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Lithic Analysis at the JJ Site: USFS #09-09-05-949, Lake County, Minnesota

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by

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Abstract

Knife Lake and Knife Lake Siltstone have long been associated with Minnesota's Paleoindian tradition, until OSL dates revealed Early Archaic, Middle Archaic, and Middle Woodland occupations at the JJ site. This thesis reviews the results of the OSL dates, and then uses lithic and statistical analysis to aid interpretations of multiple cultural occupations at the JJ site, specifically through the lens of technological change. Adding data to the use of Knife Lake Siltstone during the Woodland tradition can add to the understanding of how and when this material was used through time.

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Chapter 1: Introduction

Research Design

Knife Lake is located along the Minnesota-Canada border within the Boundary Waters Canoe Area Wilderness (BWCAW), and has become known as an important lithic quarry site for Knife Lake Siltstone (KLS). Thirteen sites have been recorded near the quarries to date, and these sites comprise the Daughter District (Muñiz 2013). Over the past several years, both United States Forest Service (USFS) and St. Cloud State University (SCSU) archaeologists have undertaken surveys and excavations at sites within the District to understand how this landscape was utilized as a lithic procurement site, specifically within the Paleoindian tradition (Muñiz 2013, 2015; Rovanpera 2012). Recent optically stimulate luminescence (OSL) dates, however, have indicated both an Archaic and a Woodland cultural component to the quarries at Knife Lake, specifically at the JJ and Lillian Joyce sites. This thesis will include a macroscopic analysis of the lithic artifacts recovered from the JJ site, and will record both qualitative and quantitative attributes of the tools and the flake debitage recovered from the two excavated units. Through this analysis, it may be possible to discern something about the stage in the reduction process these artifacts represent, the lithic production technologies occurring at JJ, and what was left at the site versus what was transported away. Furthermore, the blades recovered from the Middle Woodland component at JJ will be compared to the blades found from the Woodland component at the Lillian Joyce site, in an effort to understand the technological relationships across sites at Knife Lake.

Because we have such little information as to how the Knife Lake quarries were being utilized through time, understanding the stone tool activities at one site can provide a window into these larger happenings. Additionally, by comparing these new data with data already collected from other Knife Lake sites, we can begin to parse out any patterns or anomalies on how quarry use may have changed through time. The new OSL dates indicative of a Middle Woodland association, specifically 1,930 +/- 240 calBP at the JJ site, ties into the Middle Woodland Laurel complex of Northern Minnesota, as defined by Arzigian (2008). Because multiple prismatic blades were found within OSL-dated Woodland contexts at two sites on Knife Lake, these blades now provide an opportunity to study Knife Lake's association with the Middle Woodland Laurel complex, and its possible ties to larger interaction spheres. It is the intention of the proposed thesis to consider the following set of interrelated questions:

- What kinds of tool technology were being produced at the JJ site through time, and does this specifically point to significant blade production? My hypothesis is guided by the OSL dates and suggests that tool production changed temporally, with an increase in blade production and a decrease in bifacial production through time. These changes would suggest a change in cultural preference, technological organization, and adaptive strategy that may speak to changes in cultural occupation.
- How does the JJ site assemblage compare to Lillian Joyce, specifically in terms of the similarly-dated blades recovered from both sites? It is likely the blades will have commonalities, given their similar proveniences within the upper levels of the excavation units and Woodland-aged OSL dates. The sites, however, are separated by part of the lake. My hypothesis is that blade technology is indicative of temporal change at the sites, meaning there should be significant similarities between the two sets of blades to support similar technological strategies associated with semi-contemporaneous Woodland occupation at both sites.

- The OSL dates indicate multiple cultural occupations of the JJ site through time; can changes in the artifact assemblages be identified that can attest to this? There could be minimal change in the cultural components at JJ, either suggesting there was little to no change in site function over time, or there were several cultural occupations but the limited technological function for Knife Lake siltstone required similar tool technologies throughout. My hypothesis is that tool production changed over time, based on OSL dates suggesting four different cultural components at the site. This hypothesis is based on the assumption that different cultural occupations would have been practicing different adaptive strategies, and those strategies should be apparent through examination of the lithic debitage and tools.
- If there is evidence for increased blade production during the Middle Woodland at the JJ site, what can be concluded about the use of Knife Lake during the Middle Woodland? The Woodland-aged OSL dates coincide with the Laurel complex of northern Minnesota. Based on evidence of Laurel's temporal association with Hopewell and an understanding of the importance of blade production and usage within Hopewell culture, statistically significant evidence supporting a significant blade industry can provide a platform for future research into an understanding between increased blade production during the Middle Woodland at Knife Lake and the Laurel culture and its association with Hopewell.

Answers to these questions were sought by conducting a lithic analysis of the JJ site tools and their associated debitage, examining the debitage to identify the kinds of lithic technologies present, and conducting a comparative study of blades to identify similarities and differences that may link the blade producing components at the JJ site to similar levels at the Lillian Joyce site.

A concise culture history of Minnesota's Middle Woodland tradition and contemporary sites on Knife Lake will be discussed in Chapter 2, followed by a discussion of the JJ site and Knife Lake siltstone in Chapter 3. The underlying theory of this analysis focuses on technological organization and its change over time, which is detailed in Chapter 4. Chapter 5 covers the methodology employed for the lithic and statistical analysis, followed by results in Chapter 6, and interpretations and conclusions in Chapter 7.

Chapter 2: Culture History

The culture history for this project will first be discussed in terms of Minnesota's Woodland tradition, followed by a discussion of the Laurel complex in northern Minnesota. This thesis focuses on new evidence supporting a Middle Woodland occupation in the Daughter District at Knife Lake, specifically based on OSL dates obtained by Muñiz (2015). Because of this new and somewhat contradictory data, as the Knife Lake quarries have previously been associated with Paleoindian use, this culture history will have a Middle Woodland focus, rather than Paleoindian or Archaic, in an effort to provide the most relevant context. Specifics concerning cultural and technological changes through time will be discussed in the following chapter, as part of a discussion on technological organization. Additionally, evidence pertaining to the Fur Trade and other historic eras of northern Minnesota are not present at the site in question and will not be discussed here. A review of Knife Lake, Woodland sites in proximity of the Daughter District, and the JJ site will also be included in this chapter.

Minnesota's Middle Woodland

The Woodland tradition in Minnesota ranges in dates from 2,950 – 2,100 calendar years before present (calBP), and is generally characterized by more intensive pottery production, as compared to the Archaic tradition; but without significant agricultural production, as compared to the Plains, Mississippian, and Oneota traditions (Arzigian 2008). Hunter-gatherer lifeways continued as they had in previous traditions, but the Woodland is differentiated by the utilization of additional food procurement strategies such as fishing, the use of wild rice, and some cultivated plants. In some areas of the state and region, large earthen mounds are attributed to this time and became important pieces of the landscape. The main proprietors of these mounds were the Hopewell of the Ohio Valley, to which many Middle Woodland cultures are often associated (Mason 1981). Agricultural practices based on maize production typically mark the end of the Woodland tradition, but areas north of the maize cultivation limits can still be found in association with similar pre-agricultural lifeway practices until early post-contact (Arzigian 2008; Gibbon 2012).

Based on Arzigian's (2008) Multiple Property Document Form (MPDF) for Minnesota's Woodland period, the typical sites associated with the state's Woodland complexes include habitation, resource procurement, resource processing, special use, and mortuary. The most commonly occurring are habitation sites, which include sites characterized by general use activities, diverse artifact assemblages, and are usually restricted to a single location. Resource procurement and processing sites, on the other hand, are more specialized and are identified by a focus on a specific resource. These site types tend to be smaller, with a limited variety of artifacts available (Arzigian 2008). Knife Lake is clearly a resource procurement and processing site, due to the exclusivity of stone tool and debitage assemblages. This makes Knife Lake a very specific type of procurement site, as a quarry for Knife Lake siltstone (KLS) and the use of KLS for manufacturing chipped stone tools. As an exclusive raw material acquisition site, it also differs from other resource sites in northern Minnesota such as subsistence or food procurement areas, copper mining, or material procurement for pottery making. Indeed, no other artifacts types have been found at Knife Lake besides lithic materials (Muñiz 2013).

Overarching research themes for Woodland lithic technology in Minnesota include refining typologies to solidify affiliations between technologies and cultural complexes; trait comparisons between Archaic, Middle Woodland, and Late Woodland to confirm or deny cultural homogeneity; use wear analysis to ascertain information regarding tool function; and lithic source studies to document how materials travelled, changed, and were used over time and space. Finally, tool and debris studies are necessary to identify function, reduction sequences, raw material selection, tool manufacture, and changes over time. Tool and debitage studies can be accomplished through studying multicomponent sites where there are good distinctions between cultural horizons, such as those present at the JJ site (Arzigian 2008; Muñiz 2015). The JJ site offers an opportunity for examining trait comparisons through time, and studying lithic debris in an effort to classify technological strategies.

Minnesota's Woodland period is comprised of 11 individual and overlapping complexes, with the Laurel complex overlapping both temporally and regionally with the OSL dates at Knife Lake. This northeastern portion of the state is ecologically dominated by the Laurentian Mixed Forest Province (Arzigian 2008). Conifers and mixed hardwood forests coupled with conifer swamps populate the landscape. Significant glacial activity occurred in the region, the results of which are areas of thin soil deposition as well as areas of thickly deposited glacial drift. This province is divided into five sections, including the Northern Superior Uplands, Northern Minnesota and Ontario Peatlands, Northern Minnesota Drift and Lake Plains, Western Superior Uplands, and Southern Superior Uplands (Arzigian 2008). The study area in question, Knife Lake, falls within the Northern Superior Uplands section.

Located in SHPO resource region 8 (Figure 1), the Border Lakes Region is a subsection of the Northern Superior Uplands. More specifically, Knife Lake falls within the Rainy River drainage system (Anfinson 2005). This northeastern part of the state has a somewhat long and muddled glacial past and although it varies greatly within the region, the overarching glacial geomorphology is dominated by erosion rather than deposition. The last glacial events to transpire at the Knife Lake quarry sites in question took place when the Herman shoreline retreated from the area around 13,000 calBP (Teller and Leverington 2004). The Northern

Superior Uplands encounter the Canadian Shield, a vast area of exposed bedrock, glacial moraines, numerous lakes, outwash plains, and patchy areas of thin, coarse, loamy till. The resulting landscape, which can be clearly seen at Knife Lake, is a thin deposit of glacial drift over the rocky and glacially scoured landscape (Arzigian 2008; Gibbon 2012).

Figure 1. Key to SHPO resource regions, the red circle indicates the location of Knife Lake.

Precontact vegetation in the Northern Superior Uplands section would have included fire-hardy species typical of a mixed conifer and hardwood forest, including red and white pine, birch, aspen, spruce, and balsam fir. Peatlands can also be found to intermix with these dense forests, where both fire and wind throw events are known to be sources of disturbance. The

Border Lakes region specifically includes over 300 lakes, most of which are found within the bedrock. Several important rivers are present as well, including the Sioux and the Vermillion (Arzigian 2008). Animal resources included large game animals such as moose and caribou, and smaller animals as well including wolf, lynx, black bear, red fox, beaver, and snowshoe hare. Hunting would likely have been a challenging endeavor due to the rugged terrain, and the wide dispersal and relatively low density of game populations. To supplement hunting activities, fish and other fresh water creatures, such as mussels and crawfish, were likely a viable resource due to the densely packed lakes and rivers. These factors, coupled with the minimal edible plant options available in the Laurentian mixed forest, would have put an emphasis on seasonal harvesting of resources, such as spawning spring sturgeon (Arzigian 2008).

Stoltman (1973) made the argument that the native vegetation of northern Minnesota would have created challenging terrain for human occupancy. The basin left by Lake Agassiz is home to poorly drained peatlands filled with conifers. A forest with a high conifer population produce highly acidic soil, and these poor soil conditions often result in regular tree and wind throw events, creating a poor environment for preservation. Evidence for pottery, bone tools, or housing structures is often challenging to recover in such conditions, and can sometimes make for an overall sparse and patchy record of Laurel cultural patterns (Mason 2001). Evidence of the Laurel complex is typically found north of the conifer bogs, which may have created a large, natural intercultural barrier between Laurel communities and contemporary complexes of central Minnesota. Based on Stoltman's (1973) boundaries for the Laurel people, Knife Lake is closer to the southern boundary.

Climatically, Minnesota's Woodland period underwent a number of changes although the degree of which may not have been as great as previously experienced. The most impactful change was one of cooler temperatures, known as the Sub-Boreal, which lasted from 4,850 – 2,900 calBP (Gibbon et al. 2002). These temperatures were maintained through the Early and Middle Woodland, and were then followed by a warming trend from 700 – 1,200 calBP, known as the Neo-Atlantic, and then the Pacific period, dating from 600 – 1,000 calBP (Gibbon et al. 2002). Finally, another cooler and wetter period lasted until 1915, known as the Neo-Boreal or Little Ice Age (Arzigian 2008; Gibbon et al. 2002). On the prairie, the effects of the climate shifts were more dramatic and resulted in localized changes in the prairie ecotone and bison herds. In the northeastern mixed forests, lake levels would have fluctuated and effected settlement and subsistence strategies. Additionally, drier climates would have encouraged fire occurrences, thereby affecting climatic conditions even further and human lifeways throughout the state (Arzigian 2008; Gibbon et al. 2002). In northeastern Minnesota fire disturbances were already a regular event, so additional fire episodes could have caused a significant impact.

Today, northern Minnesota is highlighted by very cold winters and mostly cool summers, with the mean temperature falling around 37 degrees Fahrenheit (Gibbon 2012). This average temperature coupled with the short frostless season puts the region below the ideal temperature range for efficient corn agriculture. Palynological evidence suggests that Laurel communities were living in a habitat that is similar to the environment encountered in the region today (Gibbon 2012; Stoltman 1973). From this, Stoltman (1973) hypothesizes that Laurel people were perhaps the first in the region to utilize wild rice, yet Arzigian (2008) maintains that further phytolith analysis is needed to substantiate this theory. Nevertheless, the similarity in climate between today and the Middle Woodland period in question helps to discern possible landscape utilization techniques.

The Laurel Complex

Ranging from approximately 2,100 – 1,300 calBP, the Laurel sites are found across the northern portion of the state and extend across the northern Great Lakes including Ontario, western Quebec, northern Michigan, and northwestern Wisconsin (Figure 2). This large range makes it the most extensive Middle Woodland culture on the continent, with most known sites concentrating around the Rainy River and Vermillion River drainages (Arzigian 2008; Gibbon 2012). Laurel sites are typified by an adaptation to northern forest hunting and gathering lifeways, as depicted by lithic, worked bone, worked antler, and copper tools. Large-scale trading patterns can also be discerned from Laurel sites, based on the presence of nonlocal raw materials and borrowed cultural patterning found on ceramics (Arzigian 2008; Stoltman 1973). As mentioned previously, the Laurel complex is considered to be a northern associate of the Hopewell trade and cultural sphere. This trade network is known to have extended as far south as Florida, with its concentrated center in the Ohio and Illinois River valleys. Much of the network surrounded the Great Lakes, and this would have included Laurel. As such, it is likely that people, raw materials, ceramic styles, ideology, and other culturally diagnostic traits travelled throughout the whole of this interaction network (Mason 1981). If this is the case, Laurel people may have contributed their own cultural resources to the interaction sphere as well.

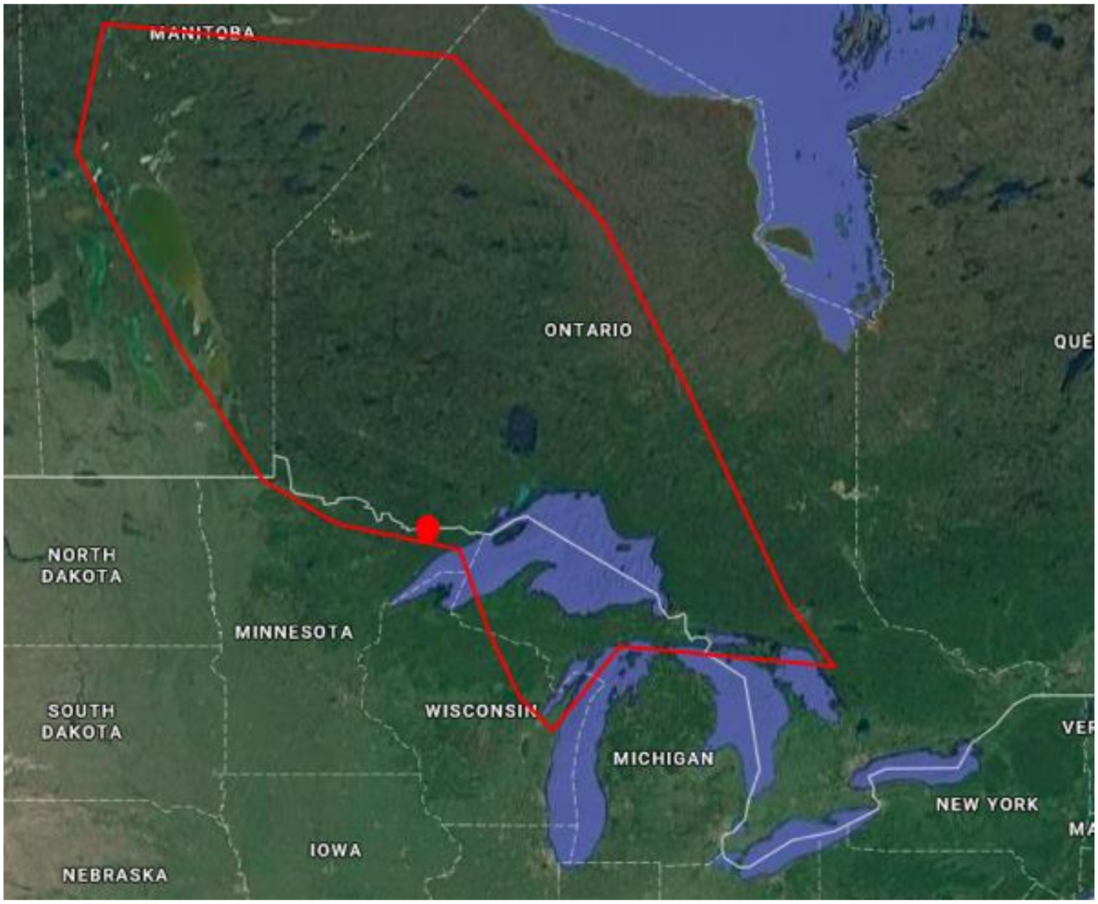

Figure 2. General boundary of the Laurel culture. The red circle indicates the location of Knife Lake.

At a more localized level, the extensive range of the Laurel complex appears to have caused a sort of internal interaction sphere. The Rock Island site of northern Wisconsin and the Naomikong Point locality in Michigan extend the Laurel complex further south and east than originally thought (Figure 3) (Mason 1991, 2001). Mason (1991) recounts the artifacts recovered from the Rock Island site, located on an island of the same name in Lake Michigan, north of the Door Peninsula in northern Wisconsin. Artifacts at the site were radiocarbon dated, making it contemporary to the Pike Bay phase of Laurel. The Pike Bay phase has traditionally been thought to be confined to northern Minnesota and western Ontario, so the addition of a site located much further to the south and east are cause for reconsideration in terms of interaction between the two localities. The variability in pottery styles at Rock Island led to the conclusion that "the spatial and temporal dimensions [of Laurel] were sufficient to produce considerable diversity in the pottery and some of the other products of the culture" (Mason 1991:122). This vast amount of artifact diversity is the basis for describing Laurel as a continuum, with sites like Rock Island resulting from kinship and trade relationships. Mason (1991) poses the argument that the Laurel complex erupted from multiple origins, likely from groups that shared descent from similar Archaic ancestors, inhabited similar environments, and regularly interacted with the Great Lakes region. The Laurel complex exhibits large variations between regions, and these regional similarities are suggestive of interaction, diffusion, and down-the-line trading (Mason 1991). Under this paradigm, it is possible to consider Knife Lake and the homogenous nature of the artifacts recovered therein as unique expression along the Laurel continuum.

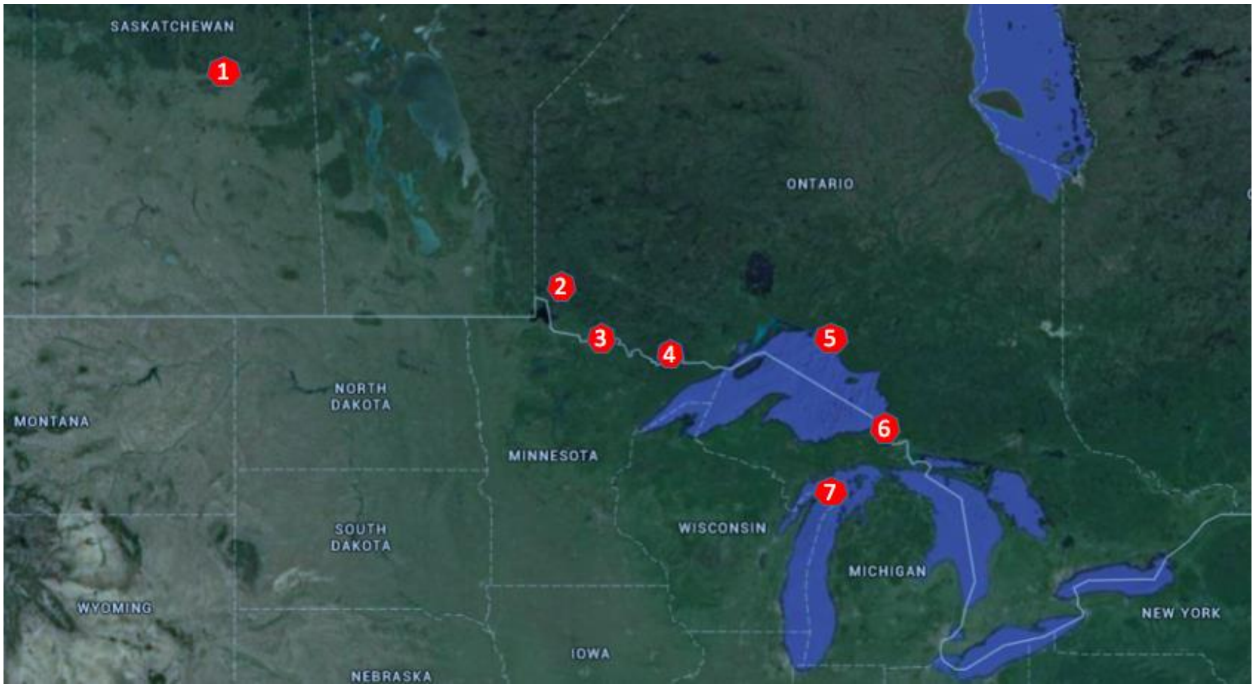

Figure 3. Geographic spread of Laurel sites. 1) River House Complex, Saskatchewan 2) Ballynacree and Fisk sites, Ontario 3) Grand Mound, Minnesota 4) Knife Lake, Minnesota and Ontario 5) Heron Bay, Ontario 6) Naomikong Point, Michigan 7) Rock Island, Wisconsin.

In general, much of the artifact data recovered from Laurel sites is focused on variations of Laurel pottery, bone tool implements, copper usage, and mound construction. It seems as though little data is provided for stone tools and raw materials, especially in comparison to the data available on Laurel pottery. Much of the early data concerning the Laurel complex in Minnesota was the result of mound excavations, and thus much of Laurel's culture history is based on these mound assemblages (Arzigian 2008; Stoltman 1973). The problem here is that mounds are a very specific site type, and considering this data alone can skew perspectives on the Laurel complex as a whole. This also helps to explain why a Middle Woodland component was not considered at Knife Lake prior to the OSL dates. Research is still needed throughout the region to delineate Laurel's spatial boundaries.

In addition, the quarrying activities at Knife Lake appear to have created a singular site type within the Daughter District, in this case resource procurement and processing sites (Arzigian 2008). If the Daughter District sites only represent one site type, then it may help to explain the lack of pottery found at these sites. That is to say, pottery may not be present at the JJ site because the function of the site may not have required the use of pottery.

Its Middle Woodland association, northern geographic location, and seasonally dictated hunter-gatherer lifeways generally summarize the primary descriptors of the Laurel complex (Arzigian 2008; Gibbon 2012). There are, of course, additional characteristics that help to define this cultural complex, including the early introduction of ceramics. A variety of ceramic types are attributed to Laurel, including Laurel Pseudo-scallop shell, Laurel Oblique, Laurel Dentate, Laurel Incised, and Laurel Bossed (Stoltman 1973). Stoltman (1973) used seriation, ceramic analysis, and radiocarbon dates to hypothesize that the earliest Laurel dates occur toward the southern boundary of the northeastern Minnesota region. He goes on to say that as Laurel expanded and time elapsed, the complex moved northward. As such, the Laurel complex can then be broken into three phases, consisting of the Pike Bay phase dating from 2,050 – 1,650 calBP; the McKinstry phase dating from 1,650 – 1,450 calBP; and the Smith phase dating from 1,450 – 1,150 calBP (Arzigian 2008; Stoltman 1973). Geographically, Knife Lake sits near the south-central boundary of the Laurel extent, likely putting it within the range of the Pike Bay or McKinstry phase. Temporally, the Woodland occupation at Knife Lake is dated to 2,170 – 1,690 calBP, evidenced by OSL dates as discussed in Chapter 3. Based on this timeframe, Knife Lake would again fall into the Pike Bay phase. The geographic location of Knife Lake and the early Laurel OSL dates mutually supportive.

