural affinity with clay, the fact remains that soapstone "won out" as the favoured vessel technology in most Neoeskimo communities. Soapstone vessels came to enjoy great demand across the Arctic, even in communities those who did not live near local geological sources. Over time, these kinds of local geological "deficits" appear to have triggered the emergence of vast soapstone exchange networks, which linked the quarries of the High Arctic to distant consumers (Morrison 1991). For example, soapstone sources around the Coronation Gulf (Fig. 1-9) provided finished vessels, which were traded westwards towards Alaska. By the early historic period, virtually all cooking-vessels from Kotzebue Sound northward were made from Coronation Gulf soapstone; some of these soapstone vessels were also traded as far as sites in northeast Siberia (Morrison 1991).

Given these dramatic shifts in the use of "rival" container technologies in prehistoric North American Arctic, it is difficult to reconcile the assumption that pottery must somehow have served as an essential functional tool – or important sociocultural artefact – with the fact that it was quickly and almost completed abandoned in favour of soapstone. But although clay containers eventually "lost out" to soapstone technologies, these stone vessels were also discarded in favour of the metal cooking pots that were circulated across the Arctic in later historical periods. These kinds of rapid adoption/abandonment sequences were probably due to the nature of life in the Arctic, where people have always had to carefully balance technological, sociocultural, and environmental factors in their attempts to survive and maintain viable communities. Every aspect of prehistoric life in the Arctic – including use of rocks and minerals – would have been caught up in the daily decisions and seasonal strategies that formed part of that relentless struggle.

VALUE AND LONG-DISTANCE EXCHANGE: RAMAH CHERT, COPPER AND METEORIC IRON

Soapstone was not the only geological resource to be circulated widely during Arctic prehistory. We will complete this paper by exploring what factors led to the long-distance exchange of some other "rare" rocks and minerals: Ramah chert, iron and copper.

Ramah chert

In the first case we must leave the Arctic proper and enter the sub-Arctic region of northern Labrador. There, nestled in the mountainous area between Nachvak Fiord and Saglek Fiord, exists a 1200-1500 million year old lithic source known as Ramah chert (Gramly 1978, Fig. 1-10). This highly-distinctive rock can only be acquired at this single narrow outcrop (Gramly 1978, Loring 2002). Interestingly, the earliest Pre-Dorset Palaeoeskimos who entered the region upwards of 4000 years ago scarcely used Ramah chert, and only very low frequencies of the material have ever been recovered from these early occupation phases (Loring 2002, 172). Use of Ramah chert becomes more widespread during the Groswater period, which is the transitional phase of Palaeoeskimo occupation in eastern Canada, and appears in higher frequencies in sites from Northern Labrador all the way to Newfoundland (Loring 2002). However, it was not until the Dorset period proper that Ramah chert became the raw material of choice among eastern Palaeoeskimos. During this period (2500-800 BP) Ramah chert is virtually the only material used in stone-tool production in Labrador (Loring 2002), and the widespread presence of Ramah chert has also been noted at Dorset sites in Newfoundland (Anstey & Renouf 2011), the coast of Ungava Bay (Monchot et al. 2013), and on Baffin Island (Odess 1998). The fact that Ramah chert found in these areas is more than 1000 km from its only geological source provides a clear indication of the importance it must have held among the Late Palaeoeskimo groups of eastern Canada.

The long-distance exchange of Ramah chert has been linked to several possible motivations: first, unlike the many other variants of chert used by Arctic hunter-gatherers to make tools Ramah chert has a unique and highly-distinctive ice-like appearance (Gramly 1978, Loring 2002), which may have been considered attractive by prehistoric peoples; second, Ramah chert has been shown to have superior flaking properties relative to other cherts (Gramly 1978). This realization may have led certain Arctic peoples to value Ramah chert above other lithic sources; third, acquisition, possession and onward exchange of this distinctive chert may have been used as a way of strengthening sociocultural connections among groups living within and between particular regions (Loring 2002, Anstey & Renouf 2011).

Prehistoric uses of metals

While the widespread use of pottery by prehistoric peoples of the Arctic may have been surprising, we close out this discussion by examining a geological resource whose use among hunter-gatherer societies is perhaps even more atypical: metal. For various geological reasons, some prehistoric communities of the Arctic were able to gain access to copper or to iron, or sometimes both. That is not to say that all prehistoric peoples of the Arctic were using metals; some groups had no access to the materials at all. However, certain Arctic groups had already become heavily dependent on using metals long before the historic times that brought trade contacts with Europeans.

