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An Experimental Study of Norton and Thule Cooking Pot Performance

by

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Abstract

Ceramic technology was adopted by hunter-gatherers of the Paleo-Inuit Norton tradition in the Western Arctic between 2800 and 2500 years B.P., corresponding with an increase in the use of aquatic resources. Pottery production and use continued until approximately 1,500 BP, and resumed during the Neo-Inuit Birnirk and Thule periods, approximately 1,350 years BP. The technical characteristics of Norton and Thule ceramics suggest they performed differently when used for cooking, with Norton ceramics best suited for cooking using direct or suspended heat, and Thule ceramics best suited for indirect heat. Prior experimental archaeological research has focused on Thule ceramics, with limited investigation into the characteristics and performance of Norton ceramics.

In this thesis, I asked how technological choices influenced the performance of ceramics for food processing, and how people in the Arctic cooked with ceramic vessels in the past. I addressed these questions through ceramics analysis and experimental archaeology. I analyzed a sample of Norton and Thule ceramics from occupation contexts from two Northern Alaskan sites, Iyatayet (NOB-0002) and Nukleet (NOB-0001), and compared the resulting data with existing ceramic data from other sites in Alaska to identify temporal and regional variation in ceramic characteristics. The results of this analysis provided metric data on which I based my experimental replications. For Phase 1 of my experimental research, I created and tested tiles with different temper types and surface treatments linked to ceramic cooking performance. For Phase 2, I replicated Norton and Thule vessels and used them to bring water to a boil using each of the three heating methods in order to answer questions of use by comparing heating performance of the two pottery traditions.

My analysis of Norton and Thule ceramic assemblages revealed significant temporal and regional patterns in the shape and composition of vessels, particularly in temper type and decoration. Phase 1 of my experimental work identified differences in strength and porosity of test tiles with specific temper and surface treatment. The experimental heating trials showed that there are significant differences in performance, measured in minutes for water to reach a boil, between vessels used for the three heating methods, with indirect (stone boiling) heating being the most effective regardless of vessel tradition. The trials did not show significant differences between the performance of Norton compared to Thule vessels. This suggests that the distinctive characteristics of Norton and Thule pottery are not necessarily the result of specific choices made by Arctic potters to meet cooking performance needs, but by other factors, potentially including constraints related to ceramic production and economic or social factors.

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To all my friends, co-workers, and fellow graduate students, thank you for the support and commiseration! And finally, to my partner, Rik Workman – I am so grateful to you for the hours you spent processing clay with me and for the thousand other things you have done to make this past year more bearable!

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Chapter 1: Introduction

Ceramic technology was adopted by hunter-gatherers of the Paleo-Inuit Norton tradition in the Western Arctic between 2800 and 2500 years B.P., corresponding with an increase in the use of aquatic resources (Anderson, et al. 2017; Farrell et al. 2014; Frink and Harry 2008). Pottery production and use continued until approximately 1,500 BP and resumed during the Neo-Inuit Birnirk and Thule periods approximately 1,350 years BP. Despite the challenges posed by resource scarcity and a cold, wet climate, the production and use of ceramics persisted in some communities until the early 20th century (Harry and Frink 2009, Fienup-Riordan 1975). Links between the adoption of ceramic technology and the intensification of marine resource use have been investigated through residue analysis (e.g. Admiraal et al. 2019, Farrell et al. 2014), but results from Anderson et al.'s (2017) Northwest Alaskan pilot study indicate that ceramics were also used for processing freshwater or mixed aquatic and terrestrial resources.

Pottery was one of the main food processing technologies used during the Norton and Thule periods, but it has not yet been studied in-depth from an archaeological perspective. Norton and Thule pottery differ in shape, wall thickness, paste composition, and decoration. Drawing on behavioral archaeology, these characteristics are understood as the result of technological choices made by potters. Technological choices, such as ceramic paste composition and vessel shape, influence how pottery performs when used. Prior research has linked certain technological choices with intended uses. The differences between Norton and Thule pottery suggest the vessels had different intended uses during those periods. Three methods of cooking using ceramics are hypothesized for the Norton and Thule periods. These include indirect heat (i.e. stone boiling), direct heat, and suspension (Harry and Frink 2009b, Linton 1944). Prior experimental research on the performance of Arctic ceramics has focused on Thule vessels (Harry et al. 2009a, Harry et al.

2009b, Harry and Frink 2009). The performance of Norton vessels when used for cooking has not yet been addressed from an experimental archaeology perspective.

Food processing and related technologies remain understudied in the archaeological record of Northern Alaska until recently. The analysis of ceramics can help us understand the role that ceramic technology played in food processing in pre-colonial Alaska. Analysis of the ceramics in archaeological collections is especially important given the limited ethnographic information on ceramic use collected during the colonial period. The goal of my thesis research is to investigate how ceramics were used to process food by cooking in the Western Arctic. More specifically, my goal is to address the questions of how technological choices influenced the performance of ceramics for food processing, and how people in the Arctic cooked with ceramic vessels in the past. I addressed these questions through ceramics analysis and experimental archaeology.

I analyzed a sample of ceramics from two Northern Alaskan sites, Iyatayet (NOB-0002) and Nukleet (NOB-0001), which date to the Norton and Thule periods respectively (Figure 1). I also compared the resulting data with existing ceramic data from other sites in Alaska to identify regional variation in ceramic characteristics. The results of this analysis provided metric data on which I based my experimental replications. For Phase 1 of my experimental research, I created and tested tiles with different temper types and surface treatments linked to ceramic cooking performance. For Phase 2, I replicated Norton and Thule vessels and used them to bring water to a boil using each of the three heating methods in order to answer questions of use by comparing the performance of the two pottery traditions.

My research into how ceramics were used in the Paleo-Inuit and Neo-Inuit periods informs understandings of diet and food processing technology. The study of changes in cooking practices and food processing technology helps archaeologists understand the culture shift which took place between the Norton and Thule periods. Studies of Norton ceramics have generally suffered from small sample sizes. Understandings of Norton and Thule ceramics from different regions of Western Alaska are also limited. For this project, I carried out the first large-scale statistical analysis of Norton and Thule ceramic data across regions in order to identify regional variation, which can inform archaeological understandings of performance and use. Experimental vessels produced for this project will be used by other researchers to further explore ceramic use in the Paleo-Inuit period. For example, a project is planned to use sherds from several experimental vessels to provide valuable reference data for future applications of residue analysis to both ceramics and activity areas. This study also connects to descendant community interest in past technologies, cooking methods, and foodways in the Arctic.

The second chapter of this thesis summarizes the theoretical and archaeological background to my research, focusing on the characteristics of pre-colonial Alaskan pottery, how it may have been used, and its hypothesized performance characteristics. In Chapter 3, I describe the methods used in my archaeological ceramic analysis, replications, and experiments. I provide an overview of project materials, analytical and experimental protocols, and archaeological expectations. In Chapter 4, I present the results of my analysis and experimental research, and discuss the results in Chapter 5. Chapter 5 also includes my concluding thoughts and recommendations for future work. Additional figures and tables follow in the appendix.

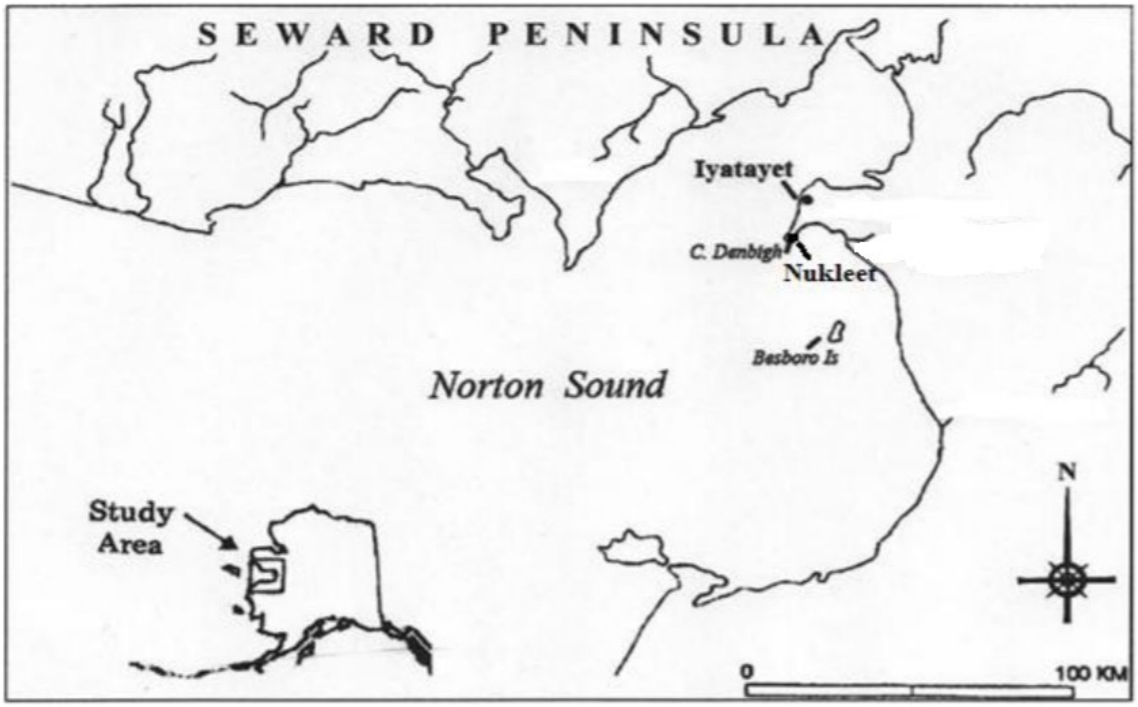


Figure 1. Map of project region, adapted from Harritt 2010.

Chapter 2: Background

2.1 Theoretical Approach

This thesis takes a behavioral archaeology approach to answering questions of how pottery technology was used in the Arctic. Within this framework, artifacts are produced by specific technological choices which affect the formal properties of an artifact, influencing in turn the behavioral capabilities of the artifact (Schiffer et al. 1994, Schiffer and Skibo 1987). Technical choices are defined as all the individual activities in material procurement and manufacture of a particular artifact, including clay processing, temper, vessel shape, and firing temperature (Schiffer and Skibo 1997). Technological choices affect performance characteristics, which are behaviorally relevant when linked to specific activities(Schiffer et al. 1994). In order to link archaeological materials to past activities, the intended use of an artifact can be inferred by considering its performance characteristics - that is, what the artifact does best - contextualized by other factors among the network of interrelated technical, social, economic, and ideological interactions within which the technology operates (Schiffer and Skibo 1987).

Experimental archaeology allows for performance characteristics and technological functions to be tested through a series of actualistic experiments (Outram 2008, Reid et al. 1975). The results of the experiments are made meaningful through scientifically rigorous analogies between past material culture and present replicated materials and activities. Although not without controversy, analogical arguments are fundamental to experimental archaeology and ethnoarchaeology, since they bridge between present observations and archaeological materials. Analogies of this sort are considered valid when supported by context as well as relevance and extent of similarity between past and present (Wylie 2002).

The goals of experimental archaeology include creating a body of knowledge that helps researchers interpret, rather than simply describe, archaeological sites and materials by reading the archaeological record as the end-result of dynamic processes and activities, rather than a collection of static materials (Millson 2010). Ceramics have long been the focus of experimental archaeological research, though mostly focusing on the ceramic technologies of the Southwest, Southeast, and Northeast in North America. Prior experimental ceramics research in Alaska consists of a series of studies conducted by Harry, Frink, and other collaborators on Thule pot manufacture and use (Harry and Frink 2009b, Harry et al. 2009). Experimental archaeology conducted in a lab can produce results under controlled conditions, however Skibo (1992) asserts the value of conducting experiments under less controlled conditions, to better replicate the conditions which created the archaeological record.

2.2 Cultural and Environmental Background

The geographic region of interest for this thesis is the area around Norton Sound, an inlet of the Bering Sea in Western Alaska, south of the Seward Peninsula. On the north-eastern edge of the inlet, Cape Denbigh extends westward into Norton Sound. Cape Denbigh is in an area characterized today as Subarctic tundra, with vegetation at low elevations along the coast consisting of grasses and taller shrubs such as alder, willow, and birch (USDA-NRCS 2004). The area currently has a moist polar climate, with early winter sea-ice. As in many other parts of Northern Alaska, wood was a limited resource around Norton Sound prior to 250 BP. The primary sources for wood were local scrub willow, poplar, alder, and birch, supplemented by driftwood, specifically spruce and cottonwood, originating from elsewhere (Giddings 1964). The driftwood may have come from the Yukon and Kuskokwim River drainage basins, and washed up annually on the beach (Alix 2005). Despite the regular renewal of driftwood in coastal areas, it was in high demand during the pre-colonial period as a building material and firewood, particularly for cooking and pottery firing.

The Norton Sound area was inhabited by several distinct cultural groups over time, starting with the people of the Denbigh Flint complex, part of the Arctic Small Tool tradition (4,500 to 2,800 BP). This period predates the use or manufacture of pottery in Alaska, and is characterized by a reliance on predominantly large terrestrial mammals such as caribou, augmented by small amounts of marine or freshwater resources (Odess 2017, Tremayne et al. 2018). Paleo-Inuit people of the Norton tradition migrated from Siberia around 2,500 BP. The Norton period is characterized by increased sedentism and intensification of aquatic resources, including marine mammals. Evidence for the intensification of aquatic resources during the Norton period includes faunal remains, the proliferation of fishing technology such as net sinkers (Giddings 1964), decreased residential mobility, increasing population size, and the production of more and heavier tool types which were difficult to transport on foot, including pottery (Tremayne 2017).

A wide variety of marine mammals were harvested in Norton Sound by Norton people, including seal, whale, and walrus. Freshwater, saltwater, and anadromous fish were all consumed during the Norton period at both inland and coastal sites. Shellfish have also been found in Norton middens along the coast, including at Iyatayet (Harritt 2010, Giddings 1964). Recent excavation has shown that 86.5% of the faunal remains identified at Iyatayet consist of marine mammals, and 5.4% of large terrestrial mammals (Tremayne et al. 2018). Coastal Norton sites contain substantial residences in the form of semi-subterranean houses, indicating permanent habitation, although seasonal mobility was likely, due to the co-existence of ephemeral campsites (Dumond 1982). Norton house structures were typically square, with an entrance tunnel, wooden benches running around the interior, and a central hearth.

After about 2,000 BP, the Norton tradition began in some areas to disappear or be replaced by different traditions. Norton chronology varies widely across Alaska, although at the Iyatayet site, Norton occupation ended around 1,840 ± 110 BP, followed by a significant gap in occupation, and a depopulation of the Norton Sound era at the end of the Norton period is hypothesized (Dumond 2000, Tremayne 2017). Neo-Inuit people of the Thule tradition were next to arrive in Norton Sound, likely coming from Siberia across the Bering Strait, although the transition between Norton and Thule is still being explored in Alaska and across the Arctic. DNA testing indicates genetic mixing between the Paleo- and Neo-Inuit populations in Alaska, showing overlap between the two populations, and it is possible that some Norton populations changed culturally without any population replacement as in Southwestern Alaska (Dumond 2000), although the two populations were more distinct further east (Raghavan et al. 2014). People of the Thule tradition are the direct ancestors of contemporary Inuit people living in Alaska and across the Arctic.

Specialization in marine mammals and other aquatic resources extended into the Thule period (Giddings 1964). Recent findings at the Iyatayet site suggest Norton and Thule people utilized the same suite of marine, aquatic, and terrestrial resources (Tremayne et al. 2018), although Thule culture is well-known for its large-scale use of aquatic resources, as well as its highly specialized and sophisticated toolkit. Thule and early ethnographic period diets included bird and fish eggs, wild greens such as sourdock, a wide variety of fish, birds, small land mammals, large land mammals such as caribou, and sea mammals such as whale, seal, and walrus (Spray 2002). Early Thule winter dwellings consisted of substantial semi-subterranean houses with entrance tunnels, and in some cases, multiple rooms and alcoves branching off either the main living area or the tunnel (Norman et al. 2017). Thule houses lack a central hearth, and there is no evidence that wood burning or cooking occurred inside the main living area (Crawford 2012). The majority of burning occurred in dedicated covered kitchens usually located on the eastern side of the entrance tunnel, either connected to the tunnel or main living room, or detached from the house entirely (Norman et al. 2017). During the summer season, most Thule people transitioned to live in tents, and migrated around the region for subsistence activities and gatherings such as trade fairs (Burch 2005).

Cultural and linguistic differences exist between contemporary Inuit people living in Western Alaska, particularly between Yup'ik speakers (Yupiit) to the south and Inupiaq speakers (Inupiat) to the north (Appendix Figure A-1). The differences between these groups likely arose during the Thule period, and material patterns relating to them can be read in the archaeological record. Comparing ceramic assemblages between regions may elucidate further differences between the material culture, technological choices, and food processing strategies of these two culturally and linguistically distinct populations during the pre-colonial period.

Although the Norton Sound was previously believed to be a region traditionally inhabited by Inupiaq speakers from further north, recent archaeological, linguistic, and ethnographic evidence suggests that Inupiaq speakers replaced the original Yupiit inhabitants of the region, following a period of upheaval resulting from a smallpox epidemic and Russian disruption of local economies in the 19th century. In the Seward Peninsula of Northwest Alaska, the early Thule house type of a main living room accessed by a straight entrance tunnel persisted into the Late Thule and early colonial period. Recent investigations at the Shaktoolik Airport Site (NOB-072) in Norton Sound show that after 550 BP, corresponding with the latest phase of Thule occupations at Nukleet and Iyatayet, house structures changed to sprawling multi-roomed dwellings connected by multiple tunnels (Darwent et al. 2017). This house type most resembles houses found at other Yupiit settlements, notably Nunalleq (McManus-Fry et al. 2018, Ledger et al. 2016), and may be a response to warfare during that period (Darwent at al. 2017). Continuity in artifacts and settlement type between the late pre-colonial period and the ethnographic Yupiit period at Shaktoolik confirms the direct lineal relationship between Thule people and contemporary Yupiit (Yup'ik speakers) (Darwent et al. 2017).

2.3 Characteristics of Norton and Thule Pottery

Pottery first appears in Alaska during the Norton period, around 2,500 BP. In the Norton Sound region, the Norton tradition came to an end around 1,500 years BP, although Norton populations persisted until 1000 years B.P. in Southwest Alaska (Dumond 2000). Pottery production and use resumed during the Birnirk and Thule periods approximately 1,350 years BP, and ceased during the colonial period. This later pottery tradition is associated with the Neo-Inuit expansion across northern North America. Although copper cooking pots appeared in coastal Yupiit and Inupiat communities during the 19th century through Indigenous and European trade networks, they may not have been an immediate replacement for clay cooking pots as taboos existed around using metal implements (Jolles 2002 [Campbell 1904]). Nevertheless, the widespread use of ceramics ceased during the 19th and early 20th centuries, likely as a result of European and Euro-American economic and cultural pressures.

Table 1 summarizes the differences and similarities between the Norton and Thule pottery traditions. Both primarily produced cooking vessels characterized by flat or rounded bases, open orifices, and high walls (Ackerman 1982, Harry and Frink 2009). Norton pottery tended to be thin-walled, tempered with fine sand or gravel in low densities, although organic tempers such as fiber are also documented, notably at the Iyatayet site (Ackerman 1982). Decorated pottery occurs more frequently during the Norton phase than in the later Thule phase, with check- and linear-stamped designs the most common decorative types. The frequency of decorated Norton vessels suggests they may have been produced with the intention of being seen publicly or exchanged, in addition to use in food processing (Anderson et al. 2017).

Thule pottery is thick-walled, often exceeding 10 mm in thickness, and contains coarse mineral temper mixed with a variety of organic tempers, including feathers, hair, grass, and crushed shells. Some paddle-stamped or linear decorations are present, although they make up a small percentage of total sherds. Changes in the characteristics of pottery technology occurred throughout the Thule period, and are particularly significant between the early Thule (Birnirk) and the later Thule phases, as documented in Northwest Alaska at Cape Espenberg (Reed et al. 2019), in Norton Sound at the Nukleet site (Giddings 1964), and in Southwest Alaska (Arnold and Stimmel 1983).

Alaskan pottery technology from the Thule tradition shows regional variability, with differences in most frequent temper types, concentration, and coarseness between assemblages found in Northwest Alaska and the Norton Sound region. Some of this variation may be accounted for by the presence of different native mineral inclusions in clay bodies harvested from different sources (Anderson et al. 2011), or the specific regional abundance of certain materials such as shellfish. Regional variability may also be a result of environmental factors including relative humidity and average temperature, which affect pottery manufacture and performance. Potters in Northern Alaska, for instance, faced harsher summer conditions than their counterparts in Southern Alaska, which likely increased drying time and decreased the rate of firing success. Characteristics such as wall thickness and temper type which vary between regions may be responses to these conditions. The issue of regional variability in Norton tradition ceramics has not yet been thoroughly explored. Furthermore, the differences between Norton and Thule tradition ceramics transcend differences between regions. Why ceramic technology changed between the Norton and Thule periods in the Arctic may be further understood by looking at how ceramics performed beyond their technical function. Behavioral studies of technology and technological change consider all the possible functions of an artifact and how it performs technically, socially, and ideologically (Rathje and Schiffer 1982). Social and ideological interactions with an artifact are considered part of that artifact's performance characteristics (Schiffer and Skibo 1987). The visual qualities of a ceramic vessel, particularly its decoration, may be intended to signal personal ownership or cultural identity (Rice 1987), embody spiritual qualities, or be more noticeable and desirable when traded or exchanged (Schiffer and Skibo

1997). Ceramic vessels formed part of extensive trade networks during the Neo-Inuit period, and both Norton and Thule vessel decorative types vary across regions and over time, suggesting that visual qualities may have played a role in the intended uses of Arctic ceramics (Anderson et al. 2011).

Table 1. Attributes of Norton and Thule pottery based on Ackerman (1982), Harry and Frink (2009), and Reed et al. (2019).

Attribute	Norton	Thule
Temper	Mineral and organic	Mineral and organic
Wall Thickness	Thin (7 mm average)	Thick (11 mm average)
Decoration	Frequently cord or paddle impressed	Some incised or paddle impressed, mostly undecorated
Surface Treatment	Smoothed	Smoothed, with oil and/or blood added post firing
Firing	Low-fired (below 1154ºC)	Low-fired (around 650ºC)
Shape	Straight or everted/bowed walls, flat bottom	Straight walls, incurved, flat bottom

2.4 Use of Ceramics

Pottery was one of the main food processing technologies used during the Norton and Thule periods, but it has not yet been studied in-depth. Analysis of the ceramics in archaeological collections is especially important given the limited ethnographic information on ceramic use collected during the colonial period. The intended uses of ceramics can be inferred from specific physical attributes, such as base type and orifice diameter; interpretation of data from these measurements can be strengthened or problematized by ethnographic and experimental data.

Ceramic vessels intended for use in cooking typically have high walls, and open orifices, while storage pots generally have more constricted orifices to protect vessel contents (Smith

1985). Norton and Thule pots, with their high walls and direct or slightly incurved rims, were most likely intended as cooking vessels, and not for storage. Unfired or low-fired vessels produced during the Thule period may have disintegrated over time if used for storage, especially when exposed to moisture (Harry et al. 2009). Thick food residue crusts and exterior sooting on sherds also provide evidence of their use as cooking pots. Further discussion of ceramic production can be found in section 2.5, Ceramic Technology and Performance.

Inuit women during the ethnographic period were responsible for processing big game, as well as hunting small game, fishing, and gathering plant foods (Braymer-Hayes 2018). Ethnographic evidence also points to women being the primary producers and users of ceramic technology (Burch 1998, Harry and Frink 2008). Women were likely concerned with producing technology well-suited to processing foods in desired ways. A variety of moist heat food preparation methods are documented in ethnographic research on traditional Inuit cuisine, including boiling, poaching, simmering, and blanching (Harry and Frink 2009, Spray 2002). Most ethnographic accounts describe metal vessels being used for cooking, as they are recorded later in the 20th century, after ceramic vessels had largely been replaced (Campbell 2004). Some accounts, such as Burch (2005, 2006), describe the use of ceramic vessels for indirect heat cooking (stone boiling), along with birch bark containers. Due to the differences in performance of metal, ceramic, and wood containers, particularly their durability when placed in a fire and their conductivity, it is possible that food preparation methods changed with the introduction of metal vessels into Alaska. The list of foods cooked by moist heat, summarized below (Table 2), does not provide direct evidence of the kinds of foods which would have been cooked in ceramic vessels, but rather what kinds of foods were prepared in pots during the ethnographic period. Not all foods were cooked, as some types of meat, fat, fish, and berries were consumed after having either been frozen, dried, rendered, or fermented (Spray 2002). Other food preparation methods include drying, smoking, and roasting (Jones 2006). In some cases, multiple food preparation methods were employed, for instance poaching frozen fish, or boiling partially-dried fish (Harry and Frink 2009, Jones 2006, Jolles 2002). Contemporary and pre-colonial Arctic cooks had detailed knowledge of which preparation methods worked best for which foods, in line with taste preferences, food safety, nutritional value, and economic efficiency.

Table 2. Traditional Northwest Alaskan foods prepared with moist heat cooking.

Food	**Preparation Method**	**Source**
Fish eggs (Tomcod, Flounder, Chum, Sheefish, Humpback and Broadnose Whitefish, Mudshark, Pike, Sucker)	Boiled, parboiled	Jones 2006
Bird eggs (Duck, Goose, Auk and Murre)	Boiled	Spray 2002, Kuhnlein and Humphries 2017
Eider duck	Boiled, boiled to render fat	Kuhnlein and Humphries 2017
Snow Goose	Boiled	Kuhnlein and Humphries 2017
Black Guillemot	Boiled	Kuhnlein and Humphries 2017
Cormorant	Boiled	Jolles 2002
Caribou	Boiled, boiled to render fat	Kuhnlein and Humphries 2017
Whale (Beluga and Bowhead)	Boiled	Kuhnlein and Humphries 2017
Seal	Boiled	Kuhnlein and Humphries 2017
Walrus	Boiled	Jolles 2002

Food	**Preparation Method**	**Source**
Tomcod	Boiled, half-dried and boiled	Jones 2006
Alaskan plaice	Boiled	Jones 2006
Smelt	Boiled	Jones 2006
Bullhead	Boiled	Jones 2006
Chum salmon, Sockeye salmon	Boiled, half-dried and boiled	Jones 2006
Dolly Varden, Arctic char	Boiled	Jones 2006
Sheefish	Boiled, boiled to render oil	Jones 2006
Humpback whitefish, Broadnose whitefish	Boiled, parboiled, half-dried and boiled, boiled to render fat	Jones 2006
Bering Cisco	Boiled, boiled to render fat	Jones 2006
Mudshark	Boiled	Jones 2006
Grayling	Boiled	Jones 2006
Northern Pike	Boiled	Jones 2006
Longnose sucker	Boiled	Jones 2006
Blackfish	Boiled	Jones 2006
Shellfish (Clams)	Boiled	Jones 2006
Crab	Boiled	Jolles 2002
Sourdock	Boiled	Spray 2002
Willow greens	Boiled (in meat broth)	Jolles 2002

Simmering was used to render fat into oil, particularly useful in the case of fish which do not have subcutaneous fat deposits. Oils were more easily skimmed off the top of simmering water rather than water brought to a rolling boil. Fish oil was a particularly valuable commodity during the ethnographic period in Northwest Alaska and likely before, and was sometimes traded long distances (Burch 2006). Grease was rendered from terrestrial mammals as well, particularly caribou. Caribou long-bones were cracked open and boiled to extract the grease, which was collected from the broth once it had cooled (Burch 2005).

From an economic standpoint, some of the advantages of using ceramics for cooking include increasing the nutritional value of food, increasing the number of edible resources, and reducing the amount of time, effort, and material resources invested in cooking. Pottery allows for direct heating over a fire or coals, which is a faster method of boiling and requires less supervision than indirect heating with stones. Pottery can also resist both water and fire, and can maintain high temperatures and long cooking times (Harry and Frink 2009). Cooking meat gelatinizes its protein content, improving digestibility and increasing the number of calories available to the consumer (Wrangham 2013). Cooking can also mitigate food safety concerns associated with freshly caught or stored foods, since prolonged boiling sterilizes food and decreases the risk of trichinosis and other diseases acquired by eating raw or undercooked wild game. On the other hand, cooking reduces the vitamin C and D content of meat, which are otherwise present in significant quantities in raw sea-mammal and fish resources (Geraci and Smith 1979, Phillips et al. 2018). This may prove problematic for communities which have limited seasonal access to other sources for these nutrients.

Limited residue analysis of ceramic vessels in Northwestern Alaska, indicated that they were used predominantly to process marine mammal meat, with little evidence of land-mammal processing (Farrell et al. 2014; Solazzo and Erhart 2007). A more recent analysis suggests that ceramics were also used to process freshwater resources, or mixtures of various resources including terrestrial, freshwater, and marine resources (Anderson et al. 2017). Due to the presence of marine mammal or fish oil as a surface treatment on many vessels, it can be difficult to determine which residues have been left by cooking and which by the process of making the pots themselves. This problem may be resolved through comparison of experimental replications to archaeological materials.

Links between pottery and aquatic resource use are widespread in the archaeological record, well beyond Alaska Pottery adoption has been associated with rendering fish oil in Northeastern Europe (Oras et al. 2017) and Northeastern North America (Taché and Craig 2015). Some of the earliest pottery in North America has been found at shell midden sites, although in that case no clear correlation has been made between the development of pottery technology and shellfish processing (Sassaman 1995). In Northeastern North America, pottery production may have begun as a result of processing freshwater fish in the context of seasonal feasting (Taché and Craig 2015). Organic residue analysis of the earliest pottery from the Jomon period in Japan have lipid markers which indicate the samples were used for processing mixed marine and freshwater resources (Craig et al. 2013). Pottery has also been associated with the intensification of aquatic resources at early Holocene shell midden sites in Korea (Shoda et al. 2017), and with Neolithic aquatic resource intensification on Sakhalin Island in Russia (Gibbs et al. 2017). Pottery use in these contexts may have also had social meanings and been used for feasting or in social exchanges.

Norton house features contain indoor hearths, usually located in the center of the house. Early Norton hearths are typically square in shape and constructed with stone or horizontal logs over a dome of sterile sand, while later Norton hearths were unconstructed, shored up with logs, or circular (Bockstoce 1979). A cooking feature identified near the end of the entrance passage of an early Norton house-pit on Cape Nome contained charcoal as well as marine mammal oil cemented sediment, and was associated with sherds of check-stamped pottery (Bockstoce 1979:37). Hearth features from the late Norton period were also located centrally in the house, and in some cases contain oil-soaked sediment as well as fragments of burned seal and caribou bone (Bockstoce 1979:41).

During the Thule period, cooking over a fire did not occur inside house features, but rather in an adjoining kitchen or outside the structure entirely, although other heat sources, such as seal oil lamps, were likely present inside the main living areas. Hearth features, which may be cooking areas or ceramic firing features, have been identified at a number of Thule sites in Western Alaska, e.g. Nukleet (NOB-0002) and features 33 and 68a at Cape Espenberg (KTZ-088 and KTZ-087 respectively). They are all outside the house features, near tunnel entrances (Crawford 2012, Giddings 1964). The hearth features all date to the Thule (in particular, Late Thule) period. The hearth features at Cape Espenberg contain high quantities of charcoal in addition to burned bone and marine mammal oil cemented sediment (clinker). These materials were likely included to help preserve the amount of wood needed to sustain a fire (Vanlandeghem et al. 2020). Additionally, Feature 68a contained fired clay in the hearth, indicating it may have been used to fire ceramics. No intentional wood burning occurred within the main living areas of Features 33 and 68a, based on charcoal analysis, and charcoal likely accidentally carried into the house from the hearth features outside (Crawford 2012).

Three methods of cooking using ceramics are hypothesized for the Norton and Thule periods. These include indirect heat (i.e. stone boiling), direct heat, and suspension (Harry and Frink 2009b, Linton 1944). One of the primary concerns for people in the pre-colonial Arctic when selecting between these methods may have been their economic efficiency (Nelson 2010). Efficiency is determined not only by the benefits of a method, such as how well heat is transferred, but also by the opportunity and material costs associated with each particular activity. For instance, how much of the cook’s attention is required to perform the task, and the amount of raw materials such as firewood it consumes.

Indirect heat cooking by stone boiling consists of heating cobbles in a fire and placing them in a container filled with water in order to heat the contents of the vessel, replacing the cobbles as they cool in order to maintain a consistent temperature. During the ethnographic period, in Northwest Alaska, this cooking method was documented in use with both pottery and non-pottery vessels such as birch-bark baskets or wooden buckets (Burch 2006). Hot rocks were placed in and out of the pot using a pair of wooden tongs, with approximately three changes of rocks necessary to cook the contents (Burch 2006).

Some archaeological evidence for stone boiling has been found at Arctic Small Tool tradition sites on Cape Denbigh in the form of concentrations of cracked, heat-modified stones around hearths, although these may also reflect the construction of the hearths themselves (Giddings 1964). Ceramic attributes favorable to indirect heat cooking include wide orifices to facilitate manipulation of the contents, thick walls, and mixed organic and inorganic tempers which help insulate the contents of the vessel, reducing heat-loss (Sassaman 1995).

One of the disadvantages to stone boiling is that it requires a certain amount of attention and maintenance, since stones must be replaced in order to keep temperatures high enough to cook with (Skibo et al. 2009). Only certain types of stones are suitable for being heated and cooled rapidly without shattering or exploding. Burch (2006) notes quartzite, a metamorphic rock, was the most commonly used cooking stone in Northwest Alaska due to its durability and resistance to thermal shock. Experimental research shows that when stones are heated in a large, hot fire, boiling temperatures in a small pot can be reached very quickly (Harry et al. 2009a). The same study demonstrated that indirect heat with stones heated in a small fire failed to bring the contents to anything beyond a simmer. In itself, this may not have posed a significant problem to Arctic cooks, since simmering was a desirable cooking method for rendering fats and briefly thawing frozen foods. Removing the cooling stones would, however, result in some loss of the fats accumulating on the surface due to sticking to the stones (Skibo et al. 2009), and replacing them with freshly-heated stones might introduce toxic ash from the fire to the contents (Hopkins 2020). Grit and spalls of shattered rock may also end up mixing with the contents of the pot, due to the damage incurred by rocks subjected multiple times to thermal shock.