Furthermore, Reid and Rajnovich (1991) were able to draw on previous work, including Stoltman (1973), to outline three Laurel composites based on their work at the Ballynacree site near Kenora, Ontario. Their work was focused on a Laurel habitation site, a rare and important find for a culture defined mostly by mound excavations. Using radiocarbon dating and ceramic seriation, combined with Stoltman's (1973) study, the authors hypothesize four Laurel complexes. The Pike Bay complex dates from 2,150 – 1,650 calBP; the McKinstry complex dates from 1,650 – 1,350 calBP; the Smith complex dates from 1,350 – 1,050 calBP; and the Hungry Hall complex dates from 1,050 – 750 calBP. Again, the OSL dates at Knife Lake, ranging from 2,170 – 1,690 calBP, suggest an affiliation with the Pike Bay phase.

Reid and Rajnovich (1991) go on to suggest the Boundary Waters as the centralized base of Laurel peoples, and theorize this area to be the birth of Laurel cultural evolution. Because Laurel sites radiate north and west into Ontario, Manitoba, and Saskatchewan, and south and east to Wisconsin and Michigan, the Boundary Waters area of northern Minnesota and southern Ontario, with its rich variety of Laurel sites, could be the epicenter of this Middle Woodland tradition. The location of Knife Lake, then, falls directly within this important area. As has been stated, Laurel sites appear to have been regionally diverse (Mason 1991; Mason 2001). If Laurel did evolve out of the Boundary Waters area, perhaps Knife Lake embodies an early expression of this complex. This could account for the lack of pottery, copper, or fishing technology present within the Daughter District, although the use of the Knife Lake quarries as resource procurement sites is likely a larger influence on these types of material culture. It may be that the

Knife Lake quarries are functionally specialized sites, which has resulted in a narrow range of recovered artifacts.

Reid and Rajnovich (1991) were also able to conclude that lodge architecture remained similar from 2,100 – 750 calBP, spanning all four phases. This important evidence is suggestive of consistency in family size. Laurel housing styles were carried into the Late Woodland, which suggests Laurel lifeways could have continued into this time as well (Reid and Rajnovich 1991). Other work on Laurel housing structure in northern Minnesota and southern Ontario has been plagued by insufficient evidence. The Ballynacree site is one of the only completely excavated Laurel habitation structures, but other sites, including the nearby Fisk site, provide some additional evidence as to what Laurel structures may have looked like. The hypothesis is an oval-shaped lodge, with poles anchored into the ground and bent together near the top to create a dome shape. The whole structure would measure six to eight meters long and three to five meters wide (Reid and Rajnovich 1985).

One of the main problems plaguing excavations of Laurel structures is the compressed stratigraphy of the boreal forest of northern Minnesota and southern Ontario. The result is multiple strata condensing into a very small vertical space (Reid and Rajnovich 1985). This creates a problem because compressed strata negate the law of superposition, which states that soil layers are deposited sequentially, making it harder to sequence the artifacts recovered therein (Harris 1979). It is likely this compressed stratigraphy may be present at other Laurel sites in the boreal forest of northern Minnesota as well, and should be kept in mind for Knife Lake sites.

Because Knife Lake includes siltstone quarry sites, it will be helpful to understand Laurel chipped stone artifacts, yet most of these previously recorded artifacts were recovered from non-quarry sites. Stoltman's (1973) monograph covers lithic items found at several mound sites near the Rainy River. These include various projectile points, scrapers, knives, cleavers, drills, axes, and choppers. He also considers raw material types, and concludes that chert is the most apparent material, with a “fine, light grey variety” appearing most frequently at the Laurel sites in question (Stoltman 1973:101). He also accounts for the widespread appearances of brown chalcedony (typically Knife River flint), quartz and quartzite, jasper, and a smattering of agate, slate, basalt, and obsidian (Stoltman 1973). These examples of slate, basalt, and light grey chert could all be indicative of Knife Lake Siltstone. The KLS quarries were not widely known until the late 1970s, with major research at Knife Lake starting in the 1980s (Muñiz 2013). Because this publication came out in 1973, it could be possible that Stoltman did not have knowledge of the Knife Lake quarries while conducting his research.

More recently, Meyers et al. (2008) report on artifacts recovered from several excavations in eastern Saskatchewan and western Manitoba that exhibit ties to Laurel, including lithic tools and debitage made of basalt and shale. Three sites, known as the River House complex, revealed radiocarbon dates, pottery styles, and lithic technologies indicative of the Middle Woodland Laurel complex. Not only did all three occupations provide contemporaneous timelines with recurring basalt and shale debitage, but several bifacially flaked knives as well, which can be produced from blades or blade-like flakes (Meyers et al. 2008). The report did not provide additional detail on the raw material sources or the shape of the knives, but there are potential similarities to Knife Lake and the blades recovered at the JJ and Lillian Joyce sites. What makes the River House complex additionally interesting is the likelihood of multiple cultural interactions, evidence of which is based on the significant distance of these sites from the Rainy River region as well as pottery traits representative of other Middle Woodland cultures, such as the Avonlea people. Meyers et al. (2008) conclude that the Laurel artifacts at the River House complex may represent a late or relic Laurel expression. This in turn supports Reid and Rajnovich's (1991) hypothesis of Laurel's continuation into the Late Woodland in some areas as well as Mason's (1991) suggestion of Laurel as a complex influenced by trade and kinship.

Laurel lithic artifacts include end scrapers, side and corner-notched projectile points, small-eared points, and a general variety of other stone tools. End scrapers are thought to be particularly abundant due to an increased reliance on fishing (Arzigian 2008; Clark 1999). Heat treatment and the use of blades are other prominent characteristics of Laurel lithic technology. Raw material distribution and use is of special interest for Laurel sites, as exotic raw materials are indicative of trade and intercultural interaction. Notable materials from Laurel sites in northern Minnesota include Knife River flint and obsidian (Arzigian 2008; Clark 1999). Indications of trade and interaction are made more significant by Laurel's association with the Hopewell Interaction Sphere, a trade network would have extended into the upper Great Lakes region (Arzigian 2008; Stoltman 1973). The question to be applied to Knife Lake then, is whether Knife Lake siltstone and any tools produced from this material, were valued export products in trade.

Ground stone technology is indicative of Archaic, Woodland, and protohistoric times, yet ground stone usage is rarely documented at Laurel sites and not at all from the Knife Lake sites. Evidence suggests that Laurel people simply did not have a habitual need for grinding or pecking, which would have assisted in tasks such as nut or seed grinding during Archaic times or maize cultivation and agricultural intensification during Woodland and protohistoric times (Salem 2016; McCullough 2007). Additionally, the boreal forest of northern Minnesota and southern Ontario during the Middle Woodland did not have an abundance of edible plant material, which would necessitate ground stone technology (Arzigian 2008). The boreal forest environment may have required a heavier reliance on game hunting as a main dietary staple based on the recovery of stone tools such as projectile points and scrapers (Mason 2001; Stoltman 1973). Finally, in terms of Knife Lake and KLS, siltstone would likely have been a poor choice for ground stone use, even if Archaic or Woodland cultures would have been utilizing grinding stones in this area. As a siltstone, KLS is typically a more fine-grained material. Ground stones, on the other hand, are mostly comprised of coarse rocks such as basalt, granite, or rhyolite. These large-grained materials would have been highly conducive to grinding plants or other stones (University of Iowa, Office of the State Archaeologist 2016). As a result, although Archaic and Woodland cultures have been known to have utilized ground stone technology extensively, little evidence is seen in Laurel cultures or at Knife Lake.

Trading appears to have been a vital component of Laurel society, as evidenced by the sometimes large variety of artifacts within assemblages recovered from sites throughout the Laurel's geographic range. Naomikong Point near Lake Superior in Chippewa County, Michigan (Figure 3) is characterized as having either the largest population of Laurel peoples or being the most frequently used site. Over 100,000 pieces of pottery were recovered, with the majority of identifiable pieces classified as Laurel. Some pieces, however, represent non-Laurel patterns and suggest interaction with another culture. Additionally, the far southeastern location of the site makes it likely that inhabitants at Naomikong Point would have interacted with neighboring peoples (Mason 2001). Heron Bay, located near the mouth of the Pic River as it flows into the north-central shore of Lake Superior within Ontario (Figure 3) is a Laurel site which exhibits an extensive array of artifacts, specifically ones which originate both within and outside of the Laurel complex distribution. Exotic materials include shell originating from Manitoba, pot sherds from the Saugeen culture east of Lake Huron, and obsidian from Wyoming (Mason 2001). Local materials include Laurel pottery and stone tools as well as bone tools which are highly "unusual in most contemporary sites in the boreal forest," such as the Knife Lake sites (Mason 2001:66). Evidence of trading at Laurel sites helps to provide explanations for the diversity of artifacts between sites, specifically in cases where an overabundance of one artifact type may appear at one site, but may not appear at all on other sites.

Along with ceramics, changes in lithic technology, and increasing trading habits, mounds and mortuary practices are probably the most distinct Laurel features. The mounds of northern Minnesota include the Pike Bay Mound, Grand Mound/Smith Mounds, and McKinstry Mound. Artifacts from these sites vary widely, but include things like copper awls and bracelets, bone ornaments, marine-shell beads, and red ochre treatments (Arzigian 2008; Torbenson et al. 1992). Additionally, punctured human remains have suggested cultural practices concerning spirit release. To date, no non-mound burials have been confirmed but some sites are suspected (Arzigian 2008; Torbenson et al. 1992). Laurel burial practices are decidedly complex and intricate, and point to a distinct cultural presence.

Torbenson et al. (1994) examined Smith Mounds Three and Four, located near the convergence of the Big Fork and Rainy Rivers. Because rivers are known to be crucial links between communities and cultures for travel and trade, it is important to note that Rainy River drains into Lake Superior, and thus connects to the rest of the Great Lakes (Torebenson et al. 1994; Gibbon 2012). Additionally, Rainy River is the corridor along which several other Laurel or Blackduck associated mounds can be found, including the state's largest mound, Grand Mound. The Blackduck-Kathio complex of northern Minnesota dates to 1,350 – 950 calBP. For the purposes of this culture history, it is helpful to know that Blackduck is considered a Late

Woodland complex, with several sites, including the McKinstry and Smith sites, having both Laurel and Blackduck occupations.

As mentioned, Laurel burial patterns are highly unique and distinct. On top of intricate burial practices, such as punctured bones and bundled burials, Torbenson et al. (1994) found several skulls in which the occipital bone, the bone at the lower back portion of the cranium, had been removed. This evidence, coupled with long bone perforation, may point to cultural practices concerning ideology. Furthermore, there was a trend towards red ochre-covered bones as well as copper grave offerings amongst adult burials, again pointing to ideology and culture-specific burial practices. Finally, analysis also revealed some injuries sustained to the bones, such as skull lesions, ulnae fractures, or penetrating trauma to the knees, which suggest these injures were sustained in conflict (Tobenson et al. 1994, 1992). Although no KLS materials have been recorded from mound excavations to date, possibly because the excavation predated the widespread knowledge of KLS and Knife Lake as a lithic material source, the mound and burial practices at least give insight into Laurel cultural values and practices.

As Reid and Rajnovich (1991) discussed, the Boundary Waters and the Rainy River appear to be both the starting and ending point for the Laurel complex, a timeline that spans 1,400 years. In this region, homes and communities were built, ceremonies and internments took place, and local resources were found and incorporated into everyday life. At Knife Lake, we see strong evidence for Laurel’s primary characteristics through the OSL dates, its location along the Minnesota-Canada border, and possibly specialized lithic artifacts. There is also some evidence for other artifacts and features associated with Laurel including ceramics and evidence of burials. As has been discussed, the Daughter District on Knife Lake is a known quarry source and therefore a specialized site type; activities taking place there would have been specialized and preplanned.

The OSL dates from the JJ site at Knife Lake indicate Middle Woodland sediments present from 1,930 +/- 240 calBP, which would put the JJ site within Stoltman's (1973) Pike Bay phase, ranging from 2,150 – 1,050 calBP, or Reid and Rajnovich's (1991) Pike Bay complex, ranging from 1,750 – 1,650 calBP. Knife Lake has already been identified as falling on the southern boundary of the Laurel complex, and Stoltman's (1973) evidence suggests earlier Laurel sites exist in the south and move northward through time. If lithic analysis can help to define an organized technological pattern in support of an adaptive strategy contingent with the lifeways discussed above, then more support can be given to a Middle Woodland presence at the Knife Lake quarries.

It has been well established that Knife Lake was used as a quarry source by Paleoindians, based on an Agate Basin point recovered from the Canadian side of the lake (Nelson 2003), the OSL dates collected on the US side (Muñiz 2015), and the characteristics of lithic technology production that are currently thought to be culturally diagnostic (Muñiz 2013). Nelson (1992) reports 28 sites on the Canadian side of Knife Lake, and Clayton and Hoffman (2009) report 8 confirmed quarry sites on the US side. Archaeologists do not yet have a full understanding as to how these quarries would have been utilized through time. The OSL dates account for a contemporaneity between the JJ site and the Laurel complex, and thus puts forth the possibility of Knife Lake siltstone as an important commodity.

Lastly, several blades have been recovered from Knife Lake that are associated with the Middle Woodland OSL dates, specifically from the JJ and Lilian Joyce sites. The best known blade technology in the precontact US is that of the Hopewell culture in Illinois, Ohio, and the

Lower Mississippi Valley (Parry 1994). Usually typed as bladelets, these tools were used for piercing, cutting, and scraping with little signs of retouch. Exotic raw materials and bifacial cores are also common finds in Hopewellian assemblages. Both blades and bifaces, in a variety of raw materials, were likely to travel long distances within this large trading system (Parry 1994). If evidence of blade and biface production can be found within the JJ site debitage and comparative data for this artifact class can be applied to contemporaneous components within the Daughter District, then interpretations can be formed concerning cultural-temporal associations and blade technology. The implications for a purposeful blade technology within the Middle Woodland at Knife Lake could be have broader ramifications. That, however, is beyond the scope of this thesis and merely serves as a sort of context within which to consider this possible Middle Woodland blade technology.

Woodland Sites on Knife Lake

As mentioned, the Daughter District on Knife Lake has been affiliated with Paleoindian cultures. The District is located in the North Arm, but the exact location of these sites, and other Knife Lake sites referenced in this thesis, will not be discussed for confidentiality purposes. Instead, sites will be will be reviewed using distance from the JJ site and references to locations outlined in Figure 4. A total of 10 Woodland-aged sites are dispersed across the U.S. side of the lake, mostly concentrated in the South Arm. These sites are temporally associated with Woodland cultures due to the presence of pottery and/or projectile points.

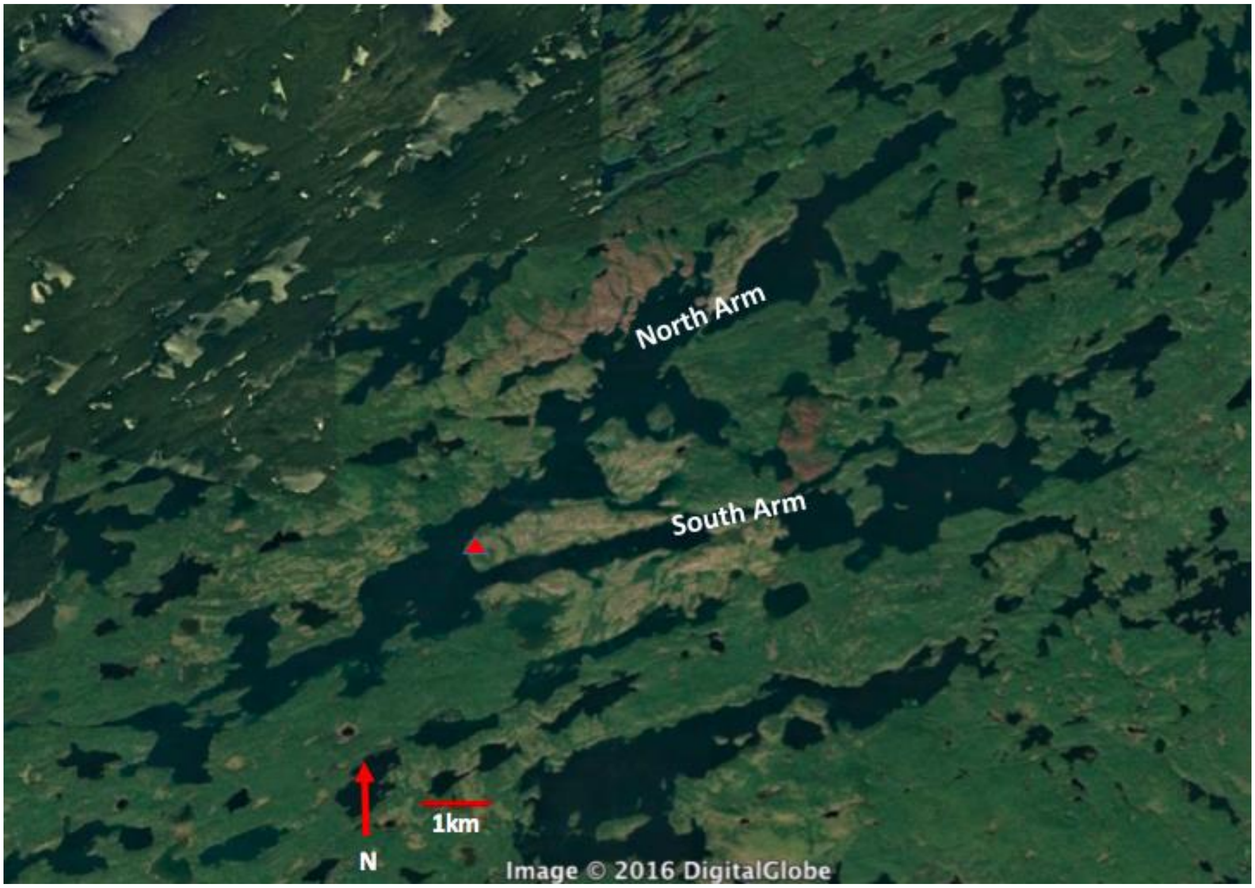

Figure 4. A view of Y-shaped Knife Lake, indicating the North Arm and South Arm. The red triangle marks Thunder Point, which serves as a point of reference. The Canadian border cuts through the middle of the North Arm of Knife Lake.

Only two of the 10 Woodland-dated sites on Knife Lake are located west of Thunder Point, while the remaining eight are located to the east. Roughly to the west of the JJ site is the Knife Lake Campsite #16 site (05-273). Recovered artifacts include one broken JT projectile point, two scrapers (one KLS, one JT), and several pieces of KLS debitage. The site faces west, and is approximately .5 km from a portage trail (United States Forest Service, Superior National Forest, Kawishwi District, Site Form #05-273). Also to the southwest of JJ, lies the Bird's Head

Point (05-228, 21LA7). The site was initially recorded by Elden Johnson (1972), and is situated on an old BWCA campsite. Surface-recovered artifacts are outlined in Table 1 below.

***n* =**	**Artifact**	**Description**
1	Knife, broken	KLS
1	Chopper/core	KLS
2	Cores	KLS
1	Blade, bifacially flaked	Mica-shist
2	End scrapers	KLS
8	Utilized flakes	4 KLS, 3 JT, 1 agate

Table 1. Surface artifacts from the U of M II site (05-228, 21LA7).

A 50x50 cm test pit was dug by Johnson's crew and uncovered a large bifacially-flaked blade, characterized as mica shist (Johnson 1972). More recent surveys have recovered a KLS lithic scatter and one unidentified pot sherd (USFS Site Form #05-228).

The remainder of the Woodland sites are located to the south and east of Thunder Point. A concentration of five sites is located approximately 3 km from the JJ site. The Big Dirt site (05-121) is located on a modern BWCA campsite, near a portage. Artifacts recovered include KLS and JT debitage and one quartz projectile point (USFS Site Form #05-121). The Camel's Back site (05-099, 21LA4) is east of the JJ site, and is located on a portage trail, adjacent to a modern campsite. Although no diagnostics were recovered, Johnson (1972) recorded one cord-marked, grit-tempered pottery body sherd, which is consistent with Laurel pottery types (Arzigian 2008; Reid and Rajnovich 1991). Several utilized KLS flakes, two utilized quartz flakes, and one non-utilized agate flake were also found. Johnson (1972) interpreted the area to be a short-term occupation site on a modern portage trail. The Knife Lake Campsite #25 site (05-277) is the campsite adjacent to the Camel's Back site, and provides the best evidence for KLS use during the Woodland. One KLS projectile point (Figure 5) was found along with several rim and body pottery sherds, several KLS waste flakes, and some pieces of burned bone (USFS Site Form #05-277).

Figure 5. Photo of KLS projectile point from the Knife Lake Campsite #25 site.

The other two sites located in the same vicinity, east of JJ, are the Birch Point site (05-077, 21LA5) and the Knife Lake Campsite #24 site (05-835). The Birch Point site, located on a modern campsite, has good evidence to suggest it was used as a Middle Woodland habitation site. Subsurface testing revealed one Laurel Dentate pot sherd. Other artifacts included over 20 retouched KLS flakes, several gunflint silica (GFS) flakes, one Lake of the Woods Rhyolite (LWR) flake, one utilized JT flake, one unifacial pink chert end scraper, one unifacial agate end scraper, and several charcoal scatters (Johnson 1972). The Knife Lake Campsite #24 site is also located on a modern campsite, just west of the Birch Point site. Recovered artifacts include several KLS flakes, one KLS core, several GFS flakes, and one JT projectile point (Figure 6) (USFS Site Form #05-077; #05-835).

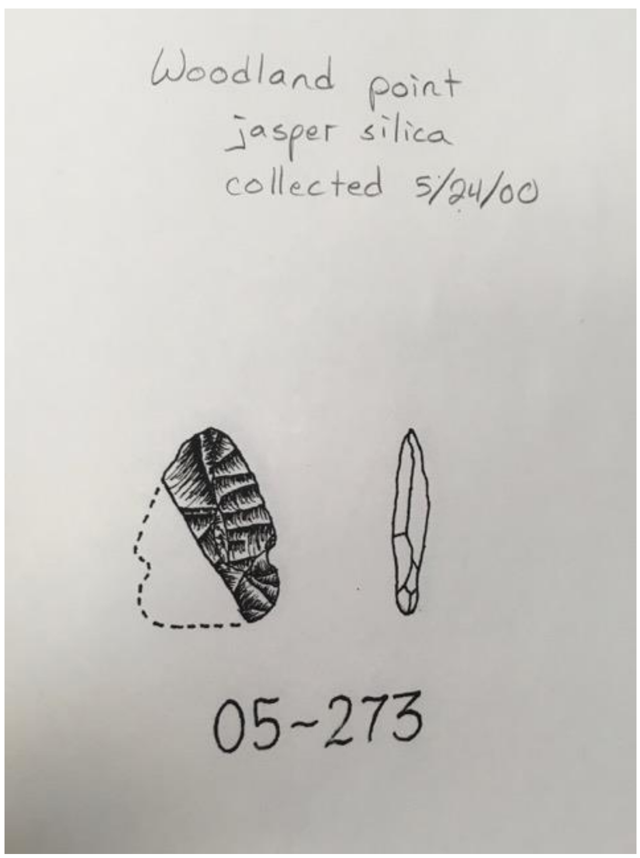

Figure 6. Drawing of JT projectile point from the Knife Lake Campsite #24 site.

Approximately 4 km east of the JJ site lies another concentration of three Woodland-dated sites. The Johnson site (05-078, 21LA3) exhibited an extensive array of recovered artifacts, as outlined in the Table 2 and Table 3. The site sits on a modern campsite, and several recovered pot sherds lend to a Laurel or Blackduck association (USFS Site Form #05-078).

Surface findings:

***n* =**	**Artifact**	**Description**
1	Knife with edge utilization	JT
1	Broken projectile point tip	Likely KLS
1	Flake with edge utilization	KLS
3	Flakes	2 agate, 1 JT
2	Pot sherds	1 smooth, 1 cord marked w/ grit temper

Table 2. Surface finds at the Johnson site (05-078, 21LA3).

Subsurface findings:

***n* =**	**Artifact**	**Description**
6	Utilized flakes	5 KLS, 1 quartzite
2	Flakes	1 agate, 1 KLS
1	Pot sherd	Cord marked
1	Rim sherd	Undecorated, cord marked
18	Burned Bone	Likely a medium-large mammal

Table 3. Subsurface finds at the Johnson site (05-078, 21LA3).

The Gravel Beach site (05-117) also sits on a modern campsite, and has sustained heavy erosion over years of recreational use. One pot sherd of an unknown type suggests a Woodland association. Additionally, recovered materials included several pieces of KLS and JT debitage (USFS Site Form #05-177).

