Paleocarpentry in the Eastern Arctic: an Inferential Exploration of Saqqaq Kayak Construction

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ABSTRACT

Because wooden artifacts are rarely preserved in ‘stone age’ archaeological contexts, it is difficult to study the actual techniques through which lithic tools were used in a complementary fashion to manipulate the natural properties of wood. Saqqaq culture (~4400-3300 BP), from West Greenland, provides an example where complex skin-on-frame kayaks were built using stone tool kits. This article will inferentially explore Saqqaq paleocarpentry by outlining the skills that are requisite to building kayaks. Though Saqqaq tools are only discussed briefly, it can be inferred that many of them would have been used in suites to achieve specific carpentry goals.

The use of stone tools for wood working can be traced back as far as the Earlier Stone Age (Dominguez-Rodrigo 2001). However, because wooden artifacts are themselves rarely preserved in most ‘stone age’ archaeological contexts, it is difficult to study the actual techniques through which lithic tools were used in a complementary fashion to manipulate the natural properties of wood. Even so, it is useful to consider lithic tools from a perspective of carpentry, and the specific tasks that they must have been used for; this involves an understanding of the way that wood is composed as well as the types of carpentry techniques that would be required to build some of the technologies that must have been constructed by paleocarpenters.

This article explores the rich ethno-historic documentation of traditional Inuit kayak construction, with the purpose of outlining the carpentry skills that are requisite to building functional skin-on-frame boats - one of the most elegant technologies known to have been built with stone tool kits. Although kayaks were built with the aid of metal implements throughout the historic period discussed, kayaks are part of a much older tradition and have been built by various Arctic cultures, in relatively similar ways, for at least 4400 years. In Greenland, specifically, Saqqaq culture (~4400 – 3300 BP) built kayaks in similar enough
ways that they would have faced many of the same carpentry challenges as later Inuit builders. Though Saqqaq tools are only discussed briefly, it can be inferred that many of them would have been used in suites to achieve specific carpentry goals.

Understanding Wood

Wood is an incredibly diverse and organic material, taking its form and characteristics from the manner that trees grow and decompose (Hoadley 2000). Different species of trees grow differently, and have distinct internal structures that determine properties such as weight, strength, flammability, buoyancy, and natural grain direction to name a few. Furthermore, every single tree has a unique life-history, twisting and branching to reach sunlight, struggling with periods of low water, adjusting to any number of events such as fire or insect damage. Indeed, even a single tree produces multiple types of wood of different utility to carpenters. Heartwood is the darker and denser wood found towards the core, which is different than the newer, lighter, and more pliable sapwood found towards the outer layers. Heavily compressed grains that naturally bend can be found on the inside curves of branches or stumps, and straighter grained pieces generally within the trunk. In any case, wood is anything but a homogenous material, and no two pieces are exactly alike.

Because wood, of all types, readily yields to modern tempered-steel carpentry tools, it is too easily imagined as a plastic material with few limits as to the shapes and forms that can be produced. However, it cannot be taken for granted that paleocarpenters had the same flexibility using stone tools. Like stone, wood does not simply fall apart into a desired shape – it breaks according to mechanics that are governed by its internal structure. In general, wood is strongest longitudinally, and splits along the grain rather than across. Reducing wood with stone tools requires an understanding of how it is composed, and how it will naturally break apart. Many tools must be used in conjunction with each other to produce different shapes. In this sense, knowledge of wood and its working properties would have constituted much of the mental schemas and ideas of function in the minds of flint-knappers who produced wood working tools. This knowledge must have governed, in part, the forms of the lithic they produced.

In Greenland, wood is a scarce commodity; only a few types can be found, and almost all of these arrive as driftwood that predominantly originates from rivers in Siberia (Figure 1) (Dyke et al. 1997; Grønnow 1996; Tremblay et al. 1997). By the time it reaches Greenland, wood is usually in poor condition, having become waterlogged, battered by ice, and often infested with worms. Most of the driftwood that naturally arrives in Greenland consists of spruce, pine, fir, and cedar, with more exotic types occasionally found (Grønnow 1996). However,
having never seen the forests or trees that produced driftwood, Greenlanders distinguished no fewer than nine types, which were not necessarily synonymous with different species of trees (Petersen 1987: 21-22). These types were generally differentiated by properties that were significant to carpentry, such as weight, straightness of grain, colour, utility for specific tasks, and even perceived magical qualities (see Table 1). Wood was extremely important for people living in the Arctic, and the value of different pieces came from their ability to be manipulated by traditional tools (e.g. Alix 2009). Before wood became more available through European trade during the historic period, it was the basis of a trade economy, and an important consideration in regional interaction and annual migration.