Placing vessels into or very close to a fire is another cooking method reported in the ethnographic record in the Arctic (Anderson 2019, Fienup-Riordan 2007, Frink and Harry 2008, Giddings 1961, Lucier and VanStone 1992) This method requires use of a fire-proof vessel which is not significantly damaged by direct heat. Ceramic and soapstone cooking vessels are relatively durable compared to baskets or other organic containers and can withstand both high temperatures and long cooking times (Harry and Frink 2009). From an economic standpoint, cooking with direct heat reduces the amount of time, effort, and material resources invested in cooking. Although vessel contents may take a longer time to reach a boil while cooking over direct heat than when using super-heated stones, pottery vessels may have been a desirable way of achieving lower-temperature simmers using direct heat. A second advantage of direct heat in this method is the "fix it and forget it" potential, given that pottery vessels over direct heat do not require constant monitoring to maintain temperatures. Wood is placed around and under the pot, lit, and stoked and added to as necessary until the vessel's contents are cooked (see Anderson 2017). Direct heat may be a more efficient method of cooking than indirect heat, per previous experimental replications using Thule-style pots, which show direct heating over a small fire brings water to a boil faster and uses significantly less wood than indirect heating with stones, which failed to bring the water to a boil and used upwards of five times more wood (Harry and Frink 2009). When fuel is plentiful and stones are heated in a much larger fire, however, these experiments showed direct and indirect heating can bring water to boil in almost the same amount of time. Direct heat may also in some cases be less efficient in terms of time and fuel usage compared to suspended heat, due to the continual process of stoking and refueling necessary during the direct heating process (Briggs 2016).

The third method of cooking considered in this study is suspension with vessels hung above a fire or lamp in order to heat their contents through radiant heat. This practice is documented in the ethnographic record (Burch 2006), and some excavated ceramics have suspension holes or lugs which suggests it was practiced in the pre-colonial period as well (Anderson 2017, Giddings 1964, Nelson 1983, Fienup-Riordan 2011). An informant recalls using a tripod made of willow branches to suspend a clay vessel above a fire (Lee et al. 1990, see Anderson 2017). Burch (2006) describes clay pots strung up above lamps. This method has not been compared to other heating methods in previous experimental studies of Arctic vessels. An experimental study of Mississippian pottery has shown the most efficient method of suspended heat cooking involves suspending the pot over a bed of coals, rather than an active fire, with hardwood coals generating the most heat over time (Briggs 2016). A potential disadvantage of suspended heating is the possibility of the pot falling or breaking, thus losing its contents and potentially extinguishing the fire in the process. Suspended heat requires smaller, lighter pots, without thick bases (Briggs 2016). Suspended heat cooking may be visible archaeologically when looking at base sherds, as suspending a pot over coals does not result in exterior sooting (Briggs 2016), although a pot which was heated in more than one way, or over an active fire, would show sooting.

2.5 Ceramic Technology and Performance

In order to address the question of how pottery was used during the Norton and Thule periods, I looked at the technical attributes of Norton and Thule pottery which have been linked to specific performance characteristics and intended use (Sassaman 1995, Smith 1985). The connection between performance characteristics and intended use is predicated on the hypothesis that the technology was produced in order to most efficiently perform certain tasks, given certain constraints. For this project, I considered how Norton and Thule pottery performs during a variety of heating methods in order to better understand how people in the Arctic used pottery to cook their food. I compared the performance of Norton pottery against the later Thule pottery in order to help identify the distinctive properties of both ceramic traditions and understand better the technological and cultural shifts occurring between the two periods.

Although the focus of this research is ceramic use, it is necessary to consider ceramic production as well, due to the overlaps between technological choices impacting both production and use. Environmental conditions in the Western Arctic posed problems for potters, particularly when it came to drying and firing ceramic vessels (Anderson 2019, Frink and Harry 2019, Frink and Harry 2009, Harry et al. 2009). Pottery production required considerable time investment by the people who made it. Short Arctic summers were periods of intense activity, where a wide variety of subsistence tasks needed to occur, including hunting, fishing, and plant and other resource gathering, into which clay procurement, pottery production, and firing must be included (Anderson 2019). Summers were particularly busy times for women, who are identified as potters in the ethnographic record (Anderson et al. 2011), and likely had a wide range of other time-sensitive tasks to accomplish during the summer months. Arctic women in the ethnographic record were (and are today) intimately involved in hunting, fishing, plant gathering, and production of material goods such as baskets and clothing (Jarvenpa and Brumbach 2006). Ethnographic data from the Arctic and elsewhere show a positive correlation between reliance on meat in the diet and the number of non-subsistence tasks performed by women, such as technology production (Waguespeck 2005). The time spent collecting clay, processing it to workability, adding tempers, forming the pots, and then eventually heating or firing them meant time not spent accomplishing a wide variety of other time-sensitive logistical and subsistence tasks. Although some aspects of pottery production may have been easily folded into other activities, such as temper procurement (Anderson 2019), the economic risk associated with taking time away from some foraging or hunting activities to produce pottery tends not to favor pottery production in hunter-gatherer societies (Eerkens 2003). Pottery is produced in hunter-gatherer societies primarily when that technology confers economic benefits outweighing the costs of producing it.

Although experimental replications of Thule pottery show the pots themselves only took an average of fifteen minutes to form (Harry et al. 2009), clay procurement could have been time-consuming, especially if the clay source was located some distance away from the settlement. Clay is heavy and difficult to transport, and would have been a significant burden for anyone carrying it, although the use of boats may have helped. Clay is also a time-sensitive material which must be used shortly after collection to prevent it drying out. If clay dries out too much, it must be allowed to dry fully and then reconstituted by adding water and letting it sit over a period of days.

The costliest aspect of pottery production was the drying and firing process. Problematic environmental conditions including high humidity and low daily temperatures likely prolonged the drying process significantly (Harry and Frink 2009). Ethnographic accounts of the drying and firing process vary, with most describing a period of drying near a fire or under the sun which could take weeks or even months (Anderson 2019, Harry and Frink 2009). Improperly dried pots are prone to cracking or shattering during firing, and weather-related firing failure rates may have been upwards of 50% (Arnold 1988). In areas above the tree line, firing pottery required the use of scarce driftwood resources, adding to the costs of firing. Although still classified as low-fired, Norton pottery appears to have been fired at higher temperatures than Thule pottery, and would have required hotter and longer fires than what has been recorded in the ethnographic record or attempted in experimental replications.

Limited archaeological evidence of firing features has been identified or published.

Given the many costs of, and constraints on, ceramic production, specific technological choices and compromises were made by Norton and Thule potters in order to produce functional vessels which could be used to heat water for cooking. These choices influenced the formal properties of the vessels, such as shape and size, wall thickness, temper, paste, drying, firing, and surface treatment. Different uses of ceramics require different performance characteristics. For example, a pottery vessel placed directly on or into a heat source would have a different shape and composition than a vessel used for indirect heating because of different heat propagation techniques. I address the question of ceramic use through analysis of these technological choices in relation to vessel performance characteristics (Table 3)

Table 3. Attributes of pottery vessels and expected functions adapted from Sassaman (1995).

Attribute	**Expectation**
Wall thickness	thick walls = indirect heat thin walls = direct heat
Base shape	flat base = indirect heat round base = direct heat
Orifice:volume ratio	high ratio = indirect heat low ratio = direct heat
Temper type	fiber temper = indirect heat mineral temper = direct heat
Vessel volume	high volume = longer to heat low volume = faster to heat

Some characteristics of Norton and especially Thule pottery are held in common with other hunter-gatherer ceramic traditions, particularly the use of fiber temper, thick walls, and oil surface treatment (Reid 1984b, Skibo et al. 1989, Sassaman 1995). These characteristics, and the other technical choices made by Arctic potters, mitigate some of the challenges of production and use. These challenges include thermal shock, caused by exposure to heat in or over a fire as well as frequent heating and cooling. Cooking activities create tensile stresses which can result in cracks and fractures, shortening the use-life of a vessel (Rice 1987, Skibo 2013). Thermal shock is also exacerbated by thick walls due to increased thermal gradients and stresses (Rice 1987). Thinner, more conductive walls, such as those found on Norton pottery, can reduce the effects of thermal shock, as can increased porosity, which reduces thermal expansion stresses. Low-fired pottery tends to have a more open, porous texture which allows vessels to expand and contract as necessary, mitigating the problems caused by thermal shock (Rice 1987, Tite et al. 2001). Porosity, on the other hand, poses problems in cooking vessels including heat loss, which can cause difficulty when attempting to boil liquids, and excessive permeability.

Different temper types have distinct properties when added to ceramic pastes and play an important role in the performance of ceramic vessels (Table 4). Organic tempers typically added to Thule-style pots consist of grass (fiber), feathers, and hair (Anderson 2019, Harry et al. 2009a, 2009b). The use of organic temper, which is burned off during firing, can increase porosity and reduce strength. Crushed shell temper and inorganic mineral temper can mitigate thermal shock due to exposure to direct heat by dispersing heat more evenly throughout a vessel's walls (Anderson 2016, Briggs 2016, Lucier and VanStone 1992). Some amount of the inorganic temper such as gravel and sand found in Norton and Thule pottery may have been natural inclusions in the clay itself, but mineral tempers were also intentionally added (Anderson 2016, Lucier and Vanstone 1992).

Table 4. Temper properties**.**

Temper Type	**Properties**	**Sources**
Mineral (sand)	Reduces thermal shock Increases durability	Rice (1987)
Fiber (grass)	Increases porosity Increases green strength Reduces drying time Insulates vessel contents	Harry et al. (2009a)
Shell	Reduces thermal shock Increases durability	Feathers (2006), Briggs (2016)

Durability and portability are also important constraints on ceramic technology for communities with residential mobility. As utilitarian cooking pots, Norton and Thule vessels likely traveled with people during seasonal migrations, resulting in additional wear and tear on the vessels beyond daily use. Additionally, there is ethnographic evidence of pottery trade between Iñupiaq communities, with higher-quality pots largely moving from the Kotzebue Sound region to areas further northwest through trade fairs (Anderson et al. 2011, Anderson et al. 2016; Burch 2006; Lucier and Vanstone 1992). Strength is an important component of ceramic vessel performance, relating to durability of the vessel, and is largely determined by the clay and temper types used to form it, alongside other factors such as drying and firing (Grimshaw 1971). Durability may also have influenced wall thickness, as thicker-walled vessels are less likely to break than thin-walled vessels, although thick walls increase vessel weight.

Thule pottery is predominantly low-fired (around 650ºC) or unfired (Harry et al. 2009, Linton 1944, Anderson 2019, 2017). Cold, wet, and windy weather during Arctic summers contributed to the long drying times and low subsequent firing temperatures recorded ethnographically (Harry and Frink 2009). Improperly dried pots are prone to cracks and shattering during firing, and weather-related failure rates may have been quite high. Low-fired ceramics tend to have high porosity, which poses several benefits and drawbacks to vessel performance as discussed above. Overly porous vessels required some form of water-proofing or surface treatment in order to be watertight.

Ethnographic, archaeological, and experimental evidence points towards the use of sea mammal oil, fish grease, and animal blood as surface treatments (Harry et al. 2009a). These substances could be either rubbed on the inside and outside of the vessel (Lucier and Van Stone 1992) or mixed in with water which filled the pot which was then heated (Harry et al. 2009a). The latter has been demonstrated with success by Harry et al. (2009a) through experimental replication. Other forms of surface treatment include the application of blood to leather-hard clay or smoothing down the still-wet walls of the vessel to seal the pores (Harry et al. 2009a). Surface smoothing, using in some cases a hand-held tool covered in seal fur (Lucier and Van Stone 1992),

Experimental archaeological research by Karen Harry and Liam Frink among others has addressed questions of manufacture and use for the specific ceramic technology developed in the Arctic (Harry et al. 2009a). Their findings are summarized in Table 5. Previous experimental research has laid a substantial groundwork to understanding the effect of temper type and other variables such as surface treatments, vessel shape, and wall thickness on heating, strength, and porosity. However, sample sizes for the experimental studies have been small and focused only on thick Thule-style pots without comparison to other experimental vessel types (i.e. Norton-style pots).

My research addresses the questions of how technological choices influence the performance of ceramics for cooking, and how Arctic people in the past cooked using ceramic vessels. I look at the way temper, wall thickness, and surface treatment influence the performance of Norton and Thule pottery in order to compare the two traditions and understand their intended use. I address these questions through ceramic analysis and experimental replication, building on prior research and expanding it.

Table 5. Summary of recent experimental research on Arctic pottery.

Test	Results	Source
direct vs indirect heat	direct heat faster, more fuel-efficient	Harry and Frink 2009b
strength	seal oil and blood improve strength	Harry et al. 2009
porosity	seal oil surface treatment reduces porosity in unfired vessels	Harry et al. 2009

Chapter 3: Methods

There are three stages to my research: 1) analysis of a sample of archaeological ceramics from contexts dating to the Norton and Thule eras excavated from sites NOB-0001 (Nukleet) and NOB-0002 (Iyatayet); 2) creation of ceramic tiles based on metrics collected from my analysis of archaeological materials in order to test hardness, porosity, and strength of a combination of temper types and surface treatments; and 3) experimental replications of complete Norton and Thule-style pots based on previously analyzed metrics (Table A-3), culminating in cooking experiments testing the time efficiency of three heating types (Table 6). In this chapter I provide an overview of the study sites and contexts and describe my methods for each of these research phases.

Table 6. Summary of research questions, hypotheses, expectations, and analysis methods.

Research Question	Hypothesis	Expectations	Analysis Method
How do technological choices influence performance of ceramics for food processing?	Choices in temper type and surface treatment will enhance performance of the vessel when used for cooking.	Surface treatment of oil increases strength and decreases porosity. Mineral and/or shell temper increases strength and does not affect porosity. Fiber temper decreases strength and increases porosity	Test tiles: hardness, porosity test, biaxial strength test
How did people in the past cook with ceramic vessels?	The cooking method will be best suited to the performance characteristics of each vessel type. For Norton vessels: direct or suspended heat. For Thule vessels: indirect heat.	Thin-walled vessels with primarily mineral temper are best suited for direct-heat cooking. Thick-walled vessels with a combination of mineral and fiber tempers are best suited for indirect-heat cooking.	Cooking trials using three heating methods: direct heat, stone-boiling, and suspended heat with replicated vessels.

3.1 Study Sites and Ceramic Assemblages

The first phase of my research consisted of analyzing Norton and Thule ceramic artifacts from the Iyatayet (NOB-0002) and Nukleet (NOB-0001) sites in the Cape Denbigh region of Norton Sound, Alaska (Figure 1, Table 6). Cape Denbigh was the focus of archaeological investigations by J. Louis Giddings during the mid-20th century, where he defined the Denbigh Flint complex, also known as the Arctic Small Tool tradition, (4250 - 3650 BP), the Norton culture (2450 - 1550 BP), and a regional variation of the Thule culture called Nukleet (800 - 250

BP) (Giddings 1964). The Nukleet site (NOB-0001) is located at the westernmost point of Cape Denbigh, and is the type-site for the Nukleet variation of Thule culture. Although Giddings (1964) refers to the Thule tradition in this region as Nukleet, after the type-site, I do not, for the sake of clarity. The Nukleet site comprises a Thule village of house-pits and middens atop a grassy bluff, with a small beach and limestone cliff nearby (Figure 2). Iyatayet (NOB-0002) is located further west, on the southern shore of the cape. Iyatayet is a multi-component village site, with Denbigh Flint (also known as the Arctic Small Tool Traditions), Norton, and Thule occupations (Figure 3).

Despite the archaeological significance of the region, limited additional work beyond Giddings' initial investigations was conducted in and around Cape Denbigh until recently (see Tremayne 2018, Darwent et al. 2017). The results of Giddings' analysis of ceramics recovered from his excavations at Nukleet and Iyatayet are presented in his monograph *The Archaeology of Cape Denbigh* (1964). However, the ceramic collection strategy Giddings and his crew implemented during excavation is not outlined in that work or elsewhere. The raw data generated during Giddings' subsequent analysis of the ceramics is also not available, nor did Giddings clearly set out his procedure for the analysis. Recent work by Murray et al. (2003) and Tremayne et al. (2018) on the Nukleet and Iyatayet sites respectively have focused primarily on refining chronology for site occupation through radiocarbon dates. No further analysis of Giddings' collection of ceramics from Nukleet or Iyatayet has taken place since the mid-20th century. Excavations at Iyatayet by Tremayne et al. (2018) yielded ceramic artifacts, but these were not included in my analysis, as I wanted to focus on improving understandings of the older Giddings collection.

Although there exists substantial data on Thule ceramics from across Alaska, only small quantities of Norton ceramics from Northern Alaska are present in museum or repository collections. Norton pottery appears in low frequency at a small number of sites, usually located on or near the coast, and little systematic analysis of Norton vessels has been conducted due to small sample sizes (Anderson et al. 2017). Giddings' Iyatayet collection provides an opportunity to systematically assess more Norton ceramics and add to archaeological understandings of this early Alaskan pottery tradition. This project also adds to the Northern Ceramics Regional Database, created by Dr. Shelby Anderson. The database compiles descriptive data collected from a large number of ceramic sherds from across Alaska for the first time, allowing for regional analysis and comparison. The Norton Sound region is largely under-represented in the database, and the data generated in my analysis contributes to filling the gap and facilitating research on ceramic technology and foodways in the Norton Sound.

Nukleet was the subject of extensive excavations by Giddings in the late 1940's. During the 1948 field season, Giddings excavated two trenches (Cut A and B), two test units (Cut C and D) and a house feature (H1). In 1949, he returned and excavated with Wendell Oswalt a large block referred to as NI or the "1949 excavation." Figure 2 shows the locations of these excavations. A full description of the excavations at Nukleet are provided by Giddings (1964) and summarized by Murray et al. (2003).

For my analysis of the Nukleet assemblage of Thule ceramics, artifacts recovered from Sections 1, 2, and 3 of Cut A were used (Figure 4). Cut A was excavated in eleven 1.8 × 3.0 m (116 × 10 ft.) sections. Excavation was carried out in arbitrary 6in levels.Stratigraphic layers were described in narrative form, and documented in a profile of the west wall (see Figure 4). A house structure was identified in Sections 1 and 2 of Cut A, including the upper end of a tunnel. The tunnel floor and house floor were found intact, although no hearth was located. The structure dates to the middle period of occupation of Nukleet, and Murray et al. (2003) suggests dates ranging from 530 to 380 ± 40 calibrated years B.P. Figure 5 shows the location of the three artifacts dated by Murray et al., which consisted of two antler harpoon heads and one antler projectile point. Cut A does not contain artifacts from the earliest period of occupation at Nukleet, and is thus not representative of the site as a whole. I targeted this context in my analysis because it had radiocarbon dates associated with a house feature, including the floor of the house feature. I also wanted to avoid analyzing ceramics from different phases of the Thule era, due to changes in material culture between the early and late Thule periods.

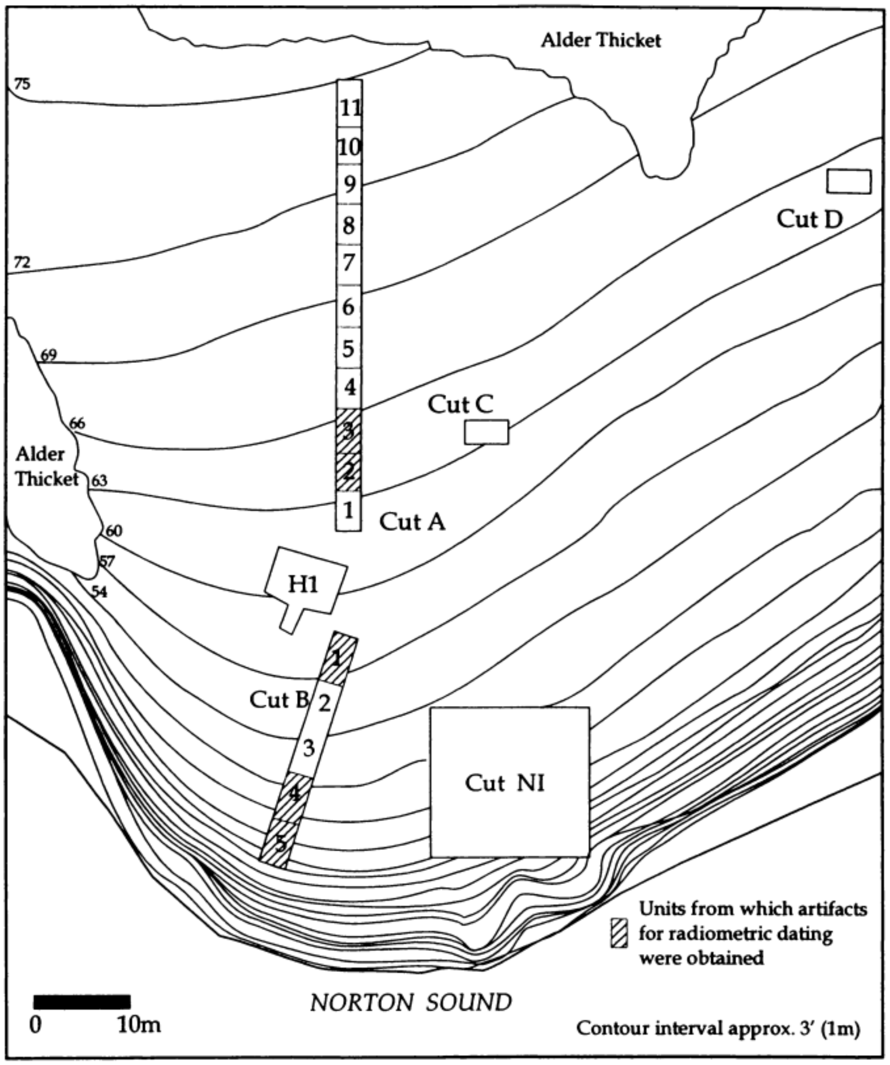


Figure 2. Map from Murray et al. (2003), showing Giddings' excavations at Nukleet, adapted from Giddings (1964).

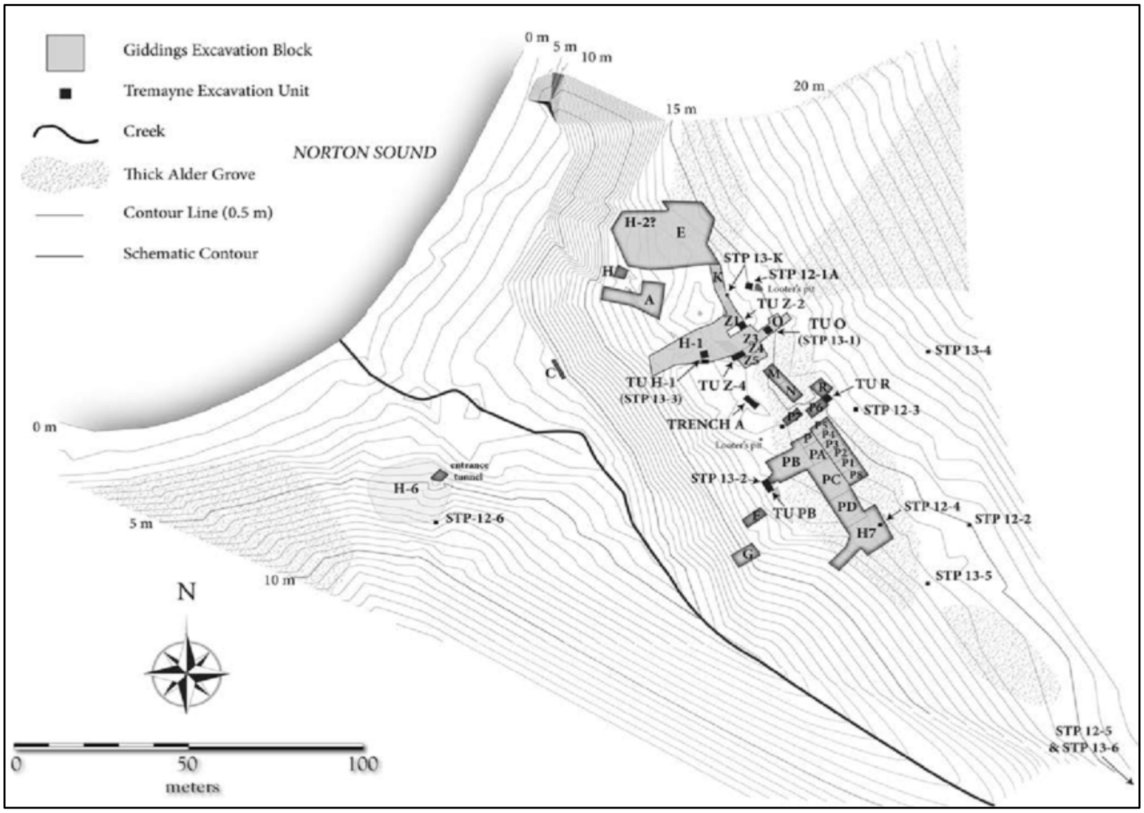


Figure 3. Site map of Iyatayet (NOB-0002) from Tremayne et al. (2018), showing location of Giddings' original block excavation of IYP and IYH7 (shown here as PA, PB, and H7 respectively), as well as the unit (TU PB) which was radiocarbon dated in Tremayne (2015).

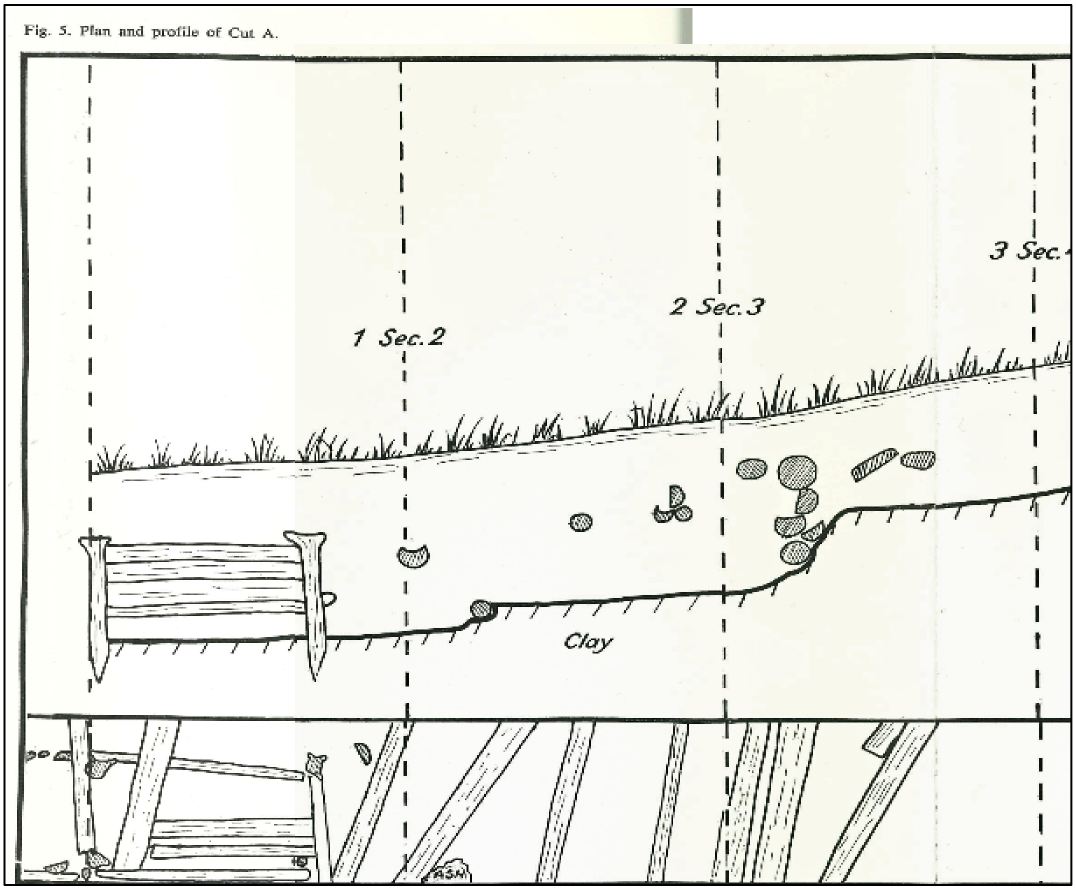


Figure 4. Profile and overview of Cut A at Nukleet showing sections 1 – 3 adapted from Giddings (1964).

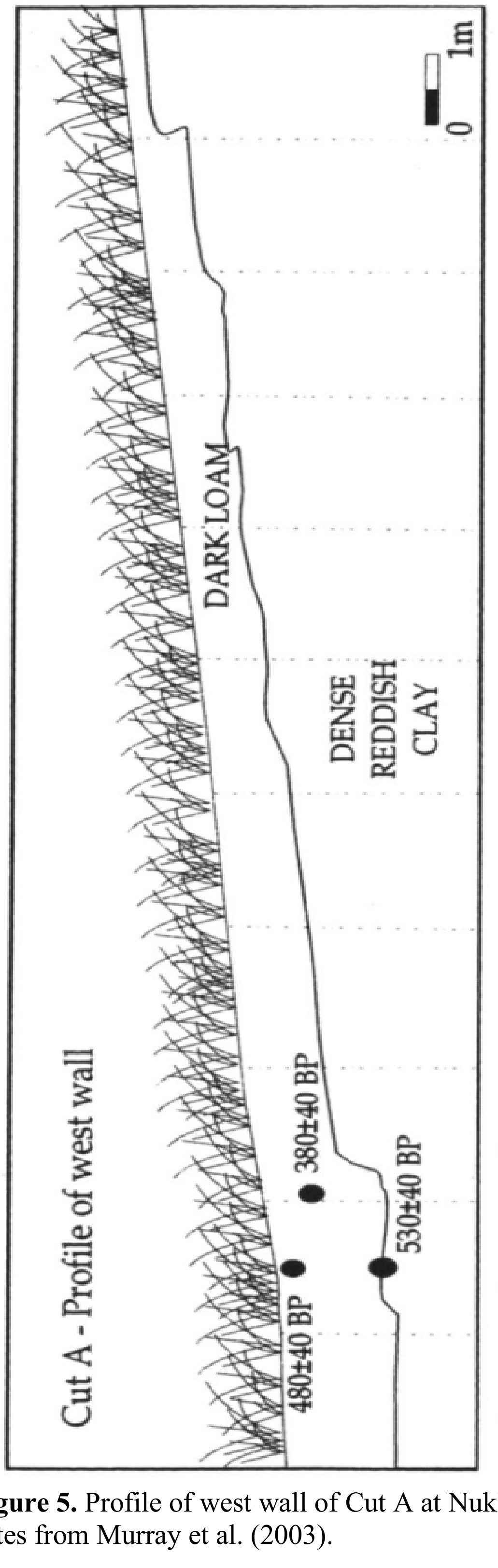


Figure 5. Profile of west wall of Cut A at Nukleet showing location of the three radiocarbon dates from Murray et al. (2003).

For my analysis of ceramics from Iyatayet, I targeted Cuts IYH-7 (House 7) and IYP for my analysis, due to the presence of intact Norton house features and floors, as well as a radiocarbon dated unit (TU PB). The goal was to select contexts with primarily Norton sherds; however, a large number of Thule sherds were also present in Norton contexts. These were included in my analysis for the purpose of comparing the two Thule assemblages from the different sites. Natural disturbances such as solifluction and human disturbance through ancient and modern digging contributed to the mixed assemblages (Giddings 1964). Although parts of Cut P, PE, and K were relatively unaffected by these processes, Tremayne et al. (2018) noted that the distinction between Norton and Thule levels at Iyatayet is not always clear, and in some cases the two layers appear to be mixed. Despite my efforts to target a dated Norton context at Iyatayet with the goal of analyzing primarily Norton ceramics, the mix of Norton and Thule materials was apparent throughout the Iyatayet contexts I looked at. The dates provided by Giddings (1964) and Tremayne (2015b) (Table 8) are not representative of the Thule period of occupation at the site. Giddings describes the Thule layer at Iyatayet as from the later part of the Thule period, based on culture-historical chronology. In order to differentiate between Norton and Thule sherds in mixed assemblages, I looked at a combination of attributes including wall thickness, paste composition including temper type, size, and density, and surface treatment including decoration, based on criteria established by prior archaeological analysis of both ceramic traditions (Giddings 1964, Dumond 2000).

Giddings' excavations at Iyatayet in 1948 consisted of fifteen 1.8 × 3 m (6 × 10 ft.) units (Figure 3). New cuts were added in 1949 and others expanded. The 1950 field season focused on Denbigh deposits. In 1952, small excavations in other areas were conducted, with the intent of obtaining samples for radiocarbon dating. Artifacts from Thule, Norton, and Denbigh periods of occupations were recovered, despite Giddings' aim of avoiding Thule occupation levels as much as possible (Giddings 1964). Excavation proceeded by natural and cultural levels, rather than arbitrary levels, due to the high level of disturbance (Giddings 1964). Tremayne et al. (2018) conducted testing at Iyatayet in 2012 and 2013 and noted that Giddings' stratigraphic descriptions were generally accurate.

IYH-7 consists of a Norton-era house and floor built into an earlier Norton midden and has associated radiocarbon dates ranging from 2790 to 1550 cal BP taken from charcoal samples of base timbers from the house feature (Tremayne et al. 2018, from Giddings 1964:245). IYP is a large cut which was extended into PA where the back wall of Norton structure was found, then to PB to define a Norton house, then to PC which had undisturbed stratigraphy. Traces of possible wood flooring immediately inside the wall and traces of posts were identified going from PA westward into PB. Ashy soil deposits suggest a hearth feature near the front of the house. The Norton deposit in PB was cut through with a Thule deposit, so Cut PB was not completed downhill. Cut PD had traces of a burned wooden structure, possibly a Norton house. A Norton date of 2240 to 2210 ± 30 cal BP is associated with a charcoal sample from TU PB excavated by Tremayne (Tremayne 2015b, Tremayne et al. 2018) at southwestern end of Cut PB.

The sherds from both Nukleet and Iyatayet were originally catalogued in lots, with a varying number of sherds from the same context included in each lot. The sherds I analyzed amount to an approximately 10% sample of sherds from Nukleet and Iyatayet respectively, based on estimates of the total number of sherds per collection. The estimated total number of sherds was created by counting the number of sherds in three catalog lots, and taking the average number of sherds per lot, then multiplying that by the total number of catalog lots per collection. Table 7 shows the total number of catalog lots per collection, and the number of sherds I analyzed from each. Radiocarbon dates associated with specific contexts in my analysis are summarized in Table 8.

Table 7. Age of sites and size of ceramic collections.

Site	**Age**	**Ceramic Collection Size**	**Sample Size**	**Excavator**
Nukleet (NOB-0001)	850 - 250 BP	564 catalog lots	241 sherds	Giddings (1964)
Iyatayet (NOB-0002)	2790 - 1550 BP No dates for Thule occupation	1222 catalog lots	135 sherds	Giddings (1964)
Total:		1786 catalog lots	376 sherds	

Table 8. Dated contexts from Nukleet and Iyatayet that provided ceramics used in this study.