On the eastern end of the South Arm lies one of the most widely-discussed Knife Lakes sites. Known as the Gold Island site (05-809, 21LA2), it was uncovered by a local resort owner, Norman Saari, in 1968. Saari reported finding skeletal remains, including a skull bone fragments (Steinbring 1974). This find prompted two University of Minnesota anthropologists, Peterson and Adams, to follow up on the lead (Johnson 1972). Peterson and Adams were able to locate a shallow, cobble-lined pit and three individual remains. The burials appeared to be secondary bundles, and were found very near the surface of a gravelly esker. Additionally, no cultural materials were recovered with the remains (Steinbring 1974). Johnson (1972) revisited the site and surmised that other burials could exist on the island, although no evidence currently suggests this. The Gold Island site quickly gained media attention, and was initially reputed as the continent's oldest skeletal remains, but the radiocarbon results remain unclear (Duluth News Tribune, 9 July 1972). Due to the sensitive nature of the site, its proximity to a campsite or portage will not be discussed.

Finally, roughly 9 km east of the JJ site near the eastern end of the South Arm lies the Knife Lake Campsite #43 site (05-278). The site is comprised of a solitary surface find; one pot sherd, of an unknown type, which was found in the roots of a tree throw. Like several other Woodland-aged sites on Knife Lake, the site is located on a modern campsite near a portage trail (USFS Site Form #05-278). Table 4 summarizes the Woodland sites, and the resulting artifacts, on the US side of Knife Lake.

USFS Site #	Site Name	Type/Function	Diagnostic Artifacts
05-077	Birch Point Site	Historic/Habitation	1 Laurel Dentate rim sherd
05-078	Johnson Site	Precontact/Habitation	2 pot sherds, 1 projectile point tip
05-099	Camel's Back Site	Precontact/Habitation	1 pot sherd, possibly Laurel
05-117	Gravel Beach Site	Woodland	1 unidentified pot sherd
05-121	Big Dirt Site	Precontact/Habitation	1 quartz projectile point
05-228	U of M Site II	Woodland	1 decorated pot sherd
05-273	Knife Lake Campsite #16	Precontact	1 broken JT projectile point
05-277	Knife Lake Campsite #25	Woodland	1 KLS projectile point, several pot sherds
05-278	Knife Lake Campsite #43	Precontact/Habitation	1 unidentified pot sherd
05-809	Gold Island Site	Woodland/Burial	Skeletal remains, burial pit
05-835	Knife Lake Campsite #24	Precontact	1 JT projectile point

Table 4. Summary of Woodland-associated sites on Knife Lake.

As previously mentioned, Stoltman (1973) used palynological evidence to suggest that the landscape of northern Minnesota has undergone minimal change between the Middle Woodland and the present, meaning the same campsites and portages on the maps today have likely been in use for at least several hundred years. If the topography of Knife Lake has undergone only minor changes since the Woodland, then many precontact sites throughout the BWCA may be found on or near modern day campsites, the Wendt site of the Daughter District included, due to the unique topography of the area. As Johnson (1972) explained, archaeological sites found on campsites can be misleading. These sites tend to be heavily eroded from decades of use, and lack projectile points, pottery, or other recognizable artifacts due to visitor collection. What is left, then, are flakes, broken tools, and undecorated pot sherds that are more challenging to identify (Johnson 1972). Evidence for Middle Woodland occupations at Knife Lake, particularly in the Daughter District, is sparse and disjointed. The OSL dates from the JJ and Lillian Joyce sites provide an additional line of evidence for precontact use of Knife Lake during the Middle Woodland, and provides an avenue for further exploration of this cultural occupation.

Chapter 3: Knife Lake

Site Summary

The JJ site was recorded in 2011 as part of an investigative survey conducted by USFS and SCSU archaeologists. The survey was undertaken to revisit two known sites, explore a fur trade era site, and examine other potential Knife Lake siltstone quarry areas (Muñiz 2013). In 2012, the JJ site was revisited with the intention of conducting a thorough surface survey and excavating test units. The goal of excavation was to examine depositional integrity, and identify the presence of various occupation levels. Two units were established, but excavations were left unfinished as a result of fire activity. The first several levels of the two units revealed valuable information, so a return trip was planned for 2014. Debitage from the initial excavations was interpreted as bifacial debris, blade manufacture, and channel flaking (Muñiz 2013, 2015). For the return trip in 2014, the two units were reopened and excavations were carried to culturally sterile levels. The goal for the 2014 trip was to complete excavations at JJ, obtain OSL dates from the JJ, Lillian Joyce, AJM, and Wendt sites respectively, and initiate collaborative archaeological efforts at Knife Lake with some of Minnesota's Native American communities (Muñiz 2015). All three objectives were successfully achieved. Prior to detailing the results of the excavations at the JJ site, a brief discussion on how OSL dating works and the raw materials local to northern Minnesota will be helpful.

Optically Stimulated Luminescence (OSL) Dating

Optically stimulated luminescence (OSL) dating is based on the quantification of two sets of radiation measurements in an effort to calculate how much time has elapsed since the sample was last exposed to either sunlight or high heat. OSL dating takes advantage of the natural radioactive isotopes commonly found in sediment, typically quartz or feldspar, to date the amount of light emitted from these minerals. This emitted light is known as luminescence (Duller 2008). It is possible to quantify these levels of radiation within the minerals based on the same principles of radioactive decay that drives radiocarbon dating. Substantial levels of sunlight or heat will reset the luminescence "clock" of a soil sample, and it is the goal of OSL dating to date back to this reset using the energy stored in the minerals. In other words, OSL dates represent the last time the sediment was exposed to sunlight, and therefore the approximate date of the artifacts found within that sediment. Duller (2008) gives the analogy of rechargeable battery, wherein the battery is charged by the sun and stores that energy until it is exposed to similar light or heat emissions. To date backward, the samples are exposed to luminescence in the lab to release the stored energy. This level of luminescence is then measured, and divided by number of years the sample would have been subject to radioactive decay. In Duller's (2008) analogy, the energy from the battery is measured and calculated to see how much had been stored. Based on these principles, it is important to note that OSL dates are presented in calendar years before the year of measurement, identified here as calBP, and represent the minimum age of the sample.

Knife Lake and Knife Lake Siltstone

Knife Lake takes its name from the French fur traders, who referred to it as *Lac des Couteaux*, meaning Lake of Knives. The sharp siltstone local to the lake was known to cut their feet if they were not careful (Nelson 1992). Prior to the fur trade, Knife Lake siltstone and other local materials made Knife Lake and the surrounding area an important resource for precontact cultures.

Knife Lake falls within the Minnesota SHPO resource region 8 (Figure 1), or the Border Lakes Region, which extends along the eastern half of the border with Minnesota and Canada.

Based on its location between two countries, local raw material sources are likely to be found on both sides of the border. Bakken (2011) groups Knife Lake Siltstone, Lake of the Woods Rhyolite, and Lake of the Woods Siltstone/Chert as the Border Lakes Greenstone Group. The greenstone outcrops extend from Minnesota to Ontario to Manitoba, with the bulk of the belt being underground. KLS not only outcrops as a primary source at Knife Lake, as evidenced by the quarries in question here, but also occurs as a secondary source, found in glacial till, of varying quality throughout the state (Bakken 2011). It is typically thought that only finer grade KLS (i.e. better for producing stone tools) could be found at bedrock sources, while glacial till cobbles produced only coarse-grained, unworkable KLS (Stroh 2011). The Bradbury Brook site, a Paleoindian quarry site located in Mille Lacs County, demonstrates that this division is not always the case. Several artifacts made of coarse-grained KLS, acquired from glacial till sources, were recovered (Gibbon 2012). At the quarries, fine-grained material outcrops in large bands, which is ideal for making tools of all sizes, but evidence can be found for KLS tools from coarse-grained till sources as well (Bakken 2011; Rovanpera 2011).

KLS is known to be a challenging material to work with (Wendt and Romano 2009). Coarser-grained materials tend to be the most challenging, but fine-grained KLS can provide its own obstacles to flintknapping, and require extensive skill and expertise to work. Flaws often disrupt tool making with KLS, but early flintknappers appear to have known how to expertly work around these flaws to create finished pieces (Stroh 2011). The wide range of grain sizes found in archaeological contexts, from fine to coarse grain KLS, supports this interpretation. KLS also appears to be resistant to pressure-flaking, except on the finest-grained pieces, which makes it less conducive to finished tools (Stroh 2011; Romano 1991a; Wendt and Romano

2009). The expert ability required to work KLS speaks to a strong cultural tradition passed on by the peoples that created KLS tools.

Wendt and Romano (2009) produced results, based on experimental archaeology, for alternative hammer techniques in creating large, well made KLS bifaces. As mentioned, pressure flaking was found to be effective on only finely-grained KLS, and direct percussion was useful for bifacial production on fine and medium-grained KLS, while often resulting in termination failures on coarse-grained material. A two-person bar and hammer technique was successful in consistently producing large, coarse-grained KLS bifaces. As a result, Wendt and Romano (2009) were able to demonstrate several hammer techniques that may have been enlisted to adapt to KLS, a material that requires extra effort to work with.

Other raw materials found at Knife Lake sites include Hudson Bay Lowland chert, Gunflint silica, Jasper taconite, vein quartz, and a few unknowns (Muñiz 2015; Rovanpera 2012; Johnson 1972). Hudson Bay Lowland chert is a very high-quality material attributed to both the West Superior and South Agassiz Resource Regions. It typically occurs in glacial till within the resource region, but has also been noted in the glacial till of northeastern Minnesota (Bakken 2011). Gunflint silica is also local to the West Superior Resource Region, but is not a bedrock source. Occurring widely in glacial till, this material exhibits excellent flaking qualities, particularly for small tools. Availability of high quality material seems to be scarce, and may limit the size of tools produced from it (Bakken 2011). Jasper taconite (JT) varies in quality, with the finest grained varieties being extremely flakeable. Primary bedrock sources have been documented in Ontario and northeastern Minnesota. Secondary till sources have been found throughout Minnesota, Iowa, and Wisconsin (Bakken 2011). Finally, the vein quartz can be seen at the Knife Lake quarry sites themselves (Muñiz 2013, 2015). While Knife Lake is the primary source for Knife Lake siltstone, neighboring raw materials were also recovered at sites in the Daughter District and are likely the result of their presence as secondary sources in the glacial till.

Knife Lake siltstone, and the Knife Lake quarries themselves, are often synonymous with Minnesota's Paleoindian tradition. Rovanpera (2012) concluded the tool assemblage and point morphology at the Lillian Joyce site on Knife Lake was indicative of a Late Paleoindian tradition. Mulholland (2002) provides evidence for KLS utilization occurring predominately during the Paleoindian period. Bakken (2011) concludes that for the West Superior Resource region, Knife Lake siltstone and Jasper taconite are the prevailing lithic materials, especially at Paleoindian sites, where fine quality pieces from local sources are preferred. Stroh (2011) suggests Paleoindians would have preferred both JT and KLS, depending on which outcropping the individuals were closer to. A large JT bedrock outcrop is located near Thunder Bay, Ontario, and Romano (1991b) suggests usage of JT increases in sites located closer to this outcropping.

Bakken (2011) finds good evidence for significant Knife Lake siltstone use among Paleoindian sites, but not Archaic or Woodland sites. Muñiz (2013) outlines previous work at Knife Lake, which includes the initial recordation of a Paleoindian occupation at the Lillian Joyce site in 2001 based on an Agate Basin-style point base recovered from the surface. In 2003, an Agate Basin point was recovered just a few miles west of Lillian Joyce at the DaJt-14 site, on the Canadian side of the lake (Rovanpera 2012). More recently, excavations at the Mackenzie River near Thunder Bay, Ontario revealed several Paleoindian points made of KLS (Norris 2012). With little debitage recovered along with these points, it is possible the points were constructed elsewhere and then brought to the Mackenzie River for hunting. Muñiz (2013) concludes that while prior research had speculated on the possibility of a Paleoindian presence at

Knife Lake, the surveys and artifacts recovered in the early 2000s support Knife Lake's association with the Paleoindian period. The results of the 2014 OSL dating projects at Knife Lake also support a Paleoindian occupation (Muñiz 2015).

The Paleoindian period in Minnesota ranges in time from approximately 12,000 – 10,000 calBP, and is characterized by the use of high quality stone and well-made tools. This reliance on high quality raw materials likely necessitated a highly mobile lifestyle (Gibbon 2012). Early occupations for the Boundary Waters region would have been plausible roughly 14,000 calBP, based on glacial retreat (Mulholland et al. 1997). As such, the aforementioned conclusions of a Paleoindian affiliation with Knife Lake have been based on these understandings of Minnesota's precontact history. Equally, evidence for a later cultural occupation, including Archaic and Woodland, had not been considered prior to the OSL dates ascertained in 2014 (Muñiz 2015). These OSL dates provide evidence for Paleoindian, Archaic, and Woodland occupations at Knife Lake (Muñiz 2015).

The JJ Site

Lithic artifacts were the only type of artifacts recovered from both units. Unit 1 at the JJ site (Figure 7) recovered 1,050 total lithic artifacts from 12 excavated levels, including surface finds, from both field seasons. The raw materials of these artifacts is mostly KLS, with some Jasper taconite, vein quartz, Hudson Bay Lowland chert, Gunflint silica, and an unknown brown chert. Formal tools include 4 cores, 2 bifaces, and 9 blades (Muñiz 2015). Stratigraphically-defined separation with few disturbances was observed and indicative of a largely intact depositional context for the artifact assemblage. As a result, the OSL dates for the site were gathered from Unit 1. Five samples were collected, with the two deepest samples returning dates of 38,100 +/- 5,200 calBP from 35 centimeters below surface (cmbs) and 45,800 +/- 5,800 calBP from 27 cmbs respectively. At 20 cmbs an OSL date of 7,870 +/- 760 calBP was recorded indicating an Early Archaic date, at 11 cmbs an OSL date of 5,970 +/- 560 calBP was recorded indicating an early Middle Archaic timeline, and at 4 cmbs a date of 1,930 +/- 240 calBP was recorded indicating a Middle Woodland date (Muñiz 2015).

Figure 7. Excavations of Unit 1 at the JJ site in 2014, facing NE.

Artifacts from Unit 2 at the JJ site (Figure 8 and Figure 9) total 2,653, with 2 blades and 2 bifaces. Raw material varieties are comparable to Unit 1, with the addition of petrified wood and several unknown pieces (Muñiz 2015). Neither test unit at JJ recovered diagnostic artifacts indicative of a particular culture. Stratigraphically, Unit 2 is currently interpreted as containing an ancient tree throw in the lower strata based on the lack of any clearly defined horizons, the presence of multiple depositional disturbances, strong evidence for these events in the Boundary

Waters region, and the possible presence of re-deposited colluvium. Nevertheless, both Unit 1 and Unit 2 exhibit evidence for intact Middle Woodland and Middle Archaic components with increased blade production associated therein, which helps to establish consistency for comparative data possibilities (Muñiz 2015).

Figure 8. Excavations of Unit 2 at the JJ site in 2014, facing NW.

Figure 9. View of Knife Lake from the JJ site near Unit 2, facing NW.

The OSL dates support a conclusion of multiple cultural occupations at JJ and other Knife Lake quarry sites in the Daughter District, but the question remains as to whether or not the artifacts support this conclusion as well. The work of this thesis is to provide additional lines of evidence, based on artifact analysis, to provide insight on the precontact activity taking place at Knife Lake. Aside from the artifacts recovered at JJ and the rest of the Knife Lake sites in question, there remains a concern as to why no pottery is present on any of the sites within the Daughter District, let alone the Middle Woodland components at JJ and Lillian Joyce. Pottery is a prime diagnostic artifact for the Woodland period in the upper Midwest, with the Laurel ware representing Laurel's unique ceramic tradition. As previously mentioned, the Laurel complex exhibits additional cultural peculiarities including burial mounds and burial practices (Arzigian 2008; Stoltman 1973). Additionally, ceramics including Laurel and Blackduck pottery, projectile points, and a burial have been recorded at Knife Lake, although similar artifacts and features have not been observed at quarry sites (Johnson 1972; United States Forest Service, Superior National Forest, Kawishiwi District, Site Forms).

One explanation for the absence of additional Woodland indicators at the JJ site, is that Knife Lake appears to have been utilized exclusively as a quarry site, and can be classified as a resource procurement property and processing sites. According to Arzigian's (2008) description of resource procurement sites,

> activities would include procurement of material and could also include workshop materials representative of initial stages of processing that material. These sites will tend to be smaller and activity or function specific and will lack many of the indicators of a habitation site (dense, extensive, and diverse artifact assemblage), although lithic workshops and quarries could be large and have a dense artifact assemblage. Although there might be some evidence of short-term occupation at the site, the presumed focus of activities should be the specialized acquisition or processing of some specific material. By contrast, a habitation site would have a more diverse set of inferred activities (Arzigian 2008:151).

Based on the JJ site's location as a KLS quarry area and the absence of finished tools, Arzigian's (2008) description not only characterizes the KLS quarries but also explains the exclusivity of artifacts, in this case stone tools and debitage. This description helps to explain why no other diagnostic Woodland-aged artifacts have been recovered at JJ and Lillian Joyce despite the OSL dates.

This thesis project was undertaken to analyze the recovered artifacts from both test units at the JJ site, excluding the microdebitage. The primary concerns for this analysis are addressing questions related to changes in all artifact classes temporally at the JJ site, and the association of one artifact class, specifically blades, with another Daughter District site (Lillian Joyce). Debitage analysis of the JJ site artifacts can aid interpretations on tool technology production, if and how this production may have changed throughout the components, and can then be used as a comparison with Rovanpera's (2012) lithic analysis of the Lillian Joyce site. A blade analysis can help to determine if contemporaneous lithic production activities were occurring elsewhere at Knife Lake. Again, Rovanpera's (2012) research will be utilized for this comparison.

Chapter 4. Literature Review

Technological Organization

Any analysis is merely a narrow perspective on a broad and intricate subject about the past lives of humans. In the case of this thesis, the theory of technological organization guides the interpretations, which are based on the culture history of the time and region combined with the results of the lithic attribute analysis. The following paragraphs will highlight some of the assumptions driving my attribute analysis and the resulting interpretations. With that in mind, some background on the guiding principles of technological organization and strategies for identifying behavior through debitage analysis will be discussed.

Technological organization suggests that site function and adaptive strategies can be understood if the underlying systems for subsistence and adaptation can be deconstructed to pinpoint the requirements of those systems. "The organization of technology in any culture reflects situational adaptations that optimize human expenditure of time and energy" (Wenzel and Shelley 2001:110). Furthermore,

> [technological] choices are thought to have been made in response to a variety of situational contingencies and organizational constraints faced by prehistoric people. An understanding of the limitations and benefits of different technologies sheds light on the problems prehistoric people were attempting to solve and in turn provides a more detailed picture of prehistoric life (Rasic and Andrefsky 2001:73-74).

At the JJ site, lithic artifacts are the products of choices made by the early inhabitants of Knife Lake in response to subsistence, environmental, and cultural necessities. An understanding of those choices, and the implicit costs and benefits, can aid in identifying the external stimuli these early inhabitants were responding to.

Technological strategies as applied to stone tool production are typically used as a means of understanding what adaptations, including subsistence strategy and cultural conditions, were influencing technology use and production. If the archaeological record is a sample of past human behavior, then technological organization is a method of understanding how those behaviors impacted activities, as seen through specific patterns. Binford (1979, 1980), for example, studied the Nunamiut Eskimos of north-central Alaska in an effort to understand site formation processes and tool disposal. Lithic tools were modified by the Nunamiut in distinctive ways, and Binford (1979) identified the adaptive behaviors underlying those technological choices. For example, raw material variability, an intrinsic aspect of any technological strategy, within Nunamiut sites was explained in tandem with their chosen subsistence strategy. Ethnographic evidence suggested that the accrual of exotic raw materials, materials originating far from Nunamiut settlement sites, was more often the result of Nunamiut mobility patterns rather than trade networks (Binford 1980). As the Eskimos mobilized to accrue other resources, such as food or trade, they leveraged their time away from camp by looking for additional resources, including lithic raw materials (Binford 1979). As such, raw material variability at Nunamiut sites was influenced by subsistence and technological strategies.

Binford (1979) also discussed the importance of analyzing the tool kit, which he defined as the gear gathered and produced to carry out a specific goal. A distinction was made between curated and expedient tool kits, with curation pertaining to tools created with a multitude of future activities in mind while expediency referenced tools created in response to immediate tasks (Binford 1979). From Binford’s (1980) research, curated toolkits were more likely to be used by collectors, or groups employing a subsistence strategy wherein small groups embark on specialized gathering trips to bring specified resources back to the larger group. Expedient toolkits were more likely to be used by foragers, or groups which tend to move the larger group to the available resources (Binford 1980). Being able to identify either expedient or curated tools and debitage at the JJ site can help to interpret the technological organization of the culture responsible for producing those artifacts.

Raw material also plays an important role in technological organization. Bamforth (1986) suggested that raw material played an impactful role on technological organization because abundant raw material resources would have allowed for a wider range of technological adaptations, while a limited raw material availability would have required different strategies, such as tool maintenance or recycling (Bamforth 1986). If technological organization is the most efficient response to one’s surroundings, “the presence or absence of certain technologies reflects solutions to particular problems, such as the availability of lithic raw material” (Wenzel and Shelley 2001:110). This is a doubly important point as the JJ site is located near the KLS quarries, where one type of raw material, KLS, is readily abundant, and “greater distance from quarries presumably corresponds to greater degrees of tool reduction” (Shott 1994:86). For the JJ site, this may mean that initial reduction behaviors dominated the technological strategy in spite of the different cultural occupations. If reduction strategies remain consistent across the four OSL-dated cultural occupations, then the proximity of the JJ site near a KLS quarry may have remained an important influence during the initial technological strategies through time.

On the continuum of lithic reduction, quarry site reduction is near the beginning. Ideally, the behaviors driving initial reduction should also allow for insight into the far end of the spectrum, whether that be a blade or biface (Shott 1996). Though cores and bifaces may be considered to be more desirable, since a variety of tools could be produced from these forms while still allowing for relative ease in production and portability, technological strategies can result in different adaptations (Rasic and Andrefsky 2001; Binford 1980). “Blade cores maximize the size of detached pieces relative to core size they can produce more large blanks than a similarly sized bifacial core,” thus providing a suitable means of efficiently maximizing raw materials (Rasic and Andrefsky 2001:75). The appearance of blade production at the JJ site could be the result of technological strategies employed in an effort to efficiently use a challenging material or to utilize a resource that could not regularly be exploited year round, due to environmental or cultural restrictions.

Finally, Bamforth and Becker (2000) suggest that typically tools are not discarded at the same site where they are produced unless the tools have a short use-life and the site has a long occupation. If a tool has a long use-life and a site has a shorter occupation, the likelihood of the tool being discarded elsewhere increases. Additionally, the authors discuss the pitfalls of assuming a low core, high biface ratio can be equated to high mobility and a high core, low biface ratio can be taken as evidence for sedentary adaptations (Bamforth and Becker 2000). In terms of Knife Lake and the KLS quarries, these ideas are important as they require tool function and site use to be considered when determining technological patterning and cultural occupations. The authors also require researchers to question what is not found at a given site as equal evidence for what may have occurred (Bamforth and Becker 2000).

Attribute Analysis

There are many theories concerning debitage analysis as it pertains to stone tool identification. Odell (2003) and Andrefsky (2005) are two major contributors to macroscopic lithic analysis, the same analysis applied in this thesis. Just as the culture history is a piece of the puzzle as to what may or may not have been happening at Knife Lake prior to 1,690 calBP, the lithic artifacts recovered are another piece. The information gleaned from this analysis will only be valuable when applied in tandem with the human history, technological strategies, and principles of debitage analysis applied herein.

Stone tool production is a process, and it is the aim of this analysis is to overlay an understanding of production strategies and technological organization on the physical attributes of the recovered artifacts. The goal is to provide a more comprehensive interpretation of the artifacts recovered from the JJ site and any relation the JJ and Lillian Joyce blades may share. As Andrefsky (2005) notes

> it is important to realize and understand that lithic tools physically change shape and that archaeologists collect lithic tools at static points in what may have been a process of change. This dynamic process associated with lithic tools has important implications for artifact typology and the assessment of artifact functions" (Andrefsky 2005:30).

The focus here is to examine the debitage in the context of the known dynamic processes of stone tool production, and attempt to discern how debitage can inform technological organization. Stone tool production is a subtractive process wherein "stone tools are the products of patterned reduction" (Shott 1994:69). If studying tool manufacture can help in determining cultural variations through time and space, then examining the lithic remains at the JJ and Lillian Joyce sites for patterned reduction strategies can help to illuminate these variations (Odell 2003). That being said, I have no doubts that the makers of the lithic artifacts recovered from the JJ site had a much better understanding of how to work KLS than I could ever hope to have. My goal is to identify the patterns in the debitage and link them to what we know about the variation of technological organization through time.

Following Andrefsky's (2005) processes, the artifacts and sites being examined in this thesis are primarily the result of the production phase, based on the characterization of the JJ and

Lillian Joyce sites as KLS quarry sites (Muñiz 2015; Rovanpera 2012). As such, this analysis focuses on how debitage can inform tool production strategies. The likelihood of parsing through waste flakes and shatter to find testable evidence of production strategies is high, as lithic reduction requires significant forethought, not only in terms of what tool to create and how, but also what needs a given tool can help to facilitate (Shott 1994; Whittaker 2009; Binford 1979). A few examples of how debitage can answer questions concerning tool production and technological strategy will go a long way in illustrating this point.