**Kayaks**

Skin-on-frame kayaks are iconographic in their association with Arctic hunter-gatherer cultures including various Aleut, Inuit, and Yu’pik groups spanning from Siberia to Greenland (see Figure 1)(Arima 1975; Brand 1991; Golden 2006; Nooter 1991; Petersen 1987; Zimmerly 1979). They are constructed with the few materials available in the Arctic; frames are built from driftwood, lashed together.
Table 1. Greenlandic naming and description of wood types (after Petersen 1987:21-22).

<table>
<thead>
<tr>
<th>Greenlandic Name</th>
<th>Description</th>
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<tbody>
<tr>
<td>Ikkeq</td>
<td>Fine grained redwood, easily bent once steamed</td>
</tr>
<tr>
<td>Pingeq</td>
<td>White, light weight, but very strong – good for harpoon shafts and kayak gunwales</td>
</tr>
<tr>
<td>Qisuk Qaqortoq</td>
<td>Similar to pingeq, but not as strong and more buoyant</td>
</tr>
<tr>
<td>Uligilik</td>
<td>White wood, but not as strong or buoyant as pingeq or qisuk qaqortoq</td>
</tr>
<tr>
<td>Kanunneq</td>
<td>Heavily scented, and retains strength when bent</td>
</tr>
<tr>
<td>Qasallak</td>
<td>Weak redwood - perceived to have magical protective properties, and often used in amulets.</td>
</tr>
<tr>
<td>Orpik</td>
<td>Indigenous to Greenland – grows in small shrubs and the grain is very twisted, but strong and easily bent</td>
</tr>
</tbody>
</table>

using baleen, sinew, and skin cordage, and are covered with waterproofed animal hide – most commonly seal. Kayaks are usually designed for a single person, with the intent that they be used for hunting and transportation. It can be seen, ethnographically, that there was a great diversity of kayak types associated with different regions and cultures. Some groups used kayaks that were developed strictly for hunting sea-mammals, others for caribou, and some were even designed for warfare.

However, in spite of the tremendous variability, there are several characteristic components that all kayaks share (see Figure 2). All kayaks take their primary support from two gunwale strakes, which are held in their distinctive shapes by a number of cross pieces. The hull itself, hangs from the gunwales, and comprises of a series of ribs which support stringers and a keel. The frame essentially functions as a ‘tent-like’ structure that holds the skin in the desired hull shape using a minimum number of contact points. Given the materials available in the Arctic, as well as the requirements of a watercraft that will not fall apart and can be used for hunting, these core elements of construction probably represent the only possible design. These are what Pierre Lemonnier (1993) would describe, as the ‘strategic moments’ which characterize kayak technology as a whole, and cannot be left out of the construction process or the technical endeavour simply would not work. In other words, in spite of the diversity in kayak types, configurations outside of the basic parameters outlined in Figure 2 may not have been possible; each kayak builder, regardless of region or
Figure 2. The ‘strategic moments’ that characterize Arctic kayaks, using the West Greenland type for illustration.
time period, minimally shared these strategic moments in their mental schemas of kayak construction.

This is useful to consider, because kayaks do not preserve well archaeologically. While there are many examples that have been conserved in the ethnographic collections of various museums, these all date to the historic period. There are no examples of complete kayaks that clearly predate the introduction of European metal carpentry tools. However, there are fragmentary remains from kayaks that confirm the technology was built and used by some of the earliest societies to populate the Eastern Arctic around 4500 years ago. The most convincing evidence is a well-formed kayak rib and paddle found at the Qeqertasussuk site, identified in Figure 1, which was occupied by Saqqaq culture Paleoeskimos between 4400-3400 BP. (Grønnow 1994; Meldgaard 2004). Materially, Saqqaq culture was very different than the later Inuit occupants of Greenland, who had only migrated from Alaska to the Eastern Arctic after 1200 A.D. (Table 2). Saqqaq culture is a part of the Arctic Small Tool Tradition (ASTt), characterized by microblades, burins, burin spalls, adzes, points, bifaces, wedges, and drills, all made with a high degree of craftsmanship (Grønnow 1996; Jensen 2006; Sørrensen 2006). Though the precise form of Saqqaq kayaks cannot be inferred from a single rib, it is sufficient to suggest that they were building them in similar enough ways that they would have been using their stone tool kits to accomplish the same general construction tasks as later Inuit builders who built the kayaks preserved in ethnographic collections. In this context it is possible to indirectly study aspects of Saqqaq paleocarpentry through examining the rich ethno-historic documentation of Inuit kayak construction techniques.

Kayak Construction

This section presents a simplified construction sequence for kayaks; only the construction stages that generalize all Arctic kayaks are included. For any given kayak type, there are, of course, thousands of additional individual technical actions, with much variability that produces a variety of functional and stylistic results. However, in spite of the diversity, the following are the key ‘strategic moments’ that characterize the technology as a whole – one must minimally have the carpentry skills to complete these stages in order to build a functional skin-on-frame kayak. The West Greenland style is used for illustrative purposes, but the text summarizes construction techniques outlined by a number of authors who document construction of different types from all over the Arctic (Arima 1975; 1987; Brand 1991; Golden 2005; Petersen 1986; Zimmerly 1979).
Table 2. Archaeological cultures that used kayaks in Greenland.