Site	**2-sig Cal BP**	**Material**	**Unit**	**Context**	**Source**
Nukleet (NOB-0001)	480 ± 40	Antler harpoon head	Cut A	Section 3, Level 2	Murray et al. 2003
	380 ± 40	Antler arrowpoint	Cut A	Section 2-3, Level 4	Murray et al. 2003
	530 ± 40	Antler harpoon head	Cut A	Section 2, Level 12	Murray et al. 2003
Iyatayet (NOB-0002)	1460 ± 200	Charred wood	Cut PA	Upper level	Giddings 1964
	2350 ± 30	Charcoal	Cut PB	n/a	Tremayne 2015b
	2010 ± 260	Charcoal	IYH-7	n/a	Giddings 1964
	2490 ± 330	Charcoal	IYH-7	n/a	Giddings 1964
	2630 ± 400	Charcoal	IYH-7	n/a	Giddings 1964
	2150 ± 320	Charcoal	IYH-7	n/a	Giddings 1964

3.2 Ceramic Analysis Methods

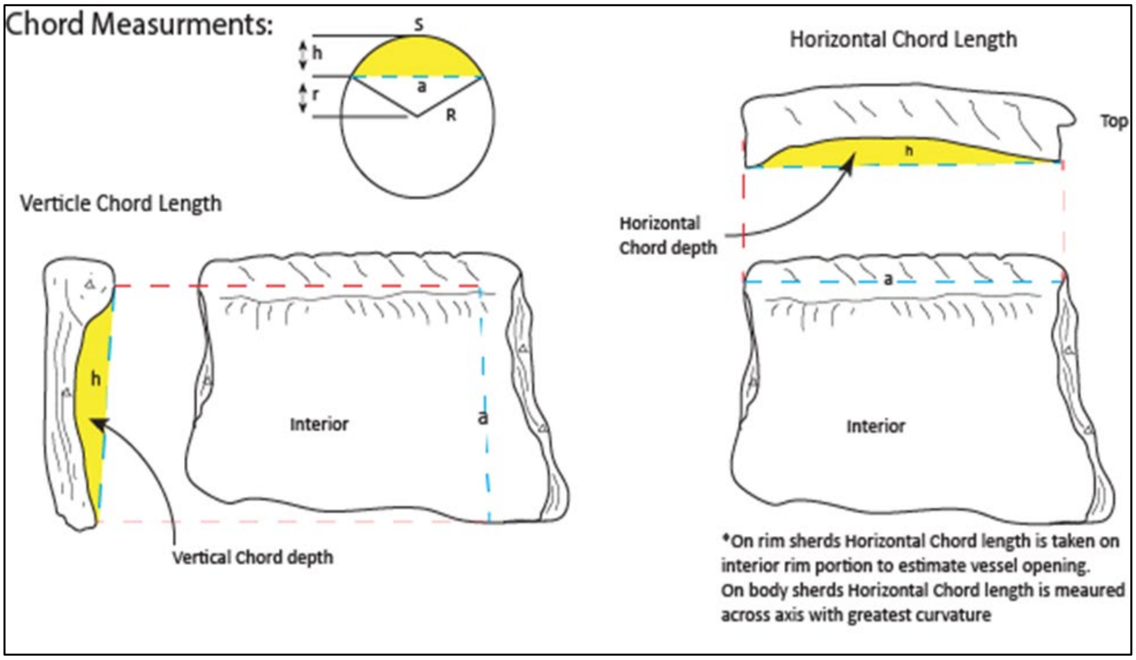
In order to understand how pottery was used during the Norton and Thule periods on the Norton Sound, I conducted a descriptive analysis of sherds from dated occupation contexts at Nukleet and Iyatayet following the protocols established in the ceramic analysis manual used at Portland State University (Anderson 2019). Data from these contexts were statistically compared to each other in order to build on prior understandings of Norton and Thule pottery by comparing how the two traditions manifested in Norton Sound. In the mixed contexts from Iyatayet, I differentiated between Norton and Thule sherds based on established, defined metrics for the two traditions described by other researchers. Thule ceramics were identified at both Nukleet and Iyatayet, while Norton ceramics are present only in the Iyatayet assemblage. I first analyzed the two Thule samples together in order to focus on larger differences between traditions, then I separated out the two Thule samples to look for inter-site differences, informing my understanding of variability within as well as between regions. My expectations for analysis are summarized in Table 9.

I collected data on complete sherds only from within the 10% sample, defined as 2 x 2 cm or larger along the horizontal and vertical axis of the sherd. Sherds were identified as "exfoliated" when they had more than 25% exfoliation on either surface. Exfoliated sherds were included in my analysis, with any attributes (i.e., surface treatment, rim category) which could not be measured due to the exfoliation left blank. I identified vessel part for each sherd, categorizing them as either body sherds, rim sherds, base sherds, or fragments. I then recorded mineral temper type, size, and density, and organic temper type and density. Temper density thresholds as described in the PSU ceramic analysis protocols are: low (<25% temper), medium (25-50% temper), and high (>50% temper), and were assessed visually when looking at a cross-section of each sherd. Mineral temper size categories are bimodal (containing temper of two different sizes), fine-medium (<0.5 mm), coarse (0.5-2.0 mm), and very coarse (>2.0 mm). Mineral temper types (aside from limestone) were not differentiated, but recorded under the category "Mineral." Organic temper types were differentiated based on identifiable characteristics including size and shape of the voids left behind. Shell temper was classified as organic temper, despite being compositionally related to limestone, as the material originally came from a living source. The categories used to identify organic temper types were fiber, feather, feather and fiber, hair and fur, shell, shell and fiber, and unknown (if unrecognizable). Limestone and shell temper fragments were occasionally difficult to distinguish, in which case I followed visual references from the Florida Museum of Natural History Ceramic Technology Lab (Wallis 2018).

I also identified surface treatment type, decorative type, and Mohs hardness, and firing core. Surface treatment fell into four categories: smoothed, burnished, none, or indeterminate. Smoothing was identified as evenly smoothed surfaces, sometimes with evidence of brushing in the form of faint lines in the clay, perhaps from use of a seal-skin smoother as noted in ethnographies (Lucier and VanStone 1992). Burnished sherds were extremely shiny and smooth and sherds marked "Indeterminate" had over 25% exterior surface exfoliation. I categorized rim type and angle for all rim sherds, and base shape for all bases. Identifications were based on the information and methods presented in the lab manual, and recorded in the Northern Ceramics Regional Database in Excel (Anderson 2019). Figures 6 and 7 show the protocols and definitions used in my analysis.

I also measured wall thickness, rim diameter, and body sherd diameter. The rim and body sherd diameters of specific sherds were reconstructed based on metric data I collected. All metric measurements were taken using Mitutoyo Absolute Digimatic digital calipers accurate to the 100th mm, and a Mitutoyo digital depth gauge accurate to the 1000th mm. All measurements were rounded up to the nearest 10th to eliminate spurious accuracy. Three wall thickness measurements were taken from different areas of every sherd which lacked significant interference from surface residue or exfoliation, and the mean thickness was calculated. I calculated radii of rim and body sherds in order to estimate orifice and vessel diameter, using the formula $r = \frac{l^2}{8m} + \frac{m}{2}$, where l=horizontal chord (mm), and m=depth (mm). Rim chord was measured as close as possible to the rim edge, and depth measurements were taken from the same place. Chord measurements below 40 mm were discarded, and no diameters were taken from those sherds, as variation in the surface of the sherds made smaller sherds difficult to take accurate measurements from. These data on vessel size I collected informed the full-size replications I produced for the experimental component of this study.

Metric data, namely wall thicknesses and vessel diameters, were compared statistically between the Norton and Thule assemblages and the two Thule assemblages from Iyatayet and Nukleet. I used one-tailed T-tests for independent means at a 0.05 significance level to assess the apparent differences between metric data. Variation around the mean was assessed through standard deviation and the coefficient of variation (CV). Statistical analyses were conducted in IBM SPSS Statistics 25.



*On rim sherds Horizontal Chord length is taken on interior rim portion to estimate vessel opening. On body sherds Horizontal Chord length is meaured across axis with greatest curvature

Figure 6. Measuring horizontal and vertical chord.

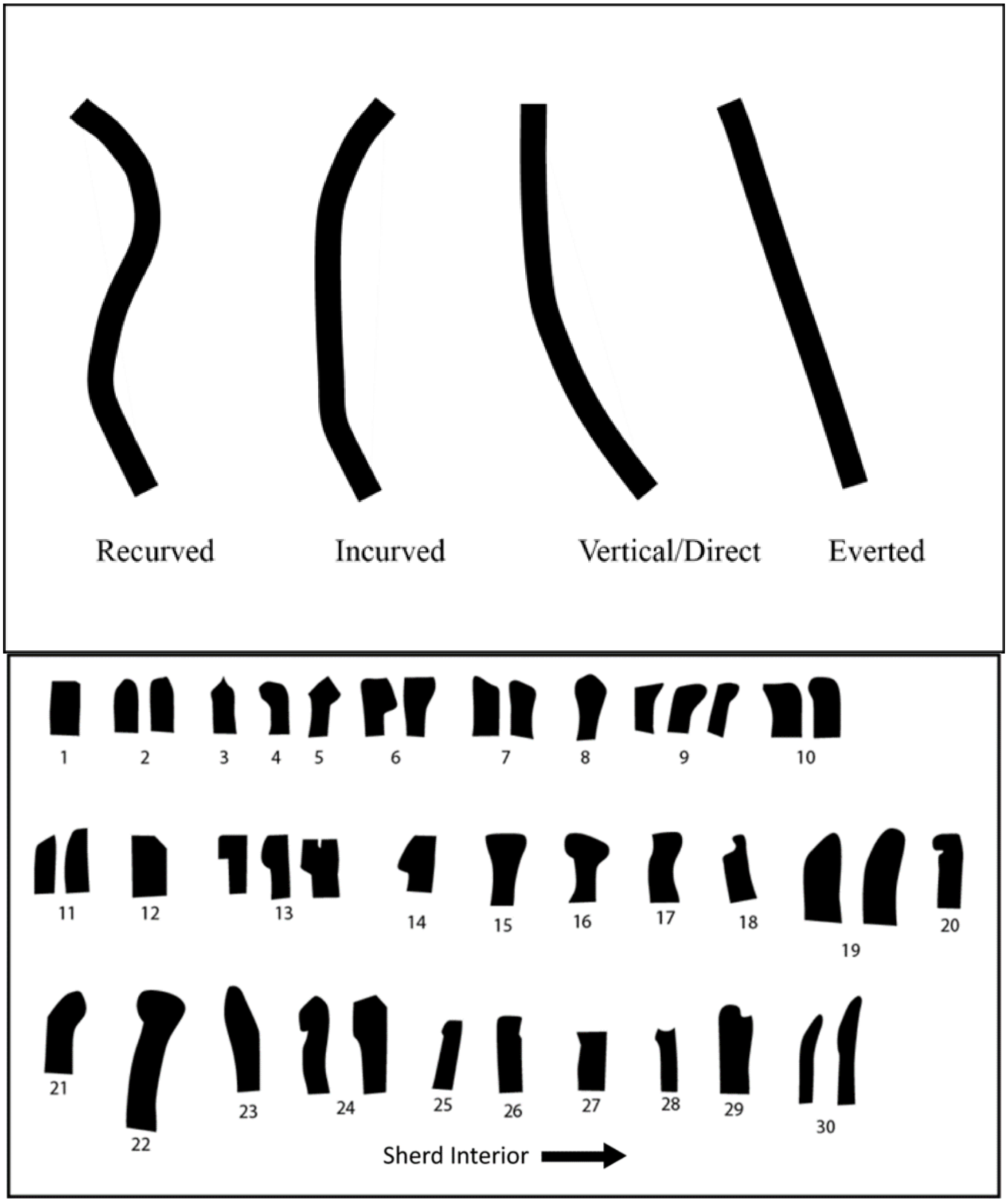


Figure 7. Rim angle (top) and rim shape (bottom) categories.

Ceramic data from Nukleet and Iyatayet were compared to ceramic data previously collected in the Northern Ceramics Regional Database, compiled by Shelby Anderson, in order to identify regional variation. I assessed differences and similarities in wall thickness, mineral and organic temper density, mineral temper size, organic temper type, rim angle, surface treatment, decoration, and mean rim and body sherd diameters between the assemblage I analyzed from Norton Sound to data from Northwest Alaska, Yukon-Kuskokwim Delta, North Slope, and Bering Strait sites. Site name and numbers of sherds from the database used in my analysis are summarized in Table A-1, in the appendix.

Table 9. Expectations for ceramic analysis based on Northern Ceramic Regional Database and the information presented in Table 1.

Category	Norton	Thule
temper type	primarily fine-grain mineral temper fiber temper in low quantities	mixture of coarse-grain mineral and organic tempers variety of organic tempers used including fiber, feather, and hair
temper density	low density per volume (>25%)	medium to high density per volume
wall thickness	thin walls (<10 mm)	thick walls (>10 mm)

3.3 Experimental Archaeology

Building on previous experimental archaeological work on Arctic ceramics (Table 5), I conducted two experiments to test the performance characteristics of Norton and Thule cooking pots and how they relate to use. Sample size for the experimental portion of my thesis is slightly larger compared to sample sizes in other experimental research involving ceramics. For example, Harry et al. (2009) had a sample size of five sets of ten tiles (50 individual samples), and five sets of three pots (15 individual samples). The sample size for the boiling experiments in Harry and Frink (2009) was seven vessels. Although sample sizes in experimental studies are often limited by time and resources, the sample sizes used by Harry and Frink (2009) are consistent with other experimental pottery projects (see Schiffer et al. 1994, Skibo et al. 1989, Skibo et al. 1997). With a 5% margin of error assumed, my study differs from Harry et al. (2009) in several ways, including a larger sample size for both test tile experiments and boiling experiments. I also included Norton-style pots in the boiling experiments, which no prior experimental archaeology study has done. For both the test tiles and the replicated vessels, I recreated original paste compositions for Norton and Thule pots, which Harry et al. (2009) did not attempt. I also used native glacial clay from Alaska, instead of processed commercial clay as Harry et al. (2009) did. This increases the number of variables related to Arctic cooking pots which have been tested experimentally and builds on Harry et al.'s (2009) study. Although the number of pots and trials used in my experimental study remains somewhat small, creating a larger sample size and conducting more trials was not feasible for this thesis, given the amount of time it takes to complete each aspect of the experimental component. Nevertheless, sample sizes for the tests in this thesis were sufficient to yield clear trends and meaningful results.

Phase 1: Ceramic Test Tiles

In order to address the question of how technological choices influenced the performance of ceramics for food processing, I created a series of ceramic test tiles to evaluate the effects of different combinations of temper types and the presence or absence of oil surface treatment on hardness, porosity, and tensile strength (Table 9). All test tiles were fabricated from gray glacial clay collected from Cape Blossom, a reported clay source in Northwest Alaska (Anderson et al. 2016). The clay was rehydrated and kneaded. Larger pebbles and organic materials were removed by hand. The clay was not processed further, as ethnographic accounts of Inuit potters show that the only processing which occurred after digging the clay was kneading it with water in order to rehydrate it (Arnold and Stimmell 1983).

After processing the clay, I separated it out with each section corresponding to a set of test tiles. Eight sets of ten test tiles were fabricated, for a total sample size of 80 tiles (Table 10). For the first set, the control, I did not add any temper to the clay. For the second set, I added mineral temper only to the clay. For the third, I added fiber temper only to the clay. For fourth, I added shell temper only to the clay. For subsequent sets of tiles, a combination of tempers were added (Table 10). The three types of temper used for the experiments were dried Timothy grass (fiber), coarse sand (mineral), and burned crushed oyster shell. Based on my previous analysis of ceramics from Nukleet and Iyatayet, I determined that the concentration of temper for the majority of sherds was low, below 25% of the paste. For the test tiles, I added between 15% - 20% temper by volume. The temper was kneaded into the clay until well incorporated, and the clay was then rolled out to an even thickness of one cm.

The tiles were cut using a round cookie cutter with a diameter of five cm and allowed to dry for a week (Figure 8). The tiles were fired in an oxidizing environment in an electric kiln. The firing schedule began with two hours below 100^o C, and then a ramp of 200^o C per hour up to 650^o C. The maximum temperature was held for half an hour before the kiln was shut off and allowed to cool overnight. Figure 9 shows fired tiles. Norwegian cod liver oil was then applied to half of the tiles of each set, with five tiles from each set receiving surface treatment, and five tiles left without (Table 10). Cod liver oil was chosen as the surface treatment as we were unable to obtain seal oil, and there is evidence of Arctic potters filling pots with oil or oily fish broth to season them by sealing the pores (Harry et al. 2009). Test tile ID numbers, temper types, and surface treatment are summarized in Appendix Table A-2.

Figure 8. Unfired test tiles showing the cutter used to make them equal sizes.

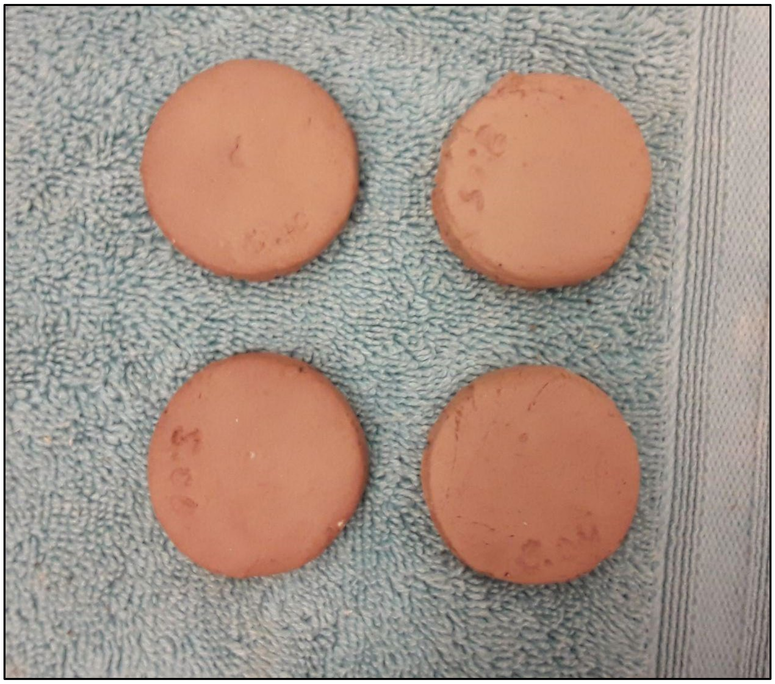


Figure 9. Fired test tiles showing unique ID number for each tile.

Once the tiles were removed from the kiln and treated, I measured hardness using the Mohs scale, porosity using a relative porosity test, and tensile strength using a ball-on-three-ball test. I measured hardness by scratching a series of indicators on the surface of each tile. I expected the tiles treated with cod liver oil would be harder than the untreated tiles, based on prior experimental results (Table 5). For the porosity test, I measured apparent porosity as the percentage ratio of void space to the total bulk volume of each sample. This test does not take into account true porosity, which includes sealed voids that water cannot penetrate; however apparent and true porosity values are very similar for high-porosity materials such as low-fired ceramics. Apparent porosity was measured by submerging the test tiles in distilled water for 48 hours, then recording their submerged weight (S) using a hanging scale, patting them dry and recording their saturated weight (M), and drying in an oven at 100º C for 24 hours, after which I took their dried weight (D). The formula $P = [100\times(M - D)] / (M - S)$ was used to calculate apparent porosity. Expectations for this test are summarized in table 10. Overall, I expected the tiles treated with cod liver oil would have a lower apparent porosity, given the efficacy of oil to waterproof pots as shown by prior experimental research (Table 5), and that the tiles containing organic temper would have increased porosity.

Finally, I measured tensile strength. The ball-on-three-ball test measures tensile strength of ceramic sherds in biaxial flexure. This test more closely mimics real-world conditions and stressors which may cause vessel breakage compared to other strength tests, and is well-suited to small or curved specimens (Neupert 1994, Danzer et al. 2007). With the assistance of Tom Bennett and the Portland State University Engineering department, such a testing apparatus was fabricated for the Instron 4411 Universal Testing Machine housed in the Engineering Department's materials testing lab. The fixture was fabricated using three 1.5 cm steel balls mounted into a hard plastic base, and a 1.5 cm jig attached to the top (Figure 10 and Figure 11). All 80 tiles were placed individually onto the base and the jig was lowered. Load was applied at a constant rate of 1 mm/second until each tile broke. The apparatus was manually reset each time. The data were logged digitally in Newtons and converted later to Kilograms. My expectations for the breakage test, based on prior experimental data summarized in Table 5, were that the cod liver oil surface treatment would increase strength, organic temper would reduce strength, and inorganic temper would increase strength (Table 11).

Table 10. Summary of experimental design including frequency of tiles by temper and surface treatment.

	Temper								
	Fiber	**Mineral**	**Shell**	**Fiber, Mineral**	**Fiber, Shell**	**Mineral, Shell**	**Mineral, Fiber, Shell**	**None**	**Total**
Cod Liver Oil ST	5	5	5	5	5	5	5	5	40
No ST	5	5	5	5	5	5	5	5	40
Total	10	10	10	10	10	10	10	10	80

Table 11. Expectations for porosity and strength tests.

	Porosity	**Tensile Strength**
Fish oil	Fish oil surface treatment decreases porosity.	Fish oil surface treatment increases tensile strength of test tiles regardless of temper type.
Mineral temper	Mineral temper does not affect porosity.	Mineral temper increases tensile strength.
Fiber temper	Fiber temper, alone or in combination, increases porosity.	Fiber temper, alone or in combination, decreases tensile strength.
Shell temper	Shell temper, alone or in combination with mineral temper, decreases porosity.	Shell temper, alone or in combination with mineral temper, increases tensile strength.

Figure 10. Ball-on-three-ball testing apparatus.

Figure 11. Testing apparatus in use.

Phase 2: Experimental Replication and Boiling

Phase 2 of my experimental research consisted of producing complete ceramic vessels and testing their performance as cooking pots when used for three different cooking methods (Table 5). I also tested the performance of unused compared to reused cooking vessels. I produced one set of Norton vessels and one set of Thule vessels, consisting of three pots each per cooking method, and three pots each which were treated with oil but not used. Each set consisted of twelve pots each (24 pots total) (Table 12, Appendix Table A-3). The same materials, including clay and temper types, and firing procedure used in the test tile experiments were repeated for the vessel replication phase. Vessels were constructed following the data on wall thickness, temper type, and temper density I collected during my analysis of Norton and Thule vessels from Nukleet and Iaytayet.

First, I processed the Cape Blossom clay, as summarized previously, and separated it into sections for Norton and Thule vessels (Figure 13). For Norton vessels, I added 10% mineral only temper per volume to the paste. Although many Norton sherds had evidence of organic temper, the density was generally low and the size very fine. As a result, I did not consider the Timothy grass fiber used in the test tile phase an appropriate additive, since it is very coarse, so I omitted organic temper in Norton pastes altogether. For Thule vessels, I added 20% per volume of equal parts of mineral, temper, and crushed shell temper to the clay (Figure 12). The Thule vessels had 10 mm thick walls.

Construction of the vessels was based on prior research and ethnographic data (Harry and Frink 2009, Harry et al. 2009, de Laguna 1947), and informed by the results of community-centered pottery workshops held in 2019 and instruction from Anne-Marie Kremer, a potter with experience in hand-building. I chose to use a combination of patch-molding and slab-building, inside plastic-lined flower pots to provide uniformity of shape and size, as well as provide stability during the drying process (Figure 14). The clay used for my replications had a high silt content which reduced plasticity and made it prone to cracking (Figure 15). I pushed a ball of clay into the bottom of the flower pots to form the base, and then applied strips of clay to build up the walls, smoothing the joints with my fingers (Figure 14). Each section of clay was rolled out between rollers 7 mm (Norton) and 10 mm (Thule) thick to ensure uniformity. I perforated all of the pots intended to be used for suspended cooking (eight total) with four small holes about 2 cm below the rim. Once leather-hard, the pots were removed from their mold and the slab breaks were smoothed from the outside until indiscernible. The pots measured approximately 20 cm tall, and 13 cm in diameter when finished. These dimensions fall within acceptable ranges based on my analysis of Norton and Thule vessels, although they are slightly on the smaller size for both traditions. The smaller size was necessary to reduce the amount of clay used, and the amount of space required when firing in the kiln. The pots were left uncovered to dry for a week, then fired. The fired pots were then coated with one layer of cod liver oil.

Although it is generally assumed that Norton pottery was fired to a higher temperature than Thule pottery, there has been limited prior work analyzing firing temperatures for Alaskan sherds, and some evidence that firing temperatures varied between sites even within the Thule period (Duelks 2015). As a result, I chose to fire all vessels regardless of tradition to 650^{o} C, the temperature when organic materials burn off within the clay body, and the sintering process is complete.

Figure 12. Sand temper, Timothy grass temper, and crushed shell temper.

Figure 13. Cape Blossom clay after rehydrating and kneading.

Figure 14. From left to right: clay slab after being rolled out on 1 cm rollers, molding the base and sides of vessel in plastic-lined pot, and finished vessel before drying.

Figure 15. Detail of dried pot showing cracking.

The Norton and Thule sets consisted of three pots each per heating method, and three pots each which were treated with oil but not used, as backups in case all the vessels were destroyed in the process of cooking. The heating methods tested were direct heat in a fire, indirect heat using the stone-boiling method, and suspended heat over coals. The replicated pots used for each heating trial are summarized below in Table 12. These methods followed as closely as possible prior heating experiments conducted by Harry and Frink (2009). I excavated a fire pit approximately 25 cm deep, with a smaller pit adjoining it to have space to build a fire and bed of coals while simultaneously heating a pot. The size and heat of the fires was kept as constant as possible, around 400º C, although some fluctuation did occur. The firewood was commercially kiln-dried pine lumber ends, which were split down into thinner pieces. Each vessel was filled with 500 ml of water, and the amount of time it took the vessel contents to reach a boil (100°C) was recorded using a stopwatch.

Table 12. Norton and Thule replicated vessels used in heating trials.

	Heating Method		
	Direct	**Indirect**	**Suspended**
Norton	4 pots	4 pots	4 pots
Thule	4 pots	4 pots	3 pots

To replicate direct heating, I built a fire and allowed it to burn down over thirty minutes to coals, occasionally adding more wood. Each pot was filled with water and placed one at a time in the smaller fire pit, where it was surrounded by hot coals which were continually replenished (Figure 16). My initial strategy was to build up a fire around each pot, however catastrophic failure of two Norton pots (2.01, 2.03) suggested that the temperature had increased too quickly around the pots, resulting in cracking from thermal shock. To replicate indirect heating using stone boiling, I heated medium-sized fine grain volcanic cobbles for 20 minutes in the active fire. After 20 minutes, I placed two at a time into the pots using tongs. The stones were replaced after approximately 20-30 seconds (Figure 18). For the suspended cooking test, I hooked wire into the holes in the rim of each pot and hung it from a metal stand over the fire, with the bottom of the pot approximately 12 cm above the bed of coals (Figure 19, 20).

Figure 16. Direct heat heating in a Thule-style replicated pot.

Figure 17. Thule-style replicated pots before stone boiling trials.

Figure 18. Norton style replicated pot during suspended heat trial, showing suspension set-up.

Figure 19. Norton-style replicated vessel in suspended heating trial.

There were two heating trials, occurring over the course of two separate days in August, 2021. All three cooking methods were practiced on both days. The first trial utilized 18 pots, with three pots per tradition left unused (6 total). Figures 17 – 19 show examples of each of the heating methods and their set-up. A second trial was conducted several weeks later, using a combination of previously used pots (which did not display major cracking or spalling), and the unused pots from the first trial. The goal of the second trial was to add more data to each heating method, due to several catastrophic failures in the first trial, as well as see what effect if any re-using a pre-heated pot had on boiling times. Results for Thule and Norton vessels were compared, and the differences were assessed for statistical significance. Pots which did not reach a boil due to a failure to maintain adequate fire temperature, excessive evaporation, or cracking, were excluded from the data-set.

Chapter 4: Results

In this chapter, I first present the results of my analysis of a sample of ceramics from Nukleet (NOB-0001) and Iyatayet (NOB-0002). Then, I summarize the results of Phase I of my experimental replications, consisting of test tiles used to test porosity and break strength. Finally, I present the results of Phase II of the experimental replications, the results of tests of how replicated Norton and Thule pots function as cooking vessels.

4.1 Ceramic Analysis

Comparison of Norton and Thule Ceramics

I analyzed a total of 61 Norton sherds and 301 Thule sherds from NOB-0001 and NOB-0002 (Table 13). The assemblages from both sites consisted mostly of body sherds, with a smaller number of rim and base sherds. I combined the Thule sherds from Nukleet and Iyatayet for the following analysis, and analyzed them separately later on.

Table 13. Vessel part frequencies by site.

	Iyatayet		**Nukleet**
	Norton	**Thule**	**Thule**
Base Sherd	2	3	7
Body Sherd	48	53	108
Rim Sherd	11	19	113
Total	61	76	241

Thule sherds have thicker walls overall than Norton sherds for all vessel parts, which conforms to prior expectations (Table 14). Both Norton and Thule base sherds are on average thicker than either body or rim sherds for both traditions. Although these findings are generally in line with the patterns identified in previous work (Table 1), Thule sherds in my analysis were slightly thinner than expected. Mean wall thickness of rim, body, and base sherds from the Thule sample show higher standard deviations compared to the Norton sample, however the discrepancy in sample size between the number of Norton and Thule sherds may have impacted how representative the Norton statistics are of the assemblage as a whole. The low proportion of Norton rims to body sherds versus the high proportion of Thule rims to body sherds may reflect preservation, given the age of the Norton assemblage. It may also reflect differences in rim diameter compared to body diameter, due to rim constriction.

Table 14. Norton and Thule mean rim, body, and base sherd thicknesses (mm), with standard deviation and coefficient of variation (%).

	Norton				**Thule**			
	N	**Mean (mm)**	**Std. Deviation**	**CV%**	**N**	**Mean (mm)**	**Std. Deviation**	**CV%**
Rim Thickness (mm)	6	6.6	.8	12.7	118	9.5	1.5	17.2
Body Wall Thickness (mm)	32	6.5	1.3	20.5	55	8.8	2.2	25
Base Thickness (mm)	1	8.9	n/a	n/a	6	9.5	1.4	14.7

Mean Norton rim sherd diameters are approximately two cm narrower than Norton body sherds, potentially indicating orifice constriction, although this difference is not significant at a 0.05 level (p=0.361778, t=-0.360, df=16) (Table 15). Standard deviations and coefficient of variation for both rim and body diameter means are very high, indicating that diameter values are not tightly clustered around the mean. Norton rim and body diameters show two distribution concentrations, between 12 and 30 cm, and 35 and 53 cm (Figures 20 and 21). This may indicate there were two size classes of vessels produced during the Norton period, although the small sample size of rim diameters makes it difficult to draw firm conclusions. The distribution of rim and body diameters shows that the majority of Norton vessel diameters clustered around 22.6 to 27.6 cm, comparable to the distribution of Thule rim diameters (Figure 22).

Table 15. Norton and Thule mean rim and body diameters (cm) with standard deviation.

	Norton				**Thule**			
	N	**Mean (cm)**	**Std. Deviation**	**CV%**	**N**	**Mean (cm)**	**Std. Deviation**	**CV%**
Rim Diameter (cm)	6	26.3	13.5	51.3	69	23.5	8.5	36.2
Body Diameter (cm)	12	28.3	10.2	36.0	67	27.5	15.7	57.1

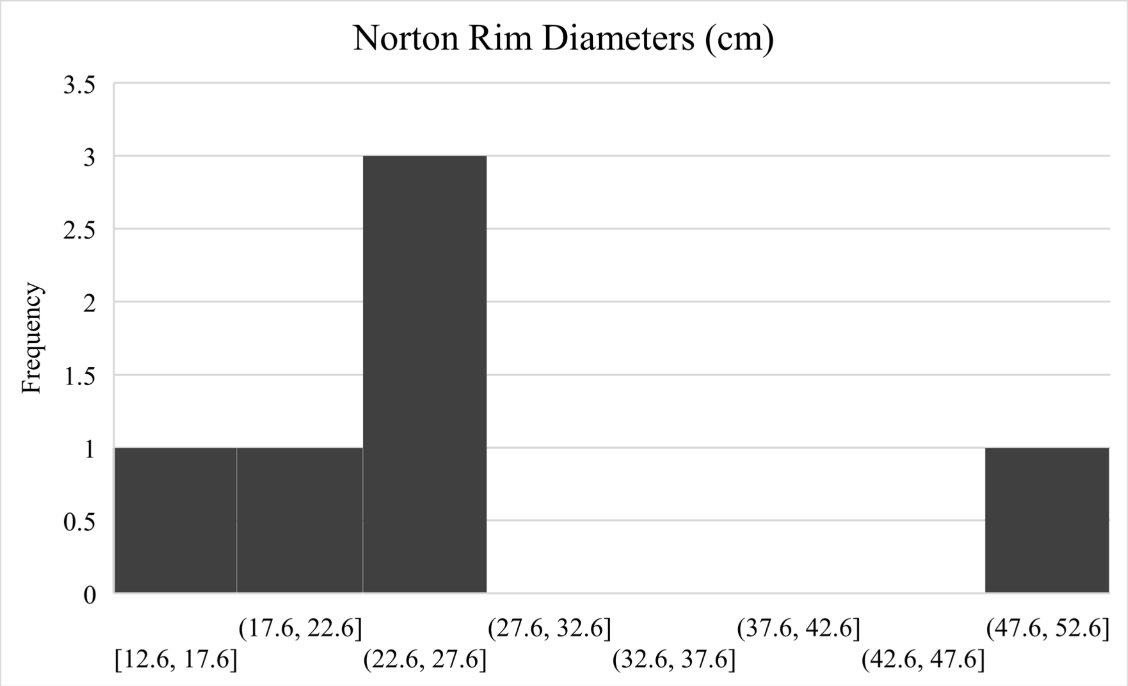


Figure 20. Histogram of Norton rim sherd diameter frequencies (cm).

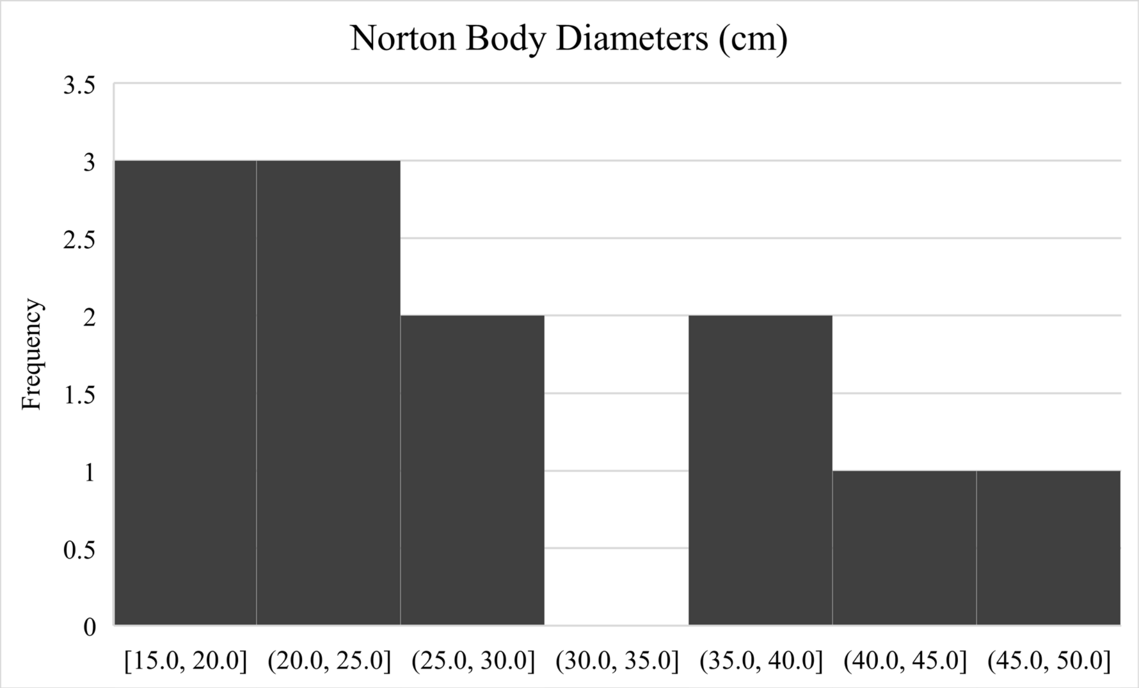


Figure 21. Histogram of Norton body sherd diameter frequencies (cm).