First, the distinguishing attributes between expedient and formal tools provides a good starting point for examining physical artifact attributes as a way of theorizing about some of the technological proclivities which impacted tool production. The classification of a tool as either expedient or formal hinges on the amount of effort a tool required to be produced (Andrefsky 2005; Whittaker 2009). Physical attributes pointing to expediency may include lower-quality raw material, locally available raw materials, or a higher percentage of cortex cover. These attributes can point to less emphasis on reduction techniques, and more on ease of production (Andrefsky 2005; Odell 2003). Formal tool production, including blades, may be interpreted through abraded and flat platforms, higher-quality raw material, and termination type. These attributes can signal more consideration of the end product and opportunities for reproduction throughout the life of the tool (Andrefsky 2005; Odell 2003).

Second, because blades, bifaces, and cores all appear within the JJ site assemblage, it is important to note some distinguishing attributes specific to each tool type. Flat platforms and feather terminations are mainstays of blade production. The flat platform allows for the blade shape to be created, wherein the flake is twice as long as it is wide, while a feather termination allows for continued removal of similar blade flakes from a specialized blade core (Andrefsky

2005; Odell 2003). Both biface and core reduction usually entails faceted and abraded platforms and feather terminations. If the goal of creating a biface or a core was for ease of transport and future reduction opportunities, then creating setting up proper platforms and terminations would have been important (Andrefsky 2005; Whittaker 2009). All three tools would also share one attribute, that of a higher-quality material. If curated technologies require more substantial forethought, effort, and time to create, then a high quality material would have been an important consideration (Andrefsky 2005; Whittaker 2009).

Technological organization is based on efficient adaptive behaviors to outside stressors. The results of these technological strategies can be seen in the attributes of a site’s lithic debitage. The next chapter will outline the methodology for the macroscopic and statistical analysis of these attributes.

Chapter 5: Methodology

Debitage

Typological analysis can uncover hints as to reduction process techniques, types of artifacts being worked or produced, and technologies being utilized (Andrefsky 2005; Odell 2003; Shott 1994). A useful technological categorization of the debitage can lead to broader inferences on tool preferences and also societal adaptations (Andrefsky 2005). Furthermore, Parry (1994) outlines different reduction sequences for different blade technologies. By understanding these differences, the variations occurring in the debitage can help to define the range of technological organization exhibited over time, and more specifically what kind of blade reduction was happening at the JJ site. As a result, the debitage was analyzed for the following attributes and corresponding reasons:

- Raw Material – Due to the nature of the site and its location at Knife Lake, the vast majority of the debitage is Knife Lake Siltstone. It is important however, to take note of non-KLS pieces and give consideration as to why these materials appear at the site and where they originate. Considering where these materials outcrop can help to understand patterns and habits of the cultures that utilized Knife Lake.
- Length – Both maximum and oriented length was measured. Maximum length is defined as the single greatest point to point measurement, regardless of flake orientation. Oriented length is defined as the length from the platform to termination. Measurements taken in millimeters.
- Width – As with length, both maximum and oriented width was recorded. Maximum width is defined as the greatest point to point measurement taken perpendicular to

maximum length. The same holds true for oriented width; the flake will be measured perpendicularly to oriented length. Measurements taken in millimeters.

- Thickness – A measurement (in millimeters) was taken from the ventral to dorsal side of the flake.
- Weight – Flake weight was measured in grams. Measurements for length, width, thickness, and weight are important because this information is used for statistical analysis to help characterize broad patterns in debitage that may be directly related to various core reduction or tool production techniques.
- Termination Type – This categorizes flake terminations into feather, hinge, step, or overshot. Termination types can help to uncover information regarding how the flake was detached from the core and what type of force was used (Andrefsky 2005).
- Platform – Platform characteristics were recorded for type, thickness, and width. Type refers to how the surface of the core was prepared for striking, and includes flat, faceted, or abraded. Flat platforms usually correspond to unidirectional cores used in flake and blade production, and both faceted and abraded platforms are often associated with bifacial reduction (Andrefsky 2005). Platform thickness is the measurement of the platform from the dorsal to ventral surface. Platform width is the measurement of the platform when the flake is oriented to the width of the flake. Both thickness and width measurements were taken in millimeters. Considering platform characteristics can aid in determining the intention of the knapper, and the intended tool technology.
- Cortex – This was based on percentage of cortex present on the dorsal side of the flake. A primary flake is categorized as 51-100 percent cortex present, a secondary flake is characterized as 6-50 percent cortex, and a tertiary is categorized as 0-5 percent cortex. In

this case, cortex is defined by Andrefsky (2005) as the chemical or mechanical weathering on the surface of a stone. The percentage of cortex present can help to elucidate what stages in the reduction process are occurring at a site. The assumption here is that a larger percentage of cortex present can be directly related to an earlier stage in the reduction sequence because cortex will typically be eliminated early on. This is potentially important data to record for a known quarry site as it may speak to the amount of early stage reduction occurring prior to the transportation of cores and tools away from the site.

- Grain Size – Based on the knowledge that finer-grained raw materials are typically used for formal tool making and coarser-grained materials lend themselves more readily to expedient tool technology, grain size will be accounted for to aid in making tool production interpretations (Andrefsky 2005). Grain size categories include fine, medium, and coarse which will be a relative measure determined through tactile analysis. Rovanpera (2012) demonstrated this to be an effective technique for Knife Lake siltstone analysis.
- Completeness/Brokenness – This indicates whether the flake is a whole specimen, or comes to the lab as a fragment. These characteristics were separated into complete, proximal, medial, or distal. A complete flake is identified by both the presence of the platform and termination, a proximal flake contains the striking platform but no termination, a medial flake has no platform or termination present, and a distal flake has an intact termination but no platform. The condition of the flake can point to how the flake was removed and how other attributes, such as platforms and metric dimensions, can be considered (Andrefsky 2005).

- Refitting – This technique was attempted as a way to address the question of tool manufacture. Refitting is defined as reuniting individual pieces that once belonged to the same core or flake. This method can help to reconstruct the exact flake-by-flake reduction sequence and technological strategies employed (Odell 2003).

Tools

Tools and debitage were analyzed similarly, but separately. Unlike debitage analysis where the goal was to determine what has been produced and removed from the site, tool analysis can enable interpretations based on what has been left at the site. The tool categories present at JJ include blades, cores, and bifaces. The traditional definition of a blade is a long flake wherein the length measures at least two times the width (Odell 2003). Parry (1994) refines this definition by adding that a true blade, as opposed to a blade-like flake, will also have a clear platform, dorsal flake scars running parallel to the blade's long axis, and parallel lateral edges. These attributes can be taken as indicators that the blade was specifically produced, likely from a specialized blade core, and is therefore an intentionally shaped tool form. Furthermore, Parry (1994) explains that the majority of blades will be prismatic in nature, making for a trapezoidal cross-section due to two dorsal ridges. As such, the following categories used in the analysis of blades were recorded for the following reasons:

- Length, width, thickness, weight, completeness – See debitage.
- Tool Edges – When the tool is oriented so that the platform is on the bottom and the ventral side is facing the analyst, tool edges are defined as being located on the proximal end, distal end, left margin, or right margin. It is possible for the tool edge to be located on more than one margin. Identifying the tool edges can help to determine how the tool was used (Andrefsky 2005). A lack of tool edges is also valuable information to record.

- Outline Morphology – The general outline of the blade is typically recorded as pointed, straight, concave, or convex. Pointed blades are characterized by a distinct point shape to the blade, usually present at the distal end. Straight blades are signaled by a mostly straight, or rectangular, shape. A concave outline results in a curved-in appearance, and a convex outline presents as a flared out appearance (Andrefsky 2005).
- Edge Angles – These attributes are segmented into three categories, including angles less than 30 degrees, angles between 30 and 60 degrees, and angles greater than 60 degrees (Andrefsky 2005).
- Edge Length – Defined as the maximum distance on the worked edge of the tool. Andrefsky (2005) recommends using a string to measure and get the most accurate distance.
- Retouch – This indicates how a tool might have been utilized, and documenting if and where the retouch occurs on the blade is important for determining use. Retouch can happen bi-marginally, meaning it occurs on both the ventral and dorsal surfaces, or it can happen uni-marginally, meaning retouch is present on only one of the surfaces. For the purposes of this study, retouch is defined as intentional and therefore caused by human action as opposed to naturally occurring edge damage (Andrefsky 2005; Odell 2003). Characteristics for intentional retouching can be observed as the presence of small, systematically removed flake scars, typically measuring less than 5-8mm, aligned perpendicularly to the margin, and typically extend along the whole of the edge in question. Natural damage will present more erratically and un-patterned, and will not typically cover the entirety of the edge (Odell 2003). Natural factors can cause edge

damage that appears intentional, and for KLS fire damage is one such factor; therefore, careful consideration must be made in discerning retouch type.

- Dorsal Flake Scar Count – The dorsal surface refers to the outside of the flake as it was broken away from the core, and the ventral surface refers to the inside. Dorsal flake scars refer to the number of flake removals prior to the blade being removed, and can help to understand where the flake falls within the core reduction sequence. Identifying previous blade removals can point to specialized blade and blade core production.
- Curvature – The depth of curvature is the distance from an imaginary flat plane which crosses from the proximal to the distal margins, measured perpendicularly from the ventral surface to dorsal surface (Figure 10). Measurements taken in millimeters. The curve index takes the measurement for depth of curvature and divides it by the maximum length of the blade, also measured in millimeters (Muñiz 2013; Andrefsky 1986).

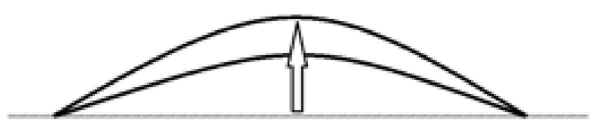

Figure 10. Illustration of curvature measurement.

A core is defined as a stone produced with the intention of removing one or more flakes from it (Odell 2003). Because blades were recovered at JJ and because true blades have been defined as produced from a specialized blade core, it will be important to analyze the recovered cores in an attempt to identify what was being produced from them. The following attributes will be recorded and considered for cores:

- Length, width, thickness – The maximum length, width, and thickness, respectively, of the core; measured in millimeters.
- Weight – See debitage.
- Maximum Linear Dimension – The measurement of the greatest linear dimension, regardless of the overall shape of the core, with measurements taken in millimeters. Andrefsky (2005) uses this measurement multiplied by weight to provide a uniform recording of core size.
- Core morphology – Cores will be categorized as multidirectional or unidirectional, with multidirectional meaning that flakes have been removed from multiple locations and often result in multiple striking platforms while unidirectional means there is one striking platform and flakes have been removed solely in one direction (Andrefsky 2005).
- Flake Removals – The number of flake removed, defined by the presence of flake scars.

A biface is defined as an artifact that shows intentional flaking on opposing surfaces, and is “usually produced along a specific reduction continuum” (Odell 2003:97). The goal of a biface analysis is to distinguish where the artifact might fall on this continuum, or perhaps why it was discarded. Typically, depending on cultural behavior, assumptions maintain that bifaces will be only mildly reduced the closer a site is to a quarry source (Andrefsky 2005).

- Length, width, thickness – See core.
- Weight – See debitage.
- Completeness/Brokenness – See debitage.
- Weight/Thickness Ratio – Andrefsky (2005) uses this ratio to help in determining the stage in the reduction process. A lower ratio signifies an earlier stage, and a higher ratio signifies a later stage.

- Edge Angle – Recorded in degrees for both maximum and minimum angle, and then used to determine the average edge angle. The greater the edge angle the more likely the biface can be categorized as early in the reduction process (Andrefsky 2005).
- Stage – Based on the above attributes, it may be possible to sort each biface into a stage category. Stages include stage 1, or initial edging, defined by widely spaced flake scars and a low weight/thickness ratio; stage 2, or primary thinning, defined by flake scars that do not cross the centerline, 40 to 60-degree edge angles, and a width/thickness ratio of either 3:1 or 4:1; and stage 3, or secondary thinning, defined by 25 to 45-degree edge angles and a width/thickness ratio greater than 4:1 (Odell 2003).

Statistics Methods

The debitage and tool attributes were used for quantitative analysis to give a statistically-derived level of confidence in making interpretations about technological organization. These tests were used in comparing data within each unit, between the two units, and across sites in the Daughter District (the JJ and Lillian Joyce sites). Such tests include t-test, to determine statistical differences between the means of two groups of data; ANOVA, to determine statistical differences between the means of three or more groups of data; and chi-square, to determine a significant association between two groups of data (Drennan 2009). The results of these tests are typically hypothesized using a null hypothesis, which states that the resulting value is caused by random variations in the sampling rather than a significant difference between the samples themselves. The null hypothesis represents what the researcher wants to disprove by being able to say that there is greater probability that a statistically significant relationship exists between two variables (Drennan 2009).

The *p*, or probability, value I chose to use is .05, which is standard for statistical testing (Drennan 2009). Another way to frame the *p* value is by referring to it as significance level, meaning that a *p* value of .05 represents a 95% confidence that the null hypothesis of equal means is incorrect. That means that if the null hypothesis is rejected, this conclusion is likely to be wrong only 5 times out of 100 observations (Drennan 2009). However, it is important to note that using a null hypothesis as a form of testing can sometimes place too much emphasis on proving a question to be true or false. Instead, as posited by Drennan (2009), it may be more helpful to maintain a null hypothesis and established *p* value while also taking into account degrees of significance. For example, if a *t*-test returns a *p* value of .06, it is still quite unlikely that the two samples are related, representing a 94% probability that the null hypothesis is false. Furthermore, if a *p* value of .10 is observed, there remains a 90% probability that the null hypothesis is incorrect. As a result, I will hold to the established *p* value of .05 to satisfy the null hypothesis, but I will also make note of any *p* value between equal to or less than .10 as evidence that the differences between samples is still quite significant, even though it technically failed to falsify the null hypothesis.

Statistics are used "to identify those attributes that best measure specific assemblage characteristics" (Johnson 2001:17). If my goal is to identify technological change over time through lithic attribute analysis, then using statistics will help to characterize the assemblage at the JJ site with probability-weighted data.

Sampling Strategy

My sampling strategy for the two units at JJ is focused on sampling the key components from each unit that correspond to the OSL dates, and thus each respective cultural component. Because the goal of this analysis is focused on technological change over time, Unit 1 was sampled based on OSL dates and artifact frequency (Figure 11, Table 5). Based on Muñiz (2015), the Woodland date of 1,930 +/- 240 calBP was taken from 3-6 cmbs, which corresponds to excavation levels 1 and 2. Similarly, the Middle Archaic date of 5,970 +/- 560 calBP was taken at 9-12 cmbs and corresponds to excavation levels 3 and 4. The Early Archaic date of 7,870 +/- 760 calBP was taken at 15-21 cmbs, and corresponds to excavation levels 5-7. Finally, excavation levels 8 and 9, which lack a corresponding OSL date but represent 21-27 cmbs, show an almost equal number of artifacts recovered in each level, with level 8 exceeding level 9 by only six artifacts. Based on the OSL samples in the lower excavation levels, dating to 38,100 +/- 5,200 calBP and 45,800 +/- 5,800 calBP from levels 9-12, levels 8 and 9 may temporally fall between the Early Archaic and Wisconsin glaciation. This is indicative of an Early to Late Paleoindian occupation and should be sampled as well (Muñiz 2015). I chose to sample the levels corresponding to the majority of the depth of the OSL dates. For example, because the 1,930 +/- 240 calBP sample was taken from 3-6 cmbs, I examined the artifacts from level 2 where 3-6 cmbs was excavated.

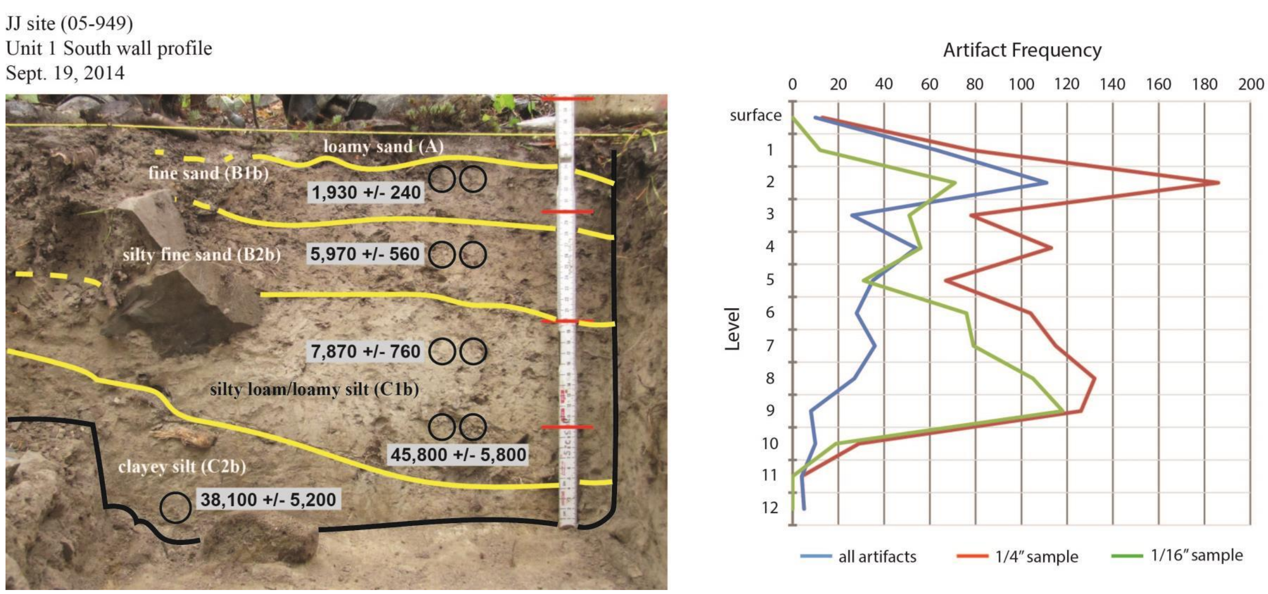

Figure 11. Unit 1 profile with OSL dates and artifact frequencies (Muñiz 2015:34).

Level #	**CMBS**	**OSL Dates (*Cultural Association)* from CMBS**
Surface	0	
1	0-3	
2	3-6	1,930 +/- 240 (*Middle Woodland*) from 3-6cmbs
3	6-9	
4	9-12	5,970 +/- 560 (*Middle Archaic*) from 9-12cmbs
5	12-15	
6	15-18	7,870+/- 760 (*Early Archaic*) from 15-21cmbs
7	18-21	
8	21-24	45,800 +/- 5,800 (*Wisconsin glacial till*) from 21-27cmbs
9	24-27	
10	27-30	
11	30-35	
12	35-49	

Table 5. Summary of Unit 1 excavations levels, OSL-date cultural horizons, and corresponding centimeters below surface (cmbs).

As mentioned, Unit 2 has a much more muddled stratigraphy suggestive of an ancient tree throw (Figure 12). The bowl-shaped lens, labeled as a B2b horizon, visible in the south wall could signify re-deposited colluvium, which has been interpreted as the infill from a tree throw event. Both Rovanpera (2011) and Norman (2013) examined the archaeological effects of ancient tree throws in the BWCA, with Norman (2013) concluding that these occurrences have provided regular depositional disturbances throughout time as the result of slow sediment accumulation and frequent wind and fire events. Despite these indicators, there is still strong depositional integrity in the upper excavations levels of Unit 2, specifically levels 1-5, including the surface. The depth of these levels correspond to the OSL-dated levels from Unit 1, indicating an intact stratigraphy associated with the Middle Woodland and Middle Archaic dates. Therefore, the same sampling strategy was used in both units. That way, if the upper excavation levels of Unit 2 do correlate temporally with the upper levels of Unit 1, then similar tool technologies will be present in both. Additionally, if artifact analysis at Unit 2 provides evidence of a relatively homogenous technological strategy within the lower levels that is significantly different than Unit 1, then interpretations based on an ancient tree throw can be supported. Unit 1 can thus provide the best baseline of the two units for examining technological change through time.

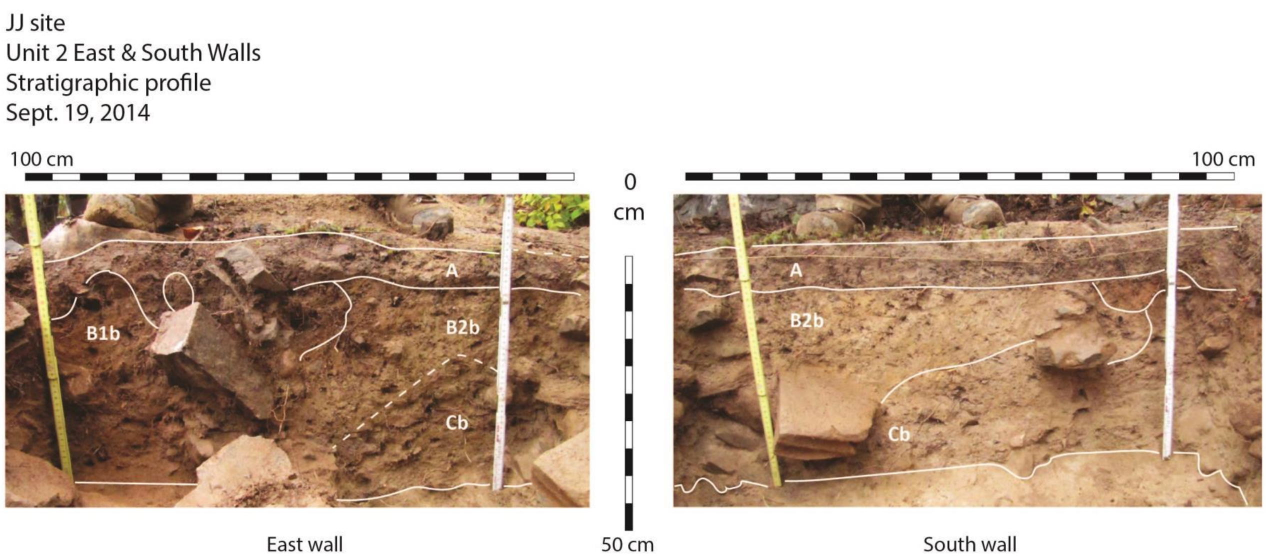

Figure 12. Unit 2 profiles (Muñiz 2015:51).

As a result, for both units I chose to sample all artifacts larger than ¼ inch from the surface, levels 2, 4, and 6, and half of the artifacts larger than ¼ inch from levels 8 and 9, respectively. As mentioned, I chose the excavation level that corresponded most closely with the depths of the OSL dates. For levels 8 and 9, the proposed Paleoindian timeline was bisected by two levels, so I chose to evaluate half of the artifacts from each level. To do this, I measured all artifacts from levels 8 and 9, then simply excluded every other flake to provide half a sample from each level. I also retained a bias for complete flakes from levels 8 and 9, and kept those within the sample. The ¼ inch cutoff measurement was determined by using a ¼ x ¼ inch square drawn on a piece of paper; if the flake in question could not cover the entirety of the ¼ inch square, then it was deemed too small. Because one quadrant from each level was screened through 1/16-inch mesh, the ¼ inch cutoff measurement was used to maintain consistency.

Unit 2 from the Lillian Joyce site was also dated using OSL techniques, and presented a date of 2,340 +/- 320 calBP from approximately 13 cmbs. This date also corresponds to Minnesota's Woodland tradition, just predating the beginning of the Pike Bay phase of the Laurel complex, and therefore provides an additional inlet for examining blade production within a Woodland-dated context. Since the upper levels from both the JJ and Lillian Joyce sites were OSL-dated to the Woodland tradition, there is an opportunity to compare the blades from each site in an effort to look for technological change. My sample included the Lillian Joyce blades.

One hundred and seventy-three pieces of debitage were examined from Unit 1 and 447 pieces of debitage were analyzed from Unit 2, for a total of 598 flakes from the JJ site. All tools from both units, which included 23 blades, 6 cores, and 5 bifaces, were analyzed regardless of provenience in an effort to answer questions concerning tool technology over time. Lastly, all 12 blades at Lillian Joyce were analyzed regardless of provenience in order to elucidate the details between the blades recovered from both JJ and Lillian Joyce. All together, 666 artifacts were analyzed.

Chapter 6: Results

Statistical Analysis

The goal of the statistical analysis for this study is twofold: the first being to state with some degree of certainty whether or not the lithic attributes from the four OSL-dated horizons at the JJ site speak to changes in technological organization over time, and the second to state with a degree of certainty whether or not the blades from the JJ and Lillian Joyce sites could be from the same parent population. Because the OSL dates provided a range of dates in which the sites were utilized, and based on what is known about the various cultural occupations of northern Minnesota, in this case from Paleoindian to Middle Woodland, I would expect the lithic attributes to differ through time. I am also hypothesizing that because there were similar blade assemblages excavated from both the JJ and Lillian Joyce sites from a similarly dated excavation level, then the blades are from the same parent population. This may indicate that the sites are somewhat contemporaneous, and would provide additional evidence for Woodland use of the Knife Lake quarries. This is important because prior to the OSL dates, there has been no evidence to suggest a Woodland occupation of the Daughter District. Failing to falsify the null hypothesis of equivalence would support the assumption that the JJ and Lillian Joyce blades are from the same parent population. The statistical analyses presented here can help to provide more or less certainty to these hypotheses.