<table>
<thead>
<tr>
<th>Kayak Culture</th>
<th>Approximate Dates</th>
<th>General Carpentry Tools</th>
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<tbody>
<tr>
<td>Saqqaq</td>
<td>~4400 – 3300 B.P.</td>
<td>Arctic Small Tool Tradition – adzes, burins, micro-blades, scrapers, drills, wedges, utilized flakes.</td>
</tr>
<tr>
<td>Thule/Inuit</td>
<td>~1200 A.D. – Present</td>
<td>Wedges, ground stone, adzes, meteoritic and Norse iron, European carpentry tools (after 1700s)</td>
</tr>
</tbody>
</table>

Gunwales

Kayak assembly necessarily starts with the construction of the gunwales, which are the primary structural components around which everything else is built, governing the strength, and most of the shape of the hull. The two gunwale strakes are bound at each end, and then they are forced apart in the middle. The effect is a bit like drawing a bow as the resulting pressure holds the frame together in the middle (see Figure 3). As the gunwales have to be the strongest part of the kayak, it is best if the wood follows the grain longitudinally from tip to tip. Places where the grain intersects the sides will be weak points that could snap – with catastrophic consequences – as the frame is stressed by the dynamic pressures it will be subjected to as it moves through waves or performs different hunting manoeuvres.

One of the most difficult, yet crucial, stages of kayak construction is ensuring that both gunwales are exactly the same strength and will bend equally. If either of the strakes is stronger than the other it will affect the symmetry of the kayak, pulling it to one side or the other. This will critically affect the performance of the boat as the hull will be asymmetrical (Figure 3). Inuit hunters used kayaks for hunting trips and journeys that could span hundreds of kilometres, and over the short term needed boats that would glide in a straight line as they stalked and harpooned sea-mammals; having a ‘lop-sided’ hull would be problematic for a number of reasons (Petersen 1986). Equalizing the gunwales requires very particular carpentry skills; as wood takes it strength from the grain, the builder must be able to carefully refine each strake, and plane them grain by grain until both bend equally. Though each gunwale strake is ideally made out of a single piece, it can be difficult to find wood this size, and in many cases builders would have had to literally sew pieces together.
Once it is assured that the gunwales match, they are held in the desired shape by cross pieces (Figure 2). These cross pieces have to be adjoined to the gunwales so that they are secure and will not ‘pop-out’ during normal operation, where the kayak will experience many different stresses that could bend the frame in different directions. Furthermore, the joints have to be formed well enough so that they do not creak as the kayak moves, which would make it difficult to stalk seals through the sea-ice. The most common strategy used in kayak construction across the Arctic is to form secure ‘mortise and tenon’ style joints (Arima 1987). This requires that the builder cut into the gunwales, perpendicular to the grain, with enough control over the resulting shape that a cross piece can be tightly fitted (Figure 4).

Ribs

Once the gunwales and cross pieces have been assembled into a top deck, the hull is formed by creating a series of small ribs (Figure 2). While the gunwales give the hull its longitudinal shape, length, and width, the ribs form the camber and depth. Different kayak types have much variability in the number of ribs, and the
hull-shapes that they form, but the main functional requirement is that there has to be enough ribs to collectively support the weight of the kayaker, as well as any impact that the hull might encounter during use. Because of the shape of the hull, no two ribs are exactly the same shape or size, and each must be precisely formed and permanently bent into the desired shape of the hull at a particular cross section (Figure 5). Each rib is mortised securely into the bottom of both gunwales, again requiring a secure joint for the same reasons as the cross pieces. There are a number of techniques that can be used to bend the ribs into their shape, mostly including some variation of soaking, heating, and steaming preformed pieces. In order to bend the wood without breaking it, each rib must be formed so that it follows the grain, otherwise the rib will split where the grain intersects the side of the rib. If such ribs do not actually break while being bent, these intersections will remain weak points in the resulting frame (Figure 5). As with the gunwales, the builder must be able to reduce the piece along the grain, and the process is further assisted by rounding the inside of the rib so that the wood will not compress and ‘kink’ as it is bent.

Keel and Stringers

The ribs act as platform for a keel, and several stringers which are the eventual resting points for the skin rather than the ribs themselves. In the case of Greenland kayaks, there is one keel and only two stringers, which together form a triangular
hull (Figure 6). However, there is much regional variability across the Arctic with everything from squared to perfectly round hull shapes involving many stringers. In any case, the carpentry skills here are similar to the construction of the gunwales and the ribs; it is necessary to reduce long pieces by the grain which will bend equally.