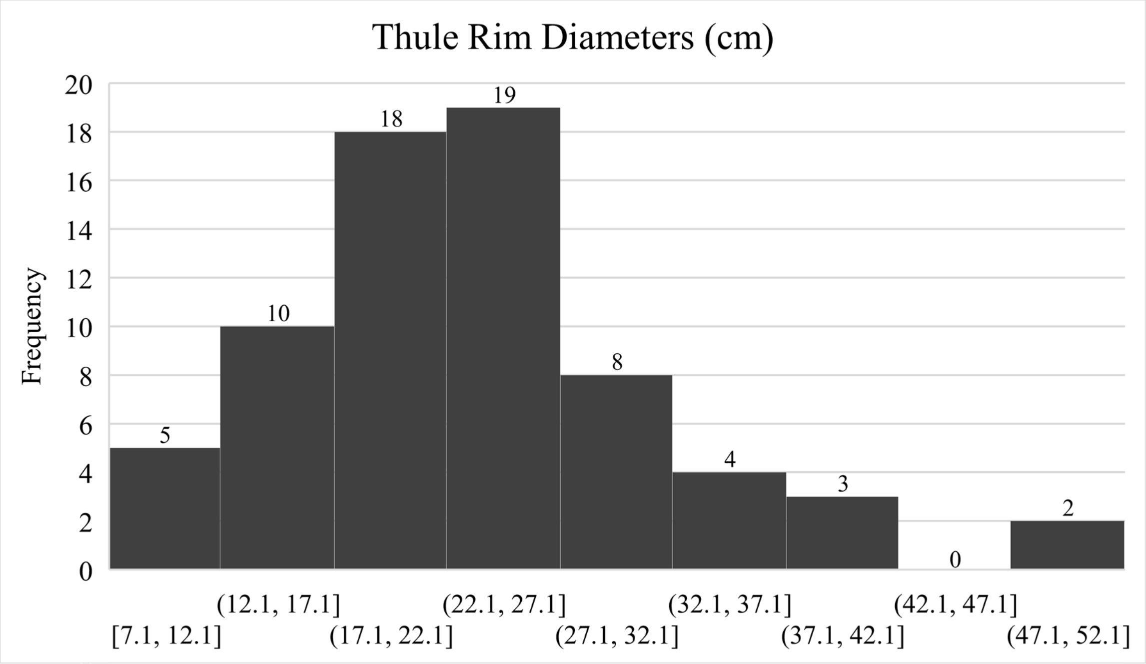


Figure 22. Histogram of Thule rim sherd diameter (cm) frequencies.

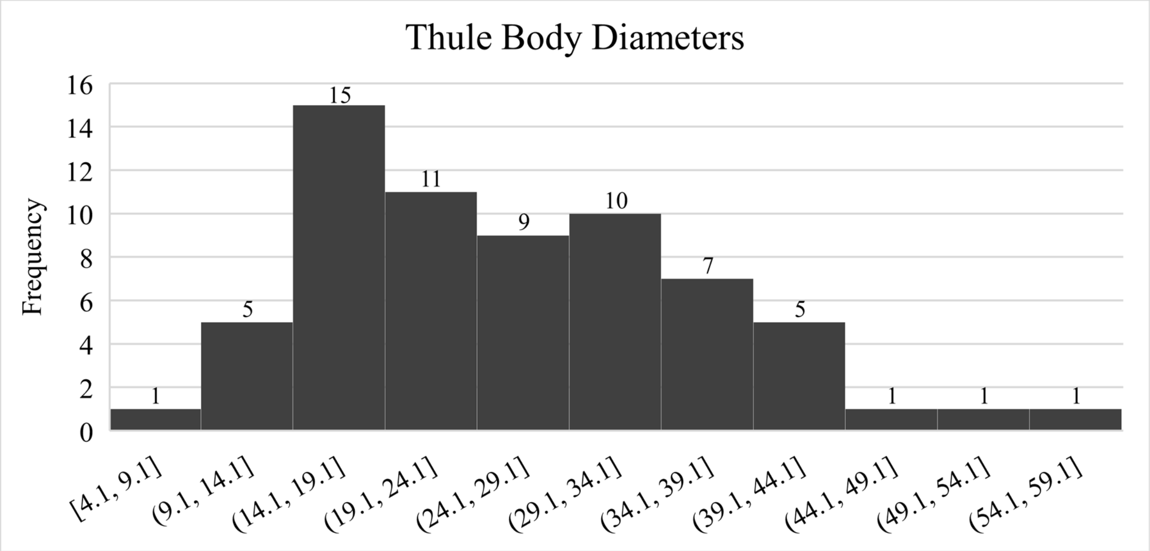


Figure 23. Histogram of Thule body sherd diameter (cm) frequencies.

Thule rim sherds have, on average, a narrower diameter than body sherds, which is significant at a 0.05 level (p=0.03, t=-1.857, df=134). Thule rim sherd diameters cluster around lower values (Figure 22), between 12 and 27 cm. Body sherds (Figure 23) have a broader distribution of diameters, with the majority falling between 14 and 39 cm. This suggests that some constriction of orifice diameters was present in Thule rim sherds compared to body sherds. Outliers below five cm and above 70 cm were discarded from my analysis, due to the high likelihood that those figures were the result of analyst error.

Rim angles for both Norton and Thule sherds were most frequently vertical/direct, followed by incurved (Table 16). The presence of incurved and recurved Thule rims confirms the orifice constriction noted previously. Smaller orifices are associated with maintaining and preserving heat, rather than prioritizing ease of accessing and handling contents, for instance when stone boiling. Type 1 was the most frequently occurring rim category for Norton sherds (Appendix Table A-4). Six rim categories overall were represented in the Norton assemblage. The Thule assemblage had a greater diversity of rim categories, with twelve total represented

(Appendix Table A-4). There was very little overlap of rim categories of Norton and Thule sherds, with only categories 1, 9, and 11 found in common between the two assemblages.

Table 16. Norton and Thule rim angle type frequencies.

	Norton		**Thule**	
Rim Angle	**Frequency**	**Percent**	**Frequency**	**Percent**
Everted	0	0.0	7	5.4
Incurved	3	33.3	32	24.8
Recurved	0	0.0	11	8.5
Vertical/Direct	6	66.6	79	61.2
Total	9	100.0	129	100.0

Suspension holes were noted on three Thule sherds: two from Nukleet and one from Iyatayet. No holes were noted for any Norton sherds. The holes all appeared to be drilled after firing in one direction, from the exterior to the interior. One sherd pictured below (Figure 24) had two holes oriented vertically above each other, suggesting purposeful alteration for suspending the vessel (Giddings 1964). The other sherds appeared only to have one hole each, although fragmentation of the sherds may have obscured other holes originally present. Holes immediately adjacent to the edge of the sherd may be evidence of repairs, rather than suspension.

Figure 24. Thule rim sherd from Nukleet with suspension holes.

Mineral temper density for Norton and Thule sherds is displayed in Figure 25 below (Appendix Table A-4). My analysis shows that mineral temper density for both Norton and Thule sherds is most frequently low (<25%). Figure 26 shows mineral temper size for Norton and Thule sherds. Mineral temper is mostly fine-medium for Norton sherds (Appendix Table A-6), while Thule sherds are more likely to contain coarse and very coarse mineral temper (Appendix Table A-6). Some of the temper inclusions in both Norton and Thule sherds may be naturally occurring in the clay bodies used for the vessels. Limestone temper was present in a total of 24 Thule sherds from Nukleet, distinguishable from shell temper (to which it is compositionally similar) by size and shape. No sherds from Iyatayet contained limestone temper. Limestone temper tends to consist of larger, more rounded white inclusions compared to the finer, plate-like shell temper inclusions (Figures 31 and 32). It is possible the frequency of limestone temper is artificially low due to analyst error, as I tended to classify fine white inclusions observed in sherd walls as shell temper unless clearly contradicted by size and shape of the inclusions. Seven sherds contained a combination of shell and limestone temper. The identification of temper inclusions in Nukleet pottery would be improved by thin-section petrographic analysis.

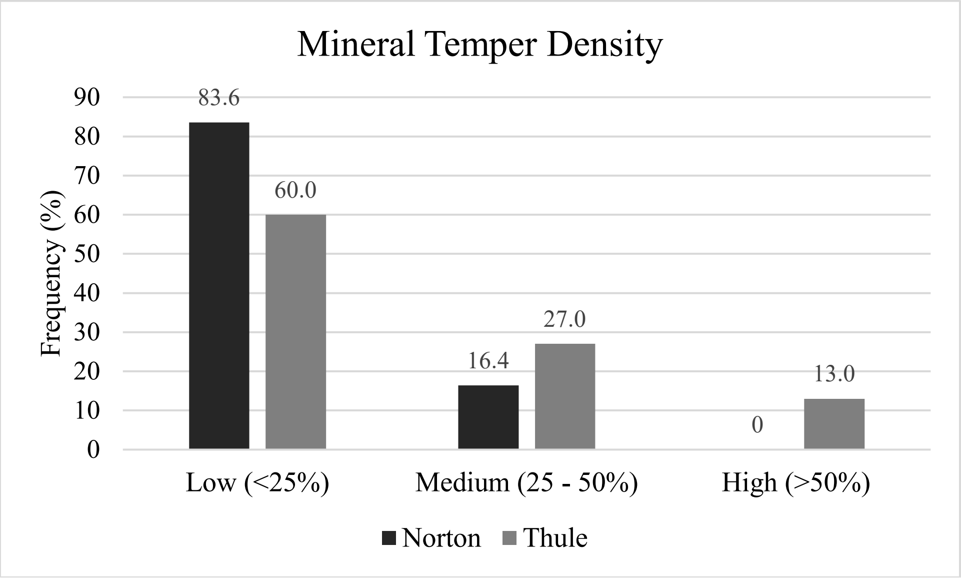


Figure 25. Mineral temper density for Norton and Thule sherds.

The overwhelming majority of Thule sherds (98%) had evidence of organic temper (Figure 25). Thule organic temper density was more evenly distributed across the categories, although still weighted towards low density (Appendix Table A-7). These data confirm my expectation that Thule pottery tended to be more heavily tempered with organic material compared to the earlier Norton tradition.

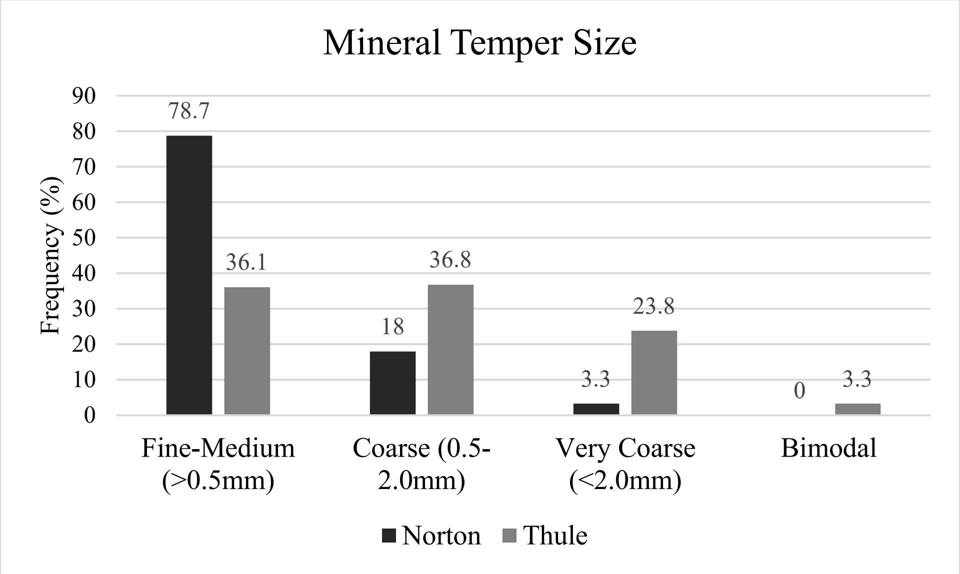


Figure 26. Percent frequency table of mineral temper sizes for Norton and Thule sherds.

Organic temper types identified in my analysis are summarized in Figure 27 and Appendix Table A-8. Out of a total of 61 Norton sherds, 49 (80%) contained evidence of organic temper. Fiber was the most commonly utilized temper, and was primarily identified in the form of voids in the sherds, indicating that organic materials had burned out during the firing process. Figure 32 illustrates a typical example of these kinds of voids. Some of the voids identified in Norton sherds were very large, compared to the thinner voids caused by fiber temper. This is most likely the result of unknown organic materials burning out during the firing process. Overall, Norton sherds had a slightly more even distribution of organic temper types compared to Thule sherds (Figure 27 and 28).

The most common organic temper type for Thule was fiber, and the second most common organic temper type was a combination of fiber and shell (Figure 28, Appendix Table A-8). Thule organic temper frequencies are heavily concentrated on fiber and shell tempers with relatively few sherds containing other organic temper types. Fiber, feather, and hair/fur temper were identified primarily through voids in Thule sherds, although in some cases (see Figure 29), organic temper remained unburned, showing the low or uneven firing temperatures used to produce the vessels.

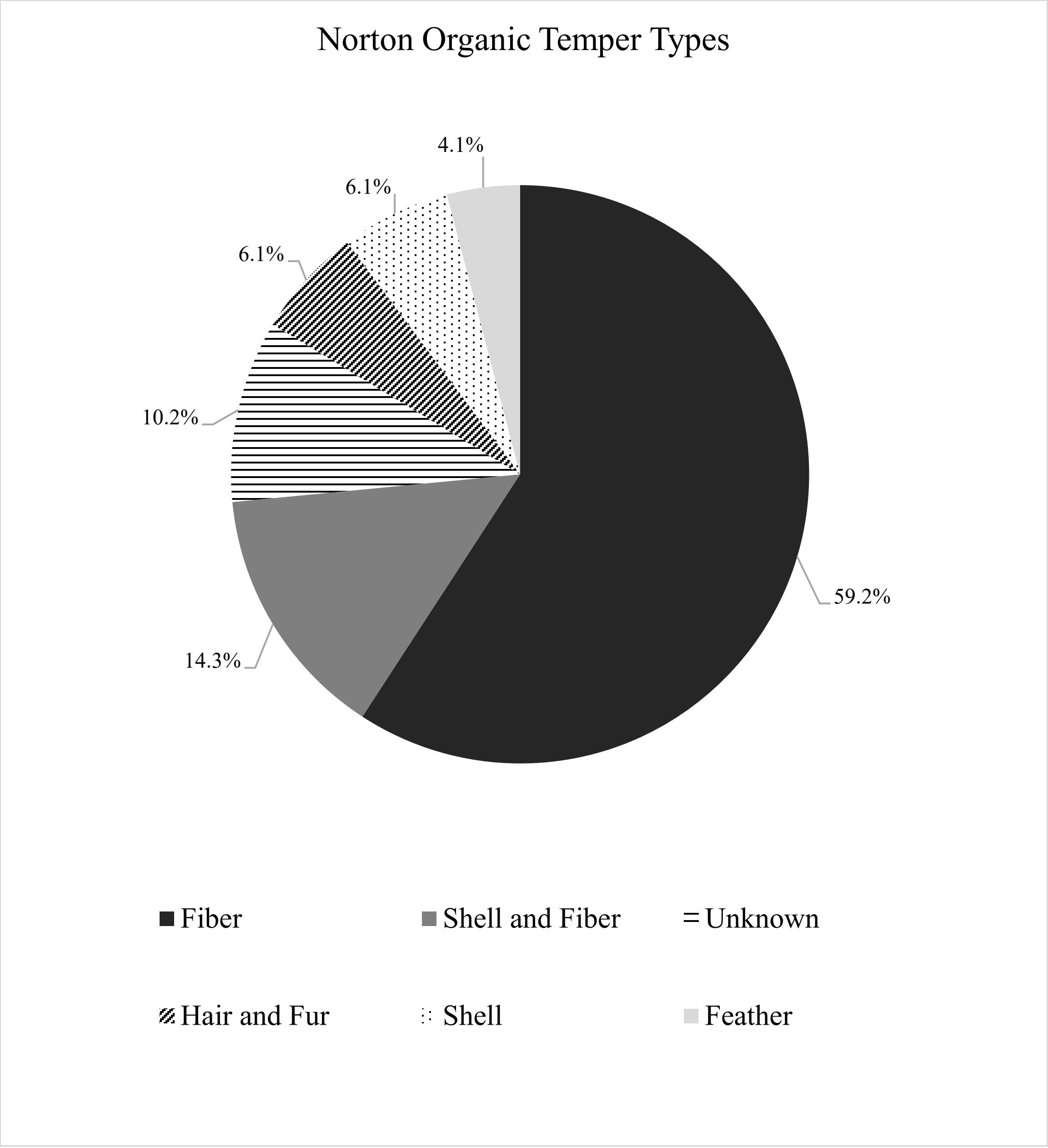


Figure 27. Percent frequency of Norton organic temper types.

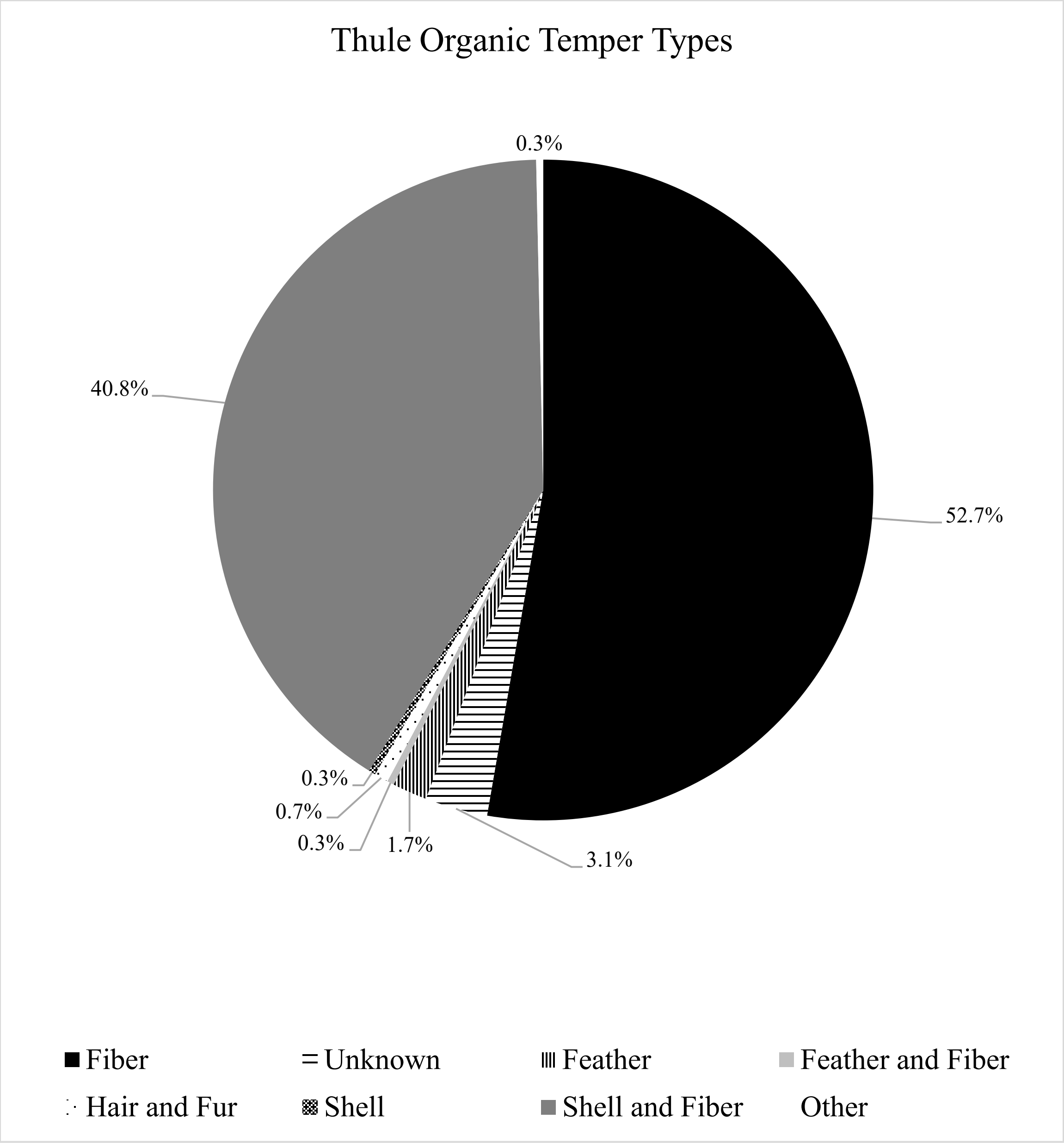


Figure 28. Percent frequency of Thule organic temper types.

Figure 29. Exfoliated Thule sherd from Nukleet showing fiber temper impressions with some un-burnt fibers intact.

Figure 30. Thule sherd wall profile from Nukleet showing shell temper.

Figure 31. Thule sherd from Nukleet showing limestone temper.

Figure 32. Interior of Norton sherd showing voids of burned-out organic material as well as fine fiber and shell temper.

Both pottery traditions primarily measured on the Mohs hardness scale between 2.5 and 3.5, with some harder Thule pot sherds (between 4.5 and 7.5) and some softer (1.5). Norton sherds had lower variability in hardness, with the majority of sherds measuring 2.5 (Table 17).

Table 17. Mohs hardness value frequencies for Norton and Thule sherds.

	Norton		**Thule**	
Hardness	**Frequency**	**Percent**	**Frequency**	**Percent**
1.5	0	0	2	.7
2.5	36	59.0	157	52.7
3.5	19	31.1	123	41.3
4.5	6	9.8	14	4.7
5.5	0	0.0	1	.3
7.5	0	0.0	1	.3
Total	61	100.0	298	100.0

Exterior and interior surface color, as well as firing core, can provide information on firing conditions. These data are summarized below in Tables 18 to 20. Dark brown, gray, and black exterior surfaces may additionally be a result of sooting from the cooking process. The majority of sherds (53.7% and 71.1% respectively) from both Norton and Thule contexts have dark or very dark brown exterior surfaces, indicating a reducing environment during firing, although firing cores reveal that 27.9% of Norton and 30.9% of Thule sherds are oxidized on the exterior and reduced on the interior. This may reflect firing conditions, although it may also indicate that fully reduced low-fired pots were placed in hot fires to cook using direct heat, resulting in oxidized exterior surfaces, as observed during cooking experiments.

Table 18. Exterior color category frequencies for Norton and Thule sherds.

	Norton		**Thule**	
	Frequency	**Percent**	**Frequency**	**Percent**
Red and Orange	0	0.0	1	.4
Brown	7	13.0	32	14.0
Dark brown to dark gray	18	33.3	32	14.0
Dark brown to black	0	0.0	1	.4
Very dark brown to black	29	53.7	162	71.1
Total	54	100.0	228	100.0

Table 19. Interior color category frequencies for Norton and Thule sherds.

	Norton		**Thule**	
	Frequency	**Percent**	**Frequency**	**Percent**
Brown	3	7.3	13	5.2
Dark brown to dark gray	3	7.3	9	3.6
Very dark brown to black	35	85.4	226	91.1
Total	41	100.0	248	100.0

Table 20. Firing core frequencies for Norton and Thule sherds.

	Norton		**Thule**	
	Frequency	**Percent**	**Frequency**	**Percent**
Fully oxidized	3	4.9	8	3.2
Fully reduced	31	50.8	143	57.4
Oxidized exterior-reduced interior	17	27.9	77	30.9
Oxidized interior-reduced exterior	2	3.3	9	3.6
Oxidized surfaces-reduced in middle	1	1.6	12	4.8

The majority of Norton sherd exteriors had no surface treatment (exterior surface smoothing or burnishing) visible (Table 21). The majority of Thule sherds were marked “indeterminate” due to exfoliation, followed closely by sherds with no visible surface treatment. The number of exfoliated sherds in the Thule assemblages is much higher than in the Norton assemblage, which may be a reflection of firing conditions, as higher fired vessels are less fragile, and more resistant to damage incurred while cooking (citation?). Some pot-lid fractures on the exteriors of Norton and Thule sherds were noted during analysis, which are likely the result of thermal shock due to direct heat, either in firing or in cooking.

Table 21. Exterior surface treatment frequencies for Norton and Thule sherds.

	Norton		**Thule**	
	Frequency	**Percent**	**Frequency**	**Percent**
Indeterminate	8	13.1	124	41.0
None	33	54.1	119	39.4
Smoothed	20	32.8	57	18.9
Burnished	0	0.0	1	.3
Total	61	100.0	302	100.0

Alaskan ceramic decorative types are temporally and regionally distinctive and can provide information on cultural relationships and economic exchanges (Anderson et al. 2011). A variety of decorative types were identified on Norton and Thule sherds from Nukleet and Iyatayet (Figure 33, Figure 34, Table A-9, A-10). No decorations were identified that did not meet the criteria of previously established decorative types. The majority of Norton sherds were decorated, which suggests there may have been a collection bias towards decorated sherds, although other analysts have also noted a preponderance of decorated sherds in Norton assemblages (Griffin 1953) versus later ceramic traditions. Over 30% of Thule sherds were decorated, which given the predominance of undecorated sherds typically found at Thule sites also suggests a bias towards collecting decorated sherds at Nukleet and Iyatayet.

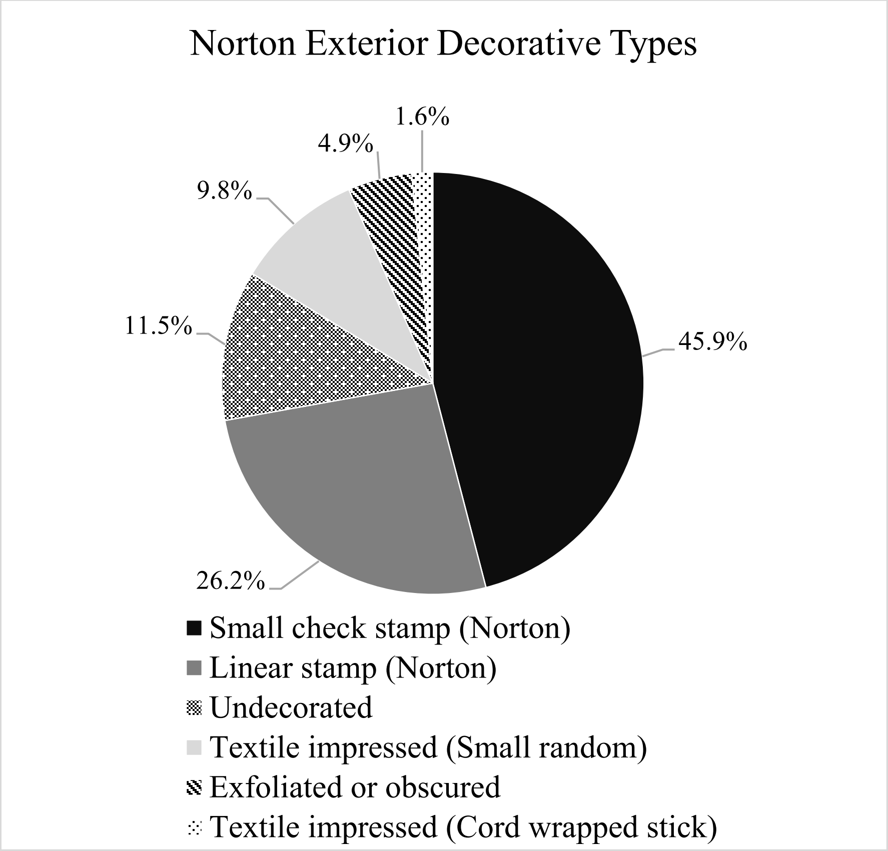


Figure 33. Percent frequencies of Norton exterior decorative types.

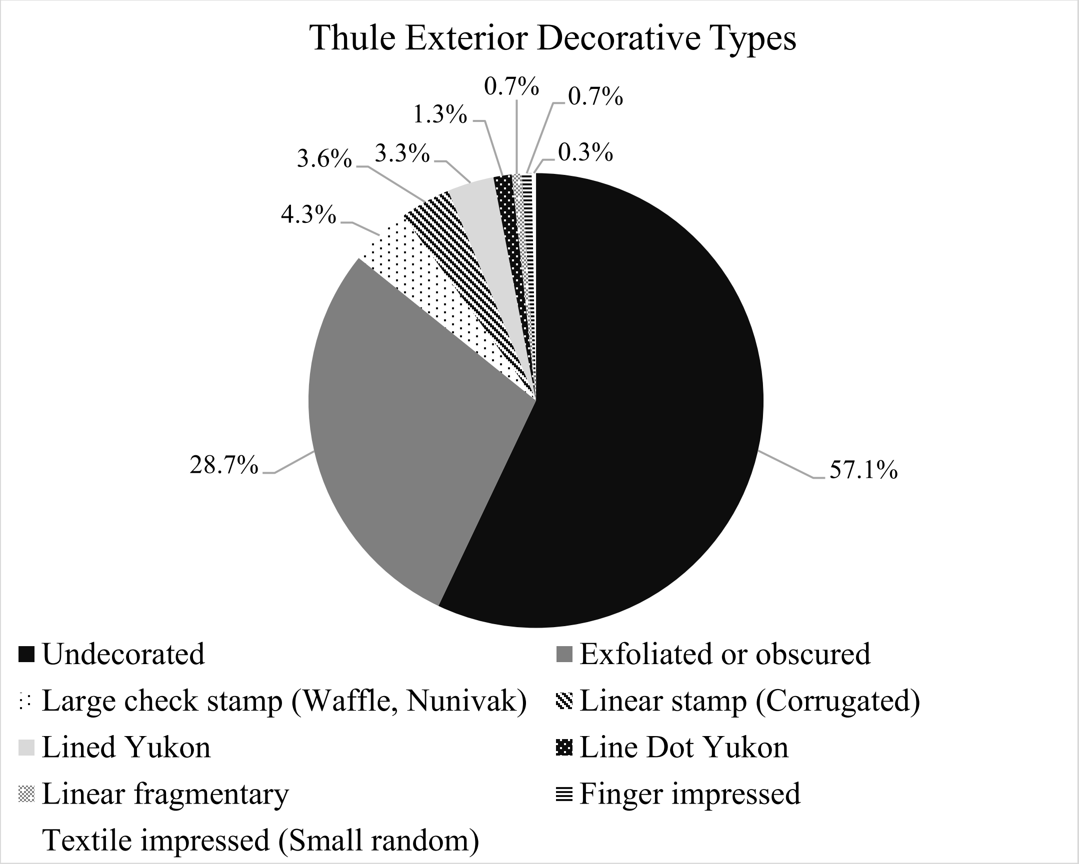


Figure 34. Percent frequencies of Thule exterior decorative types.

4.2 Comparison to the Regional Database

In order to understand regional variation in pottery characteristics, as well as whether the pottery found at Nukleet and Iyatayet has distinctive qualities, I compared the sherds I analyzed from Nukleet and Iyatayet against sherds from other sites in the Bering Strait, North Slope, Northwest, and Yukon-Kuskokwim (Y-K) regions, as well as against two additional Norton Sound sites (Table 22). Site names, numbers, and assemblage sizes used in my regional analysis are summarized in Table A-1 in the appendix. The assemblages I included in my expanded analysis of the Norton Sound region are Difchahak (NOB-00005), which is a Norton village site excavated by Harrit (2010) and Darwent and Miszaniec (in press), and Shaktoolik (NOB-072), a late-Thule to early colonial site excavated by Darwent et al. (2017).

I focused on rim and body wall thickness, rim and body sherd diameter, rim angle and type, base shape, mineral temper density, mineral temper size, organic temper type, hardness, firing core, external and internal surface treatment types, and external and internal decoration types. Tables 23 and 24 show how many vessel parts per region were considered in this study.

Table 22. Number of Norton and Thule sherds by region.

	Bering Strait	**North Slope**	**Northwest**	**Y-K**	**Norton Sound**
Norton	0	0	83	25	140
Thule	24	416	6895	159	54

Table 23. Norton vessel part frequencies by region.

	Northwest	**Y-K**	**Norton Sound**
Rim	11	6	4
Body	71	18	100
Base	1	1	0

Table 24. Thule vessel part frequencies by region.

	Bering Strait	**North Slope**	**Northwest**	**Y-K**	**Norton Sound**
Rim	15	364	958	40	9
Body	9	52	586	117	41
Base	0	0	79	2	0

Comparison of Ceramics within Norton Sound

Norton body sherds from Difchahak had significantly thicker walls (Table 25) than Norton body sherds from Iyatayet (p< 0.01, t=-4.569, df=44). No rim thickness measurements were taken for Norton sherds from Difchahak. Mean vessel diameters from Difchahak, summarized in Table 27, are significantly smaller than mean Iyatayet vessel diameters (p=0.02 t=-2.289, df=17). All rim angles recorded from Difchahak were vertical/direct, which is also the most frequent type of rim angle at Iyatayet.

Statistical comparisons of Thule ceramics from Iyatayet, Nukleet, and Shaktoolik show mainly small differences between the three samples. Mean wall thickness measurements for rim and body sherds range from 7.5 to 10 mm (Table 26). The differences between Nukleet and Iyatayet rims (p=0.49 t=-0.018, df=116), between Iyatayet and Shaktoolik rims (p=0.10 t=1.310, df=21), and between Nukleet and Shaktoolik rims (p=0.09, t=1.341, df=105) are not statistically significant. Differences in body sherd thickness between Nukleet and Iyatayet (p<0.01, t=2.939, df=77), between Iyatayet and Shaktoolik (p<0.01, t=3.205, df=44) are statistically significant at a 0.05 level, although the difference in mean body sherd wall thickness between Nukleet and Shaktoolik is not (p=0.20, t=-0.835, df=67).

Mean Thule rim and body sherd diameters between Nukleet, Iyatayet, and Shaktoolik are summarized below in Despite variability in mean rim diameters between sites, rim diameters are not significantly larger at Nukleet than Iyatayet (p=0.14, t=-1.113, df=67), nor are Nukleet rim diameters are significantly smaller than rim diameters at Shaktoolik (p=0.10, t=-1.291, df=53) (Table 28). Iyatayet rim diameters are significantly smaller than those at Shaktoolik (p=0.04, t=-1.861, df=16). The small sample size of Shaktoolik ceramics likely contributes to difficulties in ascertaining meaningful differences between the assemblages. Rim angles of Shaktoolik sherds are only vertical/direct, indicating no constriction at the rim.