As mentioned in Chapter 4 on methodology, the *p* value I chose for this analysis is .05, which is standard for statistical testing (Drennan 2009). However, it is important to note that using a null hypothesis as a form of testing can sometimes be misleading, and place too much emphasis on proving a question to be true or false, which is why I will also note *p* values of .10 or less.

A *t*-test was used to analyze one attribute from two samples, in an effort to provide the probability that both samples stem from the same parent population, and was used for the JJ and Lillian Joyce blade analyses. ANOVA testing allows for one variable to be tested from three or more samples, and was used for flake and blade attributes. Finally, chi-square testing was used to determine how likely the observed flake attributes at the JJ site were caused by random chance (Drennan 2009). The coding for all of the following tests are: n represents the number of items in each sample, s represents standard deviation, and s^2 represents variance. All tests were run with PAST 3.0 software, which automatically calculates Levene's test for homogeneity of variance, Tukey's HSD, and t test and ANOVA significance at .05.

Statistical testing and an examination of the data to test for technological change across the four cultural horizons at the JJ site will be examined first through ANOVA and chi-square testing of flake and blade attributes, followed by discussion and *t*-testing of JJ and Lillian Joyce blade attributes.

ANOVA for Flake Attributes at JJ

ANOVA testing was performed on flake attributes including weight, maximum length, maximum width, oriented length, and oriented width, for all four cultural levels across both units. Since the OSL-dated levels suggest different cultural occupations, then we may see significant differences in the technological strategies used to reduce lithic material, and these strategies may present themselves in the form of differences between attributes. An ANOVA test will help to determine significant differences for specific attribute categories across OSL-dated populations. This hypothesized relationship between the four cultural components and p values at or below .05 will apply throughout the remainder of the debitage attribute analyses to follow.

Below are the results of the ANOVA tests for weight in Unit 1 (Table 6) and Unit 2 (Table 7). The resulting *p* values are .45 for Unit 1 and .002 from Unit 2. The latter unit provides a high probability that the resulting differences in weight across the four cultural horizons is caused by the artifacts stemming from different populations, while the weights from Unit 1 cannot be accepted as significantly different across the four horizons.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 89	n = 29	n = 22	n = 33
mean = 7.5	mean = 7.7	mean = 2.9	mean = 4.0
s = 15.3	s = 21.6	s = 9.1	s = 11.7
s^2 = 234.7	s^2 = 466.9	s^2 = 32.1	s^2 = 137.9
p = .45 (>.05)			

Table 6. Summary of Weights (g) for Unit 1, with ANOVA *p* results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 137	n = 89	n = 122	n = 99
mean = 5.9	mean = 3.7	mean = 8.0	mean = 7.6
s = 12.9	s = 9.3	s = 18.0	s = 17.3
s^2 = 166.8	s^2 = 86.2	s^2 = 322.2	s^2 = 299.2
p = .002* (<.05)			

Table 7. Summary of Weights (g) for Unit 2, with ANOVA *p* results. **Levene's test for homogeneity of variance from means.*

Below are the results of the ANOVA tests for maximum length in Unit 1 (Table 8) and Unit 2 (Table 9). Unit 1 resulted in a *p* value, at .09, while Unit 2 has a *p* value, at .19. As a result, maximum length in Unit 1 can be considered an importance difference, while the differences in maximum length in the Unit 2 levels could be explained by random chance.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 89	n = 29	n = 22	n = 33
mean = 32.8	mean = 31.5	mean = 24.6	mean = 24.2
s = 21.0	s = 18.9	s = 13.2	s = 18.3
s^2 = 441.7	s^2 = 356.5	s^2 = 173.1	s^2 = 336.7
p = .09 (>.05)			

Table 8. Summary of Maximum Lengths (mm) for Unit 1, with ANOVA *p* results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 137	n = 89	n = 122	n = 99
mean = 29.5	mean = 26.4	mean = 32.0	mean = 29.9
s = 17.7	s = 14.0	s = 19.4	s = 20.3
s^2 = 311.8	s^2 = 195.1	s^2 = 377.2	s^2 = 412.0
p = .19 (>.05)			

Table 9. Summary of Maximum Lengths (mm) for Unit 2, with ANOVA *p* results.

Below are the results of the ANOVA tests for maximum width in Unit 1 (Table 10) and Unit 2 (Table 11). Again, Unit 1 resulted in a low *p* value at .07, and Unit 2 resulted in a higher *p* value at .19. Maximum width in Unit 1 has a notably low *p* value, while the same attribute in Unit 2 levels is too similar to falsify the null hypothesis.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 89	n = 29	n = 22	n = 33
mean = 20.3	mean = 20.3	mean = 16.0	mean = 14.4
s = 13.0	s = 13.7	s = 9.8	s = 10.0
s^2 = 169.2	s^2 = 188.9	s^2 = 96.5	s^2 = 99.9
p = .07 (>.05)			

Table 10. Summary of Maximum Widths (mm) for Unit 1, with ANOVA *p* results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 137	n = 89	n = 122	n = 99
mean = 17.8	mean = 16.2	mean = 20.0	mean = 18.6
s = 10.8	s = 10.9	s = 14.2	s = 14.9
s^2 = 116.4	s^2 = 119.7	s^2 = 201.1	s^2 = 223.4
p = .19 (>.05)			

Table 11. Summary of Maximum Width (mm) for Unit 2, with ANOVA *p* results.

Below are the results of the ANOVA tests for oriented length in Unit 1 (Table 12) and Unit 2 (Table 13). The *p* value is .12 for Unit 1 and .36 for Unit 2. The *p* value in both units fails to falsify the null hypothesis, and suggests that any difference between the populations is due to random chance.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 89	n = 29	n = 22	n = 33
mean = 25.0	mean = 23.9	mean = 17.8	mean = 19.0
s = 17.4	s = 13.5	s = 9.1	s = 15.9
s^2 = 301.5	s^2 = 183.6	s^2 = 82.5	s^2 = 251.7
p = .12 (>.05)			

Table 12. Summary of Oriented Lengths (mm) for Unit 1, with ANOVA *p* results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 137	n = 89	n = 122	n = 99
mean = 22.3	mean = 20.7	mean = 23.9	mean = 20.7
s = 14.4	s = 12.7	s = 16.4	s = 16.5
s^2 = 208.7	s^2 = 160.2	s^2 = 269.4	s^2 = 273.8
p = .36 (>.05)			

Table 13. Summary of Oriented Lengths (mm) for Unit 2, with ANOVA *p* results.

Finally, below are the results of the ANOVA tests for oriented width in Unit 1 (Table 14) and Unit 2 (Table 15). The *p* values are similar to each other, where $p = .14$ in Unit 1 and $p = .13$ in Unit 2. As such, oriented width fails to falsify the null hypothesis across all four OSL-dated levels, for both units.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
$n = 89$	$n = 29$	$n = 22$	$n = 33$
mean = 23.0	mean = 23.6	mean = 19.4	mean = 16.4
$s = 15.4$	$s = 18.9$	$s = 11.4$	$s = 12.7$
$s^2 = 237.2$	$s^2 = 358.1$	$s^2 = 128.9$	$s^2 = 160.6$
$p = .14$ (>.05)			

Table 14. Summary of Oriented Widths (mm) for Unit 1, with ANOVA *p* results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
$n = 137$	$n = 89$	$n = 122$	$n = 99$
mean = 21.0	mean = 19.6	mean = 23.2	mean = 24.1
$s = 13.1$	$s = 12.4$	$s = 15.3$	$s = 18.3$
$s^2 = 170.7$	$s^2 = 153.0$	$s^2 = 233.0$	$s^2 = 333.3$
$p = .13$ (>.05)			

Table 15. Summary of Oriented Widths (mm) for Unit 2, with ANOVA *p* results.

Performing an ANOVA for weight, maximum length, and maximum width is helpful because these attributes can provide an overall representation of the shape and mass of the flakes from each level. In Unit 1, maximum length and width strongly suggest that the debitage from the four sampled levels are more different from each other than they are similar. In Unit 2, weight is the only attribute that provides significant data for cultural change in flake debitage over time. Oriented length and width were tested using ANOVA as a way to provide a broader picture of what the flintknappers intended to create with the KLS at the JJ site. Neither of these attributes from either unit rejected the null hypothesis. Below are photos of flake samples from each unit and level tested (Figure 13-Figure 31).

Figure 13. Sample of Unit 1 flakes from the surface, dorsal side.

Figure 14. Sample of Unit 1 flakes from the surface, ventral side.

Figure 15. Sample of Unit 1 flakes from level 2, ventral side. *No photo of dorsal side

Figure 16. Sample of Unit 1 flakes from level 4, dorsal side.

Figure 17. Sample of Unit 1 flakes from level 4, ventral side.

Figure 18. Sample of Unit 1 flakes from level 6, dorsal side.

Figure 19. Sample of Unit 1 flakes from level 6, ventral side.

Figure 20. Sample of Unit 1 flakes from level 8, dorsal side.

Figure 21.Sample of Unit 1 flakes from level 8, ventral side.

Figure 22. Sample of Unit 2 flakes from the surface, dorsal side.

Figure 23. Sample of Unit 2 flakes from the surface, ventral side.

Figure 24. Sample of Unit 2 flakes from level 2, dorsal side.

Figure 25. Sample of Unit 2 flakes from level 2, ventral side.

Figure 26. Sample of Unit 2 flakes from level 4, dorsal side.

Figure 27. Sample of Unit 2 flakes from level 4, ventral side.

Figure 28. Sample of Unit 2 flakes from level 6, dorsal side.

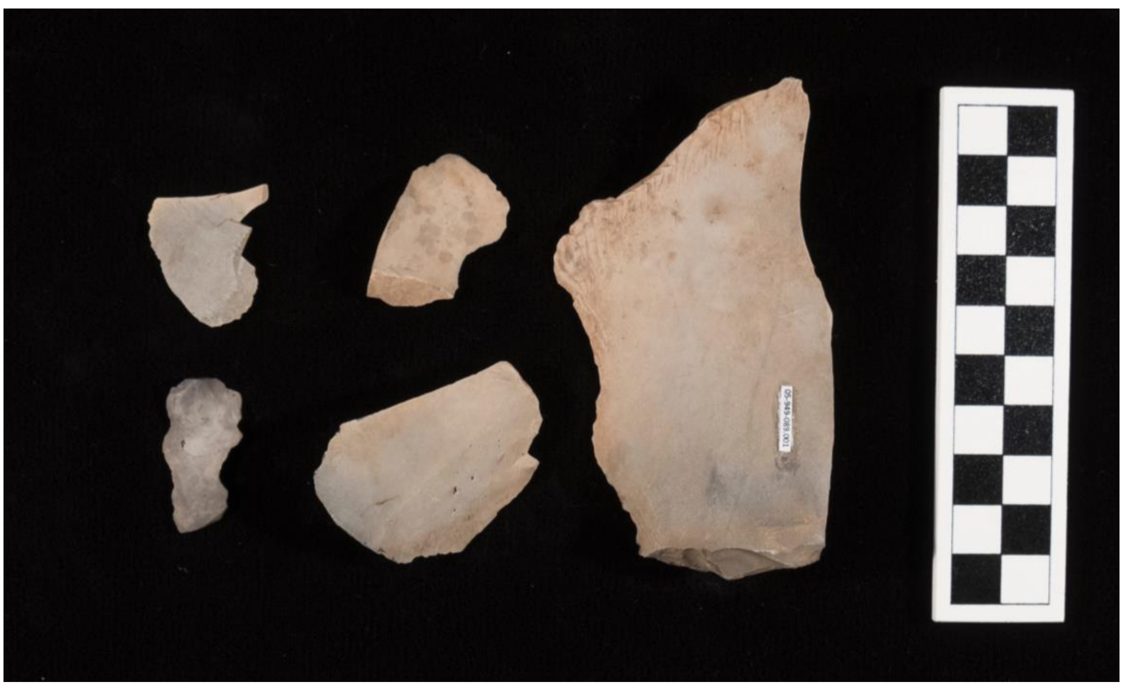

Figure 29. Sample of Unit 2 flakes from level 6, ventral side.

Figure 30. Sample of Unit 2 flakes from level 8, dorsal side.

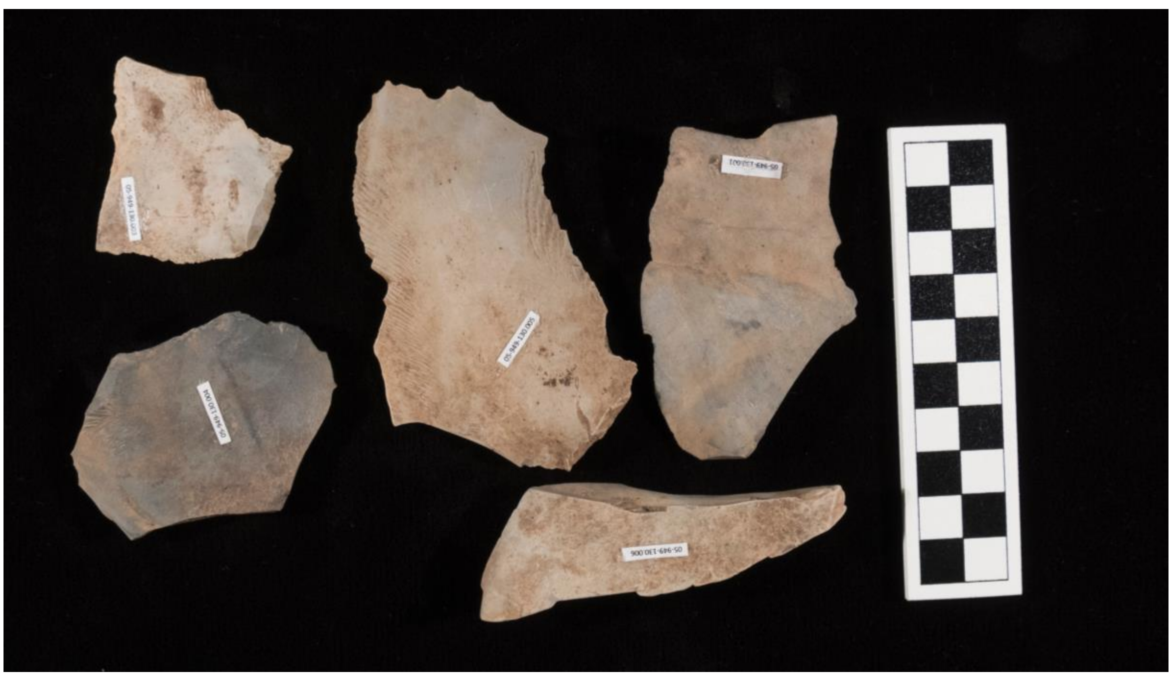

Figure 31. Sample of Unit 2 flakes from level 8, ventral side.

Flat vs. Faceted Flake Platforms

Change between the four cultural occupations is fairly easy to see from the data itself, even before utilizing statistical testing. Table 16 and Table 17 outline the total number of flat and faceted platforms, the predominate platform types recorded at the site, for Units 1 and 2. The total number of flakes recorded indicates the total number of flakes analyzed for the given level, including both flat and faceted platforms, as well as incomplete flakes where no platform was present. Not all flakes were complete, with many missing a platform due to breakage. These broken flakes account for the difference between total number of flakes recorded and those with either flat or faceted platforms, as recorded in the tables below. Percentage of total for both flat and faceted indicates the percentage of a given platform type in relation to the total number of flakes with intact platforms for a respective level.

Excavation Level (*Cultural Occupation*)	**Total Number of flakes recorded**	**Total Number of flakes w/ intact platforms**	**Flat Platforms**	**% of Intact Platforms (Flat)**	**Faceted Platforms**	**% of Intact Platforms (Faceted)**
Surface and Level 2 (*Middle Woodland*)	89	35	9	26%	26	74%
Level 4 (*Middle Archaic*)	29	15	3	20%	12	80%
Level 6 (*Early Archaic)*	22	9	1	11%	8	88%
Level 8/9 (*Paleoindian*)	33	13	7	54%	6	46%

Table 16. Summary of flake platform types across four OSL-dated cultural occupations in Unit 1.

Excavation Level (*Cultural Occupation)*	**Total number of flakes recorded**	**Number of flakes w/ intact platforms**	**Flat Platforms**	**% of Intact Platforms (Flat)**	**Faceted Platforms**	**% of Intact Platforms (Faceted)**
Surface and Level 2 (*Middle Woodland)*	137	75	21	28%	54	72%
Level 4 (*Middle Archaic)*	89	43	11	26%	32	74%
Level 6 (*Early Archaic)*	122	75	19	25%	56	75%
Level 8/9 (*Paleoindian*)	99	64	14	22%	50	78%

Table 17. Summary of flake platform types across four OSL-dated cultural occupations in Unit 2.

As can be seen from the tables, faceted platforms typically outnumber flat platforms in both units, with the exception of the Paleoindian horizon in Unit 1, where the percentage of flat platforms peak at 54%. These levels provide the only instance where flat platforms outnumber faceted platforms in either unit, with faceted platforms contributing to 46% of the total. The Middle Woodland and Paleoindian cultural horizons both contain the largest percentages of flat platforms for Unit 1.

Unit 1 also provides good evidence for technological change over time, as the percentages of flat and faceted platforms fluctuate between the four cultural levels. As mentioned, flat platforms make up the majority of the Paleoindian flakes, fall substantially in the Early Archaic, and then even out in the Middle Archaic and Middle Woodland. Meanwhile, faceted platforms appear the least often on Paleoindian flakes, the most often on the Early Archaic flakes, and again even out on the remaining two cultural occupations. Overall, there is marked change in both platforms types, across the four cultural levels.

In Unit 2 (Table 17), percentages of flat and faceted platforms remain relatively constant throughout all cultural horizons, which is much different than Unit 1. These results will be further examined through chi-square testing. A chi-square test was used to determine the probability that the observed platform types present are representative of random chance. Below are the results of the chi-square test for flat and faceted platforms from both units. Unit 1 (Table 18) yielded a p value of .10 and Unit 2 (Table 19) a p value of .84. The probability of the differences in the Unit 1 platforms resulting from random chance is notably low, while Unit 2 presents a higher probability that any differences in the two populations of flake platforms is the result of random chance.

Unit 1 (Observed)	**Flat**	**Faceted**	**Total**
Middle Woodland	9	26	35
Middle Archaic	3	12	15
Early Archaic	1	8	9
Paleoindian	7	6	13
Total	20	52	72
Unit 1 (Expected)	**Flat**	**Faceted**	**Total**
Middle Woodland	9.722222222	25.27777778	35
Middle Archaic	4.166666667	10.83333333	15
Early Archaic	2.5	6.5	9
Paleoindian	3.611111111	9.388888889	13
Total	20	52	72
$p = .10$ ($>.05$)			

Table 18. Chi-square results for flat and faceted platforms from Unit 1.

Unit 2 (Observed)	**Flat**	**Faceted**	**Total**
Middle Woodland	21	54	75
Middle Archaic	11	32	43
Early Archaic	19	56	75
Paleoindian	9	35	44
Total	60	177	237
Unit 2 (Expected)	**Flat**	**Faceted**	**Total**
Middle Woodland	18.98734177	56.01265823	75
Middle Archaic	10.88607595	32.11392405	43
Early Archaic	18.98734177	56.01265823	75
Paleoindian	11.13924051	32.86075949	44
Total	60	177	237
p = .84 (>.05)			

Table 19. Chi-Square results for flat and faceted platforms from Unit 2.

Abraded Platforms

Abraded platforms also occurred throughout the flake assemblage at the JJ site, but to a far less degree than flat or faceted. Abraded platforms are often indicative of increased platform preparation, and are a means of strengthening the platform so as to produce a better flake.

Abrasion can help to avoid crushed edges and hinge fractures (Whittaker 2009). This platform type was also confined to those flakes larger than ½ inch x ½ inch.

Unit 1 (Table 20) exhibited abraded platforms only within the Middle Woodland levels, at five flakes. Unit 2 (Table 20) contained abraded platforms across all four cultural horizons, in which the Middle Woodland and Early Archaic each contained nine abraded platforms. The Middle Archaic and Paleoindian levels each had six abraded platforms. There is a difference in the number of abraded platforms between the two units, but with the Middle Woodland from each unit containing some of the highest amount.

Excavation Level (*Cultural Occupation)*	**Unit 1**	**Unit 2**
Surface and Level 2 (*Middle Woodland)*	5	9
Level 4 (*Middle Archaic)*	0	6
Level 6 (*Early Archaic)*	0	9
Level 8/9 (*Paleoindian*)	0	6

Table 20. Abraded platforms from Unit 1 and Unit 2.

Platform Metrics

Platform thickness and width were measured for the flake debitage from both units, and may help to facilitate this discussion on platform characteristics at the JJ site through time. Platform thickness is defined as the measurement of a flake platform from the dorsal to the ventral surface. Below (Table 21 and Table 22) are the results of the ANOVA for platform thickness (*p*=.51 and .46, respectively), which both failed to reject the null hypothesis and suggest no change in platform thickness occurred through time.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 35	n = 15	n = 9	n = 13
mean = 5.2	mean = 5.04	mean = 3.8	mean = 70.8
s = 3.8	s = 3.7	s = 2.6	s = 4.9
s^2 = 14.5	s^2 = 13.8	s^2 = 6.6	s^2 = 21.0
p = .51 (>.05)			

Table 21. Summary of Platform Thickness (mm) for Unit 1, with ANOVA p results. **Levene's test for homogeneity of variance from means.*

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 77	*n* = 44	*n* = 76	*n* = 64
mean = 4.0	mean = 4.0	mean = 4.8	mean = 4.1
s = 4.2	*s* = 3.1	*s* = 3.9	*s* = 3.3
s^2 = .5	s^2 = 9.9	s^2 = 15.2	s^2 = 11.0
p = .46 (>.05)			

Table 22. Summary of Platform Thickness (mm) for Unit 2, with ANOVA p results.

Platform width is defined as the measurement of the platform along the same orientation as the flake width. Below (Table 23 and Table 24) summarize ANOVA testing for platform width from both units. As with platform thickness, the results of the platform width tests (*p*=.94 and .19, respectively) failed to falsify the null hypothesis and do not suggest a change in this attribute over time.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 35	*n* = 15	*n* = 9	*n* = 13
mean = 14.6	mean = 14.4	mean = 13.3	mean = 12.8
s = 9.7	*s* = 9.5	*s* = 11.2	*s* = 7.3
s^2 = 93.3	s^2 = 89.4	s^2 = 125.4	s^2 = 53.8
p = .94 (>.05)			

Table 23. Summary of Platform Width (mm) for Unit 1, with ANOVA p results.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)	**Paleoindian** (Levels 7 and 8)
n = 77	n = 44	n = 76	n = 64
mean = 11.9	mean = 13.7	mean = 15.5	mean = 14.5
s = 9.7	s = 10.03	s = 11.5	s = 10.1
s^2 = 94.8	s^2 = 100.6	s^2 = 132.4	s^2 = 101.3
p = .19 (>.05)			

Table 24. Summary of Platform Width (mm) for Unit 2, with ANOVA p results.

Termination Types

Just as platform data can provide indications for technological organization strategy, so too can flake termination data. Feather terminations are ideal for formal tool production, as they allow for creating a predictable flake shape as well as continued flake removal from the same core. Additionally, within blade making strategies, feather terminations types are ideal for creating the desired blade shape (Whittaker 2009; Andrefsky 2005). Feather, hinge, and step terminations were observed in both units. Table 25 and Table 26 provide an overview of termination types for Unit 1 and the Chi-square results.

Excavation Level (*Cultural Occupation)*	**Total number of flakes recorded**	**Number of flakes w/ intact terminations**	**Number of Feather (% of intact)**	**Number of Hinge (% of intact)**	**Number of Step (% of intact)**
Surface and Level 2 (*Middle Woodland)*	89	16	15 (94%)	1 (6%)	0 (0%)
Level 4 (*Middle Archaic)*	29	9	8 (88%)	1 (11%)	0 (0%)
Level 6 (*Early Archaic)*	22	6	6 (100%)	0 (0%)	0 (0%)
Level 8/9 (*Paleoindian*)	33	6	5 (83%)	0 (0%)	1 (17%)

Table 25. Summary of flake termination types across all four OSL-dated cultural occupations in Unit 1.

Unit 1 (Observed)	**Feather**	**Hinge**	**Step**	**Total**
Middle Woodland	15	1	0	16
Middle Archaic	8	1	0	9
Early Archaic	6	0	0	6
Paleoindian	5	0	1	6
Total	34	2	1	37
Unit 1 (Expected)	**Feather**	**Hinge**	**Step**	**Total**
Middle Woodland	14.7027027	0.864864865	0.432432432	16
Middle Archaic	8.27027027	0.486486486	0.243243243	9
Early Archaic	5.513513514	0.324324324	0.162162162	6
Paleoindian	5.513513514	0.324324324	0.162162162	6
Total	34	2	1	37
p = .37 (>.05)				

Table 26. Chi-square results for flake terminations from Unit 1.

Feather terminations make up the majority of all termination types in Unit 1, and the Chi-square results (p = .37) reflect the likelihood that the differences in termination type are the result of random chance.