Iron was perhaps the metal of greatest importance to Arctic peoples, and one important source was located in the Arctic proper, at Cape York in Greenland (Fig. 1-11). This site has around 58 tons of iron-bearing meteoric fragments, and these have been exploited by Arctic hunter-gatherer groups for at least 2000 years. The first pieces of meteoric iron appear in Late Palaeoeskimo contexts in the High Arctic (McCartney & Mack 1973, McGhee 1984), and although the full extent to which Late Palaeoeskimo groups relied on this material is unknown, its use may have been more important than often assumed, as awls, endblades, engraving tools and other objects made from meteoric iron have all been recovered from Late Dorset Palaeoeskimo contexts (Holly 2013).

In contrast, the importance of iron tools to Neoeskimo groups living in and around the Bering Strait region has been much more widely acknowledged (see McCartney & Mack 1973 for a general overview). The iron used in this region was not from local sources, but originated in East Asia, and was traded up into the Arctic via extensive exchange networks that spanned Siberia and led to the complex urban societies of China. Archaeologists have argued that many new technological innovations would have been made possible after adoption of iron into the hunter-gatherer communities of the Bering Strait, and that this must have had major socio-economic consequences. Perhaps not surprisingly, it first starts to appear in some of the earliest Neoeskimo sites in the Bering Strait region, and may even have been the catalyst for the emergence of a new kind of "complex" hunter-gatherer culture that was heavily reliant of harvesting large marine mammals; these groups eventually expanded outwards across the North American Arctic in the form of the Thule Inuit dispersal (Mason 1998).

This replacement of earlier Palaeoeskimo Dorset culture by these expanding Thule Inuit communities is one of the most important cultural developments in Arctic prehistory (Hoffecker 2005, 135). Recent research suggests that it was a very rapid migration, taking place in just a number of decades, with Thule groups moving from Amundsen Gulf in the west, and reaching Greenland around 1000 BP (Friesen 2016). Given its importance for Arctic prehistory, the causes of the Thule migration have seen extensive debate (Friesen 2016).

Some archaeologists have even suggested that the Thule migration was triggered by the quest to access the alternative sources of (meteoric) iron that were located in Greenland; if this argument is correct, it would represent a very powerful instance of geological materialism shaping the entire course of Arctic prehistory. Thule people may have first heard about the distant Greenlandic iron sources via their encounters with Late Dorset peoples; the Thule were already making extensive use of Asian iron, but this had to be traded in over long distances, and so the opportunity to both acquire, and control the exchange of, high-quality iron from another location may have become a powerful motivation to move closer to that secondary source (McGhee 1984, Gulløv & McGhee 2006).

Whether access to Cape York's meteoric iron was the primary cause of the Thule Inuit migration is yet unclear, there is general agreement that iron implements quickly became an integral part of Thule tool-kits after they arrived into the High Arctic. Importantly, the role of iron in Thule communities underwent a significant shift: in the west (Bering Strait region and Alaska) the Asian iron had primarily been used for engraving and decorating tools and objects that were made from other materials (e.g. bone) but in the eastern Arctic, iron was now being used widely for projectile points and knife blades (McCartney & Mack 1973, McCartney & Kimberlin 1988).

As Thule groups consolidated their presence across the North American Arctic and Greenland, they also supplemented their use of local meteoric iron with additional supplies that could occasionally be acquired through contacts with the Norse pioneers who were expanding outwards into the North Atlantic rim, settling in Greenland and exploring eastern North America (Dugmore et al. 2007). In fact, much of the iron recovered from later Thule sites in the High Arctic and Greenland may originally have been Norse in origin (McCartney & Mack 1973); some of this was probably reworked into new tools, but a range of Norse implements has also been recovered from Thule sites, including chain-mail, knives, spikes, and other objects (Holly 2013, 118).

Thule Inuit uses of iron expanded even further in more recent times, as trade contacts with Russians and Europeans intensi-fied. By the 19th Century iron from the Hudson Bay Company was also being widely circulated up into the High Arctic (Morrison 1987, 4). In fact, such was the importance of this metal for later Thule Inuit communities that McGhee (1984, 15) has argued that they should rightly be defined as an "Iron Age" people, not a label that one would expect to be given to prehistoric hunter-gatherer societies living in remote Arctic environments.