Mean body sherd diameters from Thule assemblages in Norton Sound are summarized in Table 28. Body sherd diameters from Nukleet are significantly larger than body sherd diameters from Iyatayet (p<0.01, t=3.021, df=65). Body sherd diameters from Nukleet are not significantly larger than body diameters from Shaktoolik (p=0.27, t=0.616, df=47), nor are body sherd diameters from Iyatayet significantly smaller than body sherd diameters from Shaktoolik (p=0.17, t=0.993, df=22). Nukleet has the highest variation in rim type of the three Thule sites in Norton Sound, followed by Iyatayet and Shaktoolik. There is some overlap between the most frequently occurring rim types between the three sites, particularly rim types 1 and 2 (Appendix Table A-11, A-12).

Table 25. Norton mean wall thickness within Norton Sound.

	Difchahak			**Iyatayet**		
	N	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**
Rim	0	n/a	n/a	6	6.6	0.8
Body	14	8.5	1.6	32	6.5	1.3

Table 26. Thule mean wall thicknesses within Norton Sound.

	Nukleet			**Iyatayet**			**Shaktoolik**		
	N	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**
Rim	101	9.5	1.5	17	9.5	1.5	6	8.7	0.9
Body	51	10.0	2.1	28	8.9	2.1	18	10.5	1.8

Table 27. Comparison of Norton mean vessel diameters (mm) within Norton Sound.

	Difchahak			**Iyatayet**		
	N	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**
Rim	0	n/a	n/a	6	26.3	13.5
Body	7	18.5	6.2	12	28.3	1.3

Table 28. Comparison of Thule mean vessel diameters (mm) within Norton Sound.

	Nukleet			**Iyatayet**			**Shaktoolik**		
	N	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**	**N**	**Mean (mm)**	**St. Deviation**
Rim	101	24.1	8.7	16	21.4	7.8	2	32.2	7.0
Body	46	31.2	16.8	21	19.4	8.8	3	25.1	7.5

Holes are primarily present in Thule sherds (n=150) from most regions, with no holes noted for any sherds from the Bering Strait and North Slope. Only two holes are present in Norton sherds, from Northwest Alaska. Despite the comparatively small sample size of Norton sherds, holes are significantly less likely to be present in Norton sherds than in Thule sherds ($\chi 2$ (1, n=7696) = 0.3032, p=0.58). This may be a result either of higher breakability of Thule pots, requiring more repairs, or the use of holes for suspending vessels.

There is high variability in organic temper type between Norton Sound sites, particularly between the Cape Denbigh sites (Nukleet and Iyatayet) and Shaktoolik and Difchahak, both located further south along the coast (Figure 35). Shell temper, alone or in combination with fiber, is the most commonly occurring organic temper type at Nukleet, and makes up approximately 9% of the organic temper identified in the Thule component at Iyatayet (Figure 36). Norton sherds at Iyatayet also contain shell or shell and fiber temper (18%). There is no evidence of shell temper being used at either Shaktoolik or Difchahak, despite the presence of a shell midden at Difchahak and local availability of shellfish (Miszaniec et al. 2021). There is also less diversity in organic temper types at Shaktoolik and Difchahak compared to Nukleet and Iyatayet.

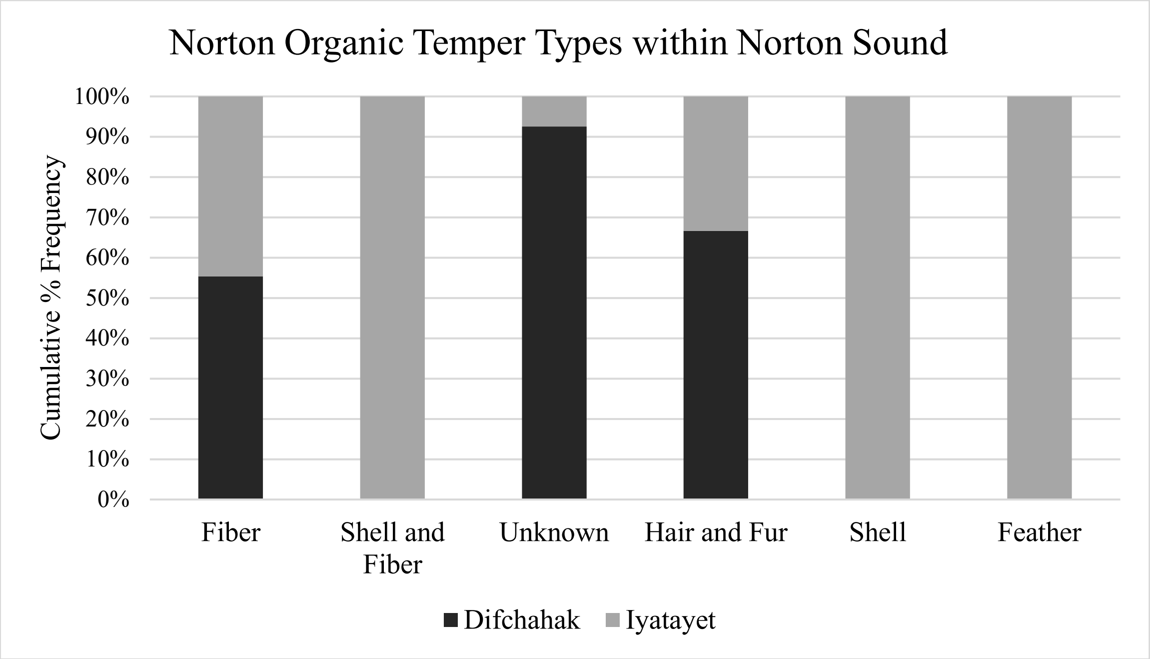


Figure 35. Cumulative percent frequency of organic temper types from Norton sites in Norton Sound.

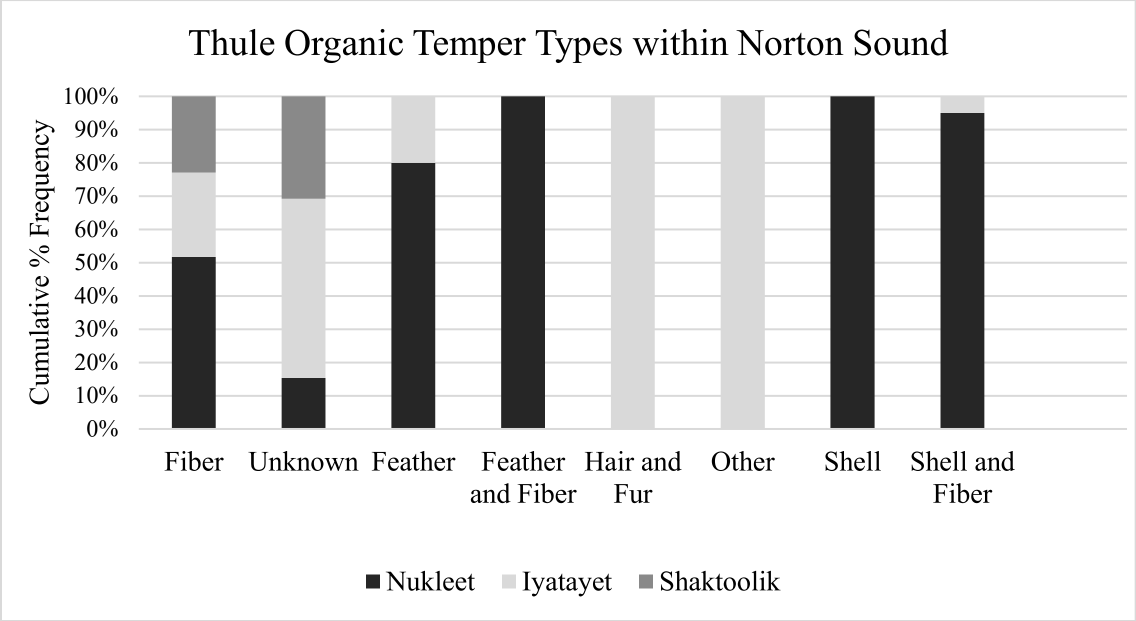


Figure 36. Cumulative percent frequency of organic temper types from Thule sites in Norton Sound.

Thule mineral temper density distributions are consistent between Nukleet and Iyatayet. Shaktoolik has a much higher proportion of sherds with medium temper density (Figure 37). Mineral temper density is mostly low (<25% temper) in the Norton component of both Iyatayet and Difchahak, and the distribution of mineral temper density frequencies are comparable between the two sites (Figures 39 and 40). Thule mineral temper size at Shaktoolik is most frequently very coarse (>2 mm). Shaktoolik also has the lowest percentage of sherds containing fine-medium (<0.5 mm) or coarse (0.5 mm-2.0 mm) temper out of the three sites (Figure 38).

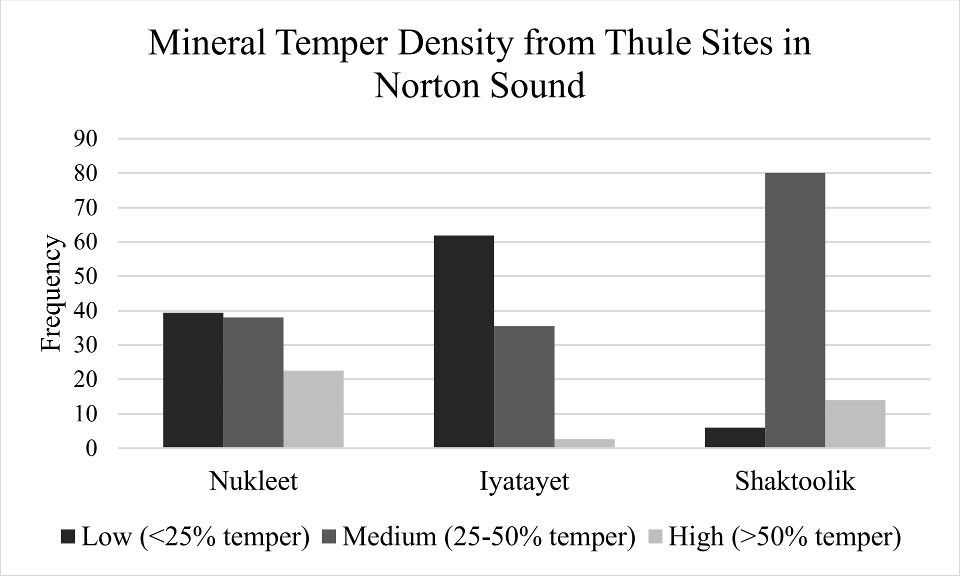


Figure 37. Frequency of mineral temper density categories from Thule sites in Norton Sound.

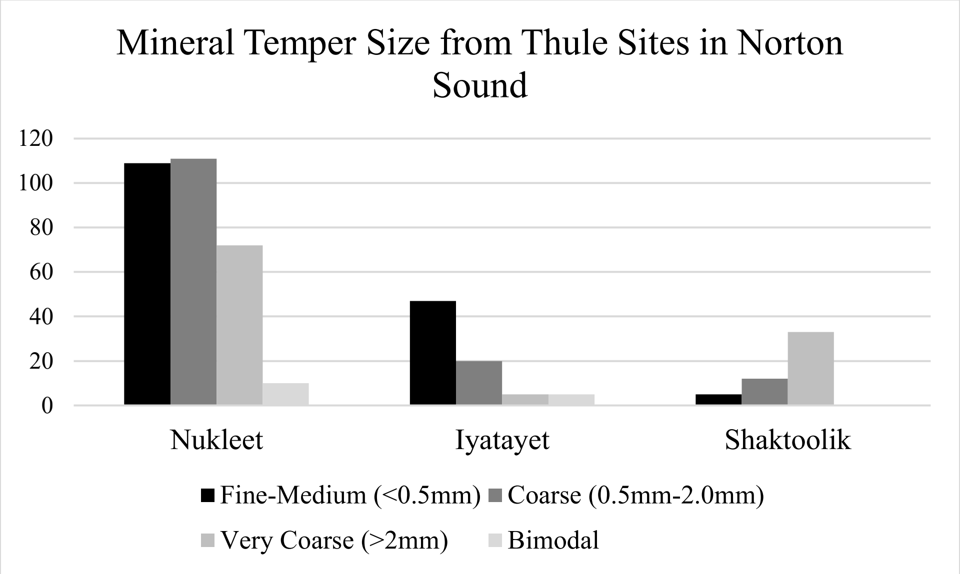


Figure 38. Frequency of mineral temper size categories from Thule sites in Norton Sound.

There are only minor differences in mineral temper size and density between the Norton ceramic assemblages from Iyatayet and Difchahak (Figures 40 and 41). Mineral temper density in Iaytayet and Difchahak sherds is most frequently low (<25%), followed by medium (25-50%) (Figure 39). Mineral temper size in sherds from both sites is most frequently fine-medium (Figure 40). There are more sherds from Difchahak with very coarse (>2 mm) mineral temper, and approximately 2% of sherds from Difchahak have high mineral temper density compared to none from Iyatayet. These differences may arise from natural mineral inclusions in clay sources local to each respective site.

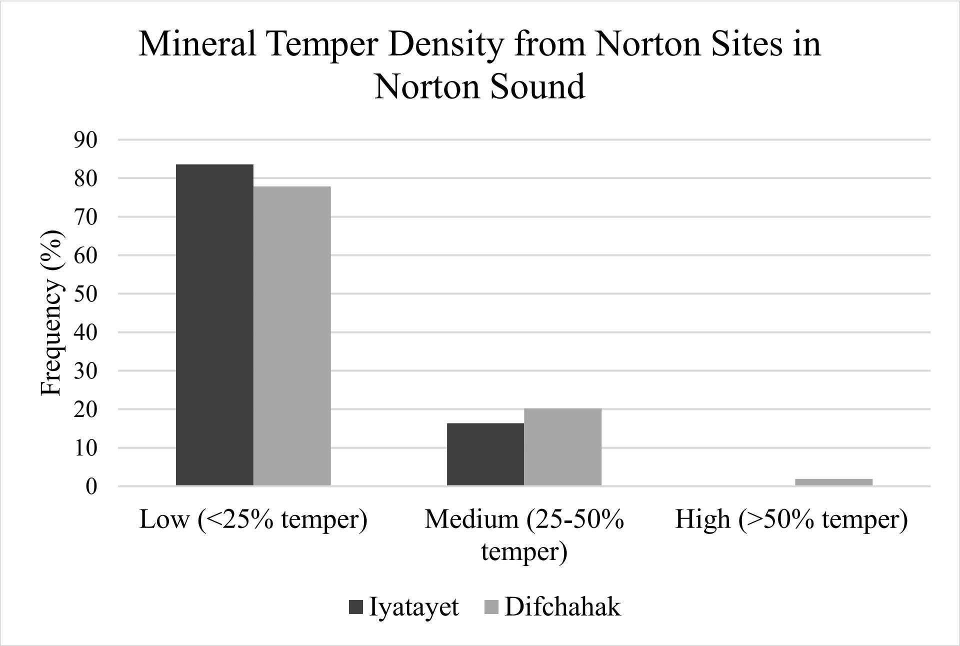


Figure 39. Percent frequency of mineral temper density from Norton sites in Norton Sound.

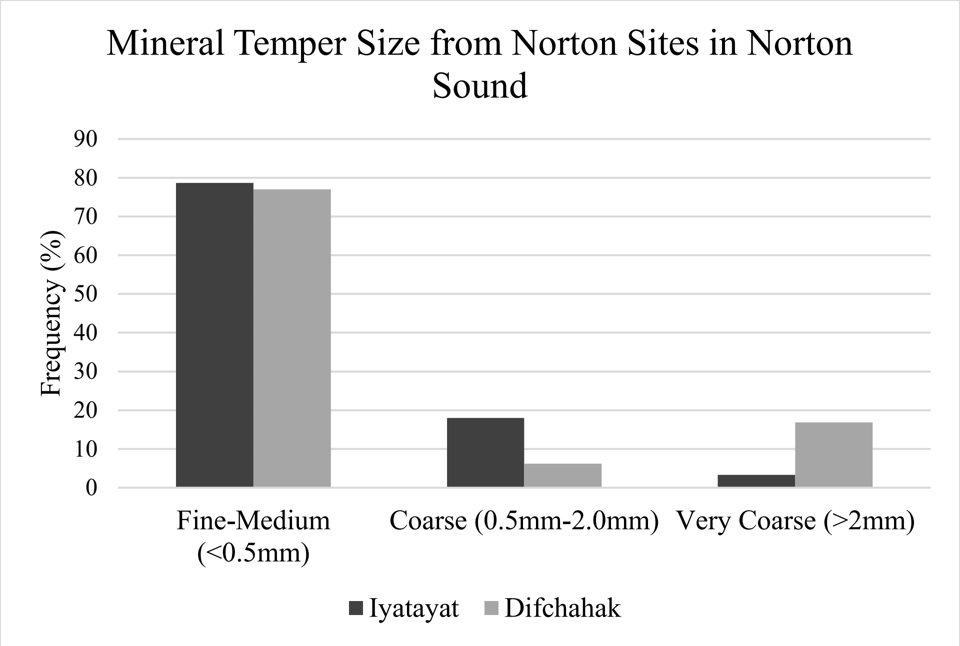


Figure 40. Percent frequency of mineral temper size from Norton sites in Norton Sound.

Mohs hardness values are most frequently 2.5 and 3.5 for Norton and Thule sherds from all Norton Sound sites considered in my analysis, indicating that Norton and Thule vessels from

Norton Sound were consistently soft and low-fired (Tables 56 and 57, Appendix). Firing cores are also consistent across time-periods within Norton Sound (Tables 58 and 59, Appendix). Sherds are most often fully reduced, with oxidized exterior-reduced interior as the second most common firing core for both pottery traditions.

Surface treatments, such as smoothing, are infrequently identified in analysis of Norton and Thule sites within Norton Sound, which are primarily categorized as having no surface treatment, or being indeterminate. (Appendix Table A-17). Absence of visible surface treatment may indicate post-depositional degradation of sherds, although sherds with residue or significant surface exfoliation were excluded from my analysis of surface treatment presence or absence. Approximately one-quarter of Thule sherds from Nukleet and Iyatayet show evidence of exterior smoothing, while no exterior smoothing was identified at Shaktoolik. Norton sherds from Difchahak have no evidence of exterior surface treatment, while 37.7% of Norton sherds from Iyatayet are smoothed (Table 60, Appendix). These findings conform to expectations established in Table 1, as no other surface treatments beyond smoothing (e.g. burnishing) are present in significant quantities for either the Norton or Thule sherds analyzed in this study.

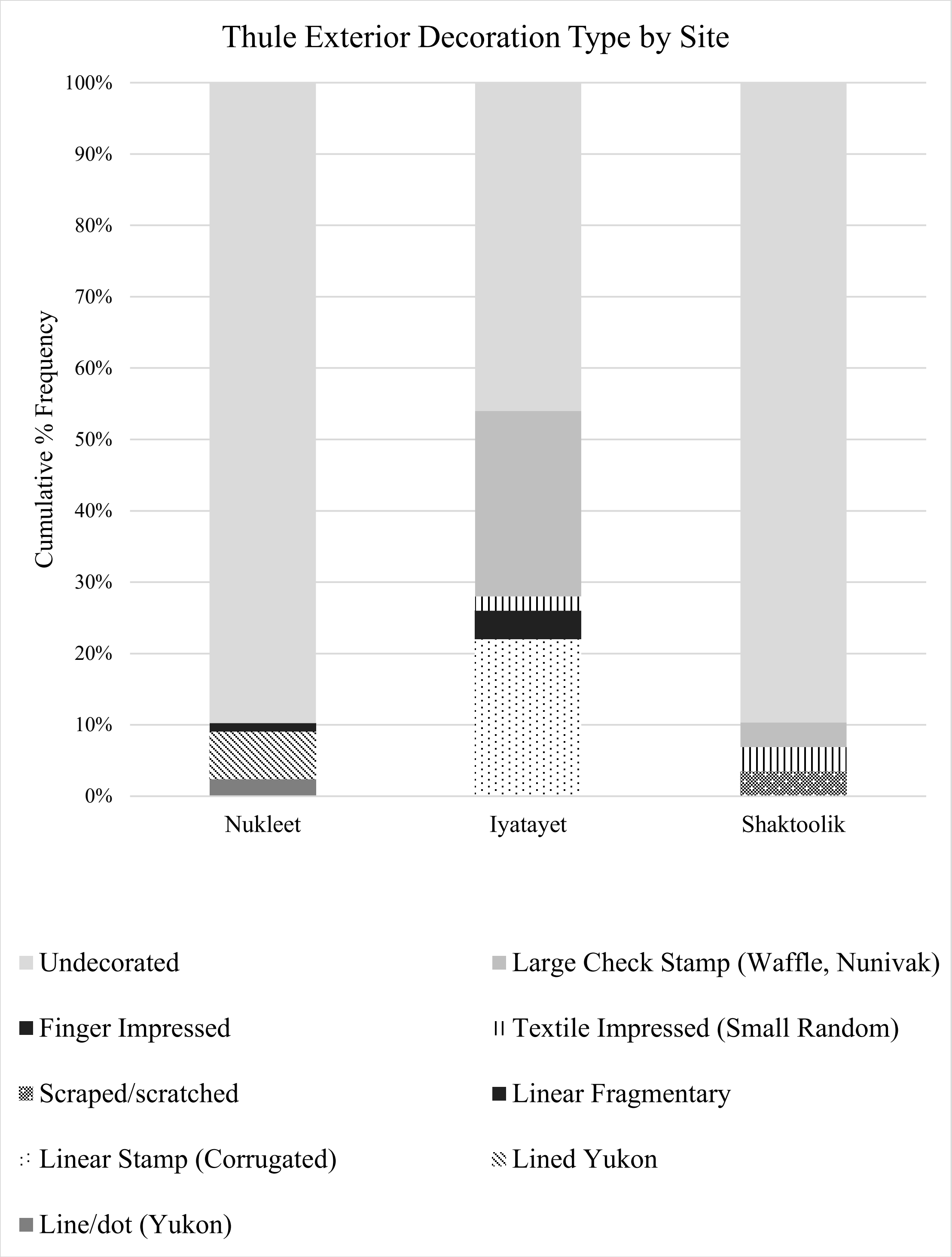


Figure 41. Thule exterior decoration type cumulative percent frequency from sites within Norton Sound.

One of the most significant differences between the Thule assemblages at each site from Norton Sound are the decorative types represented within the sample (Figure 41). Large check stamped sherds (also known as waffle stamp, or Nunivak stamp) most frequently occur at Iyatayet, with one instance identified at Shaktoolik. while Line Dot Yukon and Lined Yukon sherds are present only at Nukleet. Additionally, linear stamped sherds (both corrugated and fragmentary) are not present in the Nukleet sample, although they appear at Iyatayet and Shaktoolik. The Thule component at Iyatayet also has a higher proportion of decorated sherds compared to the Thule sherds from Nukleet and Shaktoolik. The high proportion of decorated Thule sherds at Iyatayet is also notable compared to a general expectation for infrequent decorations on Thule sherds based on previous work (Table 1). This may suggest a bias towards collecting decorated sherds at Iyatayet, but the higher number of decorated sherds at Iyatayet compared to Nukleet, both excavated by Giddings (1964), indicates that this pattern is real and not a result of collection bias.

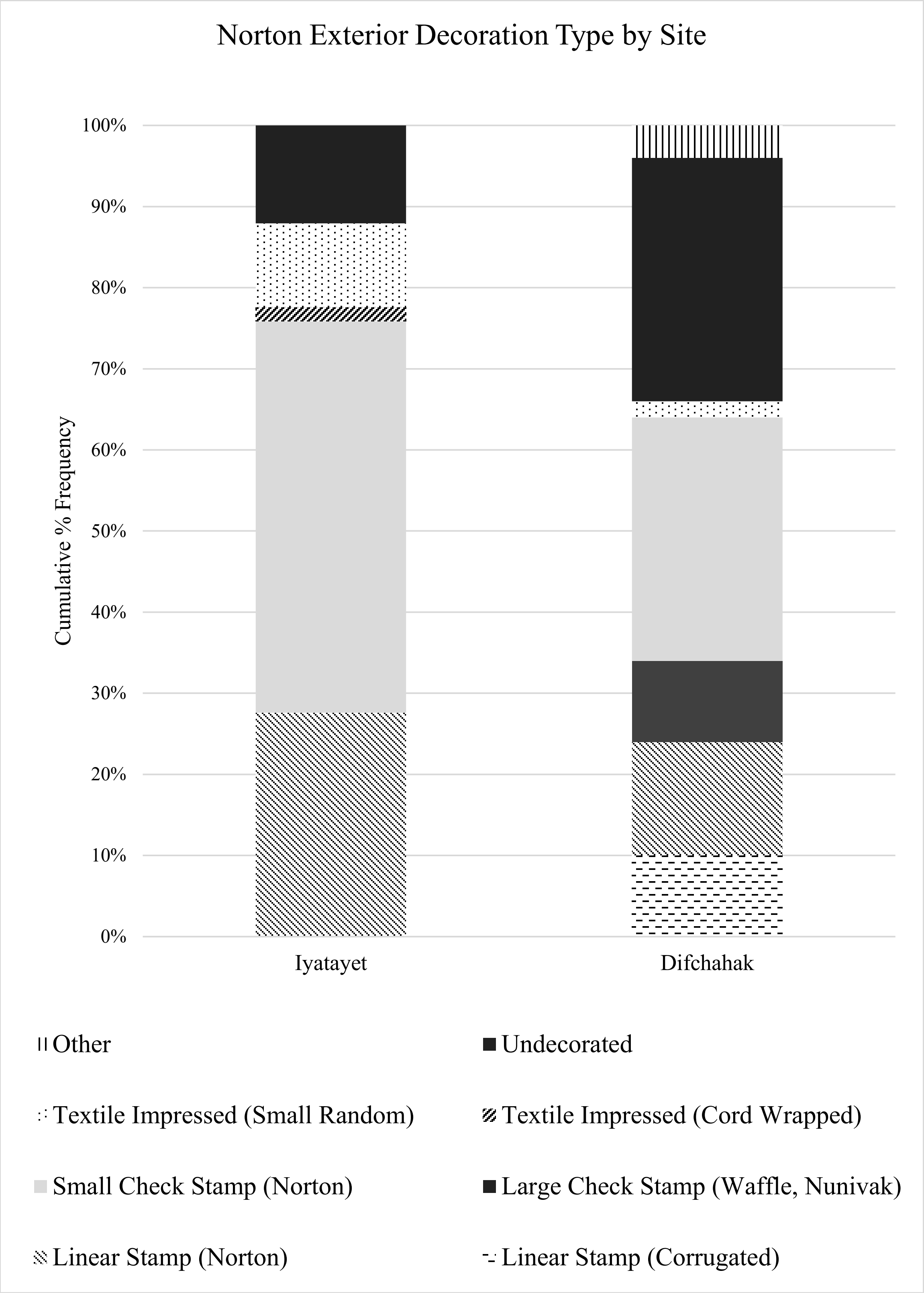


Figure 42. Norton exterior decoration type cumulative frequency by site within Norton Sound.

At both Iyatayet and Difchahak, decorated sherds make up 86% and 73% respectively of the Norton sample. Although Difchahak has a slightly lower percentage of decorated sherds, it contains more decoration types than the Iyatayet sample (Figure 42). Both sites have small check stamped (Norton) sherds, which is the most common decorative type at Iyatayet. Difchahak also has 5 sherds identified as large check stamp (Waffle, Nunivak). Although this decoration type is generally associated with Thule-era vessels, it may represent a variation on the Norton check stamp decorative tradition which includes larger impressed squares, originally appearing on St. Lawrence Island (Dumond 1969).

Comparison of Sherds from Outside Region

Norton body and rim sherd thicknesses from Northwest, Y-K, and Norton Sound sites fall between 6.6 and 8.5 mm (Table 29). Rim sherds from Y-K are significantly thicker than rim sherds from Norton Sound ($p<0.01$, $t=4.570$, $df=9$). No other differences in Norton mean wall thickness between regions are statistically significant. Rim and body sherd thicknesses of Thule sherds from the Bering Strait, North Slope, Northwest, and Norton Sound regions range between an average of 10 and 13 mm (Table 30). North Slope rim sherds are significantly thicker than rim sherds from Bering Strait ($p<0.01$, $t=2.902$, $df=46$), North Slope ($p<0.01$, $t=5.3732$, $df=67$), Northwest ($p<0.01$ $t=3.732$, $df=669$), and Norton Sound ($p<0.01$, $t=10.834$, $df=155$). Bering Strait rim sherds are significantly thicker than Norton Sound rim sherds ($p<0.01$, $t=3.755$, $df=137$) and Y-K rim sherds ($p=0.02$, $t=2.115$, $df=49$). Body sherd thickness is fairly consistent across regions, except for body sherds from North Slope which are significantly thicker than body sherds from Y-K ($p<0.01$, $t=3.640$, $df=145$) and Norton Sound ($p<0.01$, $t=8.448$, $df=231$). Mean body sherd thickness from Northwest sites has an extremely high standard deviation (Table 30) indicating a high level of variation between or within Northwest sites.

Table 29. Mean Norton wall thickness (mm) by region.

	Northwest			Y-K			Norton Sound		
	N	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**
Rim	11	7.5	1.2	5	8.5	0.6	6	6.6	0.8
Body	36	7.8	2.7	12	8.0	1.7	46	7.1	1.7

Table 30. Mean Thule wall thickness (mm) by region.

	Bering Strait			North Slope			Northwest			Y-K			Norton Sound		
	N	Mean (mm)	St. Dev.	N	Mean (mm)	St. Dev.	N	Mean (mm)	St. Dev.	N	Mean (mm)	St. Dev.	N	Mean (mm)	St. Dev.
Rim	15	11.1	2.0	33	13.1	2.3	638	10.8	3.6	36	9.8	2.0	124	9.5	1.5
Body	9	11.5	3.6	136	13.1	3.5	2250	12.6	56.6	11	9.2	2.0	97	9.7	2.2

Mean Norton vessel diameters are summarized in Table 31. The difference between mean rim and body sherd diameters for Northwest sites is not statistically significant (p=0.08, t=1.620, df=6), indicating that no significant orifice constriction occurs at the rim. This corresponds with the most frequent rim angle for Norton sherds across regions, which is vertical/direct. Norton body sherd diameters from Northwest sites are significantly wider than body sherd diameters from Norton Sound (p<0.01, t=2.953, df=21).

Mean Thule vessel diameters are summarized below in Table 32. Rim diameters from Bering Strait are significantly wider than rim diameters from North Slope (p<0.01, t=8.441, df=14), and rim diameters from Northwest sites are also significantly wider than rim diameters from North Slope sites (p<0.01, t=2.788, df=393). Body sherd diameters from North Slope sites are significantly wider than body sherd diameters from Y-K (p=0.01, t=2.329, df=55). No other differences between regions are statistically significant. Rim sherd diameters from Bering Strait, North Slope, and Northwest sites are all several centimeters lower than their respective mean body diameters, with the only significant difference occurring in sherds from the North Slope (p<0.01, t=3.060, df=55). Whether the general trend of narrower mean rim diameters indicates widespread orifice constriction is difficult to determine, as the most common rim angle type for Thule sherds across all regions is vertical/direct. Bering Strait sites have the closest distribution of Thule rim angle types to the Thule rims found in Norton Sound.

Table 31. Mean Norton vessel diameter (cm) by region.

	Northwest			**Norton Sound**		
	N	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**
Rim	4	20.0	9.7	6	26.3	13.5
Body	4	32.5	12.0	19	24.7	1.7

Table 32. Mean Thule vessel diameter (cm) by region.

		Bering Strait			**North Slope**			**Northwest**			**Y-K**			**Norton Sound**	
	N	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**	**N**	**Mean (mm)**	**St. Dev.**
Rim	5	29.6	2.0	11	19.5	2.3	324	28.2	13.0	7	23.6	6.5	71	23.7	8.5
Body	2	26.3	7.8	46	30.6	11.9	1175	29.8	25.1	11	21.5	10.4	70	27.4	15.5

Norton mineral temper density from Northwest Alaskan sites is most frequently medium, followed by low and high (Table 33). Mineral temper density from Y-K sites is most frequently low, followed by medium and high. High temper density was not identified in any Norton sherds from Norton Sound. Temper density for Norton sherds from that region was most frequently low. The differences in temper density between regions may be a result of different clay bodies, with greater or fewer natural mineral inclusions, or may represent specific choices made by Norton potters. Since multiple analysts collected data from all the sites in the regional database, it is also possible that there is inter-analyst error.

Table 33. Norton mineral temper density frequencies by region.

	Northwest	**Y-K**	**Norton Sound**
Low (<25% temper)	29	14	132
Medium (25-50% temper)	42	9	31
High (>50% temper)	12	2	2

Thule mineral temper density from Bering Strait and North Slope sites is most frequently medium, with a smaller number of sherds containing low and high temper density (Table 34). Mineral temper density in Thule sherds from Northwest sites is overwhelmingly low, followed by medium and high. Norton Sound sherds have a similar proportion of mineral temper densities to Northwest sites.

Table 34. Thule mineral temper density frequency by region.

	Bering Strait	**North Slope**	**Northwest**	**Y-K**	**Norton Sound**
Low (<25% temper)	4	69	6257	39	139
Medium (25-50% temper)	17	200	280	78	153
High (>50% temper)	3	146	16	42	60

Mineral inclusion size for Norton sherds from Northwest and Y-K sites is most frequently fine-medium, although mineral temper in Y-K sherds is overwhelmingly fine-medium, while sherds from Northwest sites are almost equally distributed between Fine-Medium and Coarse temper size classes (Table 35). This is fairly consistent with Norton Sound sherds, although temper size of sherds from Iyatayet is slightly more weighted towards fine-medium. Overall, Norton sherds in Northwest Alaska show more diversity in temper size and density compared to other Norton sites considered in this study.

Table 35. Norton mineral temper size frequency by region.

	Northwest	**Y-K**	**Norton Sound**
Fine-Medium (<0.5mm)	34	24	135
Coarse (0.5mm-2.0mm)	32	1	18
Very Coarse (>2mm)	17	0	21

Thule mineral temper size from Bering Strait sites is most frequently fine-medium, followed by very coarse and coarse (Table 36). North Slope sherds contain a majority of very coarse temper, followed by fine-medium and coarse. Potters on the North Slope of Alaska, which typically experiences more extreme weather conditions compared to other regions, notably a lack of warm, dry weather in the summer, faced many challenges to producing useable pots, which may explain the prevalence of very coarse mineral temper, as well as higher temper density. Norton Sound Thule sherds have a similar distribution of mineral temper sizes to Northwest sherds, although Norton Sound sites have a higher number of sherds with bimodal mineral temper. Environmental differences between regions during the Norton period may also have some bearing on mineral temper size, with sherds from regions located further north (Northwest, followed by Norton Sound) containing higher frequencies of coarse and very coarse mineral temper compared to sherds from further south (Y-K) (Table 35).

Table 36. Thule mineral temper size frequency by region.