Excavation Level (*Cultural Occupation)*	**Total number of flakes recorded**	**Number of flakes w/ intact terminations**	**Number of Feather (% of intact)**	**Number of Hinge (% of intact)**	**Number of Step (% of intact)**
Surface and Level 2 (*Middle Woodland)*	137	52	31 (60%)	18 (35%)	3 (6%)
Level 4 (*Middle Archaic)*	89	34	23 (68%)	10 (29%)	1 (3%)
Level 6 (*Early Archaic)*	122	38	23 (61%)	14 (37%)	1 (3%)
Level 8/9 (*Paleoindian*)	99	36	27 (75%)	8 (22%)	1 (3%)

Table 27. Summary of flake termination types across all four OSL-dated cultural occupations in Unit 2.

Unit 2 (Observed)	**Feather**	**Hinge**	**Step**	**Total**
Middle Woodland	31	18	3	52
Middle Archaic	23	10	1	34
Early Archaic	23	14	1	38
Paleoindian	27	8	1	36
Total	104	50	6	160
Unit 2 (Expected)	**Feather**	**Hinge**	**Step**	**Total**
Middle Woodland	33.8	16.25	1.95	52
Middle Archaic	22.1	10.625	1.275	34
Early Archaic	24.7	11.875	1.425	38
Paleoindian	23.4	11.25	1.35	36
Total	104	50	6	160
p = .77 (>.05)				

Table 28. Chi-square results for flake terminations from Unit 2.

Table 27 and Table 28 show the results for termination types in Unit 2. Again, the majority of terminations were classified as feather, and the probability (p = .77) fails to reject the null hypothesis.

Cortex Cover

As previously mentioned, examining cortex cover can go a long way in discussing technological organization (Andrefsky 2005). The more cortex a flake exhibits, the more likely that flake was removed early on in the reduction sequence. This is a general principle of lithic analysis and is only one piece of the puzzle (Odell 2003). As mentioned in the methodology section, a primary flake is described as having 51-100% cortex, a secondary flake has 6-50% cortex, and a tertiary flake has 0-5% cortex. The tables below outline the total number and percentage of each flake type for each cultural level.

Excavation Level (*Cultural Occupation)*	**Total number of flakes recorded**	**Number of Primary flakes (% of total)**	**Number of Secondary Flakes (% of total)**	**Number of Tertiary flakes (% of total)**	**Dominant Flake type**
Surface and Level 2 (*Middle Woodland)*	89	14 (16%)	34 (38%)	41 (46%)	Tertiary
Level 4 (*Middle Archaic)*	29	0 (0%)	6 (21%)	23 (79%)	Tertiary
Level 6 (*Early Archaic)*	22	1 (5%)	6 (27%)	15 (68%)	Tertiary
Level 8/9 (*Paleoindian*)	33	3 (9%)	11 (33%)	19 (58%)	Tertiary

Table 29. Flake types describing cortex cover across all four OSL-dated horizons in Unit 1.

Cortex cover in Unit 1 (Table 29) is quite variable. The Middle Woodland levels exhibit the greatest percentage of primary flakes, at 16%, while the Middle Archaic had no primary flakes at all. Secondary flakes are relatively consistent across all four cultural levels, ranging from 21-38%. Tertiary flakes peak in the Middle Archaic, at 79%, and decline in the Middle

Woodland, at 46%. As with platform type in Unit 1, these percentages show variation through time, which could be indicative of technological change.

A chi-square test was also used to determine the probability that the observed cortex cover was the result of random chance. As can be seen in Table 30, the resulting *p* value is .04, and thus the null hypothesis can be falsified. A Bonferroni correction with adjusted standardized residuals (ASR) was run because the *p* value was less than .05. The results of the adjusted standardized residuals identified that tertiary flakes from the Middle Woodland and Middle Archaic levels were outside the expected totals. The Middle Woodland ASR showed a smaller than expected number of tertiary flakes, while the Middle Archaic showed a larger than expected number of tertiary flakes (Table 31).

Unit 1 (Observed)	**Primary**	**Secondary**	**Tertiary**	**Total**
Middle Woodland	14	34	41	89
Middle Archaic	0	6	23	29
Early Archaic	1	6	15	22
Paleoindian	3	11	19	33
Total	18	57	98	173
Unit 1 (Expected)	**Primary**	**Secondary**	**Tertiary**	**Total**
Middle Woodland	9.260115607	29.32369942	50.41618497	89
Middle Archaic	3.01734104	9.554913295	16.42774566	29
Early Archaic	2.289017341	7.248554913	12.46242775	22
Paleoindian	3.433526012	10.87283237	18.69364162	33
Total	18	57	98	173
p = .04 (<.05)				

Table 30. Chi-square results for cortex cover from Unit 1.

Unit 1	Primary	Secondary	Tertiary
Middle Woodland	2.361566372	1.513458457	**-2.890452388**
Middle Archaic	-2.011459108	-1.539400063	**2.699352502**
Early Archaic	-0.963442941	-0.60619251	1.168541359
Paleoindian	-0.274764883	0.052355019	0.119628392
z value = 2.64			

Table 31. ASR for cortex cover in Unit 1. Bolded values represent those outside the expected range.

Unit 2 cortex cover (Table 32) differs from Unit 1, mainly in primary flakes. In this instance, each cultural level had an equal percentage of primary flakes. Secondary flakes are relatively equal, as seen in Unit 1, making up 10-22% of the total. Tertiary flakes peak in the Early Archaic, at 89%, followed closely by the Paleoindian, at 88%. The Middle Woodland and Middle Archaic levels can be compared to the results of Unit 1. The Middle Archaic levels for both units are quite similar, while the Middle Woodland levels deviate substantially. In Unit 1, the Middle Woodland was comprised of 16% primary flakes, with the Unit 2 assemblage containing just 1%. Similarly, tertiary flakes for the same levels in Unit 1 were the lowest for the whole unit, at 46%, while tertiary flakes in Unit 2 rise markedly to 81%. The Middle Archaic for both units is very similar in terms of cortex cover, while the Middle Woodland is quite different.

Excavation Level (*Cultural Occupation)*	**Total number of flakes recorded**	**Number of Primary flakes (% of total)**	**Number of Secondary Flakes (% of total)**	**Number of Tertiary flakes (% of total)**	**Dominant Flake type**
Surface and Level 2 (*Middle Woodland)*	137	1 (1%)	25 (18%)	111 (81%)	Tertiary
Level 4 (*Middle Archaic)*	89	1 (1%)	20 (22%)	68 (76%)	Tertiary
Level 6 (*Early Archaic)*	122	1 (1%)	13 (11%)	108 (89%)	Tertiary
Level 8/9 (*Paleoindian*)	99	1 (1%)	10 (10%)	88 (88%)	Tertiary

Table 32. Flake types describing cortex cover across all four OSL-dated horizons in Unit 2.

A chi-square test was also used for Unit 2. Table 33 shows the resulting *p* value, at .19. The probability that cortex cover in Unit 2 is the result of random chance is too high for the .05 cutoff, and therefore fails to reject the null hypothesis.

Unit 2 (Observed)	**Primary**	**Secondary**	**Tertiary**	**Total**
Middle Woodland	1	25	111	137
Middle Archaic	1	20	68	89
Early Archaic	1	13	108	122
Paleoindian	1	10	88	99
Total	4	68	375	447
Unit 2 (Expected)	**Primary**	**Secondary**	**Tertiary**	**Total**
Middle Woodland	1.225950783	20.84116331	114.9328859	137
Middle Archaic	0.796420582	13.53914989	74.66442953	89
Early Archaic	1.091722595	18.55928412	102.3489933	122
Paleoindian	0.88590604	15.06040268	83.05369128	99
Total	4	68	375	447
p = .19 (>.05)				

Table 33. Chi-square results for cortex cover from Unit 2.

Evidence for technological change through time is less clear in Unit 2, with many similarities between flake types occurring across cultural horizons. The comparison of the upper two cultural levels in Unit 2 to the same levels in Unit 1 yielded mixed results. The Middle Archaic levels in both units showed similar uses of flake types, yet the Middle Woodland did not.

Raw Materials

Raw material is an important lithic attribute to consider at a quarry site. If the JJ site is adjacent to a KLS quarry, then the assumption is that the assemblage will be dominated by KLS. This is the case at the JJ site, but there were other materials present as well. The significance of non-KLS materials is compounded by their location within the units, specifically because the non-KLS materials were confined to the Middle Archaic and Middle Woodland levels. The presence of non-KLS debitage may be suggestive of a change in technological organization. In Unit 1 (Table 34), the Middle Woodland levels produced six Hudson Bay lowland chert (HBLC) flakes while the Middle Archaic levels produced eight HBLC, two jasper taconite (JT), and two quartz flakes, for a total of 12 non-KLS flakes. The Paleoindian levels, specifically excavation level 9, also produced one quartz flake. In Unit 2 (**Error! Reference source not found.**), the Middle Woodland levels produced two flakes of an unknown material, and the Middle Archaic produced one JT flake. Other non-KLS materials were found within the 1/16 inch screened samples throughout both units, but were not included in this analysis, as discussed in the Chapter 4.

Excavation Level (*Cultural Occupation)*	**HBLC**	**JT**	**Quartz**	**Unknown**	**Total**
Surface and Level 2 (*Middle Woodland)*	6	0	0	0	6
Level 4 (*Middle Archaic)*	8	2	2	0	12
Level 6 (*Early Archaic)*	0	0	0	0	0
Level 8/9 (*Paleoindian*)	0	0	1	0	1

Table 34. Unit 1, non-KLS raw materials.

Excavation Level (*Cultural Occupation)*	**HBLC**	**JT**	**Quartz**	**Unknown**	**Total**
Surface and Level 2 (*Middle Woodland)*	0	0	0	2	2
Level 4 (*Middle Archaic)*	0	1	0	0	1
Level 6 (*Early Archaic)*	0	0	0	0	0
Level 8/9 (*Paleoindian*)	0	0	0	0	0

Table 35. Unit 2, non-KLS raw materials.

The differences in raw material use for the ¼ inch screened flakes is an important distinction. As stated previously, raw material availability can play a large role in technological strategies. KLS remained the dominant material across all cultural horizons at the JJ site, most likely due to the site's proximity to a primary source area, yet non-KLS materials consistently appeared in the Middle Woodland and Middle Archaic levels. If technological organization is based on making the most efficient decisions with the materials at hand, then it is possible the Middle Woodland and Middle Archaic occupations at JJ had more access to non-KLS materials and were strategically using them in addition to the KLS at Knife Lake. The observed non-KLS materials do originate in northwestern Minnesota and southern Ontario as both bedrock and till sources (Bakken 2011). This suggests that the non-KLS materials were somewhat local to Knife Lake. Evidence for technological change over time is apparent from the presence of non-KLS materials, specifically for the Middle Woodland and Middle Archaic.

Chi-Square Testing for Grain Size

Among the KLS debitage, grain size was also recorded. As Rovanpera (2012) pointed out, the various grain sizes of KLS can be a useful aid in determining cultural patterning and technological organization. More finely-grained KLS is considered higher in quality, and would likely be preferred for creating a curated toolkit (Wendt and Romano 2009). Grain size, classified here as fine, medium, or coarse, will be tested using chi-square across the four cultural components for both units. Below are the results of the tests, with Unit 1 (Table 36) resulting in a *p* value of .0000096 and Unit 2 (Table 37) a *p* value of .003. Both values are significantly low, and reject the null hypothesis.

Unit 1 (Observed)	**Fine**	**Medium**	**Coarse**	**Total**
Middle Woodland	28	24	37	89
Middle Archaic	10	18	1	29
Early Archaic	12	10	0	22
Paleoindian	13	6	14	33
Total	63	58	52	173
Unit 1 (Expected)	**Fine**	**Medium**	**Coarse**	**Total**
Middle Woodland	32.4104046	29.8381503	26.7514451	89
Middle Archaic	10.56069364	9.722543353	8.716763006	29
Early Archaic	8.011560694	7.375722543	6.612716763	22
Paleoindian	12.01734104	11.06358382	9.919075145	33
Total	63	58	52	173
p = 9.66E-06 (<.05)				

Table 36. Chi-Square results for grain size Unit 1.

Unit 2 (Observed)	**Fine**	**Medium**	**Coarse**	**Total**
Middle Woodland	114	17	6	137
Middle Archaic	65	20	4	89
Early Archaic	89	22	11	122
Paleoindian	59	33	7	99
Total	327	92	28	447
Unit 2 (Expected)	**Fine**	**Medium**	**Coarse**	**Total**
Middle Woodland	100.2214765	28.19686801	8.581655481	137
Middle Archaic	65.10738255	18.31767338	5.574944072	89
Early Archaic	89.24832215	25.10961969	7.642058166	122
Paleoindian	72.42281879	20.37583893	6.201342282	99
Total	327	92	28	447
$p = .003$ (<.05)				

Table 37. Chi-Square results for grain size in Unit 2.

Adjusted standardized residuals for Unit 1 (Table 38) showed that coarse KLS was used less than would be expected during the Middle Archaic and Early Archaic, and used more than expected in the Middle Woodland. Medium-grained KLS was used more often than expected in the Middle Archaic levels. Adjusted standardized residuals for Unit 2 (Table 39) showed that fine KLS was used less than expected in the Paleoindian levels, and used more than expected in the Middle Woodland. Medium KLS was used less than expected in the Middle Woodland levels and more than expected in the Paleoindian levels.

Unit 1	**Fine**	**Medium**	**Coarse**
Middle Woodland	-1.394268212	-1.881251512	**3.400186853**
Middle Archaic	-0.23716354	**3.56880573**	**-3.425545302**
Early Archaic	1.891497236	1.268575073	**-3.291204779**
Paleoindian	0.395170365	-2.075598045	1.722314302
z value = 2.64			

Table 38. ASR for Grain Size in Unit 1. Bolded values represent those outside the expected range.

Unit 2	**Fine**	**Medium**	**Coarse**
Middle Woodland	3.18976241	-2.841244596	-1.093030832
Middle Archaic	-0.028700799	0.492863884	-0.769846034
Early Archaic	-0.059496394	-0.816655471	1.471386716
Paleoindian	**-3.450112792**	**3.55671038**	0.375429791
z value = 2.64			

Table 39. ASR for Grain Size in Unit 2. Bolded values represent those outside the expected range.

Cores

Five KLS cores were recovered and examined from the JJ site. Four were excavated from Unit 1, distributed between levels 1, 2, 3, and 5, and one core was excavated from Unit 2, from the surface. Below, Table 40 shows the measurements for weight, maximum length and width, and thickness, for each core.

Catalog #	**Unit**	**Weight (g)**	**Absolute Maximum Length (mm)**	**Absolute Maximum width (mm)**	**Thickness (mm)**
30.001	1	1406.0	181.3	103.6	51.9
35.006	1	14.4	33.6	22.4	18.8
39.001	1	737.0	205.8	91.9	41.4
49.015	1	431.0	152.6	91.2	32.0
58.003	2	196.3	113.0	87.5	20.7

Table 40. Measurements for weight (g), maximum length (mm), maximum width (mm), and thickness (mm) for each core from both units.

The cores from Unit 1 were generally larger than the core from Unit 2. Maximum linear dimension was also calculated for each core, and can be used to provide a general, uniform measurement for each artifact (Andrefsky 2005). Maximum linear dimension takes the largest overall measurement, either maximum length or width, and multiplies it by the weight of the core. Core morphology, recorded as either multidirectional or unidirectional, flake removals, and grain size were also recorded. Table 41, below, provides these measurements for each core.

Catalog #	**Unit**	**Maximum Linear Dimension (mm)**	**Core Morphology**	**Flake Removals**	**Grain Size**
30.001	1	181.3	M	10	fine
35.006	1	33.6	U	6	medium
39.001	1	205.8	M	18	fine
49.015	1	152.6	M	7	fine
58.003	2	113.0	M	7	fine

Table 41. Core measurements from each unit.

The cores from Unit 1 range from 33.6mm to 205.8mm in maximum linear dimension, while the Unit 2 core measured 113.0mm for this attribute. Core 30.001 from Unit 1 is the anomaly of the group, being substantially smaller than the rest. If this core is considered an outlier, and removed from the Unit 1 population, then the range of maximum linear dimension falls between 152.6mm and 205.8mm. As a result, the cores from Unit 1 are generally larger than the core from Unit 2. In addition, only one unidirectional core was recorded, 30.001 from Unit 1, and the rest have been categorized as multidirectional.

Flake removals vary quite a bit amongst all the cores, with three of the five exhibiting six or seven removals, and the two larger cores exhibiting 10 and 18 removals, respectively. Additionally, grain size skews more to fine, and 30.001 represents the outlier again, with a medium grain. Below are photos of the cores from both units (Figure 32-Figure 39).

Figure 32. Core from Unit 1, patinated side; 30.001.

Figure 33. Core from Unit 1, non-patinated side; 30.001.

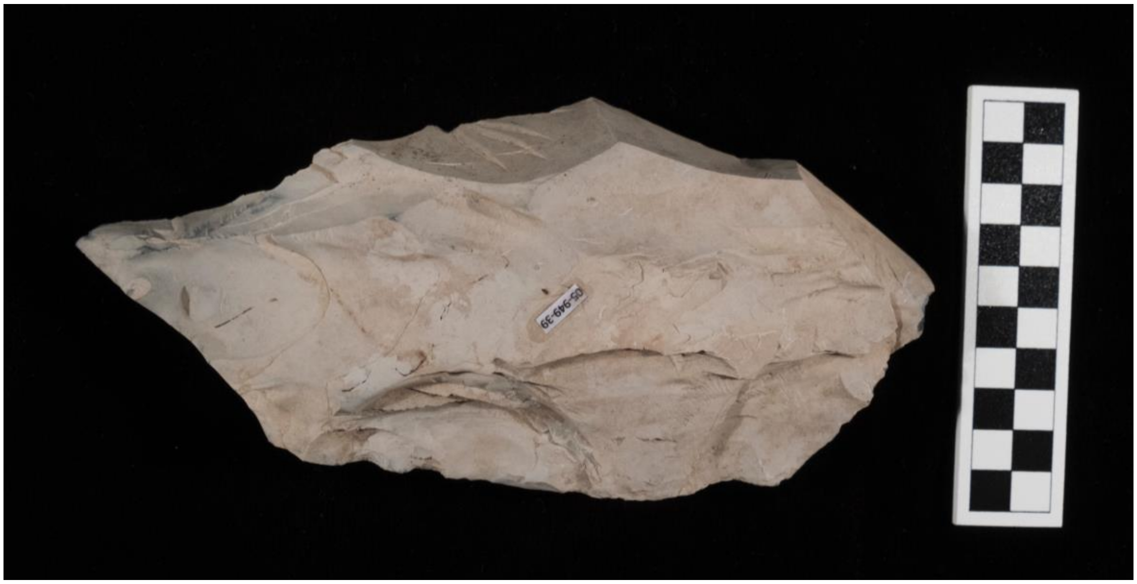

Figure 34. Core from Unit 1, patinated side; 39.001.

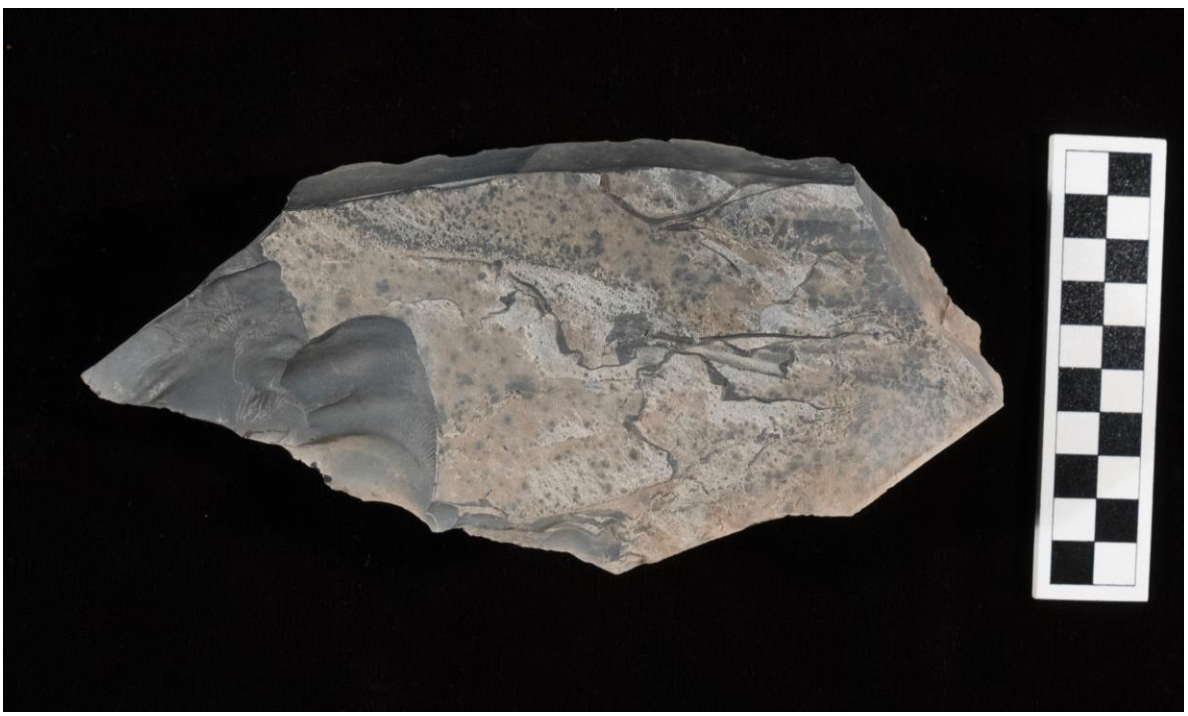

Figure 35. Core from Unit 1, non-patinated side with cortex; 39.001.

Figure 36. Cores from Unit 1; 49.015 (on left) and 36.006 (on right).

Figure 37. Cores from Unit 1, other side; 49.015 (on left) and 36.006 (on right).

Figure 38. Core from Unit 2; 58.003.

Figure 39. Core from Unit 2, other side; 58.003.

Bifaces

Five bifaces were recovered from the JJ site excavations, two, one from the surface and one from level 4, from Unit 1 and three, representing levels 5, 8, and 11, from Unit 2. Table 42, below, summarizes maximum length and width, thickness, and weight.

Catalog #	**Unit**	**Weight (g)**	**Absolute Maximum Length (mm)**	**Absolute Maximum width (mm)**	**Thickness (mm)**
93.001	1	138.2	119.3	61.1	15.1
43.010/011*	1	280.4	104.8	88.9	23.3
80.001	2	247.7	126.7	87.5	18.6
131.001	2	192.1	145.8	48.4	18.2
155.001	2	235.6	92.7	71.6	44.7

Table 42. Measurements for weight (g), maximum length (mm), maximum width (mm), and thickness (mm) for each biface from both units. **Catalog #43.010/011 is a complete biface that was found in two pieces, and therefore has two catalog numbers.*

Three of the five bifaces were broken, including 93.001, 80.001, and 131.001. Although 43.010/011 was broken in two pieces, those pieces combined for a complete biface with some edge damage. Biface 155.001 was also complete, with some edge damage. In addition to the above attributes, and completeness or brokenness of each biface, weight/thickness ratio, and edge angle were also analyzed. These attributes can help to determine what stage in reduction each biface might fall under.

Catalog #	**Unit**	**Weight/Thickness Ratio**	**Average Edge Angle**
93.001	1	.009:1	30
43.010/011*	1	.012:1	60
80.001	2	.013:1	30
131.001	2	.010:1	35
155.001	2	.005:1	55

Table 43. Biface weight/thickness ratio and average edge angle. *Catalog #43.010/011 is a complete biface that was found in two pieces, and therefore has two catalog numbers.

A lower weight/thickness ratio can provide evidence for an early stage biface, while a larger degree for average edge angle will also indicate a biface representative of an early reduction stage. The biface with the lowest value for weight/thickness ratio and the highest average edge angle is 155.001 (Table 43), from Unit 2. Biface 131.001 from Unit 2 also had a moderately low weight/thickness ratio and moderate edge angle, suggestive of an early to mid-stage biface. Conversely, biface 80.001 had the highest weight/thickness ratio and one of the lower edge angles, suggesting this biface was in a later stage than the other bifaces. This biface is also from Unit 2. In Unit 1, 93.001 had a moderately low weight/thickness ratio and the lowest edge angle. On a much different note, 43.010/011 from Unit 2 exhibited one of the highest weight/thickness ratios as well as the highest edge angle. Below are photos of the bifaces from both units (Figure 40-Figure 45).

Figure 40. Bifaces from Unit 1; 93.001 (left) and 43.010/011 (right).

Figure 41. Bifaces from Unit 1, other side; 93.001 (left) and 43.010/011 (right).