Other Necessary Skills

The stages outlined above are limited to those that involve carpentry. Other necessary skills include binding elements with baleen and sinew cordage, and most importantly, the preparation and sewing of the waterproof skin. The skin not only keeps the water out, but is also a primary structural component, because as the skin shrinks it dries and holds the frame together tightly.

Overview

In sum, complete kayak frames can be almost entirely built without cutting across the grain. The primary carpentry is in the reduction of long pieces that are cut along the grain, and in the case of the gunwales are consistent enough to each other that they bend the same way and form a symmetrical shape. Further reduction is necessary to build precise joints for cross pieces and ribs, which require refined chiselling and carving skills.

Requisite Carpentry Skills and Associated Saqqaq Tools

Grønnow (1994; 1996) reports that in addition to the aforementioned kayak rib and paddle, the Qeqertasussuk site also produced approximately 15,000 fragments of wood débitage consisting mostly of adzed shavings and split pieces. Kayak construction is likely one of the main activities that account for this quantity of
débitage. Combined with the classic assemblage of ASTt lithic tools recovered at the site, there is much room to speculate as to how Saqqaq builders approached the carpentry tasks outlined above.

The most important skill would have been the ability to reduce large straight-grained driftwood into long pieces such as gunwales, stringers, cross pieces, and ribs, which followed the grain from tip to tip. This was probably primarily accomplished using the ‘split and wedge’ technique, involving the use of burins alongside wedges (pieces esquilles) made of whalebone and antler (see Adney & Chapelle 1964 for a good description). The process starts with scoring a long groove along the grain of the wood with a burin. The burin is then worked backwards in long strokes, using the tip to deepen the groove into the soft space between grains – an effect which could be likened to a single-toothed saw. Once established, the piece can be split by pounding wedges into the trench. This technique gives the builder a tremendous amount of control, because the scoring phase allows them to choose precisely where the wood will be split at the level of the grain. As the technique depends on the natural structure of the wood, the straighter the natural grain, the straighter the resulting pieces will be. Large pieces, such as the gunwales, keel, and stringers, can be further refined and ‘squared-off’ using an adze. Adze blades have the ability to dive into the grain a little, and pull back characteristically long strips of wood along the grain. Grønnow (1996) suggests that adzing produced most of the débitage at Qeqertasussuk. Indeed, the burin and wedge technique would not have produced much débitage other than unused split waste.

In the case of the gunwales and ribs, it is important to be able to plane off pieces by grains so that they will bend appropriately. This is quite difficult, and was probably accomplished using a number of different techniques simultaneously. Because of the shape, the hardest task would have been to plane
large flat pieces, such as gunwales – they cannot simply be carved down utilizing sharp flakes and bifacial knives. Flakes and knives are, however, effective at roughening the surface of a piece so that the grain is easily picked up and peeled off in strips by the strokes of an end scraper. This technique seems to be especially effective if the piece is slightly damp.

Setting the cross pieces and ribs into the gunwales requires making mortises that actually cut into the grain. These were also probably made using a combination of techniques. The bulk of the gunwale matter would probably have been removed from the mortises by a series of drilled holes created by use of the bow drill. Having formed the rough outline of the mortise in this manner, the joint would have been squared using various chisel tools, possibly including hafted micro-blades and burin spalls.

Conclusion

The nature of kayak use, specifically the need for a hull that is strong, symmetrical, and quiet, governs the ‘strategic moments’ of carpentry involved in kayak construction. These carpentry goals involve much more complex considerations than the simple tasks that archaeologists usually ascribed to individual tools – i.e. scrapers for scraping, gougers for gouging, drills for drilling etc. For example, shaping and planing a gunwale, or making a ‘mortise and tenon’ joint, require techniques that involve suites of tools that are used in a complimentary fashion to manipulate the natural properties of wood into desired forms. These considerations – the interdependency of tools in carpentry techniques – must have governed, in part, their form.

Because wood rarely preserves in ‘stone-age’ archaeological contexts, most wood working tools tend to be thought about in terms of the techniques and sequences of how they are produced rather than their position in composite technical systems. However, the flint-knappers who produced them were probably also carpenters, and the mental schemas of function that influenced the ways they produced the tools must have been heavily influenced by this. When stone tools are considered from a perspective of carpentry techniques, they may be placed into very different emic categories. Understanding the links between tools and carpentry techniques could influence many lithics-based archaeological interpretations, such as site use and activity areas; a complete chaîne opératoire analysis has to expand beyond lithics themselves. This is useful to consider, especially in the Arctic, where much has been made about the relationship between culture-history and slight changes in single tool types – such as burins. In this context, it would seem as though such typologies would have to be understood, at least partly, in terms of changes in the goals of technical systems.
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