	Bering Strait	**North Slope**	**Northwest**	**Y-K**	**Norton Sound**
Fine-Medium (<0.5mm)	13	95	2158	58	161
Coarse (0.5mm-2.0mm)	4	50	3250	27	143
Very Coarse (>2mm)	7	268	1233	74	110
Bimodal	0	2	5	0	15

Organic temper type frequencies vary noticeably between regions and across temporal periods. Norton sherds from Norton Sound, compared to Northwest and Y-K sites, have the greatest diversity of fiber temper types (Appendix A-19). Figure 43 shows that the organic temper most frequently identified in Norton sherds from Northwest Alaska and Y-K is unknown, followed by fiber. This may be due in part to inter-analyst differences resulting in varying identification of Norton temper types. The large number of Norton sherds found at Northwest sites where organic temper type was marked Unknown also suggests that we may not have adequate identification guidelines for the types of organic tempers used in Norton ceramics, due to the low number of Norton ceramics previously analyzed.

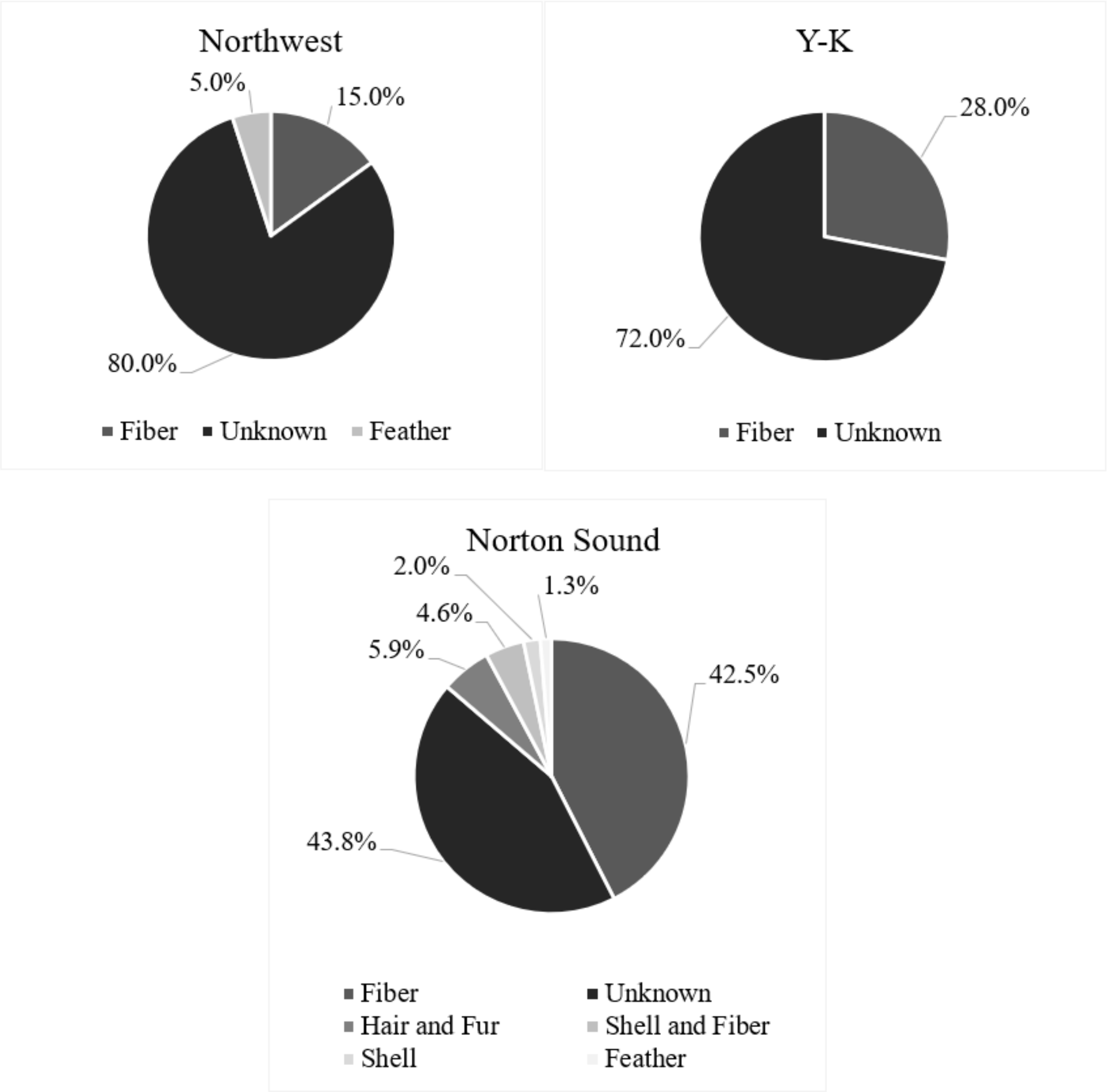


Figure 43. Percent frequency of Norton organic temper types by region.

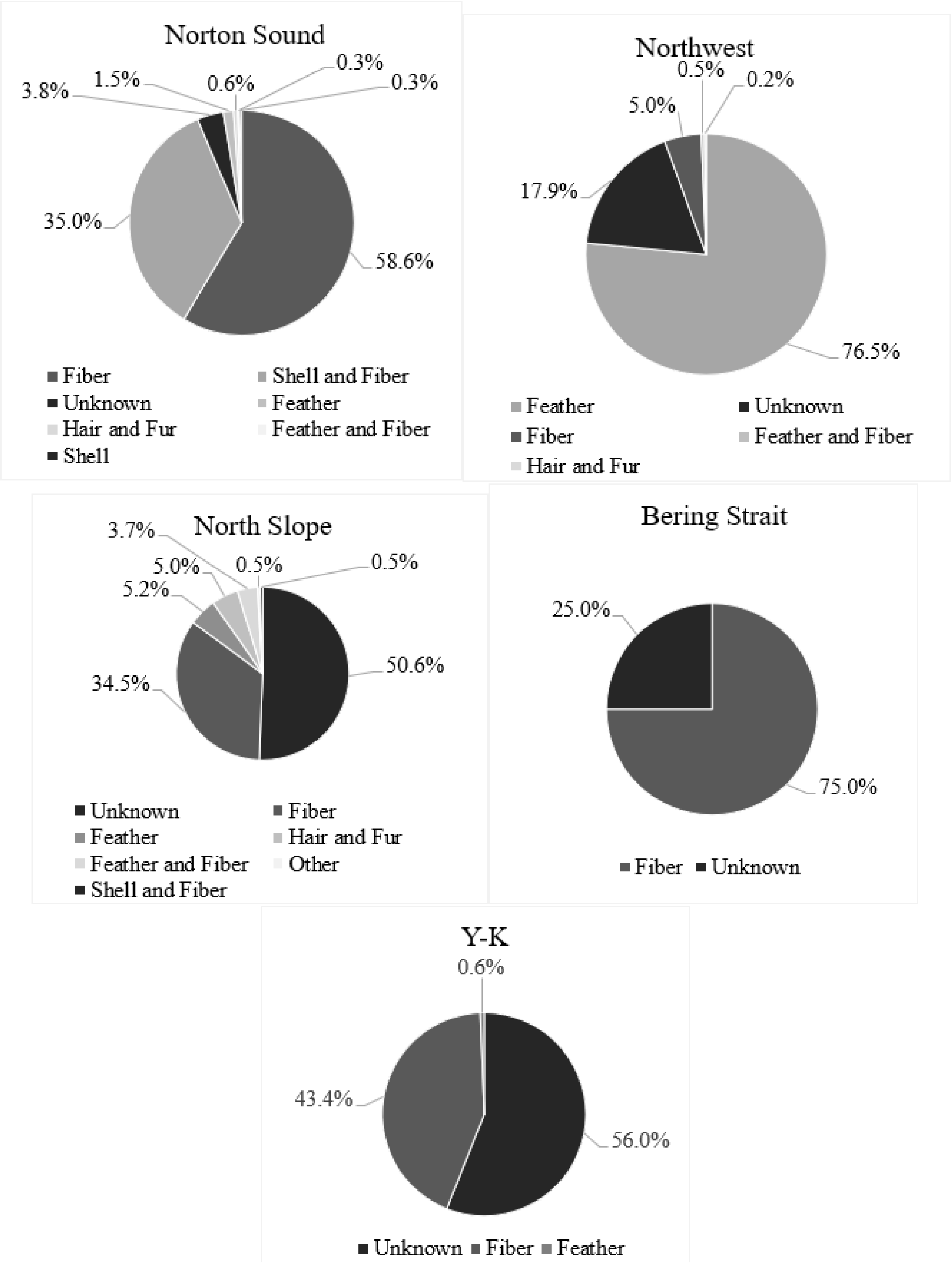


Figure 44. Thule organic temper percent frequencies by region.

Organic temper identified in Thule sherds by region has a wider variety of types compared to Norton sherds, as expected (Figure 44). Shell temper, either in combination with fiber or alone, is present only in the North Slope (two sherds) and Norton Sound (Appendix Table A-20). Feather temper, which occurs in low quantities in sherds from the North Slope, Y-K, and Norton Sound, is by far the most prevalent organic temper type in Northwest Alaskan pottery. The presence of some feather-tempered sherds at sites outside the Northwest region provides possible evidence of exchange of finished vessels from the Kotzebue Sound region.

Norton decorative types vary most between Northwest sites and Y-K/Norton Sound sites (Figure 45) although each region has overlap in the decorative types present, particularly small check stamp and large check stamp. The presence of sherds designated large check stamp may be a result of analyst error, as the two decorative types are similar in appearance and can be easily confused. There is also variability in the size and shape of the checks within the two styles, with some small check stamped sherds having longer, narrower checks, and others having fully square checks. There is also a regional offshoot of Norton small check stamp originating in St. Lawrence Island which has larger, more square checks (Dumond 1969) and may be represented in these data.

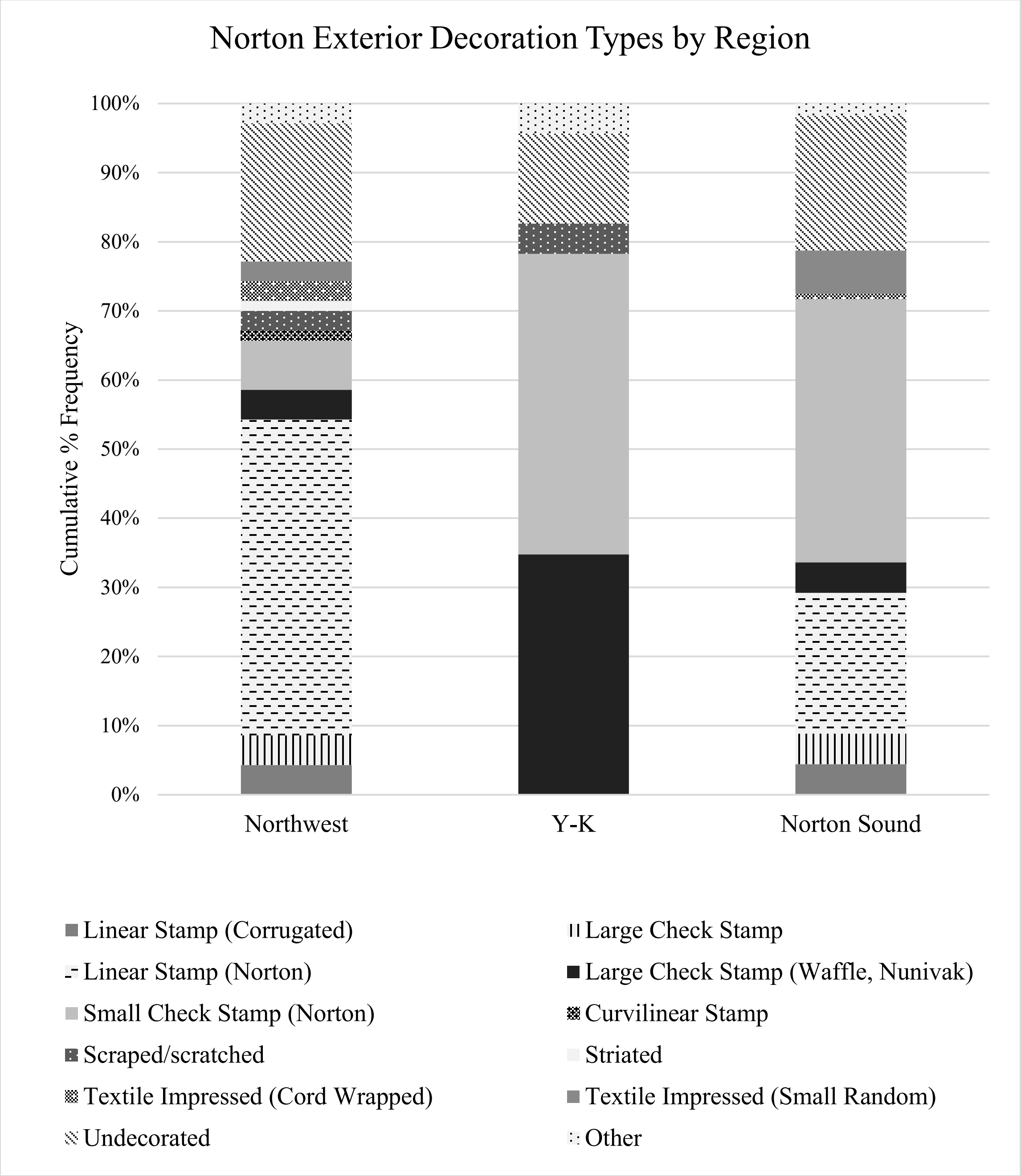


Figure 45. Cumulative percent frequency of Norton exterior decoration types by region.

Thule sherds are most frequently undecorated, regardless of region, aside from sherds from the Bering Strait, which have a greater than 50% proportion of decorated sherds (Figure 46). I expected to see a broader distribution of Yukon line/dot and Yukon lined decoration across regions, given its appearance in sites from the Seward Peninsula to Bristol Bay (Dumond 1969), and its presence at Nukleet in higher amounts than other decorative types. Yukon line/dot appears in Bering Strait, Northwest, and Norton Sound sites, and in the highest proportion in Bering Strait sites. Yukon lined appears only in Norton Sound. Large check stamped, which characterizes the decorated sherds in the Thule component at Iyatayet, is the most frequently occurring decorative type at Y-K sites, and appears in small quantities in Northwest. Linear stamp (corrugated) is the only decorative type aside from undecorated which appears in all five regions.

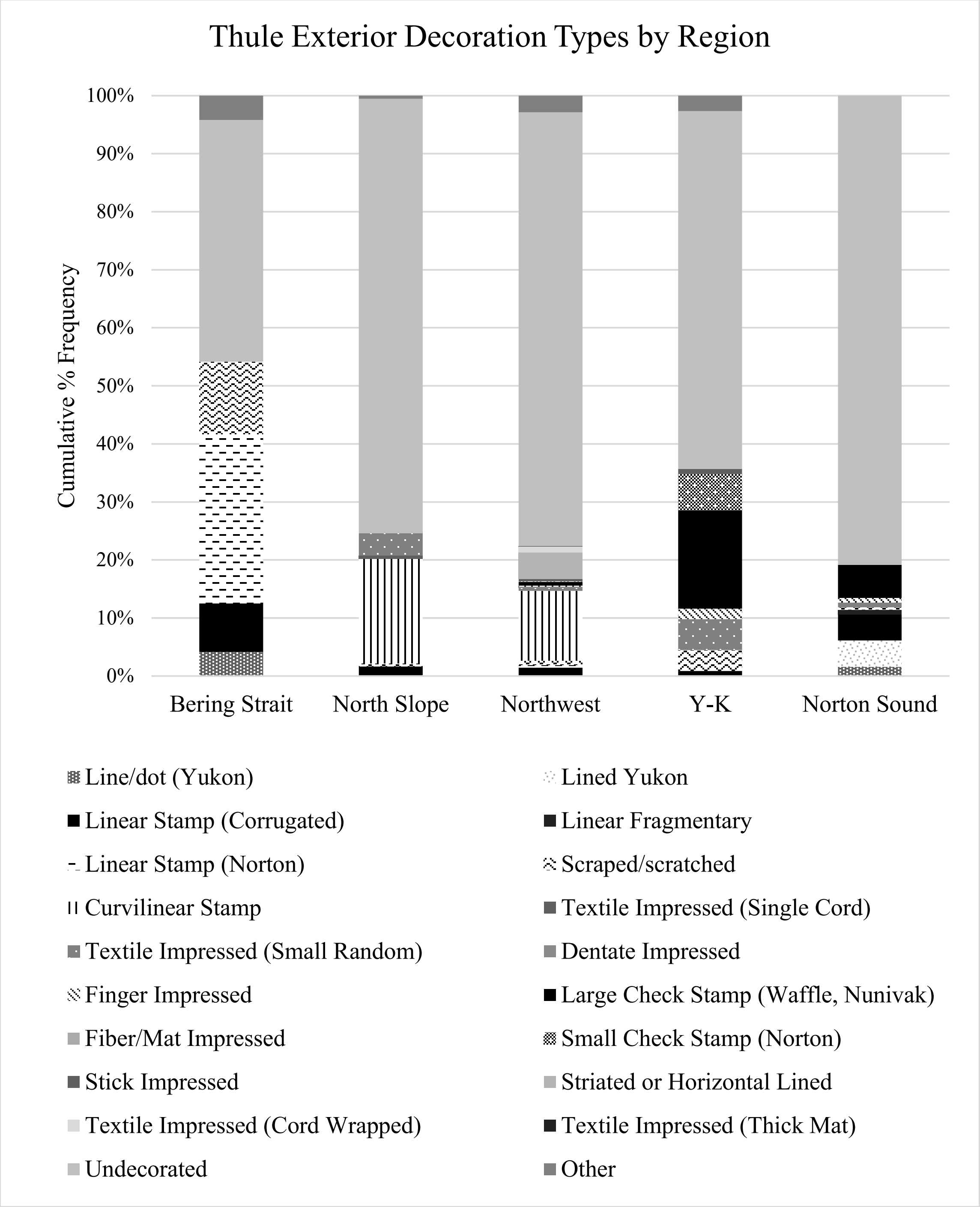


Figure 46. Cumulative percent frequency of Thule exterior decoration types by region.

Mohs hardness values for Norton sherds across regions fall between 1.5 and 4.5, with the highest frequency measuring 2.5 (Appendix Table A-13). There is greater variation in hardness during the Thule period overall, with most sherds measuring between 1.5 and 3.5 (Table 37, Appendix Table A-14). Norton Sound sherds display the greatest range in hardness of all regions. Northwest sites have a higher proportion of extremely soft sherds, measuring 1.5, compared to any other region. This is contrary to my expectation that North Slope sherds, which are extremely friable due in part to paste composition, extremely low firing temperatures, and freeze-thaw damage from permafrost, would have the highest proportion of soft sherds.

Table 37. Thule Mohs hardness value frequencies by region.

Mohs Hardness Value	Bering Strait	North Slope	Northwest	Y-K	Norton Sound
1.5	3	5	1709	4	6
2.5	11	159	2800	91	191
3.5	9	137	275	53	130
4.5	1	13	43	1	14
5.5	0	7	3	0	1
7.5	0	0	0	0	1

Norton sherds across all regions were most frequently fully reduced (Appendix A-15). Northwest sherds made up the highest proportion of sherds with oxidized exteriors and reduced interiors, followed very closely by sherds from Norton Sound. Y-K sherds were, after fully reduced, most frequently fully oxidized or had oxidized interiors and reduced exteriors. This may indicate that more Norton vessels from Y-K were fired under different conditions than vessels from other regions. Across all regions, Thule sherds are most frequently fully reduced, followed by oxidized exterior-reduced interior (Appendix Table A-16). Y-K Thule sherds have a similar pattern to Norton sherds from the same region, with oxidized interiors and reduced exteriors being the most frequent after fully reduced.

Norton rim angles by region are mostly vertical/direct (Table 38). The second most frequent rim angle for sherds from Y-K sherds is everted, and the second most frequent rim angle for Norton Sound sherds is incurved. Thule rim angles by region are summarized below in Table

39 and Figure 47. For all regions aside from Northwest, the most common rim angle was vertical/direct. For Northwest sherds, 31.5% were incurved, and 19.9% everted. Y-K had a larger percentage of recurved sherds compared to all other regions, indicating orifice constriction just below the rim, rather than at the rim itself. Bering Strait and Norton Sound sherds also show evidence of orifice constriction. North Slope has only two rim angle types present, and all orifices are open, rather than constricted. Rim angle plays a role in vessel performance, suggesting different intended uses for vessels although stylistic preferences may also play a role in regional variability.

Table 38. Norton rim angle frequency by region.

	Northwest		**Y-K**		**Norton Sound**	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Everted	0	0.0	1	16.7	0	0.0
Incurved	0	0.0	0	0.0	3	25.0
Vertical/Direct	4	100.0	5	83.3	9	75.0

Table 39. Thule rim angle frequency by region.

	Bering Strait		**North Slope**		**Northwest**		**Y-K**		**Norton Sound**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Everted	1	6.7	6	15.0	185	19.9	1	2.6	8	5.0
Incurved	3	20.0	0	0.0	293	31.5	1	2.6	43	26.7
Recurved	1	6.7	0	0.0	2	0.2	13	33.3	13	8.1
Vertical/Direct	10	66.7	34	85.0	449	48.3	24	61.5	97	60.2

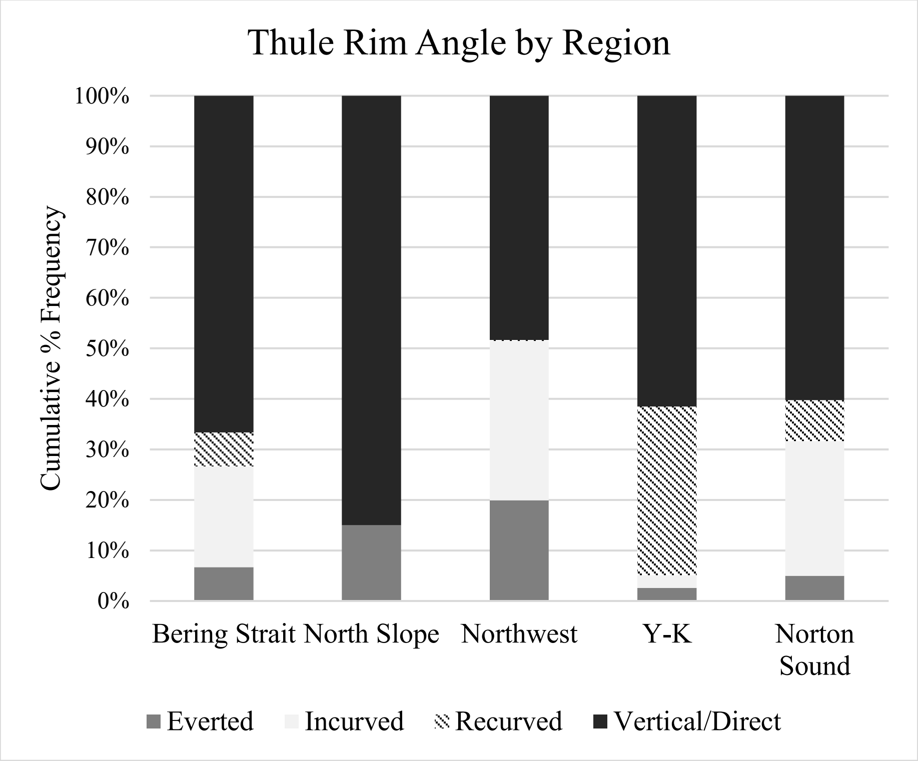


Figure 47. Thule rim angle cumulative percent frequency by region.

4.3 Test Tiles

The first test conducted on the ceramic tiles after fabrication was a hardness test. Despite expectations that a post-firing surface treatment of oil would increase hardness, hardness remained consistent for all test tiles regardless of temper type and surface treatment, measuring 2.5 on the Mohs scale. This value falls within the range of Mohs hardness for Norton and Thule sherds (2.5 to 3.5) despite differences in firing conditions and preservation between my experiments and the archaeological materials analyzed in this study.

Mean relative porosity for each of the temper combinations, both with and without cod liver oil surface treatment, is summarized in Appendix Table A-21, and displayed below in Figure 48. The results of the relative porosity test show a trend of overall lower relative porosity values for the tiles with oil surface treatment compared to the tiles without, indicating that application of oil was successful in sealing some of the pores in the fired tiles.

Mineral temper alone had no significant effect on porosity compared to the control tiles with no temper, regardless of whether the tiles had oil surface treatment ($p=0.43$, $t=0.176$, $df=8$) or no surface treatment ($p=0.08$, $t=1.627$, $df=6$) (Figure 48). Control tiles with no temper had the second lowest relative porosities regardless of surface treatment, after mineral tempered tiles. These findings are in line with my expectations that tiles with no or only mineral temper would have the lowest porosity.

Fiber temper significantly increased porosity in comparison to the control tiles with oil surface treatment ($p<0.01$, $t=8.218$, $df=8$) and without ($p<0.01$, $t=4.711$, $df=8$). Fiber temper also significantly increased porosity in comparison to mineral-tempered test tiles, both with oil surface treatment ($p<0.01$, $t=11.154$, $df=8$), and without ($p<0.01$, $t=5.651$, $df=8$). Fiber-tempered tiles compared to test tiles with shell and mineral temper were not significantly more porous, with oil surface treatment ($p=0.26$, $t=0.661$, $df=8$) or without surface treatment ($p=0.30$, $t=0.542$, $df=8$). Fiber and Mineral temper in combination did not significantly increase porosity compared to the control tiles which had no surface treatment, however fiber and mineral-tempered tiles with oil surface treatment were significantly more porous than control tiles with surface treatment ($p<0.01$, $t=7.664$, $df=8$). Tiles with mineral, fiber, and shell temper were not significantly more porous than tiles tempered with fiber only, whether with oil surface treatment ($p=0.04$, $t=1.985$, $df=8$) or without ($p=0.22$, $t=0.795$, $df=8$). These findings suggest that the addition of fiber temper, regardless of combination, significantly increased relative porosity of the test tiles, even when treated with oil, because the fiber burned out during firing, leaving behind a higher number of pores in the ceramic paste.

Shell temper without surface treatment had no significant impact on porosity, but in tiles with oil surface treatment, shell temper significantly increased porosity compared to the control (p<0.01, t=4.054, df=8). Shell and mineral temper in combination significantly increased porosity in test tiles with no surface treatment compared to the control (p<0.01, t=4.841, df=8) as well as in test tiles with oil surface treatment (p<0.01, t=3.777, df=8). This is contrary to my expectation that shell temper would behave the same way as mineral temper. Instead, it appears to increase porosity, although not as much as fiber temper does. Tiles with only shell temper were significantly less porous than fiber-tempered tiles without surface treatment (p<0.01, t=4.789, df=8), although there was no statistically significant difference in porosity between shell and fiber-tempered tiles when a surface treatment of oil was applied (p=0.31, t=0.527, df=8).

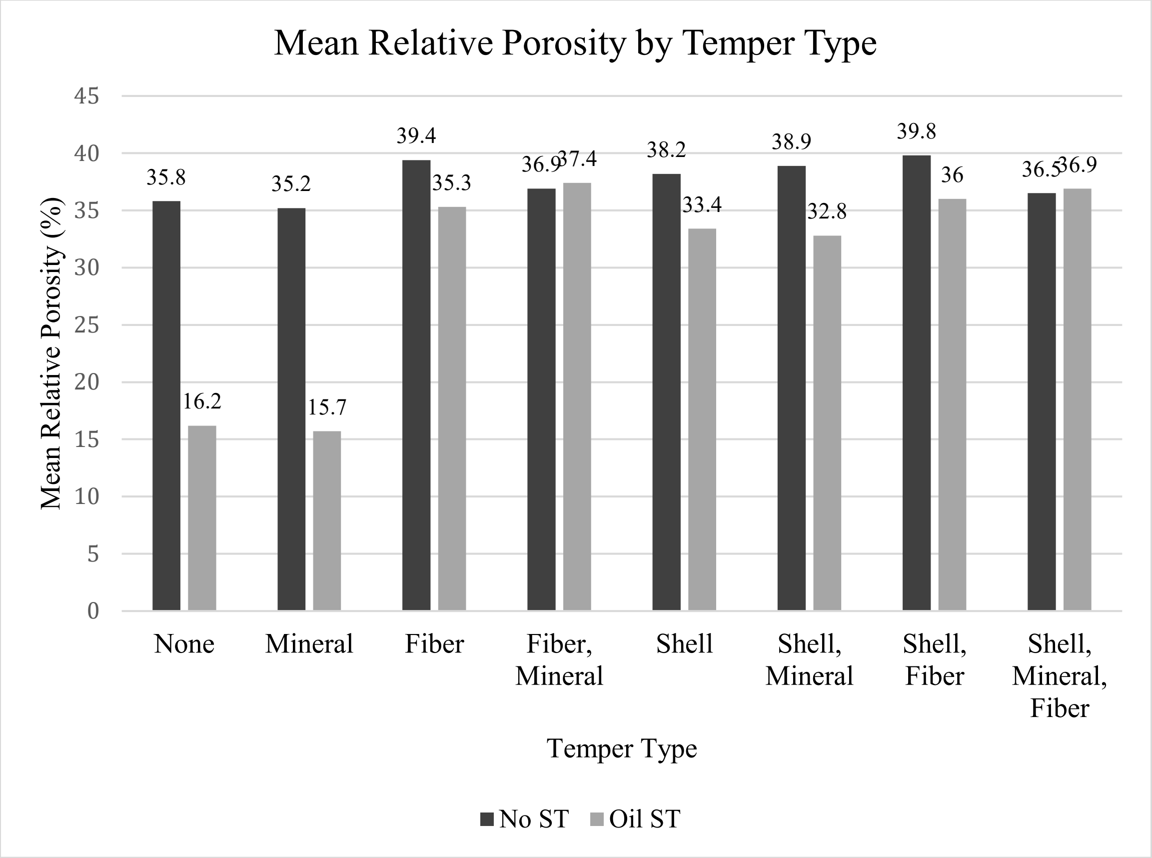


Figure 48. Mean relative porosity (%) of test tiles with different temper types and surface treatment (ST).

Mean breakage weight (kg) varied for each temper and surface treatment combination (Table 40, Figure 49). Tiles with cod liver oil surface treatment generally had a lower breakage weight compared to tiles with no surface treatment. This result was contrary to my expectation, indicating that the addition of an oil surface treatment reduced the amount of weight test tiles could withstand before breaking. These differences are statistically significant when compared to tiles of the same temper type without surface treatment for shell and mineral-tempered tiles ($p<0.01$, $t=14.221$, $df=8$), and shell, mineral, and fiber-tempered tiles ($p=0.01$, $t=2.773$, $df=8$). Only tiles with oil surface treatment and either no temper or mineral temper were stronger than the same tiles without surface treatment (Table 40), however these differences are not statistically significant. Tiles with shell temper or a combination of shell and mineral temper had the highest mean breakage weights for tiles without surface treatment, compared to the untempered control, however these differences are not statistically significant ($p=0.22$, $t=0.819$, $df=6$ and $p=0.32$, $=0.479$, $df=6$).

Tiles with fiber temper alone or in combination had a lower breakage weight compared to other temper types (Figure 49), indicating that the addition of fiber temper lowered the strength of the test tiles, as expected. Fiber-tempered tiles with oil surface treatment were significantly weaker than the control tiles without oil surface treatment ($p<0.01$, $t=4.215$, $df=8$), as were fiber and mineral tempered tiles ($p<0.01$, $t=4.201$, $df=8$). No significant differences existed between shell and fiber tempered tiles regardless of surface treatment type.

The results of the breakage test are complicated by the presence of occasional natural gravels in the clay which were not detected and removed prior to fabricating the tiles. The tiles tended to break where inclusions were present, and this may have resulted in premature failures of certain tiles. It is likely however that pre-colonial Arctic potters faced the same challenges, as their ceramics frequently appear to contain natural mineral inclusions instead of or in addition to other tempering agents, based on personal observation. Nevertheless, one benefit conferred by surface treatment was apparent when looking at fragmentation rates after the breakage test. Table 41 shows that in some cases, though not all, tiles broke into fewer pieces if they were pre-treated with cod liver oil. This was especially true for tiles with mineral and/or shell temper, indicating that adding an oil surface treatment to mineral and shell tempers may have an impact on the amount of force applied to the breakage point. Even in the case of a mineral or shell-tempered vessel breaking, it might more easily be repaired, due to the lower fragmentation rate.

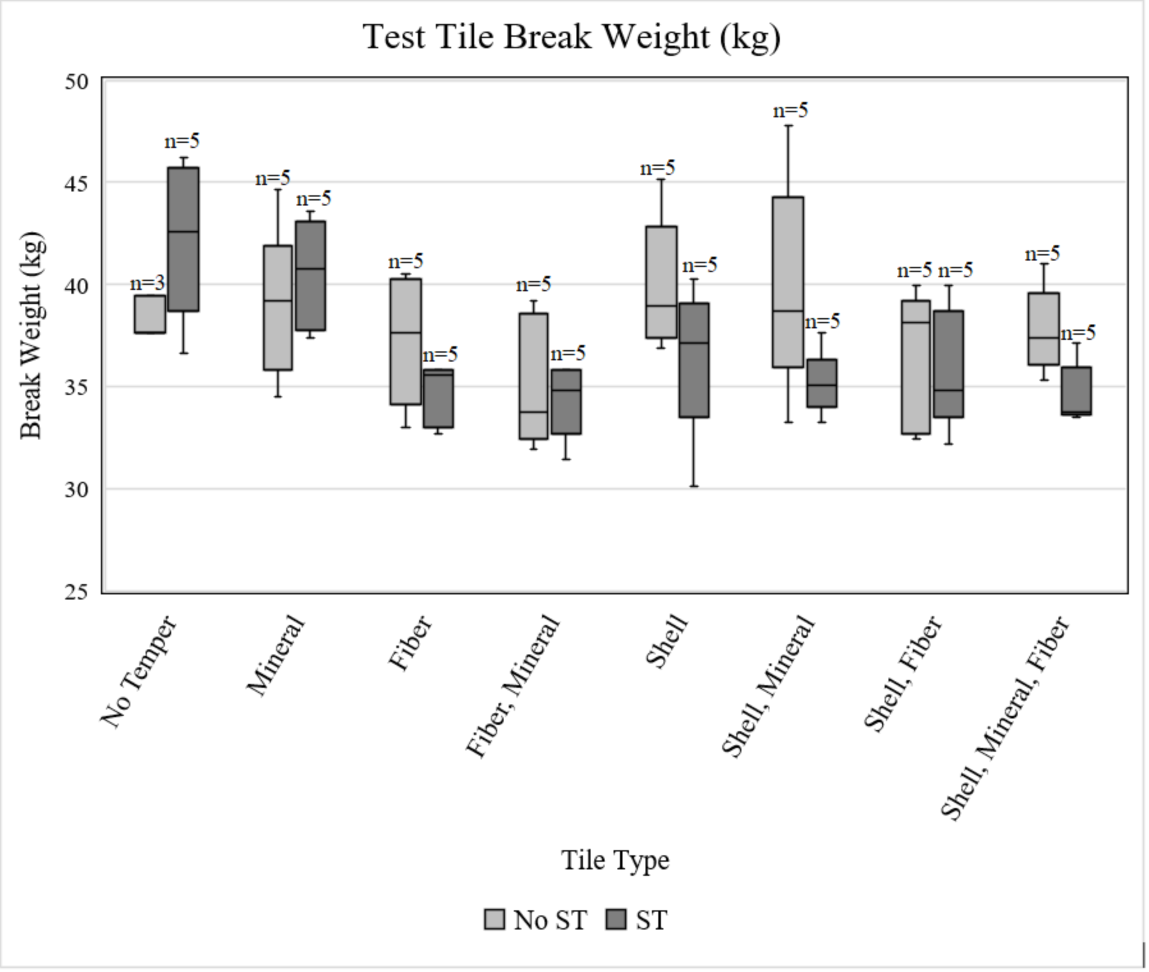


Figure 49. Median, high, low, and quartile values of load required to break test tiles (kg) by surface treatment (ST).