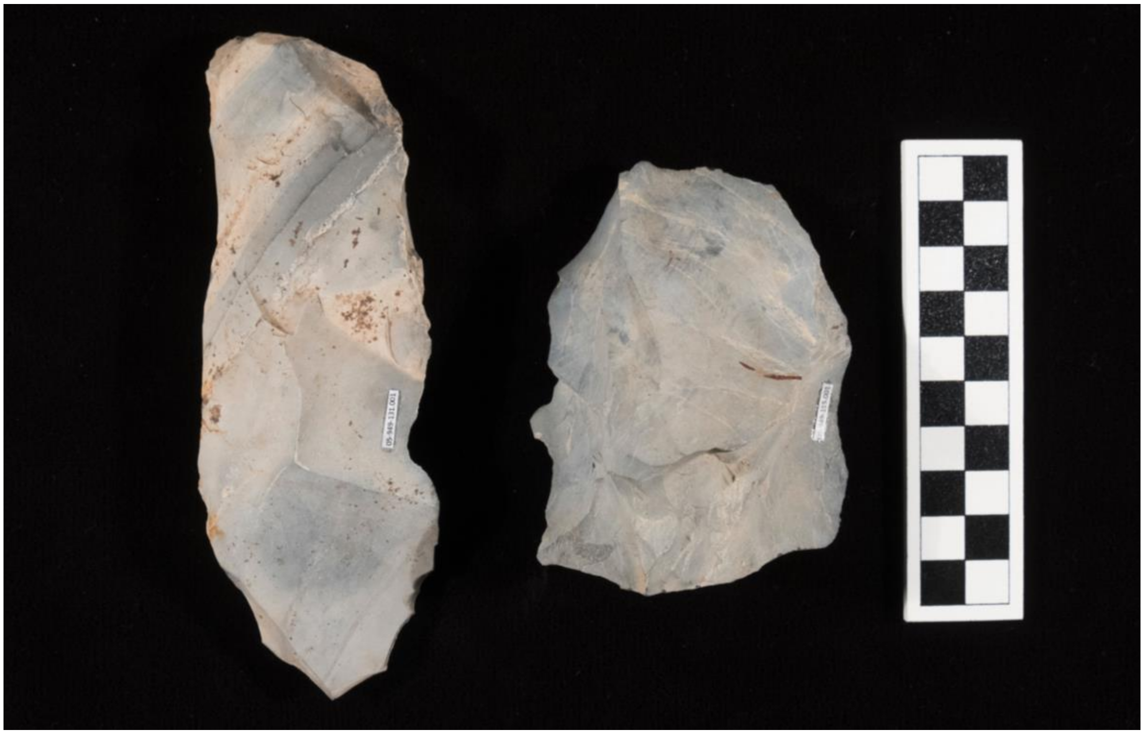

Figure 42. Bifaces from Unit 2; 131.001 (left) and 155.001 (right).

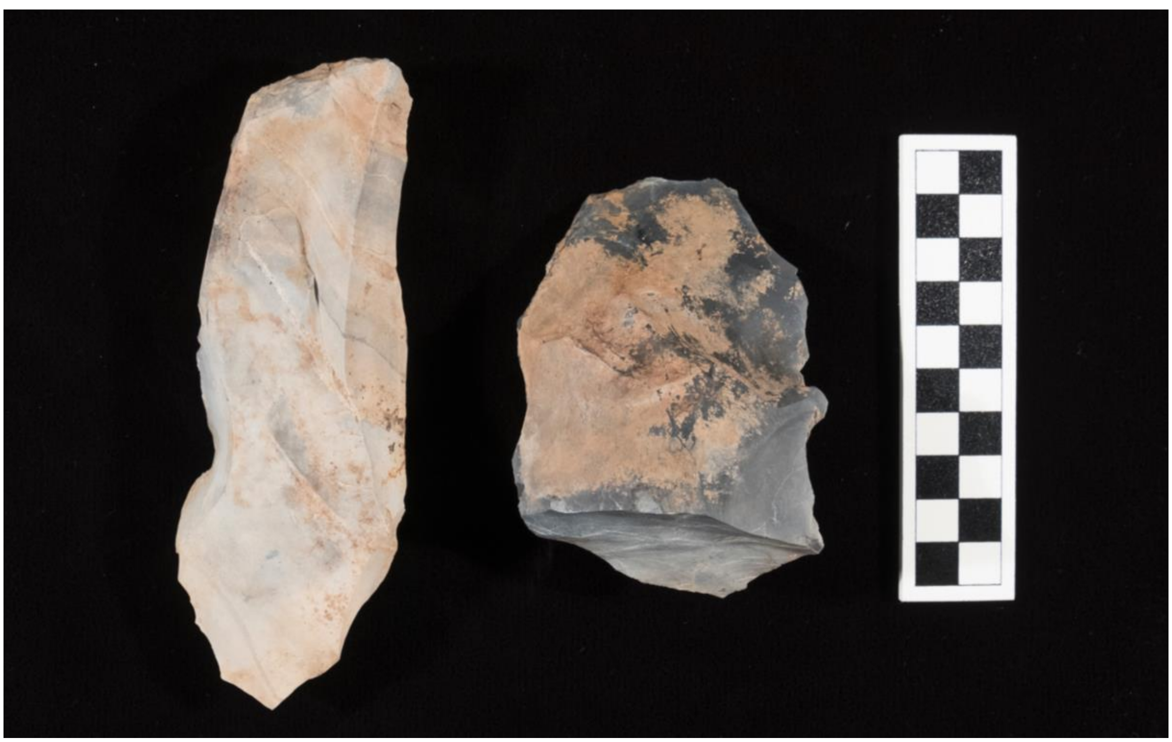

Figure 43. Bifaces from Unit 2, other side; 131.001 (left) and 155.001 (right).

Figure 44. Biface from Unit 2, patinated side; 80.001.

Figure 45. Biface from Unit 2, non-patinated side; 80.001.

Attributes of Blades at JJ

Blade attributes were tested across all cultural levels at the JJ site, using ANOVA, to discern any changes through time. Blades were assigned to a cultural level based on Table 5 from Chapter 5, so that the Middle Woodland OSL-dated levels cover excavation levels from the ground surface – level 2, the Middle Archaic represent levels 4 and 5, the Early Archaic represents levels 6 and 7, and the Paleoindian covers levels 8 and 9. No blades were excavated from level 3 at the JJ site, so this level is not included. In the following tests, the Paleoindian blades were left out, as only one blade is associated with those levels; for an ANOVA test, there needs to be at least two values for each column (Drennan 2009). The same attributes that were used to determine significant differences between cultural levels for flakes will be examined first, including weight, maximum length and width, oriented length and width and blade thickness, followed by dorsal flake scar count and blade curve index.

ANOVA testing for blade weights (Table 44) failed to reject the null hypothesis, with a *p* value of .05. This means there is an 95% chance that any differences between the populations is the result of vagaries of sampling, and suggests there is a significant difference in blade weight across these three cultural horizons.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	n = 7	n = 2
mean = 21.1	mean = 64.2	mean = 29.4
s = 20.4	s = 55.8	s = 3.5
s^2 = 417.5	s^2 = 3114.1	s^2 = 12.0
p = .05* ($\leq$.05)		

Table 44. ANOVA results for Weight (g) of JJ blades. **Levene's test for homogeneity of variance from means.*

Testing for maximum length between the Middle Woodland, Middle Archaic, and Early Archaic (Table 45) concluded with a *p* value of .09, which provides important data for change in blade length through time.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	n = 7	n = 2
mean = 66.7	mean = 94.1	mean = 84.9
s = 27.8	s = 22.8	s = 15.5
s^2 = 770.0	s^2 = 521.2	s^2 = 239.8
p = .09 (>.05)		

Table 45. ANOVA results for Maximum Length (mm) of JJ blades.

ANOVA testing for maximum width (Table 46) came close to providing important data towards falsifying the null hypothesis, with a *p* value of .11, but ultimately it is not enough evidence to support change in maximum width of the JJ blades.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	n = 7	n = 2
mean = 27.4	mean = 39.8	mean = 35.9
s = 12.1	s = 12.0	s = 10.5
s^2 = 147.2	s^2 = 144.9	s^2 = 109.5
p = .11 (>.05)		

Table 46. ANOVA results for Maximum Width (mm) of JJ blades.

ANOVA testing for oriented length (Table 47) returned a *p* value of .04, which rejects the null hypothesis. A visual inspection of the data below suggests the Middle Woodland blades were shorter than average when compared to the Middle and Early Archaic.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	n = 7	n = 2
mean = 55.9	mean = 88.4	mean = 83.1
s = 27.4	s = 25.7	s = 16.6
s^2 = 749.1	s^2 = 659.8	s^2 = 276.1
p = .04 (<.05)		

Table 47. ANOVA results for Oriented Length (mm) of JJ blades.

The ANOVA test for oriented width (Table 48) once again fails to reject the null hypothesis, with a *p* value of .77, and suggests a high degree of similarity is present.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	n = 7	n = 2
mean = 32.6	mean = 39.4	mean = 33.3
s = 24.6	s = 10.9	s = 6.9
s^2 = 604.9	s^2 = 119.8	s^2 = 48.0
p = .77 (>.05)		

Table 48. ANOVA results for Oriented Width (mm) of JJ blades.

Finally, the ANOVA test for blade thickness (Table 49) resulted in a notably low *p* value, at .06. Blade thickness rejects the null hypothesis that the difference is the result of random chance, and suggests a notable difference has been observed with this attribute. Based on six blade attribute tests, significant and notable similarities were seen in oriented length and blade thickness, which is not enough evidence to support significant changes in the JJ blades through time.

Middle Woodland (Surface and Level 2)	**Middle Archaic** (Level 4)	**Early Archaic** (Level 6)
n = 13	*n* = 7	*n* = 2
mean = 8.5	mean = 13.3	mean = 12.1
s = 4.3	*s* = 3.9	*s* = 3.04
s^2 = 18.2	s^2 = 15.1	s^2 = 9.2
p = .06 (>.05)		

Table 49. ANOVA results for Thickness (mm) of JJ blades.

ANOVA testing was also performed for dorsal flake scar count and blade curve index. Dorsal flake scar count is important to consider because the higher the number of negative flake scars on a blade's dorsal side, the more likely the blade was created within a specialized blade-making industry (Andrefsky 2005). Curve index is also important, because blades have been known to be purposefully produced with an increased curve, as opposed to intentionally producing a flat blade. A higher blade curve index may suggest intentionality, and again a specialized blade-making strategy (Muñiz 2013). The curve index is calculated by dividing the curvature of each blade by its maximum length, as defined by Andrefsky (1986).

Dorsal flake scar count (Table 50) and blade curve index (Table 51) resulted in a *p* value of .24 and .08, respectively. If these attributes are good indicators of technological production preferences, then it appears as though dorsal flake scar count remained relatively unchanged through time, while blade curve is suggestive of important differences across cultural occupations.

Middle Woodland (Surface – Level 2)	Middle Archaic (Levels 4 and 5)	Early Archaic (Levels 6 and 7)
$n = 13$	$n = 7$	$n = 2$
mean = 2.6	mean = 3.7	mean = 2.5
$s = 1.0$	$s = 2.1$	$s = 0.7$
$s^2 = 0.9$	$s^2 = 4.2$	$s^2 = 0.5$
$p = .24$ (>.05)		

Table 50. ANOVA results for Dorsal Flake Scar Count across all four OSL-dated cultural occupations at the JJ site.

Middle Woodland (Surface – Level 2)	Middle Archaic (Levels 4 and 5)	Early Archaic (Levels 6 and 7)
$n = 13$	$n = 7$	$n = 2$
mean = .15	mean = .18	mean = .12
$s = .04$	$s = .02$	$s = .042$
$s^2 = .0016$	$s^2 = .0005$	$s^2 = .0018$
p = .08 (>.05)		

Table 51. ANOVA results for Blade Curve Index (mm) across all four OSL-dated cultural occupations at the JJ site.

Below are photos of the blades from both units at the JJ site (Figure 46-Figure 55).

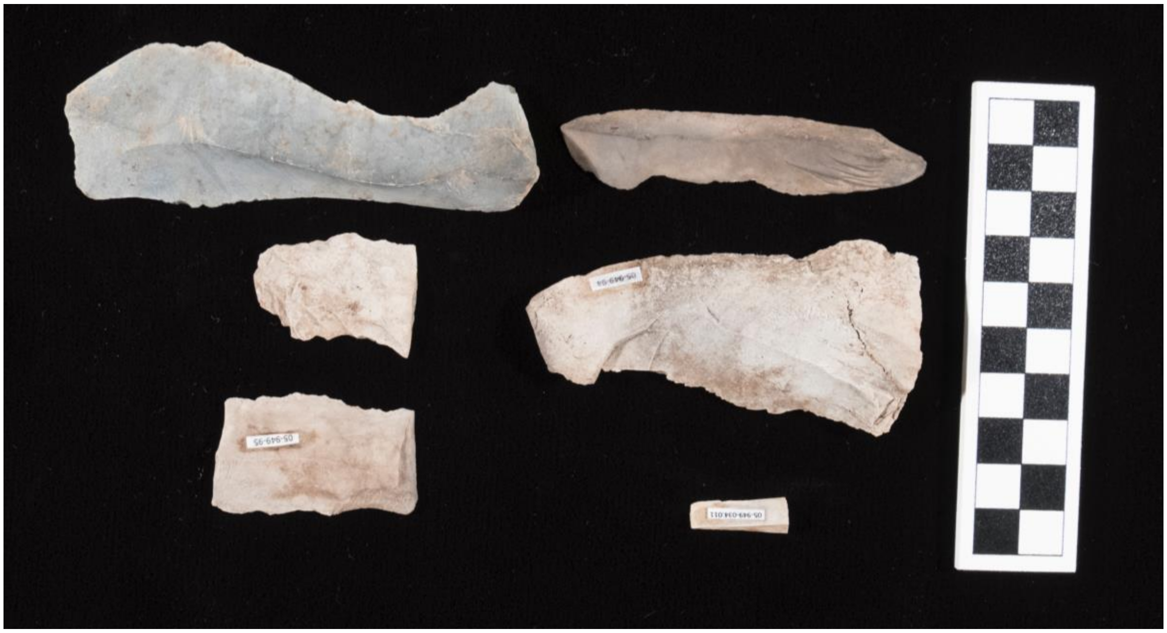

Figure 46. Blades from Unit 1, dorsal side. Clockwise from top left: 33.001, 27.001, 94.001, 34.011, 95.001, 31.001.

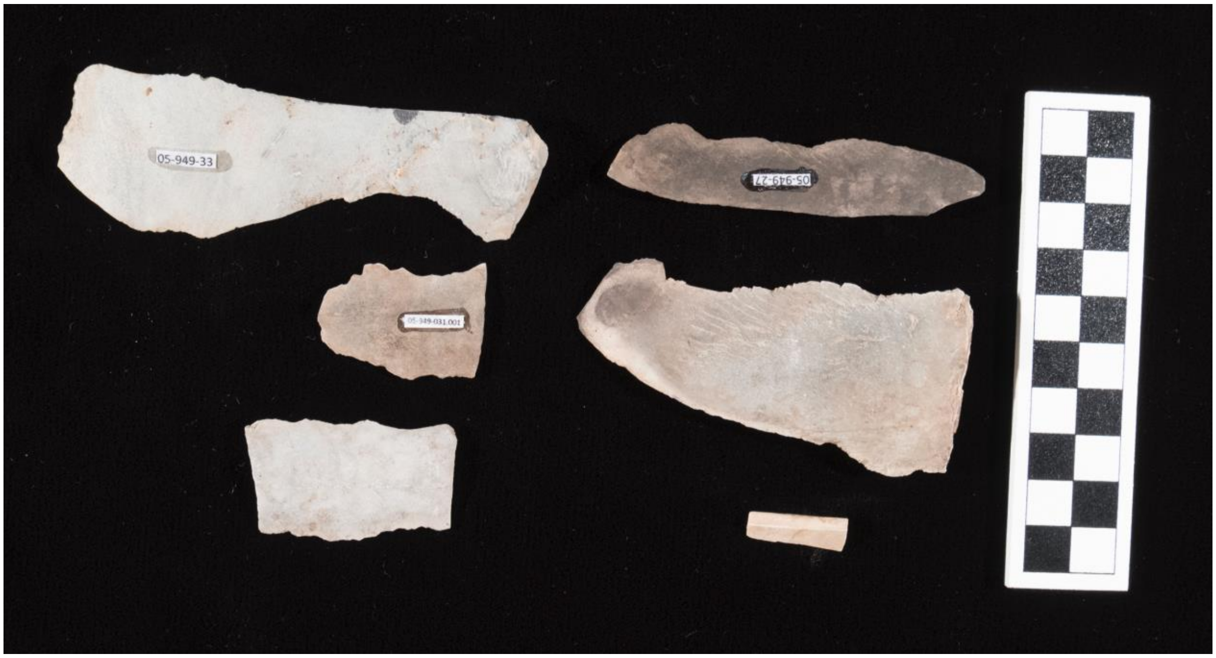

Figure 47. Blades from Unit 1, ventral side. Clockwise from top left: 33.001, 27.001, 94.001, 34.011, 95.001, 31.001.

Figure 48. Blades from Unit 1, dorsal side. Clockwise from blade of the left: 47.005, 37.001, 36.001, 47.006.

Figure 49. Blades from Unit 1, ventral side. Clockwise from blade of the left: 47.005, 37.001, 36.001, 47.006.

Figure 50. Blades from Unit 2, dorsal side. From left: 92.001, 76.001, 91.001 (possible blade core rejuvenation flake, and not included in blade analysis).

Figure 51. Blades from Unit 2, ventral side. From left: 92.001, 76.001, 91.001 (possible blade core rejuvenation flake, and not included in blade analysis).

Figure 52. Blades from Unit 2, dorsal side. From left: 88.001, 121.001, 118.001, 58.001.

Figure 53. Blades from Unit 2, ventral side. From left: 88.001, 121.001, 118.001, 58.001.

Figure 54. Blades from Unit 2, dorsal side. From left: 85.001, 63.001, 58.002, 83.121.

Figure 55. Blades from Unit 2, ventral side. From left: 85.001, 63.001, 58.002, 83.121.

Middle Woodland and Middle Archaic Blades at JJ

Because of the unusually high number of Middle Archaic blades, it may be helpful to compare these to the Middle Woodland blades to look for clues as to whether this number is the result of natural site formation processes. If the two sets of blades are significantly similar to one another, then the recovered artifacts from the Middle Archaic level may be more accurately associated with the Middle Woodland. A *t*-test was used to help determine this probability.

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = 21.1	mean = 64.2
s = 20.4	s = 55.8
s^2 = 417.5	s^2 = 3114.1
p = .09* (>.05)	

Table 52. *t*-test results for Weight (g) of Middle Woodland and Middle Archaic blades from JJ.

**t-test for unequal variance used.*

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = 66.7	mean = 94.1
s = 27.7	s = 22.8
s^2 = 770.0	s^2 = 521.2
p = .04 (<.05)	

Table 53. *t*-test results for Maximum Length (mm) of Middle Woodland and Middle Archaic blades from JJ.

Middle Woodland	**Middle Archaic**
n = 13	*n* = 7
mean = 27.4	mean = 39.8
s = 12.1	*s* = 12.0
s^2 = 147.2	s^2 = 144.9
p = .04 (<.05)	

Table 54. *t*-test results for Maximum Width (mm) of Middle Woodland and Middle Archaic blades from JJ.

Middle Woodland	**Middle Archaic**
n = 13	*n* = 7
mean = 55.9	mean = 88.4
s = 27.4	*s* = 25.7
s^2 = 749.1	s^2 = 659.8
p = .02 (<.05)	

Table 55. *t*-test results for Oriented Length (mm) of Middle Woodland and Middle Archaic blades from JJ.

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = 32.6	mean = 39.4
s = 24.6	s = 10.9
s^2 = 604.9	s^2 = 119.8
p = .40* (>.05)	

Table 56. *t*-test results for Oriented Width (mm) of Middle Woodland and Middle Archaic blades from JJ. **t-test for unequal variance used.*

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = 8.6	mean = 13.3
s = 4.3	s = 3.9
s^2 = 18.2	s^2 = 15.1
p = .02 (<.05)	

Table 57. *t*-test results for Thickness (mm) of Middle Woodland and Middle Archaic blades from JJ.

The above results (Table 52-Table 57) show that four of the six attributes provide a significant or notable likelihood that these two sets of blades do not share the same parent population. Weight, maximum length, and oriented length have significantly low p values that reject the null hypothesis. The t-test for thickness (p=.09) also suggests the blades are morphologically distinct.

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = 2.6	mean = 3.7
s = .96	s = 2.1
s^2 = .92	s^2 = 4.2
p = .22 (>.05)	

Table 58. *t*-test results for Dorsal Flake Scar Count of Middle Woodland and Middle Archaic blades from JJ.

Middle Woodland	**Middle Archaic**
n = 13	n = 7
mean = .15	mean = .18
s = .04	s = .02
s^2 = .002	s^2 = .0005
p = .05* ($\leq$.05)	

Table 59. *t*-test results for Blade Curve Index of Middle Woodland and Middle Archaic blades from JJ. **t-test for unequal variance used.*

Dorsal flake scar count (Table 58) and blade curve index (Table 59) split in terms of providing evidence for similarities between the Middle Woodland and Middle Archaic blades, with the latter providing a significant evidence rejecting the null hypothesis. Overall, five of the eight tests suggest a significant or notable likelihood that the two sets of blades did not stem from the same parent population.

JJ and Lillian Joyce Blades

The blades from the JJ and Lillian Joyce site were analyzed for similarities in the technological strategies used to produce them. If the Woodland-dated levels from both sites contained the most blades, then it is likely that flintknappers at both sites used similar reduction strategies. If that is the case, then the blade assemblages from both sites may have stemmed from the same parent population.

As with the flakes and blades from the JJ site, weight, maximum length and width, oriented length and width, and blade thickness can be tested using a *t*-test to determine whether any significant differences exist between the Woodland-aged blade assemblages from JJ and Lillian Joyce. The Woodland-aged levels provided a combined range from the ground surface through excavation level 3. My hypothesis is that no significant difference will exist, meaning the likely blades stem from the same parent population. Unlike with the previous tests, failing to falsify the null with a *p* value greater than .05 will help to support this hypothesis. Below are the results (Table 60-Table 64) of each *t*-test.

JJ	**Lillian Joyce**
n = 13	n = 5
mean = 21.1	mean = 24.6
s = 20.4	s = 24.8
s^2 = 417.5	s^2 = 614.9
p = .77 (>.05)	

Table 60. *t*-test results for Weight (g) of JJ and Lillian Joyce blades.

JJ	**Lillian Joyce**
n = 13	n = 5
mean = 66.7	mean = 66.6
s = 27.8	s = 26.9
s^2 = 770.0	s^2 = 725.8
p = .99 (>.05)	

Table 61. *t*-test results for Maximum Length (mm) of JJ and Lillian Joyce blades.

JJ	**Lillian Joyce**
n = 13	n = 5
mean = 27.4	mean = 31.8
s = 12.1	s = 12.7
s^2 = 147.2	s^2 = 160.9
p = .51 (>.05)	

Table 62. *t*-test results for Maximum Width (mm) of JJ and Lillian Joyce blades.

JJ	**Lillian Joyce**
n = 13	n = 5
mean = 55.9	mean = 63.8
s = 27.4	s = 26.1
s^2 = 749.1	s^2 = 681.4
p = .59 (>.05)	

Table 63. *t*-test results for Oriented Length (mm) of JJ and Lillian Joyce blades.

JJ	**Lillian Joyce**
n = 13	*n* = 5
mean = 32.6	mean = 28.5
s = 24.6	*s* = 9.4
s^2 = 605.9	s^2 = 88.4
p = .62* (>.05)	

Table 64. *t*-test results for Oriented Width (mm) of JJ and Lillian Joyce blades. **t-test for unequal variance used.*

JJ	**Lillian Joyce**
n = 13	*n* = 5
mean = 8.6	mean = 8.5
s = 4.3	*s* = 6.1
s^2 = 18.2	s^2 = 36.7
p = .99 (>.05)	

Table 65. t-test results for Thickness (mm) of JJ and Lillian Joyce blades.

These tests show the resulting *p* values, which all well exceed .05. As such, the null hypothesis cannot be falsified, and there is no significant difference between the two sets of blades. Below are photos of the blades from Lillian Joyce (Figure 56and Figure 57).

Figure 56. Lillian Joyce blades, dorsal side. Clockwise from top left: 93.025, 113.567*, 90.005, 116.003, 94.018, 102.002, 113.356*, 116.233*, 113.353*, 96.009, 001.048*, 50.002, 104.089.

**indicates Woodland-dated blades*.

Figure 57. Lillian Joyce blades, ventral side. Clockwise from top left: 93.025, 113.567*, 90.005, 116.003, 94.018, 102.002, 113.356*, 116.233*, 113.353*, 96.009, 001.048*, 50.002, 104.089. **indicates Woodland-dated blades*.

t-test for Blades for Dorsal Flake Scar Count and Curve Index

Dorsal flake scar count and blade curve index were examined for the Woodland-dated JJ and Lillian Joyce blades. The same null hypothesis applies for both attributes, which states that statistically there will be no difference between the two sets.

JJ	**Lillian Joyce**
$n = 13$	$n = 5$
mean = 2.6	mean = 3.0
$s = 1.0$	$s = 0$*
$s^2 = 0.9$	$s^2 = 0$*
$p = .17(>.05)$	

Table 66. The results of t-test performed on Dorsal Flake Scar Count for JJ and Lillian Joyce Woodland-dated blades. **All five blades from Lillian Joyce each had 3 dorsal flakes scars, resulting in 0 for standard deviation and variance.*

As seen in Table 66, the average of each set combined with the standard deviation (*s*) for each is enough to conclude that the difference between dorsal scars from both the JJ and Lillian Joyce blades is minimal as the averages, plus or minus the standard deviation, would create an overlap. The *t*-test confirms this, and the resulting probability (*p*) that the null hypothesis is true for this *t*-test is .17. Therefore, there is not enough statistical difference in dorsal flake scar counts between the JJ and Lillian Joyce blades from the Woodland-dated levels to falsify the null hypothesis.