Copper was also exploited in some parts of the prehistoric Arctic, but to a lesser extent than iron. In the North American Arctic, the primary sources of this metal are located in the Coronation Gulf area (Fig. 1-9): in the Copper Mountains west of the Coppermine River mouth; near Prince Albert Sound on Victoria Island; on islands in the Bathurst Inlet (Jenness 1923). Use of the copper sources in this area has an extended history; a few copper artefacts have been recovered from Late Dorset archaeological sites in the High Arctic (McGhee 1984). However, exploitation appears to have intensified after the arrival of the Thule Inuit into the area after 1000 BP (Morrison 1987). No doubt, the growing popularity of copper in Thule communities was linked to its softness, malleability and durability, all features, which would have enabled it to be shaped and hammered into a variety of useful objects.

Thule-era assemblages from this region frequently include copper ulus, needles, end-blades, barbs, knives, bracelets and rivets (MORRISON 1987).

Of course, the Thule-era groups living along the Coronation Gulf were also producing the highly-coveted soapstone vessels (see earlier) as well as extracting and working local copper. But although the soapstone artefacts were circulated over vast distances, the copper never really played a major role in these wider exchange networks (MORRISON 1991). The reasons for these differences remain unclear, but may be linked to the fact that Thule groups living further to the west were already making widespread use of iron acquired from Asian sources, and had little additional need for additional imports of copper (MCCARTNEY & MACK 1973, MORRISON 1991). In contrast, the Thule communities living along and around the Coronation Gulf were distant from Asian and also Greenlandic iron sources, and this perhaps encouraged use of local copper until well into the historic period. For a time, these local sources of copper were supplemented by supplies of European copper, which was acquired through both trade and scavenging from ship wrecks. But eventually, copper use also declined here as European iron eventually took over as the metal of choice (MORRISON 1987). Interestingly, descendent communities still living in this region were traditionally known as "Copper Inuit", highlighting the ancestral exploitation of these local mineral resources.

CONCLUSION: ARCTIC GEOSCIENCES AND THE "PEOPLE BEHIND THE ROCKS"

This paper has examined how hunter-gatherer societies were making widespread "subsistence" use of Arctic minerals for much of the last 30,000 years. Through numerous casestudies we have seen that this sustained exploitation of geological resources involved diverse rocks and minerals, through to use of clays and meteoric metal sources. Studying how and why past societies made use of these mineral resources is an important task for Arctic Archaeology because it demands consideration of the complex range of factors that motivated innovation processes and shaped past technological traditions. Furthermore, understanding exactly how, why, where and when particular sets of geological resources were being sourced and converted into cultural objects can shed light on migrations, interaction networks and long-term cultural transformations.

Clearly then, studying the role of mineral resources in Arctic prehistory is far from a simple exercise in geological determinism. The real goal is to reconstruct and explain the long-term cultural dynamics of Arctic societies, that is, to better understand the life-ways of the "*people behind the rocks*". Archaeologists study use of Arctic mineral resources as one entry point into examining how and why past circumpolar societies were making creative use of a wide range of natural resources to adapt, survive and maintain viable cultural and biological life-ways within particular palaeoecological, palaeoclimatic and geological contexts.

Importantly then, this emphasis on situating prehistoric societies within earlier environmental settings means that Arctic Archaeology can align itself with a broader inter-disciplinary vision for Arctic Geosciences, whose overarching goal is to understand long-term change in the Arctic, including the complex role played by humans in circumpolar environments. Improved cooperation between archaeology and other fields of Arctic Geosciences will undoubtedly lead to a much more complete picture of past human occupations of the northern world, and there are numerous ways in which improved cooperation can address emerging questions in Arctic Archaeology:
First, many circumpolar archaeological sites are embedded in frozen and/or permafrost contexts, or are situated along eroding coastlines whose maritime resources were of crucial importance for past hunter-gatherers. Archaeologists need to improve collaboration with environmental and climatic scientists to understand better the growing impacts of modern climate change on vulnerable archaeological sites before they are lost to rising sea-levels and melting permafrost (see: BLANKHOLM 2009).
Second, higher-resolution records of past climatic, ecological, environmental and oceanographic (e.g. sea ice) conditions can provide a much more complete picture of the past worlds in which past Arctic hunter-gatherers adapted and survived.
Third, and related to the last point, the creation of higher-resolution radiocarbon chronologies across more areas of the Arctic can provide the essential framework for linking shifts in past climates and environments to human cultural responses.

In conclusion, Arctic Archaeology can play a key role within Arctic Geosciences by highlighting the closely interconnected human *and* environmental histories that have shaped both the past and present of the circumpolar Arctic, and which are now set to define its increasingly uncertain future.

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