Table 40. Mean load (kg) and standard deviation required to break test tiles by temper type.

Temper Type	N	No Surface Treatment	Standard Deviation	N	Oil Surface Treatment	Standard Deviation
No Temper	3	38.3	1.0	5	42.3	3.8
Mineral	5	38.9	3.7	5	40.5	2.7
Fiber	5	37.3	3.2	5	34.6	1.5
Fiber, Mineral	5	35.2	3.2	5	34.4	1.8
Shell	5	39.9	3.2	5	36.5	3.8
Shell, Mineral	5	39.8	5.2	5	35.2	1.6
Shell, Fiber	5	36.4	3.4	5	35.8	3.0
Shell, Mineral, Fiber	5	37.8	2.1	5	34.6	1.5

Table 41. Mean fragmentation of tiles (# of pieces) in tensile strength test.

Temper Type	No Surface Treatment	Oil Surface Treatment
None	2.6	2.6
Mineral	4.2	2.4
Fiber	2.8	2.8
Fiber, Mineral	4.2	3.2
Shell	4.2	3.2
Shell, Mineral	5.2	3.4
Shell, Fiber	4.2	2.6
Shell, Mineral, Fiber	2.6	2.8

4.4 Cooking Experiments

Indirect heating using hot rocks was by far the fastest heating method of the three tested (Table 42, Figure 50, Appendix Table A-23, A-26), and did not result in any catastrophic failures impacting the performance of the pots. No superficial damage to the interior or exterior of each pot was observed either. The process of adding and replacing the rocks displaced approximately 150-200ml of water per trial, and added ash to the contents of the pots, although this could be mitigated by quickly rinsing the rocks before adding them to the pot contents. There was no significant difference in time to boil between Norton and Thule pots when used for indirect heating (p=0.41, t=0.246, df=6).

Direct heat boiling took slightly longer for Norton vessels than for Thule vessels (Table 42, Appendix Table A-22, A-25), although this difference is not statistically significant (p=0.40, t=0.297, df=5), due to the high standard deviation of boiling times for Thule vessels. Some pots sustained damage through cracking, spalling, and in one case the complete detachment of the pot base (Norton, 2.03). Nevertheless, the water remained clean for the whole heating process, and aside from occasionally refreshing the coals around the pot, did not require much effort to heat. In the second heating trial with pre-used pots, mean times for both Norton and Thule pots decreased, although not significantly (Table 43).

Suspended heat was the least effective method for bringing water to a boil using either Norton or Thule pots (Table 42, Appendix Table A-24, A-27). When attempting to bring pot contents to a boil, water temperature tended to plateau around 93 degrees Celsius, only sufficient for bringing the water to a light simmer. During initial trials with the suspended heating method, I prepared a bed of coals beneath the pots, per previous research done on the subject (Briggs 2016). However, for Norton and Thule-style pottery, being suspended 10 cm over a bed of coals failed to bring all but one of the pots to a boil. Only those pots which successfully brought water to a boil are included in the data, resulting in a lower sample size for the Thule suspended heat trial (1 pot) compared to the other trials (3 to 4 pots). A very hot fire beneath the suspended pot was required to bring the contents to a boil. This may have been a result of the type of wood used for the fire, since non-hardwood coals radiate less heat.

Table 42. Mean minutes to boil for each heating method using first-use pots.

	Norton			**Thule**		
	N	**Mean Minutes to Boil**	**St. Deviation**	**N**	**Mean Minutes to Boil**	**St. Deviation**
Direct	3	22.3	5.5	4	20.5	9.2
Indirect	4	4.7	1.1	4	4.9	1.2
Suspended	2	30.1	9.1	1	28.2	n/a

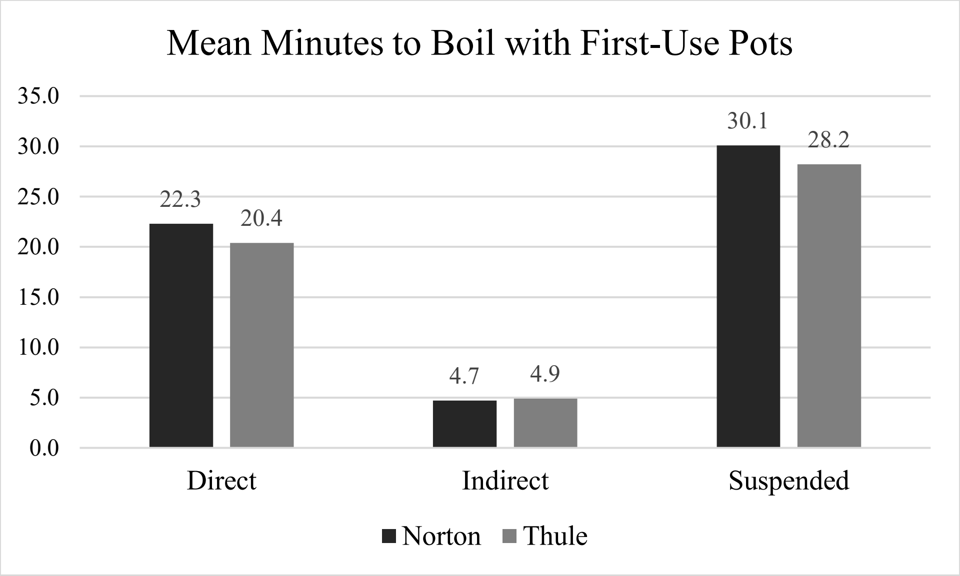


Figure 50. Mean Minutes to boil for each heating method using first-use pots.

Two pots with minimal breakage (for instance, only minor cracks or potlid fractures) from each category were re-used for a second cooking trial in order to understand whether heat-seasoned pots performed differently than first-use pots. They were not re-coated with cod liver oil, as I wanted to see whether heating water in the coated pots during the first trial helped seal the pores, reducing porosity and potentially also decreasing time to boil.

Mean time to boil for direct heat was several minutes lower for both Norton and Thule vessels during the second trial, a statistically significant difference (p=0.05, t=2.470, df=3 and p=0.12, t=1.362, df=4 respectively) (Table 43, Figure 51, Appendix Table A-28). Indirect and suspended times to boil also did not significantly change in the second trial for either Norton or Thule vessels. Thule vessels appeared to take longer than Norton vessels to boil using suspended heat in the second trial, although this difference is not statistically significant (p=0.16, t=1.340, df=2). Small sample size and high standard deviations for suspended heating trials in particular make it difficult to draw meaningful conclusions from the data. The pre-used pots also largely held up to a second round of heating, with minimal additional damage aside from some pot-lid fracturing on the exteriors.

Table 43. Mean minutes to boil by heating method using second-use pots.

	Norton			**Thule**		
	N	**Mean Minutes to Boil**	**St. Deviation**	**N**	**Mean Minutes to Boil**	**St. Deviation**
Direct	2	11.4	3.1	2	11.1	0.1
Indirect	2	3.3	1.0	2	4.2	0.1
Suspended	2	26.3	8.2	2	34.2	1.5

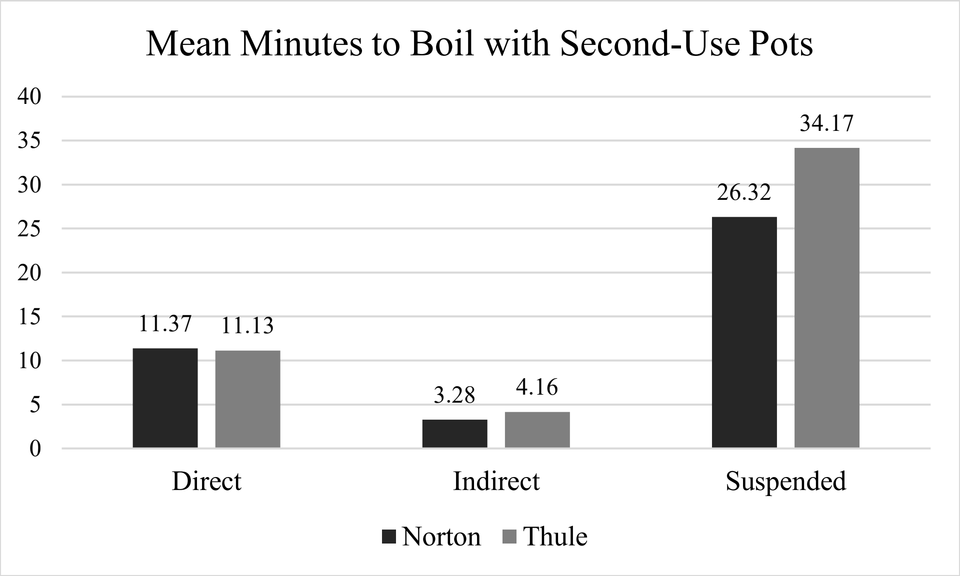


Figure 51. Mean minutes to boil by heating method with second-use pots.

Figure 52. (Left) Pot-lid fracture on exterior of pot used for direct heat, dark areas are likely due to contact with smoke. (Center) Ashy interior of pot used for indirect heat, otherwise interior and exterior surfaces are intact. (Right) Evidence of sooting on base of pot used for suspended heat.

Damage and visible effects of heating varied by heating method on the exteriors and interiors of the experimental vessels. In about 50% of cases, direct heat resulted in pot-lid fractures on the exterior of the pots (Figure 52), as well as cracks either running from the rim towards the base or around the base at the slab break. Some of the cracks were hairline and did not affect performance of the vessels for heating, although in two instances resulted in catastrophic failure due to water loss. Exterior surfaces also show evidence of smoking, due to close prolonged proximity to smoke from the fire the vessels were placed in. 6 total first-use vessels showed significant damage which impacted performance, 3 of which were Norton (vessels 2.01, 2.02, 2.03) and 3 Thule (vessels 6.01, 6.02, 6.03). Indirect heat did not result in any damage to vessels, although the rocks occasionally fractured due to thermal shock when taken from the hot fire and added to cold water. Ash and grit from fractured cooking rock was visible on the interior of the indirect heat pots (Figure 52). Suspended heat resulted in exterior sooting on the vessel base, as well as some basal damage due to thermal shock including in one instance the complete detachment of the base around the slab break. Only 1 vessel (Norton, 3.01) sustained damage while used for suspended heating which impacted performance.

Chapter 5: Discussion and Conclusions

Despite the frequent occurrence of ceramics at Neo- and Paleo-Inuit sites throughout Northern Alaska, the performance of their technical characteristics has not been thoroughly investigated. The goal of my thesis research was to address through ceramic analysis and experimental replication how ceramics were used to process food by cooking in the Western Arctic (Table 44). More specifically, my thesis addresses the following questions:

- What were the performance characteristics of pottery from NOB-0002 (Iyatayet) and NOB-0001 (Nukleet)?
- What were the intended uses of pottery from NOB-0002 (Iyatayet) and NOB-0001 (Nukleet)?
- How did people in the Arctic cook with ceramic vessels in the past?
- How do technological choices influence the performance of ceramics for food processing?

Table 44. Summary of research questions, hypotheses, expectations, analysis methods, and observations.

Research Question	**Hypothesis**	**Expectations**	**Analysis Method**	**Observations**
How do technological choices influence performance of ceramics for food processing?	Choices in temper type and surface treatment will enhance performance of the vessel for cooking.	Surface treatment of oil increases strength and decreases porosity. Mineral and/or shell temper increases strength and does not affect porosity. Fiber temper decreases strength and increases porosity	Test tiles - hardness, porosity test, biaxial strength test	Temper type and surface treatment have a significant effect on performance. Mineral and shell temper do not decrease strength. Mineral temper does not affect porosity. Shell temper increases porosity. Fiber temper decreases strength and increases porosity.
How did people in the past cook with ceramic vessels?	The cooking method used will be best suited to the performance characteristics of each vessel type.	Thin-walled vessels with primarily mineral temper are best suited for direct-heat cooking. Thick-walled vessels with a combination of mineral and fiber tempers are best suited for indirect-heat cooking.	Cooking trials using three heating methods: direct heat, stone-boiling, and suspended heat with replicated vessels.	The differences in performance of Norton and Thule vessels when used to boil water were minimal Thin and thick-walled vessels are equally capable of cooking either with direct or indirect heat Indirect heat is the fastest method of bringing water to a boil regardless of pot type.

5.1 Performance Characteristics of Ceramics at Iyatayet and Nukleet

The Norton and Thule sherds I analyzed from NOB-0001 and NOB-0002 conformed largely to my expectations for Norton and Thule pottery based on prior understandings of the two traditions. Norton vessels at Iyatayet are thin-walled vessels with low amounts of fine-medium mineral temper and some organic temper, usually fiber, shell and fiber, or hair and fur. The majority of vessel diameters fall between 12 and 28 cm. Rims are typically direct, without orifice constriction. The vessel exteriors are usually decorated, most often with small check stamped designs. Overall, most of the metric data I gathered for Norton vessels from Iyatayet falls within the range of expected parameters for Norton vessels, and are not significantly different aside from the presence of shell temper either alone or in combination with fiber temper, which does not appear in any other Norton assemblages in the Northern Ceramics Regional Database. The prevalence of small check stamp decoration at Iyatayet and low frequencies of other Norton decorative types is also distinctive.

Thule vessels at Nukleet and Iyatayet shared similarities in size and wall thickness, with moderately thick walls of approximately 9mm, and most vessel diameters ranging between 13cm and 31cm. Low density of fine-medium temper was noted in Thule ceramics from both sites, although Thule sherds from Iaytayet had lower overall amounts of mineral temper and smaller mineral temper size than Thule sherds from Nukleet, which had more instances of coarse and very coarse temper and higher temper densities. The two assemblages differed most in types of organic temper used at each site as well as exterior decoration. Rim angles at Nukleet were most frequently vertical/direct, followed by incurved, while rim angles at Iyatayet were most frequently incurved.

Body sherds make up the bulk of both the Norton and Thule samples I analyzed, with smaller quantities of rim and base sherds. One notable difference between the samples, however, is the proportion of rim to body sherds, which for the Norton assemblage is much smaller than the

Thule. Norton rim sherds make up approximately 18% of the total number of Norton sherds, while Thule rim sherds make up approximately 43%. The trend continues for the other Norton sites I looked at, in the Northwest, Yukon-Kuskokwim, and Norton Sound regions, with rim sherds making up between approximately 4 and 25% of the total number of sherds per assemblage, compared to Thule rim sherds from Bering Strait, North Slope, and Northwest regions, where rims make up between approximately 57 and 83% of the total number of sherds. This may be explained by differences between vessel and rim diameters – for instance, more globular vessels with constricted rims may have a higher proportion of body sherds to rim sherds – although for the Norton sample I did not identify any significant differences in rim or body diameters. Rim diameters for Norton and Thule vessels at Nukleet and Iyatayet have roughly within the same distribution, with the majority of vessels from both traditions ranging between 21 and 27cm. Norton vessels may have been taller than Thule vessels, resulting in more body to rim surface area, although this cannot be confirmed due to the lack of complete vessels in my sample, as well as the general scarcity of complete vessels for either tradition. Differential preservation likely contributes to the disparity in vessel part, with more fragile, friable Thule vessels fragmenting more than Norton vessels after deposition. Collection bias may also play a role. Given that Thule sherds are more frequently undecorated than Norton sherds, and some Thule decorative types are concentrated around the rim, there may have been more incentive to preferentially collect rim sherds from Thule contexts.

One of the most interesting results of my comparison of Nukleet and Iyatayet ceramics to the regional database was the presence of shell temper in Norton sherds from Nukleet and Iyatayet. Shell temper occurs in only two sherds outside the Norton Sound region, in the North Slope. Otherwise, shell temper either alone or in combination is particular to the Norton Sound region, and especially Cape Denbigh, as no sherds from Difchahak or Shaktoolik contained shell temper. One possible explanation is regional availability. Kotzebue Sound, in Northwest Alaska, has a small amount of available shellfish, specifically clams, which may have resulted in less shell available for potters (burned or unburned). This explanation does not account for the absence of shell temper at sites where shellfish are otherwise present, such as Difchahak, unless the vessels were made elsewhere (Miszaniec et al. 2021). Although burning and then crushing the shells involved some time investment on my part, shells used by Norton and Thule potters may have already been burnt as a result of heating them to cook their contents, expediting the process. The reasons for the selective use of shell temper may reflect other considerations, such as performance (Bebber et al. 2018, Feathers 2006).

Giddings (1964) noted the presence of shell temper in some Thule sherds at Nukleet, as well as possible crushed limestone temper in a small number of sherds from the same site. Both are forms of calcium carbonate, and do not appear significantly visually different in some case, although limestone temper tends to look more like white gravel, as opposed to the plate-like inclusions of crushed shell. The proximity of the Nukleet site to a limestone cliff would make limestone temper a locally available material (Giddings 1964). Although compositionally the same, limestone and shell tempers have slightly different performance characteristics in fired vessels. Limestone tempered vessels have greater strength, as defined by ability to withstand initial fracture, compared to shell tempered vessels, which have greater toughness as defined by resisting deformation under stress (Bebber et al. 2018). Thus, limestone tempered vessels may have held up better to the stressors of transport, while shell-tempered vessels may have held up for longer after initial fracture (Bebber et al. 2018). These performance characteristics may have been valuable for Arctic potters, given the transport of pots as part of their seasonal rounds, as well as the need for pots to remain usable even if fractured or cracked. The combination of locally available shell with durability needs may therefore have resulted in shell temper use on Cape Denbigh by potters living in the area.

Organic temper types in general varied widely between regions. My analysis of the ceramics in the regional database showed distinctive organic temper use in Northwest Alaska (feather) and Norton Sound (shell), aside from the ubiquity of fiber temper, which appeared in all regions considered in my analysis. Some regions, such as Y-K, the Bering Strait, and Northwest had low variation in organic temper types, while other regions such as the North Slope had a wider range of tempers in excavated sherds. This may result from resource availability, but may also be evidence of trade in finished vessels. Ethnographic and archaeological evidence points towards the exchange of ceramic vessels in Alaskan networks prior to the 20th century (Burch 1998). Prior research shows that a mix of locally-made and traded vessels appear at many sites throughout Northwest Alaska (Anderson et al. 2011). Based on the assumption that vessels of similar composition are likely clustered in the areas where they were made and used, it appears that the majority ceramic vessels at Nukleet and Iyatayet were produced in the area, rather than coming from further afield, due to their distinctive composition and the low frequency of temper types associated with other regions. The two North Slope sherds containing shell temper may represent evidence of trade in finished vessels between the North Slope and Norton Sound. The presence of five Thule sherds with feather temper in Norton Sound also suggests some exchange in finished vessels with Northwest Alaska.

The distinctiveness of Thule pottery from Iyatayet and its similarity to pottery from the Norton component at the same site suggest to me that it is possible some regional differences stem from more than resource availability or intended function. Thule potters at Iyatayet may have modelled the composition and decoration of their wares on Norton pottery present at the site. The high percentage of decorated sherds in the Thule component at Iyatayet, along with the decorative types present (particularly large check stamp), as well as the prevalence of fine-medium mineral temper all bear more similarity to the Norton component at Iyatayet than other Thule pottery from Norton Sound. See Section 2.3 for a discussion of why this may be the case.

Differences in ceramic assemblages within the Norton Sound region show the difficulty with making broad generalizations about regionally-specific characteristics. Changes in pottery form and possibly function occurring within the Thule period, from early to late, may also be responsible for the variation between Thule ceramic assemblages within Norton Sound. Radiocarbon dates for Cut A at Nukleet indicate that the assemblage is from the Late Thule period, reinforced by the presence of later line-dot ceramics as opposed to the curvilinear stamped ceramics Giddings (1964) identified at the site in the early Thule component. In Northwest Alaska, vessel wall thickness and rim diameters fluctuated over time throughout the Thule period. The differences between early and late Thule pottery may reflect changes in intended use of the vessels (Reed et al. 2019) although more analysis and experimental research is necessary to understand how and why ceramic technology changed during that period.

5.2 Intended Uses of Ceramics at Iyatayet and Nukleet

My analysis of the technical choices made by Norton and Thule potters at NOB-0001 and NOB-0002 provided sufficient evidence to infer intended use of the vessels at both sites. Norton vessels were most likely used for direct or indirect heat. Exterior exfoliation of Norton sherds may have been a result of thermal shock either during firing or from direct contact with a heat source during cooking, providing evidence of direct heat cooking. Exterior decoration, including check stamping and corrugation, may also have conferred advantages when used for direct heat, as there is some evidence that deeply textured exterior surfaces may mitigate thermal shock and increase ease of handling the vessels (Schiffer et al. 1994, Pierce 1999). The prevalence of vertical/direct rims supports the hypothesis that they could have been used for indirect heat cooking as open, non-constricted orifices aid vessel content manipulation, which is required when adding and removing hot rocks. The Norton vessels at Iyatayet were not modified for use with suspended heat, due to the absence of suspension holes, although this does not rule out the possibility that other suspension methods could have been employed. Holes are scarce in Norton sherds as a whole, with only two Norton sherds from Northwest Alaska containing holes, which may have been used for repair rather than suspension.

Based on my analysis, the only hypothesized cooking method during the Thule period supported by direct evidence at either Nukleet or Iyatayet is suspended heat. Holes were present in five Thule sherds: three found at Nukleet and two at Iyatayet. The holes are assumed to be suspension holes as they were not close to the edges of the sherd, which might be the case if the holes were used for mending broken or cracked pots. However, due to the frequency of fully reduced sherds, exterior sooting was not a meaningful metric to look at when attempting to interpret actual use of pots, as it could not be identified from already very dark, reduced sherds. Why the suspension holes present in Thule vessels at Nukleet and Iyatayet were drilled into the walls post-firing is unclear. Although, it could be that the vessels were not purpose-built to be used for suspended heat, but were later modified as conditions changed or the need arose. The disadvantage of drilling suspension holes after pot fabrication is that it places pressure against the wall of the pot, during the drilling process, which may damage the vessel. Perhaps suspended heat was not the preferred method of cooking, but used when other heating methods were unavailable.

Thule vessels at both Nukleet and Iyatayet also show evidence of being used for direct heating. Extensive exterior exfoliation of Thule sherds, including some pot-lid fractures observed during my analysis, suggest direct contact with a heat source either during firing or cooking. As is the case with decorated Norton sherds at Iyatayet, the prevalence of large check stamp sherds in the Thule component at Iyatayet may have been intended to mitigate thermal shock and improve vessel handling when used for direct heat. This type of exterior decoration is absent on the ceramics from Nukleet. Further support for regular use of direct heating during the Thule component at Iyatayet comes from vessel shape. Thule vessels from Iyatayet have the highest proportion of incurved rims of all regions included in my analysis. The high frequency of incurved and vertical/direct rim sherds points towards intended use for direct heat cooking. A very low number (<5%) of rim sherds from Nukleet and Iyatayet are everted, most similar in proportion to sites in Y-K. Everted sherds are most clearly linked to use for indirect heating, due to the openness of the orifice allowing for access to vessel contents. These metrics suggest that performance characteristics related to direct heat cooking may have been incorporated into the pottery made by potters at Iyatayet more than at Nukleet.

5.3 How Were Arctic Ceramics Used for Cooking?

Arctic women, identified as both cooks and potters in the ethnographic record, were likely concerned with producing technology well-suited to processing foods in desired ways. A variety of moist heat food preparation methods are documented in ethnographic research on traditional Inuit cuisine, including boiling, poaching, simmering, and blanching (Spray 2002). In some cases, multiple food preparation methods were employed, for instance poaching frozen fish, or boiling partially-dried fish (Harry and Frink 2009, Jones 2006, Jolles 2002). Contemporary and pre-colonial Arctic cooks had detailed knowledge of which preparation methods worked best for different foods, in line with taste preferences, food safety, nutritional value, and efficiency.

Direct heat was the riskiest method for cooking as it resulted in the highest amount of damage impacting pot performance out of all heating methods for both Norton and Thule pots. Even cosmetic damage such as smaller pot-lid fractures worsened over time with repeated use, resulting sometimes in pot failure. Vessels which survived initial heating could be used to bring their contents to a boil quite rapidly, approximately 11 minutes with second-use pots. For the first direct heating trial, however, the rate of vessels which incurred damage due to thermal shock was 50%. There was no significant difference between performance of Norton and Thule pots in terms of minutes to a boil, when heated directly in a fire.

Indirect heat cooking was the fastest method of bringing water to a boil, between approximately 4 and 6 minutes, with no significant differences between Norton and Thule vessel heating times. This finding differs from the results of prior experimental work by Harry and Frink (2009), who found that stone boiling with a larger fire, similar to mine, was comparable in terms of minutes to boil to direct heat boiling, but not significantly faster. They also found that when simulating a fuel-scarce environment, limiting the amount of wood used for the fire, the stones failed to heat sufficiently to bring the contents of any of their test vessels to a boil. Differences in stone size and fire temperature may contribute to the disparate results between our two experiments, as Harry and Frink used larger cobbles than I did, which may take a longer time to absorb sufficient heat.

I found that stone boiling resulted in the least amount of damage to the vessels, with no damage visible on either first- or second-use pots. Disadvantages to this method include the displacement of vessel contents by the addition of cooking rocks. I used small rocks, never more than two at a time, and each trial typically displaced around 100-200ml of water. This would not pose a problem for larger pots, although for smaller vessels such as the ones I produced, which measured approximately 15cm in diameter, it would represent a significant loss.

Suspended heating was the least effective method for bringing water to a boil in either Norton or Thule pots. Although the contents of the pots were brought to a simmer through suspended heat, I was unable to bring most pots fully to a boil, even after building hotter fires beneath the suspended pots. Although this represents a failure in terms of my stated goal, it is notable that the contents of pots suspended over heat maintained a stable temperature for a long period of time once the water reached approximately 93^{0} C, even when heating times exceeded 35 minutes. Further trials comparing temperature stability for each of the three heating methods would be valuable here. Performed differently, suspended heat may be a more effective method to bring water to a boil than my study suggests, given the logistical constraints I experienced during my experiments as well as my own inexperience, which likely resulted in an increased rate of failure.

The failure of most pots to bring water to a boil when suspended over a fire may ultimately have been desirable for Thule cooks, given ethnographic evidence that water was not boiled but brought to a simmer to aid in defrosting food. Simmering was used to render fat into oil or grease, either from fish or terrestrial mammals such as caribou, as oils were more easily skimmed off the top of simmering water rather than water brought to a rolling boil (Harry et al. 2009, Anderson et al. 2011). Oil and grease could also be collected from broth once it had cooled (Burch 2005). Furthermore, taste preferences for thawed or partially-cooked foods would only have required water to be brought to a simmer (Spray 2002).

The quality of the wood may also have contributed to the failure of the suspended heat trials. Briggs (2016) specifies that hardwood coals reach high temperatures and radiate heat for up to 45 minutes without replenishing. The kiln-dried pine board ends used for my experiments burned hot (upwards of 500C at their maximum, measured using a thermocouple) but quickly, and the coals did not radiate heat for as long as other species, and required frequent refreshing. Thule people had preferences for which kinds of wood to use for which purposes, and may have chosen a different species of wood to burn when cooking suspended over a fire, although ethnographic evidence points towards Sitka spruce which is quite similar in properties to pine being one of the most popular woods for firewood (Alix 2005). Ethnographic reports also point towards pots suspended over lamps, which would be unlikely to bring the contents to a boil, given the small but concentrated amount of heat generated by seal oil lamps. Thus, boiling the contents may not, as previously discussed, have been the priority with this method of cooking.

Some of the difficulties I experienced when trying to boil water in Norton and Thule pots included creating and maintaining a bed of hot coals which generated sufficient heat to boil the contents of pots suspended above them over an extended period of time. The fire required constant replenishing and was rarely hot enough to bring the contents of the pots suspended above it to a boil. High levels of fat found saturating the charcoal in hearth features at Cape Espenberg (KTZ-087 and KTZ-088), along with burned bone, indicate that other materials were used to supplement driftwood and/or brush fires (Crawford 2012). This practice has also been documented in the ethnographic record (Birket-Smith 1929) and at other Inuit archaeological sites (Alix 2003). These fires would undoubtedly have had different properties than the fires I used to heat water in this study. Fires composed of 80% bone and 20% wood by weight have been shown in an experimental study to burn the longest, compared to fires with less bone and more wood (Thery-Parisot 2001).

The addition of fat to the fires, particularly marine mammal fat, may have prolonged the fires' duration, although animal fat does not burn more easily or hotter than dry wood (Buonasera et al. 2019 and Vanlandeghem et al. 2020). The autoignition point of animal tallow is around 375 C, and pine wood is around 300 C. Through personal observation of attempting to cook over oil lamps, I have found that when mammal oils such as bear grease and seal oil are burning, skewers of meat held over the flames cooks surprisingly quickly. It is possible, therefore, that pots with suspension holes may have also been used to successfully heat water over seal oil lamps, particularly lamps with multiple wicks, although testing this hypothesis must remain the subject of future research.

Norton hearths show evidence of similar practices, particularly the presence of burned bone (although not noted in significant quantities) and oil-soaked charcoal. The construction of Norton hearths over a bed of sand may have been advantageous to heating and conserving fuel. Sand has a low heat transfer coefficient, allowing it to heat quickly, hold in heat, and maintain temperature for a long period of time, compared to hearths with a clay substratum (Brodard et al. 2016). Hearths constructed in sand may also have aided in the firing process. Personal observations from conducting pit-firings in beach sand east of Cape Nome indicate that burying the just-fired vessels in sand and leaving them overnight allows them to cool slowly, preventing breakage. Firing features identified archaeologically and described in the ethnographic record suggest that Arctic pots were fired in pits lined either with rocks or sand (Anderson 2019). Norton hearths built into sand pits likely radiated more heat, and stayed hot for longer than fires built in soil or clay alone, and may have aided Norton cooks in bringing the contents of pots to temperature faster, and sustaining that temperature without excessive fuel consumption.

Cooking experiments using more intense heat sustained for a longer period of time through the addition of bone and oil may change the performance of Norton and Thule pots when used for direct, stone-boiling, and suspended heating. A comparison of cooking with only wood, and cooking with a mixture of wood, bone, and oil may also show whether fuel scarcity, and by extension the need for fuel conservation, played as much of a role in cooking strategies as previously hypothesized. It is possible that cook-time was less of a consideration given the ability to build and sustain fires using a minimal amount of wood (as little as 20% by weight in some cases). Cooking over sand, rather than soil, would also be an interesting point of comparison which may highlight the specific choices made by cooks during the Norton period.

The differences between Norton and Thule pottery traditions have informed hypotheses that Norton and Thule pots perform differently during cooking. My research shows that both pottery traditions are highly flexible, able to be used for indirect and direct heat cooking without significant differences in the performance of both vessel types, once they have been seasoned by prior use. This is in line with recent research which shows similarity in the diets of Norton and Thule people, consisting of a combination of aquatic and terrestrial resources including fish, marine mammals, and caribou (Tremayne et al. 2018).

Thule pottery performed “better” (in the sense of fewer minutes to boil) when used for the first time for suspended heating, while second-use Norton pottery took less time to reach a boil when used for the same heating method. Overall, the minor differences between the performance of Norton and Thule replicated pots, and the significant differences in terms of cook-time caused by my own skill in building and maintaining sufficiently hot fires, suggest that the technological choices of Arctic potters in the past had less of a bearing on their ability to use pots for a variety of heating methods than previously expected. Norton and Thule pots, when used for direct heat cooking, tended to function in roughly the same way once the initial learning curve of how to heat ceramic pots in a fire leveled out. Second-use pots, seasoned by use, displayed even less of a difference in heating time. This leads me to believe that there may be other factors influencing the choices made by Norton and Thule potters resulting in two highly distinct pottery traditions.

One of the possible explanations for the differences between Norton and Thule pottery is that production costs – specifically, the costs of raw material procurement, vessel production, and firing – outweighed cooking performance. During short Arctic summers, women had a wide range of subsistence tasks to perform, including fishing and plant and raw material gathering, into which clay procurement, pottery production, and firing needed to be included (Anderson 2019). Collecting clay, processing it to workability, adding tempers, forming the pots, and then eventually firing them represented a significant time investment. Although some aspects of pottery production such as clay and temper procurement may have been easily folded into other tasks (Anderson 2011, 2019), the economic risk associated with taking time away from some foraging or hunting activities to pottery tends overall not to favor pottery production in hunter-gatherer societies (Eerkens 2003). Pottery is produced by hunter-gatherers primarily when that technology confers economic benefits outweighing the costs of producing it. The desirability of processing fish, marine mammal, and terrestrial mammal foods through simmering or boiling to increase caloric yield, food safety, and palatability indicates that ceramic technology was a worthwhile investment for Arctic potters during the Norton and Thule periods, despite the level of effort required. Nevertheless, these constraints may have influenced how much effort could be expended in producing ceramic vessels, and the specific constraints may have been different for Norton and Thule potters.

Producing costly vessels which perform well only when used in one specific cooking method may not have been an efficient choice, resulting in vessels with more than one intended use. Fuel scarcity or cooking location may have played a role in what cooking method was employed by Norton and Thule women. Cooking over small household fires, as in Thule kitchen alcoves, limited fire size which likely made stone boiling a less attractive heating method (Harry and Frink 2009). Norton central hearths could have allowed for larger fires, making other heating methods feasible, including stone boiling. Fuel scarcity may also not have been constant, but varied seasonally, or after a long period of occupation in one place, and would also require vessels to be flexible in terms of how they could be used. Poor preservation of organic materials at some Norton sites (i.e. Bundy 2007) makes it difficult to determine how intensive Norton use of driftwood was, although it is found most often in house structures. Thule people used wood in a variety of ways, including structures and boats. The increase in population during the Thule period may have placed greater demands on the driftwood supply, potentially making fuel scarcity more of a concern when cooking.

5.4 Performance Characteristics of Norton and Thule Ceramics

How a vessel performs when used for cooking is dependent not only on the heating method used but also the performance characteristics of that vessel given the specific technological choices involved in its production. Temper, wall thickness, and vessel shape all play a role in performance, and are linked to specific properties (see Chapter 2.5 and Table 4 for a detailed discussion of these characteristics and how they relate to each other). The desirable characteristics of some temper types may be outweighed by their disadvantages when used, particularly when used in high quantities.