Below are the results of the *t*-test for blade curve index from the Woodland-dated blades. Again, Table 67 shows that the probability (*p*) of the null hypothesis being true is .86, far exceeding .05. As a result, the blade curve index at both Lillian Joyce and JJ within the Woodland levels supports the hypothesis that there is no statistical difference between blade production at the two sites. If there is no difference in dorsal flake scar count and curve index between the two sites, support is given to the hypothesis of a similar blade technology, with a high likelihood that the two assemblages stem from the same parent population.

JJ	**Lillian Joyce**
n = 13	*n* = 5
mean = 0.15	mean = 0.15
s = 0.04	*s* = 0.05
s^2= .002	s^2= .002
p = .86 (>.05)	

Table 67. The results of t-test performed on Blade Curve Index (mm) for JJ and Lillian Joyce Woodland-dated blades.

Chapter 7. Discussion and Conclusions

Flake Attributes at JJ

The null hypothesis for flake attributes states that the differences in flake attributes between the four OSL-dated levels is the result of random chance. Based on the OSL dates, I would expect the majority of the statistical tests to reject the null hypothesis. In Unit 1, maximum length (p = .09), maximum width (p = .07), and platform type (p = .10) provided important evidence for technological change over time. In Unit 2, flake weight (p = .002) is also suggestive of cultural change.

Overall, flake weight, cortex cover, and grain size (three out of the ten attributes tested), rejected the null hypothesis and provided statistically significant data pointing to technological change over time. In addition, maximum length, maximum width, and platform type provided important and highly probable data in support of technological change through time. Therefore, seven of the ten flake attributes at the JJ site provided either statistically significant or highly probable data to reject the null hypothesis and therefore support technological change through time.

The majority of this evidence, including cortex, grain size, maximum length, maximum width, and platform type, stemmed from Unit 1. Two flake attributes from Unit 2, including grain size and weight, contributed to these findings. As previously hypothesized, Unit 2 may lack depositional integrity as the result of an ancient tree throw (Muñiz 2015). This ancient depositional disturbance could account for the discrepancies of the statistical analyses between the two units.

Flake Platforms at JJ

Flake platforms are of particular interest, as they can speak directly to questions of technological organization, and therefore change over time. Platforms also tend to be unaffected by natural site formation processes in a way that other attributes, such as flake size and weight, may be subject to these forces. Faceted platforms typically outnumbered flat platforms in both units, with the exception of the Paleoindian horizon in Unit 1. Flat platforms can be indicative of a blade making technological strategy while faceted platforms may be more illustrative of biface making (Odell 2003, Andrefsky 2005). In Unit 1, the percentage of flat platforms peaked in the samples from levels 8 and 9, and provided the only instance where flat platforms outnumber faceted platforms. The Middle Woodland and Paleoindian cultural horizons both contained the largest percentages of flat platforms for Unit 1. If both the Middle Woodland and Paleoindian lithic traditions can generally be typified by an increase in blade production, then the platform data from Unit 1 in the Middle Woodland and Paleoindian levels supported this trend.

Furthermore, the only instance from either unit where flat platforms exceeded faceted platforms is in the Paleoindian levels from Unit 1, where both flat and faceted platforms are fairly equally represented. An increase in flat platforms in the Paleoindian levels and the presence of only one blade from these same levels may be suggestive of blade transportation away from the JJ site during the Paleoindian occupation.

Platform data from Unit 1 also provided good evidence for technological change over time. The percentages of flat and faceted platforms fluctuated between the four cultural levels. As mentioned, flat platforms made up the majority of the Paleoindian flakes, fell substantially in the Early Archaic, and then evened out in the Middle Archaic and Middle Woodland. Meanwhile, faceted platforms appeared the least often on Paleoindian flakes, the most often on the Early Archaic flakes, and again evened out on the remaining two cultural occupations. Overall, there is marked change in both platforms types, across the four cultural levels.

In Unit 2, percentages of flat and faceted platforms remain relatively constant throughout all cultural horizons, which is much different than Unit 1. This consistency throughout the cultural levels in Unit 2 supports Muñiz's (2015) interpretations of an ancient tree throw event, especially affecting the deeper levels. If Unit 2 represents an old tree throw for levels 6, 8, and 9, then the artifact frequencies may be more equally mixed throughout these cultural horizons. The similarity in percentages for each platform type throughout all the levels analyzed is good evidence for this type of floralturbation.

The Middle Woodland and Middle Archaic cultural levels in Unit 2 may be more likely to have retained depositional integrity as they occurred above the stratigraphic indication of the disturbance. Flat platforms made up 28% and faceted platforms represented 72% of the Middle Woodland flakes, while flat platforms represented 26% and faceted platforms accounted for 74% of the Middle Archaic flakes. If excavations levels 2 and 4 are considered intact, then it is more likely that both units represented similar technological strategies for both the Middle Woodland and Middle Archaic.

Abraded platforms also occurred throughout the assemblage, but to a far lesser degree than flat or faceted. Abraded platforms are indicative of increased platform preparation, and were a means of strengthening the platform, so as to produce a better flake. Abrasion could help to avoid crushed edges and hinge fractures (Whittaker 2009). This platform type was confined to those flakes larger than ½ inch x ½ inch, which could either suggest that the flinkknappers were taking better care when removing larger flakes or it is the result of sampling bias and abrasion was easier to identify on bigger flakes.

There is also a marked difference between the two units, with Unit 1 having abraded platforms in only one cultural level, but with the Middle Woodland from each unit containing the highest amount. This similarity may point to similar technological strategies across the Middle Woodland levels for both units, a strategy that differs from the other cultural levels. Future research could further examine this phenomenon, particularly how it relates to retouch and expedient technological strategies.

Finally, platform thickness and width were also analyzed using ANOVA testing, with the results suggesting that these attributes exhibited little difference through time. Combined with the discussion on platform type, it is possible that the platform metrics on KLS flakes may be limited to capacities of the raw material itself. Perhaps the technological organization in place at any given time, whether reliant on a flat, faceted, or abraded platform, still required the same size of platform in order to successfully remove a desirable flake.

Termination Type at JJ

Just as with platform metrics, termination type varied little through time. In Unit 1, feather terminations are the majority, with hinge and step terminations observed intermittently throughout all cultural levels. In Unit 2, feather terminations remain the majority, consistently representing 60-75% of the total. Hinge terminations typically made up 20-35% of the total, and step termination represented 3-6%. Many flakes from the entire assemblage were broken and missing the distal end, which made for a smaller sample, particularly in Unit 1.

Feather terminations are ideal because they allow for a variety of tools to be created, including blades and bifaces, and allow for easy removal of additional flakes from the same core. Termination type is likely impacted by several factors, including grain size, core size, the skill of the flintknapper, and unseen flaws in the rock (Whittaker 2009; Andrefsky 2005). As a result, it is no surprise that these three termination types are present, and that feather terminations are the most prevalent. Because feather terminations would have been useful for so many applications, a change in termination type through time would not necessarily be expected.

Cortex Cover at JJ

The Middle Woodland exhibited the most primary flakes, followed closely by the Paleoindian levels. These same levels also exhibited lower tertiary flakes. Both factors suggest that more initial reduction was taking place in these levels than in the Middle or Early Archaic (Odell 2003). The Middle Archaic presented the most tertiary flakes, suggesting more late stage reduction techniques were occurring (Odell 2003). The distinct changes between the four cultural horizons, specifically for primary and tertiary flakes, provides evidence for technological change through time. These changes also suggest that different initial reduction strategies were occurring throughout the four cultural components, despite the JJ site's proximity to a quarry site. As mentioned, many sites located near primary source areas exhibit initial reduction behaviors (Odell 2003; Andrefsky 2005). This may be the case at the JJ site as well, but those initial reduction behaviors appear to have varied through time.

Raw Materials at JJ

Raw material variability peaked in Unit 1 within the Middle Woodland and Middle Archaic levels, and in Unit 2 within the Middle Archaic level. The Paleoindian level in Unit 1, with one non-KLS flake, was the only instance of non-KLS from the Early Archaic or Paleoindian levels from this sample. This uptick in non-KLS in the upper cultural components is suggestive of a change in technological organization through time. As discussed, raw material availability can often play a critical role in technological organization (Binford 1980; Bamforth 1986). An increase in raw material variability may be the result of differing adaptive strategies or mobility patterns. At the JJ site, the presence of non-KLS in the Middle Archaic and Middle Woodland levels suggests that a technological strategy inclusive of other raw materials was being implemented. The distribution of the Laurel complex (Figure 3) throughout northern Minnesota and Canada covers the areas where HBLC and JT would have outcropped or could have been acquired from secondary till sources (Bakken 2011; Arzigian 2008). If this is true, then it is also possible to consider the reverse, where KLS tools may have travelled with the same people to the HBLC and JT outcroppings. This may be one vector for KLS transportation away from the JJ site, and this transportation may have been happening during the Middle Woodland and Middle Archaic as suggested by the increased raw material variability.

Grain Size at JJ

Significant difference in grain size occurred across the four cultural horizons. The importance of grain size has already been discussed, especially as it pertains to technological strategies used in reducing KLS. Adjusted standardized residuals from the chi-square test for Unit 1 showed that medium-grained KLS was used more frequently than expected in the Middle Archaic debitage, while coarse-grained material was used more often than expected in the Middle Woodland and less often than expected in the Middle and Early Archaic levels. Adjusted standardized residuals for Unit 2 showed fine-grained KLS to be used more frequently than expected in the Middle Woodland, and less frequently in the Paleoindian levels. Medium-grained was the inverse, with the Middle Woodland showing less than expected frequencies, and the Paleoindian showing more than expected.

The Middle Woodland component generally utilized differently-grained KLS in unexpected ways, with fine and coarse being used more frequently, and medium less frequently used. Because fine-grained KLS typically produces more consistent results, the assumption is that this material would be preferred over coarse KLS (Stroh 2011; Wendt and Romano 2009), yet the Middle Woodland debitage skews more towards utilizing fine-grained and coarse-grained almost equally. The increase in Middle Woodland coarse-grained KLS use suggests a technological strategy that differs from the Archaic or Paleoindian levels.

Additionally, the Paleoindian levels show a lower than expect usage of fine-grained KLS. Paleoindian tools are generally known for being formal and well-made, a technological strategy that requires a high quality raw material, particularly when it comes to KLS (Gibbon 2012; Wendt and Romano 2009). A lack of fine-grained KLS cannot be the reason for its absence in these levels, as it occurs in the other cultural levels. As a result, the significantly low frequency for fine-grained KLS in the Paleoindian levels may suggest a technological strategy not focused on formal tool making.

Debitage Retouch and Refitting

Only one flake was considered to have retouch, from the surface collection of Unit 2. In addition to exhibiting retouch, the flake also has an abraded platform. The presence of this flake within the Middle Woodland levels as well as both retouch and an abraded platform supports the hypothesis that abraded platforms may be more indicative of expedient technology. It is likely that more flakes exhibit retouch, but my confidence in distinguishing retouch from naturally derived edge damage is limited.

Several flakes were able to be refitted including two flakes from Unit 1, level 6, two flakes from levels 8 and 9 in Unit 1, and two flakes from levels 8 and 9 in Unit 2. These refits are exclusively the result of fire spalling rather than individual pieces that would have originated from the same core. Refitting was not the main focus of the lithic analysis, which explains the small number of refits.

Cores at JJ

Cores were recovered from levels 1, 2, 3, and 5 in Unit 1, and one core was excavated from Unit 2, from the surface. Only one unidirectional core was recorded, #30.001 from Unit 1, and the rest were categorized as multidirectional. Multidirectional cores were present in both units, and suggest a similar reduction strategy was present in both. The unidirectional core from Unit 1 appears as the outlier. Additionally, core 30.001 was excavated from level 2, which was part of the Woodland-dated excavation levels. When these data are combined with the presence of an increased number of blades, and the unique debitage attributes including abraded platforms and an increase in both fine and coarse-grained KLS, it is suggestive of a technological strategy that is present in the Woodland-dated levels that differs from the remaining three cultural components.

While flake removals were varied enough to suggest change over time, grain size provided evidence that fine-grained KLS may have been preferred, especially where multidirectional core reduction was being used. Because 30.001 was the only unidirectional and the only medium-grained core, it suggests a different technological strategy was executed for a different KLS grain size. The small sample size from Unit 2 makes interpretations challenging, but initially suggests a distinction in core-making technological preferences based on grain size.

Bifaces at JJ

The bifaces from level 4 in Unit 1 and levels 5, 8, and 11 from Unit 2 are more similar than different. I am interpreting each biface as indicative of stage 1, or the results of early reduction techniques. This is based on the low weight/thickness ratios and larger edge angles, which provide evidence for an early stage biface (Andrefsky 2005; Odell 2003). However, lithic reduction may be better represented by a continuum than a staged process. Biface 155.001 has the lowest weight/thickness ratios and one of the highest average edge angles, which likely puts this biface earlier on in the continuum than any of the others. Biface 80.001 has one of the highest weight/thickness ratios and the lowest average edge angle, which would place it further along the continuum.

Based on Bamforth and Becker's (2000) interpretations, a low core to high biface ratio would suggest a more mobile culture while the reverse would suggest a more sedentary culture. At the JJ site, the core/biface ratio is neutral in this respect, with five cores and five bifaces. The results of the debitage analysis, based on the consistent presence of faceted platforms and a low number of cores and bifaces when compared to the large amount of flakes, suggest that both bifaces and cores were produced at the JJ site and then transported elsewhere. Bamforth and Becker (2000) go on to say that when a tool is discarded at a site, it is likely the result of a short use-life of the tool and a longer occupation of the site. Because KLS can be a challenging material to work with, it seems likely that tools would have been discarded at the site. It seems less likely the JJ site was occupied for long periods of time, based on a lack of artifacts suggestive of a longer-term habitation. Perhaps an increase in mobility strategies was necessary to access the JJ site and surrounding quarries, regardless of cultural occupation.

Blades at JJ

Of the eight blade attributes tested for the blades at the JJ site, two resulted in a significantly low p value. Blade weight (p =.05) and oriented length (p = .04) reject the null hypothesis, which states that any differences between the blades from the OSL-dated levels are more likely to be from random chance. Additionally, two attributes provided p values less than .10, and add additional support to the JJ blades coming from different parent populations. Those attributes were maximum length (p = .09) and blade curve index (p = .08). The remaining statistical tests failed to falsify the null, resulting in four out of seven blade attributes falsifying the null hypothesis that the blades from the JJ site are from the same parent populations.

As mentioned, Wendt and Romano (2009) identified a technological strategy for flintknapping coarser-grained KLS through a unique bar and hammer technique. This technological strategy is an important revelation because a variety of KLS grain types exist, yet these types must be approached differently to produce successful results. The somewhat mixed results of the statistical tests for the JJ site blades may be evidence for this principle. As with all raw materials, KLS also has its production limitations, particularly when it comes to grain size (Wendt and Romano 2009; Rovanpera 2012). The similarities between the JJ site blades from three different cultural occupations may have more to do with a limited number of ways to produce a blade from KLS rather than similar technological strategies employed across three cultural components.

The outline morphology of the JJ site blades trends toward straight, with the Middle Woodland blades comprised of eight straight, four pointed, and one convex; the Middle Archaic comprised of four straight, no pointed, and three convex; the Early Archaic composed of one straight, one pointed, and no convex; and the Paleoindian resulting in one pointed and no straight or convex blades. Overall, the blades totaled 13 straight, six pointed, and four convex.

None of the blades from the JJ site exhibited intentional retouch, and thus no blades provided a value for edge length, defined as a tool’s cutting edge (Andrefsky 2005). This is also valuable information to record, and suggests that the blades were produced at the JJ site and then discarded without being used. This may be suggestive of blade core production for transportation. If blades were being produced and discarded, perhaps the goal was to produce a transportable blade core. The presence of blades increased through time, and peaked in the

Middle Woodland component, yet no blade cores were recovered from the site. Based on an understanding of the Laurel culture, its geographic distribution, and evidence for ties to larger trade networks, it is possible that the blades of the JJ site had a short use-life and were produced from blade cores that were subsequently removed from the site (Arzigian 2008; Bamforth and Becker 2000).

Middle Woodland and Middle Archaic Blades at JJ

The presence of seven blades in the Middle Archaic levels prompted a comparison of these blades to the Middle Woodland blades. Similarities between the two sets would suggest that natural site formation processes are influencing the JJ site more than previously expected. Of the eight attributes tested, four of the tests rejected the null hypothesis and one of the tests provided notable evidence for rejecting the null. These attributes included, weight, maximum length, oriented length, blade curve index, and thickness. As a result, it is unlikely that the Middle Woodland and Middle Archaic blades share a parent population.

What is interesting to note is that blade curve index was notably different among the blades from the three statistically tested cultural levels at JJ, as well as between the Middle Woodland and Middle Archaic blades. Blade curve index was measured because it is a purposeful characteristic, one that can help to decipher technological organization and cultural patterning. The notable difference of this attribute across cultural occupations is important evidence for the continued but varying use and creation of KLS blades through time.

Based on the results of the statistical tests, the increase in Middle Archaic blades cannot be explained by site formation processes. Instead, blade production steadily increased through time at the JJ site, and produced morphologically distinct blades as a result. It is possible that the flintknapping mechanics required to successfully manipulate KLS often resulted in blades and blade-like flakes. The high number of faceted platforms within the Middle Archaic suggests that blade making was not the focus of their reduction efforts. Perhaps blades were a byproduct of the technological organization being utilized during this time.

JJ and Lillian Joyce Blades

The blades from the JJ and Lillian Joyce sites were analyzed for similarities in the technological strategies used to produce them. If the Woodland-dated levels from both sites contained similar blades, then it is possible that flintknappers at both sites used similar reduction strategies. If that is the case, then the blade assemblages from both sites may have stemmed from the same parent population. The null hypothesis states that any differences will be the result of random chance, and and p value greater than .05 will fail to falsify this null hypothesis.

Of the eight attributes tested, all eight failed to reject the null hypothesis. As a result, it is highly probable that the Woodland-dated blades from the JJ and Lillian Joyce sites are from the same parent population. The statistical results and the OSL dates suggest that a similar blade-making strategy was occurring at both the JJ and Lillian Joyce sites during the Woodland tradition.

The Lillian Joyce blades also resembled the JJ site blades in their respective outline morphologies. Four of the five Lillian Joyce blades were straight, and one was pointed. In addition, no retouch or utilized edge length was observed. If the blades from the Lillian Joyce and JJ sites exhibit similar morphological attributes and no evidence of retouch or use, additional evidence is provided to a similar technological strategy occurring at both sites. Therefore, if blade cores could have been the goal during the Middle Woodland occupation at the JJ site, the same may hold true for the Lillian Joyce blades as well.

Conclusions

This thesis used macroscopic analysis to examine the lithic artifacts recovered from the JJ site. The goal was to record both qualitative and quantitative attributes of the tools and the flake debitage recovered from the two excavated units in an effort to discern something about the lithic production technologies occurring at JJ. Understanding the stone tool activities at one site can provide a window into how the Knife Lake quarries were used through time. I will return to my original questions to address the results and observations made so far. The first question was concerned with what kinds of tool technology were being produced at the JJ site through time, and whether or not this technology specifically points to a significant blade industry. I hypothesized that based on temporal data provided by the OSL dates, four cultural components are present at the JJ site, with a trend toward increased blade production through time. The flake attributes at the JJ site support technological change over time, with general flake shape and size, as evidenced by weight, maximum length and width, and oriented length, providing both statistically significant data and highly probable data in support of this change. In addition, cortex cover, grain size, and platform types were very different between the cultural components of Unit 1. In Unit 2, grain size and weight were very different. Unit 1 exhibited more change than Unit 2, which may be the result of an ancient tree throw present in Unit 2 that mixed the older deposits.

The specific types of technology present appear to be bifacial reduction, based on the presence of bifaces and faceted platforms within the debitage; blade production, based on the presence of blades and flat platforms within the debitage; and core production, based on the presence of recovered cores. There does appear to be a specific blade technology, which increases over time and peaks during the Middle Woodland, as well as a general increase in core production through time (Table 68). The Paleoindian component has strong evidence for blade production, based on a majority of flat platforms from the Paleoindian levels, but a lack of recovered blades. This is suggestive of blade production at the JJ site and subsequent transportation of the blades away from the JJ site.

Paleoindian	Early Archaic	Middle Archaic	Middle Woodland
1 blade	2 blades	7 blades	13 blades
No cores	No cores	2 cores	3 cores
2 bifaces	No bifaces	2 bifaces	1 biface

Table 68. JJ site tools.

I also questioned whether blade production increased through time, while biface production decreased. Blade and biface production are mostly equal within the Paleoindian component; biface production takes precedence in the Early and Middle Archaic levels; and blade production increases again in the Middle Woodland levels. Blade and biface production both fluctuate through time, while both remained present throughout all four cultural levels.

My second question was focused on technological change over time, based on the results of the OSL dates. Six of the eight flake attributes examined provided a highly probable likelihood that the flakes from the four cultural components were different, and not originating from the same parent population. In general, the Paleoindian assemblage is comprised of flakes with flat platforms, a larger number of primary flakes, and fewer than expected fine-grained flakes. These data point to blade reduction, initial reduction strategies, and perhaps a technological strategy not focused on formal tools, based on the more predominate use of medium and coarse-grain KLS. The Early and Middle Archaic assemblages can be broadly described as having more of a focus on bifacial reduction techniques, due to the large number of faceted platforms, and the use of fine-grain KLS, which may point toward technological organization focused on formal tool making. The Middle Woodland component generally exhibits a greater degree of technological variety. A greater number of abraded platforms, flat platforms, primary flakes, and non-KLS flakes suggests several early reduction techniques were taking place. At the same time maintenance of non-KLS tools occurred, which is represented by the presence of non-KLS flakes. The greater than expected frequencies of fine and coarse-grain KLS also suggests several technological strategies were employed, based on evidence that different KLS grain sizes require different reduction techniques (Wendt and Romano 2009). Finally, the increased presence of blades and cores in the Middle Woodland is unique, and suggests multiple approaches to technological organization were taking place.

This increase in technological variety in the Middle Woodland is important because not only does it provide evidence for a change in technological organization between the Middle Woodland component and the three preceding cultural components, but it may also help to provide an inroad for examining the increase in blades recovered at both sites. Future research could examine other blades from Daughter Districts sites to look for similarities and differences.

The statistical tests of the blades from the JJ site produced five out of eight attribute tests with significantly different results, suggesting the JJ site blades exhibit important differences through time. As mentioned, the Middle Woodland and Middle Archaic blades were compared and resulted in significant data which also supports morphological change through time. Similarities between the cultural components may be the result of the technological constraints inherent in KLS.

The third question considers how the JJ and Lillian Joyce blades compare to one another. The blades from the Woodland-dated levels were statistically similar, and highly likely to have originated from the same parent population. Additionally, the overall morphology and lack of utilized tool edge suggests a similar technological strategy at both sites. This strategy may represent specialized blade core production. As part of this question, I also considered if KLS was used as a valuable export item. If the Middle Woodland components at two sites from the Daughter District were employed in creating blade cores, yet no blade cores have been recovered from either site, then transportation away from Knife Lake was likely. Additionally, the Middle Woodland components provide evidence for a Laurel affiliation, and thus access to a large trade network known to use blade technology

Finally, the last question addressed the likelihood that some of the artifacts from the JJ site may have been produced by Laurel peoples. The presence of other sites on Knife Lake with diagnostic artifacts suggestive of Laurel occupations suggests the possibility that the same people also utilized the Knife Lake quarries, and the JJ site in particular. The Middle Woodland-dated component of the JJ and Lillian Joyce sites provide evidence for expedient technology, blade production, and non-KLS raw materials. These details corroborate known characteristics of Laurel cultures. More research is needed to expand this observation, especially in terms of what role Knife Lake may have played in larger trade and interaction spheres, including Hopewell.

The JJ site assemblage held no diagnostic artifacts, so conclusions concerning multiple cultural occupations still hinge on the results of the OSL dates. Despite this, the analysis and results of this thesis provide enough evidence to determine that technological change did occur over time, a unique blade production strategy was being implemented, and Middle Woodland use of the Knife Lake quarries existed to some degree. Woodland sites exist across Knife Lake, including Laurel sites, and efficient technological organization sometimes requires opportunistic resource procurement. As a result, I think there would have to be a significant reason why Middle Woodland peoples would not have taken advantage of such a large resource area.

The assemblage at the JJ site is generally characterized by secondary reduction techniques. It is likely that large KLS cobbles were procured and initially reduced at the quarry site, and then brought to the JJ site to be further reduced for transportation away from the site. Furthermore, change in technological organization through time is apparent from this assemblage, with an emphasis on increased technological variety during the Middle Woodland occupation. Further research should examine other blades from Daughter District sites, and compare them to the JJ and Lillian Joyce blades. Additional OSL dating and studies focusing on technological change over time throughout the Daughter District would also be useful. The experimental data compiled by Stroh (2011) and Wendt and Romano (2009) is compelling, and would likely yield worthwhile results when applied to KLS and blade technologies, which would also be a good topic for future research.

Overall, the JJ site appears to have maintained a similar site function, but yields significant data for technological change through time. The Knife Lake quarries are such a large resource procurement area that would likely have been in use throughout several cultural traditions, and the debitage at the JJ site help to support this finding.

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