My analysis shows that Thule pots contained coarser mineral temper and higher mineral temper density than Norton pots, although temper density was low for the majority of Norton and Thule pots at Nukleet and Iyatayet. This may be a result of Arctic potters trying to reduce vessel weakness caused by high amounts of mineral and organic temper. Nevertheless, the presence of mineral temper suggests Arctic potters were attempting to mitigate the damaging effects of thermal shock caused by direct exposure to heat. It also increases durability, as shown by the higher break weight (kg) values for test tiles with mineral temper, as compared to test tiles containing fiber temper, in my experimental study. Test tiles with shell temper alone or in combination with mineral temper had comparable break weights to tiles with mineral temper alone. The addition of mineral temper to wet clay also increases its strength and usability when building vessels, which was notable in my experimental replications. The lower density and size of mineral temper at Nukleet and Iyatayet, compared to other ceramic assemblages outside the region, may be a result of less concern on the part of Norton Sound potters about thermal shock if they were using the vessels for indirect or suspended heating, or may simply reflect aspects of the local clays they were using to produce vessels, since more plastic clays would require less mineral temper to be workable.

Organic temper helps speed drying time and reduces cracking during the firing process, both desirable characteristics for potters in the Arctic (Harry et al. 2009a). The presence of mineral temper, shown in fragmentation rates of the test tiles in my experimental study, increases the number of fragments each tile broke into, while tiles tempered with fiber had lower fragmentation rates. The addition of fiber temper, on the other hand, increases relative porosity as shown by the higher levels of relative porosity in test tiles which contained fiber temper as opposed to tiles with no organic tempering agents. Shell temper also increased relative porosity of test tiles, compared to mineral temper alone. That increase in porosity was mediated in some cases by the addition of cod liver oil as a post-firing surface treatment, however it did not significantly reduce relative porosity for test tiles containing fiber or shell temper (either alone or in combination with other temper types).

Porosity also proved to be a significant problem during the initial trial of cooking, with pots losing upwards of 150-200ml of water (out of 500ml to start with) during the heating process, although part of the water loss may also be attributed to evaporation. The success of re-used pots in the second round of cooking trials suggests that even with the surface treatment of oil, the process of cooking (namely, heating water in the coated pot) helped reduce porosity further, decreasing cook times significantly. This finding is in line with prior experimental work (Harry et al. 2009) and several ethnographic accounts which document seasoning pots with oil or broth (Anderson 2019, Harry et al. 2009). Porosity was not expected to be as problematic for the replicated Norton pots, which did not contain organic temper. Phase I of my experimental research supported this expectation, as ceramic tiles with mineral temper only showed statistically similar relative porosity to the control tiles with no temper. After a surface coating of cod liver oil, the control and mineral temper only tiles showed significantly lower relative porosity, indicating that the surface treatment was highly effective at preventing moisture from entering the pores of the tiles.

This work shows Norton potters also faced significant challenges to cooking in ceramic vessels using suspended and direct heat caused by high porosity. Despite a surface coating of cod liver oil applied to the interiors and exteriors of the pots, there was a significant amount of evaporation (150-200ml) in four of the first-use Norton pots before boiling temperatures could be reached. Two of the pots were heated using suspended heat, and the other two were heated using direct heat. The exterior surfaces of the pots showed evidence of moisture seeping through the clay body, and steamed when directly adjacent to the heat of the fire. These observations suggest that despite lower amounts of mineral temper in the Norton pots, and an absence of shell or organic temper, porosity still affected the performance of Norton pots on their first use. Second-use Norton pots did not show signs of extensive evaporation, suggesting that heating water in a pot treated with oil helps seal the pores. The addition of a surface coating of oil was therefore essential to the usability of porous Thule pots, and served as a mitigating factor for the porosity caused by the inclusion of fiber or shell temper.

Despite the usefulness of the oil surface treatment to reduce porosity, thereby increasing the cooking performance of the pots, the major drawback to surface treatment was my finding that oil surface treatment reduced the strength of the test tiles. Vessel strength is an important consideration for mobile populations, or when vessels are incorporated as part of trading networks, as more durable vessels have a lower chance of breaking during transit. The reduction in strength caused by adding oil surface treatment only occurred for tiles with certain temper combinations – shell and mineral, and shell, mineral, and fiber. There was no significant difference between treated and untreated tiles with no temper or mineral only temper, suggesting that potters could make specific choices in temper type to maintain vessel strength despite application of an oil surface treatment. Under some conditions, such as pots intended to be used in one location rather than traded or brought with people on their seasonal rounds, the trade-off between decreased porosity and decreased strength would not necessarily pose major problems. For vessels intended to travel longer distances, specific temper choices could help mitigate the decrease in strength associated with oil surface treatment.

It is necessary also to consider performance characteristics of Norton and Thule pottery beyond their technical performance – that is, the way they may have been intended to perform socially or ideologically. Increased visibility through decoration is useful for trade or exchange with people from other regions (Skibo and Schiffer 1997), and the diversity of decorative types present on Thule vessels, as well as their regional distribution, may be linked to the trade in finished ceramic vessels in Alaska (Anderson et al. 2011). The proliferation of decorative types during the Thule period may also have been a means to signal identity, perhaps on a village level, given the clear differences between decorative types between Iyatayet and Nukleet, despite their geographic proximity. The visual qualities of Norton pottery, generally described as more finely made and more frequently decorated than Thule pottery, may also reflect whether or not it was intended to be seen. The centrality of Norton hearths may indicate that ceramic vessels were more on view to family members and guests in Norton homes, as cooking occurred in the main room, rather than in a cooking alcove. Visual qualities may also have been important for ceramics used in social gatherings such as feasts and trade fairs, an integral part of the yearly cycle in the ethnographic period and almost certainly earlier (Atkinson et al. 2021).

5.5 Future work

This thesis comprises one part of a larger research project in conjunction with Dr. Shelby L. Anderson and Dr. Tammy Buonasera. Although my research for this study focused primarily on ceramic performance, I also produced samples for future residue analysis. Five of the vessels produced for my study were also used to cook caribou and sheefish samples from Northwest Alaska to provide a baseline for the comparison of archaeological residue samples. Potential avenues for future research expanding upon these results include testing the performance of other types of oil surface treatments, such as seal oil. Seal oil coated pottery could then be used to boil caribou, in order to provide a second controlled sample of sherds with a mixed terrestrial and marine lipid residue signature.

Additional future work which would benefit the research I began in this thesis includes more practice making and using the pots, as well as more heating trials, may also contribute to higher rates of success and a more accurate reflection of Arctic cooking. The role expertise plays in achieving meaningful results through experimental archaeology is clear from my experiences with this study. Arctic potters and cooks in the past were highly skilled in producing pottery and using it, after a lifetime of observation and practice. The overall decrease in minutes to boil per heating method with successive trials suggests that as my skills increased, the quality of my data increased as well. Additionally, the metric of boiling may be invalid given the strong possibility that Arctic cooks only needed to simmer vessel contents rather than boil them. Further trials calculating the number of minutes each vessel type takes to reach a simmer may yield valuable results on vessel performance.

The point-estimate technological investment model (PEM) introduced by Bettinger et al. (2006) demonstrates that there is a threshold of use (measured in time or total caloric yield) before which a more expensive but more productive technology is too costly to manufacture compared to the benefits of using it. Future research utilizing this model could calculate the advantages and disadvantages of using pottery as a cooking method in terms of time costs, and provide further analysis on why Arctic potters made specific choices when making and using ceramics.

Further research into regional variation using the Northern Ceramic Regional Database is forthcoming, in collaboration with Dr. Shelby Anderson, and will expand upon the findings summarized in my thesis. This research will also include a statistical assessment of inter-analyst error within the Northern Ceramic Regional Database, which would help us better understand and use the data collected in the database, especially considering the number of analysts who have worked on it over time, as well as the changing definitions and metrics guiding their analysis, based on revisions of the ceramic analysis handbook associated with the database. This would also help future researchers identify which data is most reliable, as well as which data requires standardization.

The statistical trends identified in my analysis of regional variation in ceramics can build upon work by Anderson and Freeburg (2011) to further understand economic interactions between groups across the Western Arctic, as well as potentially clarify the relationship between ceramic variability and traditional ethnic/linguistic boundaries. This would in part help increase archaeological understandings of population movement and interaction during the pre-colonial and colonial periods.

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Appendix A: Additional Tables and Figures

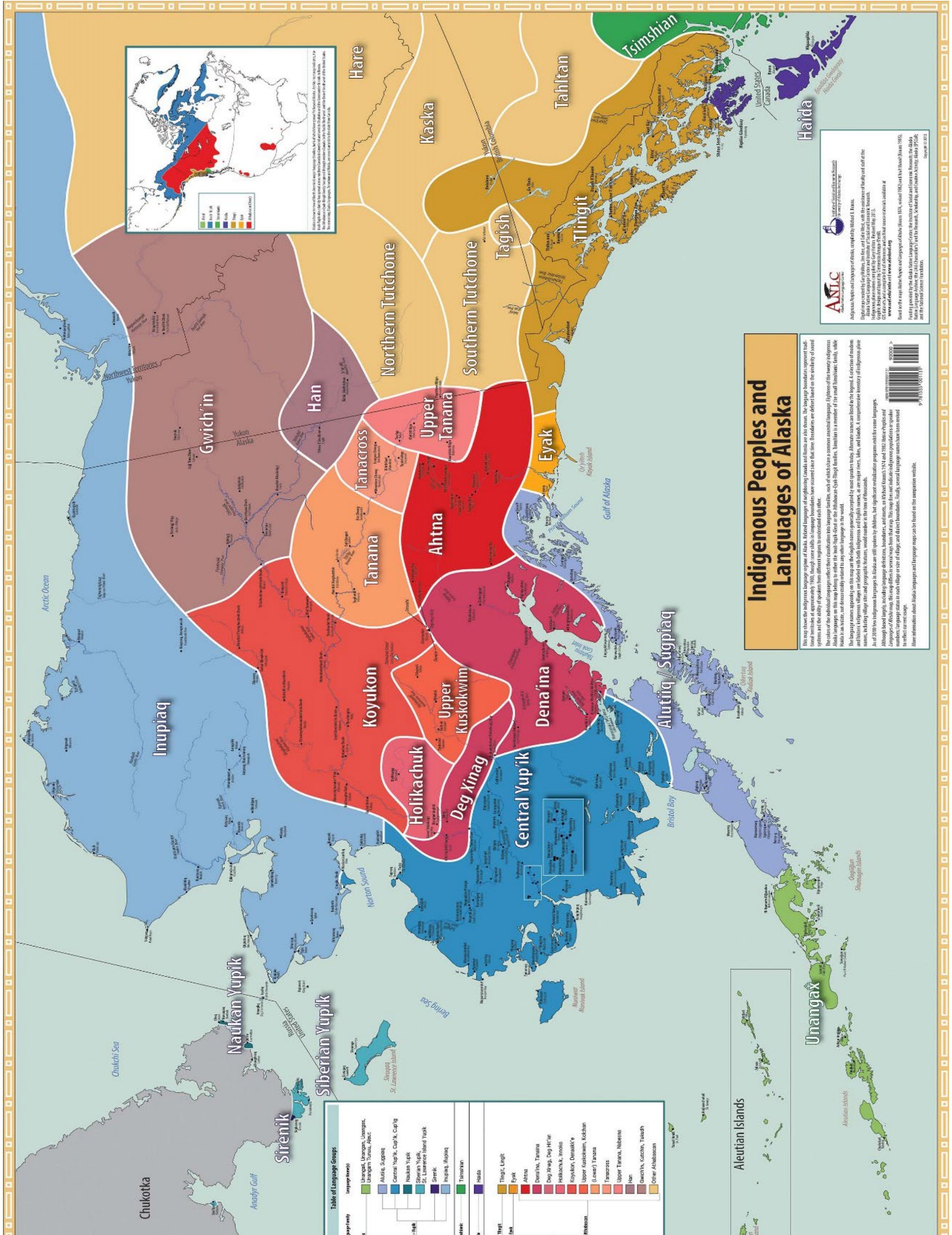

Figure A-1. Map of contemporary Native Alaskan linguistic groups (Holton et al. 2013).

Table A-1. Site names, numbers, and assemblage sizes of sherds from the Northern Ceramic Regional Database used in my regional analysis.

Region	Site Name	Site No	No. of Sherds
Bering Strait	Gambell Hillside Site	XSL-00001	20
Bering Strait	Ketnigpalak	XSL-00010	12
Bering Strait	Punuk Island	XSL-00006/7	5
Bering Strait	Kukulik	XSL-00009	5
North Slope	Birnirk	BAR-00001	84
North Slope	Walakpa	BAR-0002/11/13	462
Northwest	Sinagauruk	TEL-00011	2
Northwest	Ambler Island	AMR-00002/6	74
Northwest	Salix Bay	BEN-00106	41
Northwest	Platinum South Spit	GDN-00002	10
Northwest	Kotzebue	KTZ-00031/32	542
Northwest	Cape Espenberg	KTZ-00087	2411
Northwest	Cape Espenberg	KTZ-00088	416
Northwest	Espenberg River	KTZ-00125	1
Northwest	Kitluk River	KTZ-00145	153
Northwest	Cape Espenberg	KTZ-00304	3094
Northwest	Cape Espenberg	KTZ-00069	2
Northwest	Cape Espenberg	KTZ-00070	1
Northwest	Cape Espenberg	KTZ-00074	2
Northwest	Cape Espenberg	KTZ-00078	1
Northwest	Cape Espenberg	KTZ-00084	1
Northwest	Cape Espenberg	KTZ-00100	1
Northwest	Cape Espenberg	KTZ-00102	2
Northwest	Cape Espenberg	KTZ-00104	1
Northwest	Cape Espenberg	KTZ-00316	1
Northwest	Cape Espenberg	KTZ-00317	2
Northwest	Cape Espenberg	KTZ-00320	1
Northwest	Cape Espenberg	KTZ-2010D-1	1
Northwest	Cape Espenberg	Unknown	3
Northwest	Aitiligauraq	NOA-00284	33
Northwest	Lopp Lagoon	TEL-00086	152
Northwest	Ahteut	XBM-00002/3	419
Northwest	N/A	KTZ-00133	4
Northwest	N/A	KTZ-00352	1
Northwest	N/A	KTZ-00362	1
Northwest	Old Tigara	XPH-00001	14
Northwest	Tigara	XPH-00008	19
Northwest	Cripple Creek	CIR-003	2
Northwest	N/A	KTZ-109	2
Northwest	N/A	KTZ-114	1
Northwest	Onion Portage	AMR-00001	47

Northwest	Agiagruat	NOA-00217	778
Northwest	Kuzitrin	BEN-00029	25
Northwest	Cloud Lake Village	BEN-00033	55
Northwest	Cape Espenberg	KTZ-00101	27
Northwest	Kitluk River	KTZ-00149	15
Northwest	Cape Espenberg	KTZ-2010J	7
Northwest	Jabbertown	XPH-00002	4
Northwest	Lake Kayak	MIS-00032	18
Northwest	Kugzruk	NA	13
Northwest	Cape Krusenstern	NOA-00002	276
Northwest	Black River	SHU-00022	19
Northwest	Choris	SLK-00007	13
Northwest	Point Spencer	TEL-00008	4
Northwest	Agulaak	TEL-00012	11
Northwest	Lopp Lagoon	TEL-00104	58
Northwest	Ekseavik	XBM-00009	190
Northwest	Maiyumerak	XBM-00131	689
Northwest	Punyik Point	XHP-00308	13
Y-K	Nuuteqermiut	XCM-00014	17
Y-K	Ciguralegmiut	XCM-00001	26
Y-K	Carwarmiut	XCM-00004	22
Y-K	Penacuarmiut	XCM-00005	13
Y-K	Nunarlugarmiut	XCM-00009	3
Y-K	Qayigyalegmiut	XCM-00012	16
Y-K	Ciqengmiut	XCM-00015	1
Y-K	Cikuyuilngurmiut	XCM-00026	5
Y-K	Nuqariillermiut	XCM-00033	11
Y-K	Cingigarrlugarmiut	XCM-00059	1
Y-K	Can'gilngurmiut	XCM-00065	3
Y-K	Qayigyarrat	XCM-00068	4
Y-K	Amyag, Aacurlirmiut	XCM-00069	2
Y-K	Kenirlermiut	XCM-00079	6
Y-K	Iqugmiut	XNI-00002	4
Y-K	Ellikarrmiut (Nash Harbor)	XNI-00003	8
Y-K	Negermiut	XNI-00007	11
Y-K	Kangiremiut	XNI-00020	36
Y-K	Acakcum Nunii	XNI-00080	1
Y-K	Tacirrarmiut	XNI-00084	5
Y-K	Qikertarrlag	XCM-00036	4
Y-K	Asweryagmiut	XCM-00080	1
Y-K	Englulrarmiut	XNI-00016	1
Y-K	Miqsarmiut	XNI-00026	2
Y-K	Ucingurmiut	XCM-00016	1
Norton Sound	Difchahak	NOB-00005	191
Norton Sound	Shaktoolik	NOB-072	54

Table A-2. Test tile temper types and surface treatment.

Test Tile No.	Temper Type	Surface Treatment
1.01	None	None
1.02	None	None
1.03	None	None
1.04	None	None
1.05	None	None
1.06	None	Oil
1.07	None	Oil
1.08	None	Oil
1.09	None	Oil
1.10	None	Oil
2.01	Mineral	None
2.02	Mineral	None
2.03	Mineral	None
2.04	Mineral	None
2.05	Mineral	None
2.06	Mineral	Oil
2.07	Mineral	Oil
2.08	Mineral	Oil
2.09	Mineral	Oil
2.10	Mineral	Oil
3.01	Fiber	None
3.02	Fiber	None
3.03	Fiber	None
3.04	Fiber	None
3.05	Fiber	None
3.06	Fiber	Oil
3.07	Fiber	Oil
3.08	Fiber	Oil
3.09	Fiber	Oil
3.10	Fiber	Oil
4.01	Fiber and Mineral	None
4.02	Fiber and Mineral	None
4.03	Fiber and Mineral	None
4.04	Fiber and Mineral	None
4.05	Fiber and Mineral	None
4.06	Fiber and Mineral	Oil
4.07	Fiber and Mineral	Oil
4.08	Fiber and Mineral	Oil
4.09	Fiber and Mineral	Oil

4.10	Fiber and Mineral	Oil
5.01	Shell	None
5.02	Shell	None
5.03	Shell	None
5.04	Shell	None
5.05	Shell	None
5.06	Shell	Oil
5.07	Shell	Oil
5.08	Shell	Oil
5.09	Shell	Oil
5.10	Shell	Oil
6.01	Shell and Mineral	None
6.02	Shell and Mineral	None
6.03	Shell and Mineral	None
6.04	Shell and Mineral	None
6.05	Shell and Mineral	None
6.06	Shell and Mineral	Oil
6.07	Shell and Mineral	Oil
6.08	Shell and Mineral	Oil
6.09	Shell and Mineral	Oil
6.10	Shell and Mineral	Oil
7.01	Shell and Fiber	None
7.02	Shell and Fiber	None
7.03	Shell and Fiber	None
7.04	Shell and Fiber	None
7.05	Shell and Fiber	None
7.06	Shell and Fiber	Oil
7.07	Shell and Fiber	Oil
7.08	Shell and Fiber	Oil
7.09	Shell and Fiber	Oil
7.10	Shell and Fiber	Oil
8.01	Shell, Fiber, and Mineral	None
8.02	Shell, Fiber, and Mineral	None
8.03	Shell, Fiber, and Mineral	None
8.04	Shell, Fiber, and Mineral	None
8.05	Shell, Fiber, and Mineral	None
8.06	Shell, Fiber, and Mineral	Oil
8.07	Shell, Fiber, and Mineral	Oil
8.08	Shell, Fiber, and Mineral	Oil
8.09	Shell, Fiber, and Mineral	Oil
8.10	Shell, Fiber, and Mineral	Oil

Table A-3. Replicated vessel types and heating methods for both first-use and reused pots.

Pot No.	Cultural Affiliation	Temper	Heating Method	Reused?	Heating Method
1.01	Norton	Mineral	Direct	N	n/a
1.02	Norton	Mineral	Indirect	N	n/a
1.03	Norton	Mineral	Suspended	N	n/a
2.01	Norton	Mineral	Direct	Y	Direct
2.02	Norton	Mineral	Direct	Y	Direct
2.03	Norton	Mineral	Direct	N	n/a
3.01	Norton	Mineral	Suspended	N	n/a
3.02	Norton	Mineral	Suspended	Y	Suspended
3.03	Norton	Mineral	Suspended	Y	Suspended
4.01	Norton	Mineral	Indirect	N	n/a
4.02	Norton	Mineral	Indirect	Y	Indirect
4.03	Norton	Mineral	Indirect	Y	Indirect
5.01	Thule	Mineral, Shell, Fiber	Indirect	N	n/a
5.02	Thule	Mineral, Shell, Fiber	Direct	N	n/a
5.03	Thule	Mineral, Shell, Fiber	Suspended	N	n/a
6.01	Thule	Mineral, Shell, Fiber	Direct	Y	Direct
6.02	Thule	Mineral, Shell, Fiber	Direct	Y	Direct
6.03	Thule	Mineral, Shell, Fiber	Direct	N	n/a
7.01	Thule	Mineral, Shell, Fiber	Suspended	N	n/a
7.02	Thule	Mineral, Shell, Fiber	Suspended	Y	Suspended
7.03	Thule	Mineral, Shell, Fiber	Suspended	Y	Suspended
8.01	Thule	Mineral, Shell, Fiber	Indirect	Y	Indirect
8.02	Thule	Mineral, Shell, Fiber	Indirect	Y	Indirect
8.03	Thule	Mineral, Shell, Fiber	Indirect	N	n/a

Table A-4 Norton rim category frequencies from Iyatayet.

Ceramic Type	Rim Category	Frequency	Percent
Norton	1	4	6.6
Norton	3	1	1.6
Norton	9	1	1.6
Norton	11	1	1.6
Norton	20	1	1.6
Thule	1	50	45.5
Thule	2	18	16.4
Thule	4	2	1.8
Thule	5	1	.9
Thule	6	2	1.8
Thule	7	1	.9
Thule	9	6	5.5
Thule	10	6	5.5
Thule	11	7	6.4
Thule	15	8	7.3
Thule	19	3	2.7
Thule	23	1	.9

Table A-5. Norton and Thule mineral temper density frequencies.

	Norton		**Thule**	
	Frequency	**Percent**	**Frequency**	**Percent**
Low (<25%)	51	83.6	180	60.0
Medium (25 - 50%)	10	16.4	81	27.0
High (>50%)	0	0	39	13.0
Total	61	100.0	302	100.0

Table A-6. Norton and Thule mineral temper size

	Norton		Thule	
Temper size	**Frequency**	**Percent**	**Frequency**	**Percent**
Fine-Medium (>0.5 mm)	48	78.7	109	36.1
Coarse (0.5-2.0 mm)	11	18.0	111	36.8
Very Coarse (<2.0 mm)	2	3.3	72	23.8
Bimodal	0	0.0	10	3.3
Total	61	100.0	302	100.0

frequencies.

Table A-7. Organic temper density for Norton and Thule sherds.

	Norton		Thule	
Organic Temper Density	**Frequency**	**Percent**	**Frequency**	**Percent**
Low (<25%)	39	78	121	41
Medium (25-50%)	11	20	108	37
High (>50%)	1	2	64	22
Total	51	100	293	100

Table A-8. Norton and Thule organic temper type frequencies.

	Norton		Thule	
Temper	**Frequency**	**Percent**	**Frequency**	**Percent**
Feather	2	3.9	5	1.7
Fiber	30	59	183	62.5
Fiber and Feather	0	0.0	1	0.3
Hair and Fur	3	5.8	2	0.7
Shell	3	5.8	1	0.3
Shell and Fiber	6	11.8	92	31.4
Unknown	7	13.7	9	3.1
Total	51	100.0	293	100.0

Table A-9. Norton exterior decorative type frequencies.

Decorative Type	Frequency	Percent
Exfoliated or obscured	3	4.9
Linear stamp (Norton)	16	26.2
Small check stamp (Norton)	28	45.9
Textile impressed (Cord wrapped stick)	1	1.6
Textile impressed (Small random)	6	9.8
Undecorated	7	11.5
Total	61	100.0

Table A-10. Thule exterior decorative type frequencies.

Decorative Type	Frequency	Percent
Undecorated	172	57
Exfoliated or obscured	87	28.7
Large check stamp (Waffle, Nunivak)	13	4.3
Linear stamp (Corrugated)	11	3.6
Lined Yukon	10	3.3
Line Dot Yukon	4	1.3
Linear fragmentary	2	0.7
Finger impressed	2	0.7
Textile impressed (Small random)	1	0.3
Total	302	100.0

Table A-11. Thule rim category frequencies by region.

Rim Category	Bering Strait	North Slope	Northwest	Y-K	Nukleet	Iyatayet	Shaktoolik	Norton Sound
10	2	0	15	10	6	3	0	9
11	1	0	5	5	7	0	0	7
15	1	0	25	2	8	0	0	8
2	9	11	101	13	18	4	2	24
6	1	8	0	1	2	3	0	5
9	1	1	0	1	6	0	0	6
1	0	19	347	9	52	5	5	62
3	0	1	0	1	0	0	0	0
12	0	1	0	0	0	0	0	0
14	0	1	8	0	0	0	0	0
19	0	1	4	0	3	4	0	7
7	0	3	9	2	1	1	0	2
31	0	1	1	0	0	0	0	0
8	0	1	14	0	0	0	0	0

13	0	0	9	0	0	0	0	0
16	0	0	2	0	0	0	1	1
17	0	0	4	0	0	0	0	0
18	0	0	5	0	0	0	0	0
20	0	0	3	0	1	0	1	2
21	0	0	4	0	0	0	0	0
22	0	0	5	0	0	0	0	0
23	0	0	5	0	1	0	0	1
24	0	0	3	0	0	0	0	0
25	0	0	1	0	0	0	0	0
26	0	0	1	0	0	0	0	0
28	0	0	1	0	0	0	0	0
29	0	0	1	0	0	0	0	0
30	0	0	3	0	0	0	0	0
4	0	0	4	3	1	2	0	3
5	0	0	2	0	1	0	0	1

Table A-12. Norton rim category frequencies by region.

Rim Category	**Northwest**	**Y-K**	**Difchahak**	**Iyatayet**	**Norton Sound Combined**
1	4	2	1	4	5
3	0	0	0	1	1
2	2	4	1	0	1
9	3	0	0	1	1
11	0	0	0	1	1
19	1	0	0	0	0
20	0	0	0	1	1
22	1	0	0	0	0
6	0	0	0	1	1

Table A-13. Norton Mohs hardness value frequencies by region.

Mohs Hardness	Northwest	Y-K	Difchahak	Iyatayet	Norton Sound Combined
1.5	9	0	8		8
2.5	70	15	60	36	96
3.5	0	9	4	19	23
4.5	0	0	0	6	6

Table A-14. Thule Mohs hardness value frequencies by region.

Mohs Hardness	Bering Strait	North Slope	Northwest	Y-K	Nukleet	Iyatayet	Shaktoolik	Norton Sound
1.5	3	5	1709	4	0	2	4	6
2.5	11	159	2800	91	118	41	32	191
3.5	9	137	275	53	95	28	7	130
4.5	1	13	43	1	11	3	0	14
5.5	0	7	3	0	1	0	0	1
7.5	0	0	0	0	0	1	0	1

Table A-15. Norton firing core frequencies by region.

Firing Core	Northwest	Y-K	Difchahak	Iyatayet	Norton Sound
Fully Oxidized	1	3	4	3	7
Fully Reduced	26	9	5	31	36
Oxidized exterior-reduced interior	12	2	4	17	21
Oxidized interior-reduced exterior	5	4	1	2	3
Oxidized surfaces-reduced middle	0	2	0	1	1
Reduced exterior-oxidized interior	5	1			0
Other	3	4	28		28

Table A-16. Thule firing core frequencies by region.

Firing Core	Bering Strait	North Slope	Northwest	Y-K	Nukleet	Iyatayet	Shaktoolik	Norton Sound
Fully Oxidized	2	23	190	3	5	3	2	10
Fully Reduced	12	172	1116	9	108	37	18	163
Oxidized exterior-reduced interior	7	42	767	2	59	18	4	81
Oxidized interior-reduced exterior	0	7	7	4	8	1	0	9
Oxidized surfaces-reduced middle	0	17	228	2	8	4	1	13
Reduced exterior-oxidized interior	0	9	70	0	0	0	0	0
Reduced surfaces-oxidized middle	2	2	12	1	0	0	0	0
Other	3	74	28	4	0	0	0	0

Table A-17. Norton exterior surface treatment types by region.

Norton	Northwest	Y-K	Difchahak	Iyatayet	Norton Sound
Smoothed	1	23	6	20	26
None	65	1	98	33	131

Table A-18. Thule exterior surface treatment types by region.

Thule	Bering Strait	North Slope	Northwest	Y-K	Nukleet	Iyatayet	Shaktoolik	Norton Sound
Smoothed	0	45	511	4	38	19	2	59
None	24	102	3450	115	92	25	48	165
Brushed	0	13	28	0	0	0	0	0
Burnished	0	1	21	0	1	0	0	1

Table A-19. Norton organic temper frequencies by region.

Organic Temper Type	Northwest	Y-K	Difchahak	Iyatayet	Norton Sound
Fiber	12	7	36	29	65
Shell and Fiber	0	0	0	7	7
Unknown	64	18	62	5	67
Hair and Fur	0	0	6	3	9
Shell	0	0	0	3	3
Feather	4	0	0	2	2

Table A-20. Thule organic temper frequencies by region.

Organic Temper Type	Bering Strait	North Slope	Northwest	Y-K	Nukleet	Iyatayet	Shaktoolik	Norton Sound
Fiber	18	139	273	69	104	51	46	201
Unknown	6	204	986	89	2	7	4	13
Feather	0	21	4219	1	4	1	0	5
Feather and Fiber	0	15	25	0	1	0	0	1
Hair and Fur	0	20	12	0	0	2	0	2
Other	0	2	0	0	0	1	0	0
Shell	0	0	0	0	1	0	0	1
Shell and Fiber	0	2	0	0	114	6	0	120

Table A-21. Test tile mean apparent porosity (%).

		No ST			**Oil ST**	
	N	**Mean Porosity %**	**St. Dev.**	**N**	**Mean Porosity %**	**St. Dev.**
None	3	35.8	0.6	5	16.2	5.1
Mineral	5	35.2	0.45	5	15.7	3.8
Fiber	5	39.4	1.6	5	35.3	1.0
Fiber, Mineral	5	36.9	2.2	5	37.4	3.5
Shell	5	38.2	2.3	5	33.4	8.0
Shell, Mineral	5	38.9	1.3	5	32.8	8.4
Shell, Fiber	5	39.8	2.6	5	36.0	6.4
Shell, Mineral, Fiber	5	36.5	8.0	5	36.9	1.4

Table A-22. Norton vessel direct heat trial with first-use pots.

Vessel no.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
2.01	100	Y	27	Significant evaporation of approximately 150 ml, hairline crack developed from rim towards base as pot began to reach boiling temperature, sooting visible on exterior
2.02	93	N	45	Fire did not reach adequate temperature around the pot, combined with significant evaporation, sooting visible on exterior
2.03	93	N	16.41	Catastrophic crack around base resulted in the pot losing all contents before boiling, sooting visible on exterior
1.01	100	Y	23.5	No damage incurred, sooting visible on exterior

Table A-23. Norton vessel indirect heat trial with first-use pots.

Vessel No.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
4.01	100	Y	4.36	8 rocks used, no damage
4.02	100	Y	5.07	8 rocks used, no damage
4.03	100	Y	6	8 rocks used, no damage
1.02	100	Y	3.3	6 rocks used, no damage

Table A-24 . Norton vessel suspended heat trial with first-use pots.

Vessel No.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
3.01	93	N	37.44	Significant evaporation of approximately 150 ml, large spall broke off base but pot remained watertight, extensive sooting on exterior
3.02	100	Y	24.43	Fire was hotter and more direct than previous fires, contributing to success of the trial, extensive sooting on exterior
3.03	93	N	37.24	Only reached a simmer, significant evaporation of 150 ml, extensive sooting on exterior
1.03	93	N	21.28	Bottom fell out and pot contents extinguished fire, only reached a simmer, extensive sooting on exterior

Table A-25. Thule vessel direct heat trial with first-use pots.

Vessel no.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
6.01	100	Y	17.46	Hairline crack from rim towards base, sooting on exterior
6.02	100	Y	21.37	No damage, sooting on exterior
6.03	96	N	32.48	Only reached a simmer, sooting on exterior
5.02	100	Y	10.5	No damage, sooting on exterior

Table A-26. Thule vessel indirect heat trial with first-use pots.

Vessel no.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
8.01	100	Y	4.5	No damage
8.02	100	Y	5.27	No damage
8.03	100	N	6.3	No damage
5.01	100	Y	3.37	No damage

Table A-27. Thule vessel suspended heat trial with first-use pots.

Vessel no.	Max. Temperature (C)	Boil (Y/N)	Minutes to Boil	Notes
7.01	93	N	45	Only reached a simmer, extensive sooting on exterior
7.02	100	Y	28.21	No damage, extensive sooting on exterior
7.03	87	N	35	Only reached a simmer, extensive sooting on exterior

Table A-28. Norton and Thule second-use vessels for all heating types.

Vessel No.	Cultural Affiliation	Time (minutes)	Boil? (Y/N)	Max Temp (C)	Method	Notes
2.01	Norton	9.2	Y	109	Direct	Large cracks forming and a spall off the base from heating
2.02	Norton	13.54	Y	110	Direct	n/a
3.02	Norton	32.13	Y	100	Suspended	n/a
3.03	Norton	20.51	Y	100	Suspended	n/a
4.02	Norton	4	Y	100	Indirect	5 rocks
4.03	Norton	2.55	Y	100	Indirect	4 rocks
6.01	Thule	11.23	Y	110	Direct	n/a
6.02	Thule	11.02	Y	100	Direct	n/a
7.02	Thule	33.11	N	95	Suspended	Lots of evaporation, about 200ml water gone but only reached a simmer
7.03	Thule	35.23	Y	100	Suspended	n/a
8.01	Thule	4.12	Y	100	Indirect	4 rocks
8.02	Thule	4.2	Y	100	Indirect	4 rocks

Appendix B: Supplemental Files

Supplemental Files associated with this thesis include:

The Nukleet and Iyatayet ceramic analysis database, which contains the raw data from my analysis of a sample of sherds from Nukleet and Iyatayet.

File name: Nukleet and Iyatayet Database
File type: CSV (comma-separated values)
Size: 206 kB
Required application software: Microsoft Excel
Special hardware requirements: None

Portland State Ceramic Analysis Procedures, created by Dr. Shelby Anderson, which contains the procedures used for my analysis of ceramics for this thesis.

File name: Ceramic Analysis Procedures Anderson
File type: PDF
Size: 2.2 MB
Required application software: Adobe Acrobat Reader
Special hardware requirements: None