Lithic Debitage Analysis of the Kelly Forks Work Center Site (10CW34)

A Thesis
Presented in Partial Fulfillment of the Requirements for the
Degree of Master of Arts
with a
Major in Anthropology
in the
College of Graduate Studies
University of Idaho
by
Daniel J. Polito

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Department Administrator: Brian Wolf, Ph.D.

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Authorization to Submit Thesis

This thesis of Daniel J. Polito, submitted for the Degree of Master of Arts with a major in Anthropology and titled, "Lithic Debitage Analysis of the Kelly Forks Work Center Site (10CW34)," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

The analysis of the lithic debitage assemblages recovered from archaeological sites has become an important tool for determining past lifeways and behaviors. Lithic debitage enters into the archaeological record where the manufacturing behavior occurred and is therefore a good indicator of spatial use patterns. The analysis of the debitage assemblage from the Kelly Forks Work Center Site found the spatial and temporal patterns are consistent with what is to be expected from a prehistoric seasonal hunting camp with no local source of quality lithic materials. The methods of analysis used a combination of both multivariate aggregate analysis and application load typological analysis. This combined approach was statistically analyzed and it was determined that a correlation exists between these two methodologies. The comprehensive data generated from this research is also intended to be used as a comparative collection and promote further research into this assemblage.

Acknowledgements

I would like to thank my committee members for their support and guidance throughout this process. In particular, the input and suggestions from my major professor, Dr. Lee Sappington, whose sense of humor and knowledge of the region was a constant source of laughter and enlightenment. I would like to recognize Dr. Mark Warner who made it possible for me to come to the University of Idaho and challenged me to see the bigger picture and beyond and Dr. Donald E. Tyler for agreeing to be on this committee.

This thesis would not have been possible without Laura Longstaff‘s incredibly detailed thesis on the site. Her meticulous site report, record keeping, and attention to detail provided a wealth of knowledge and the raw data on which this research was based. The knowledge imparted by Dave Quinn on flint knapping and fracture mechanics proved invaluable to this research. My Brother James L. Polito’s statistical assistance and guidance made the completion of this thesis not just a probability, but a reality. And Cynthia Hannold who made sure that my thesis made sense on paper and in context.

I would also like to express my gratitude to family and friends alike that supported me throughout this academic endeavor. And lastly, I am grateful for Floyd, my dog, who sat patiently (not always) by my side waiting for his walk while I worked on this thesis. Thank you one and all!

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Introduction

Lithic analysis at both the micro and macro levels is key to the understanding of past lifeways of hunter-gatherers, especially those behaviors related to site activities, mobility, exchange, and settlement patterns. Lithic analysis is particularly significant in the Columbia Plateau due to the lack of ceramic artifacts and soil conditions that do not favor the preservation of animal and plant remains. Because of their durability, the lithic remains of a past culture or temporal component are often the only material evidence to survive within the archaeological record on the Columbia Plateau. Both completed and fragmentary bifacially worked projectile points and knives can offer insights into many of the aforementioned activities of the past lifeways of hunter-gatherers. However, these tools are often found in isolate as a result of loss or discard. These can be good markers of temporal components and the spatial distributions of prehistoric cultures, but offer little in the way of determining site activities and therefore behaviors. Additionally, complete projectile points and knives are usually underrepresented when analyzing lithic assemblages associated with a site or occupation. While considered highly desirable, and very "sexy," projectile points and knives do not offer the insights into site activities that manufacturing processes (and the resulting lithic debitage which is a by-product of these manufacturing processes) can provide in determining site activities and behaviors (Sappington 2016).

Formal and expedient tools, as well as preforms, were transported by prehistoric hunter-gatherers to and from various locations along their seasonal or foraging routes. The regular maintenance and curation of these tools was a necessary behavior to ensure the tools longevity and efficacy. When finished tools are found in isolate, far from their manufacturing, curation, and use locations, they offer limited insights on human behaviors. Lithic debitage, however, is generated by these manufacturing, maintenance, and curation processes and is the direct result of a discrete episode of human behavior. This by-product of the lithic reduction process is most likely deposited into the archaeological record at the location of the activity. Because these “lithic scatters” are located where the behaviors occur, there is also the potential for inferring the spatial, seasonal, and subsistence structures and patterns associated with the cultures from which they were deposited (Ahler 1989:86).

Don Crabtree, world renowned flint knapper and experimental archaeologist, viewed the lithic debitage associated with tool making as the “finger prints” of these manufacturing processes (Crabtree 1972). The use of the implied forensic analytical term of “fingerprint” alludes to the study of debitage assemblages to determine tool manufacturing activities even when the finished tools themselves are not present in the archaeological record. In other words, lithic debitage is the clue that has been left behind at the scene of the manufacturing process.

Previously overlooked as an unimportant indicator of past behaviors and lifeways, the analysis of lithic debitage associated with tool manufacture has gained credibility and acceptance by most archaeologists in recent years (Andrefsky 2001:2). Conferences on lithic debitage analysis in both the experimental and archaeological records have been held with increasing frequency and attendance. Additionally, dedicated books and edited volumes of works regarding this previously disregarded artifact category are now a common fixture on university library bookshelves and in lithic laboratories. Lithic debitage analysis is now an accepted way to interpret the behaviors associated with lithic tool manufacture and thus site activities, mobility, and settlement patterns.

The Kelly Forks Work Center Site (10CW34) is located in the Clearwater National Forest (Figure 1.1) is an ideal site for analyzing lithic debitage in order to investigate hunter-gatherer lifeways and behaviors (n=15,763). Intact strata and twenty-six radiocarbon dates, ranging from13,740 to 280 cal. BP, document reoccurring seasonal occupations of the site beginning in the Paleoindian period and continuing through the protohistoric period. A multivariate aggregate and typological analysis of this debitage assemblage was performed to investigate the behaviors associated with tool manufacture and their significance to the site and region as a whole. The generated data was then mapped in both two and three dimensions to identify patterns and areas of behavioral foci. Area E, designated in yellow outline in Figure 1.2 and Figure 1.3, was the focus of the intensive analysis and three dimensional mapping.

Discussion of the Kelly Forks Work Center Site's geological, geographical, climatic, and natural setting contexts will not be included in this thesis. The cultural and historical settings have also been omitted from this thesis. It was determined that to rewrite these natural and cultural contexts would be an exercise in redundancy given the thorough summary provided in the site report by Laura Longstaff in 2013. Therefore, when necessary, these contexts are referenced to Longstaff 2013.

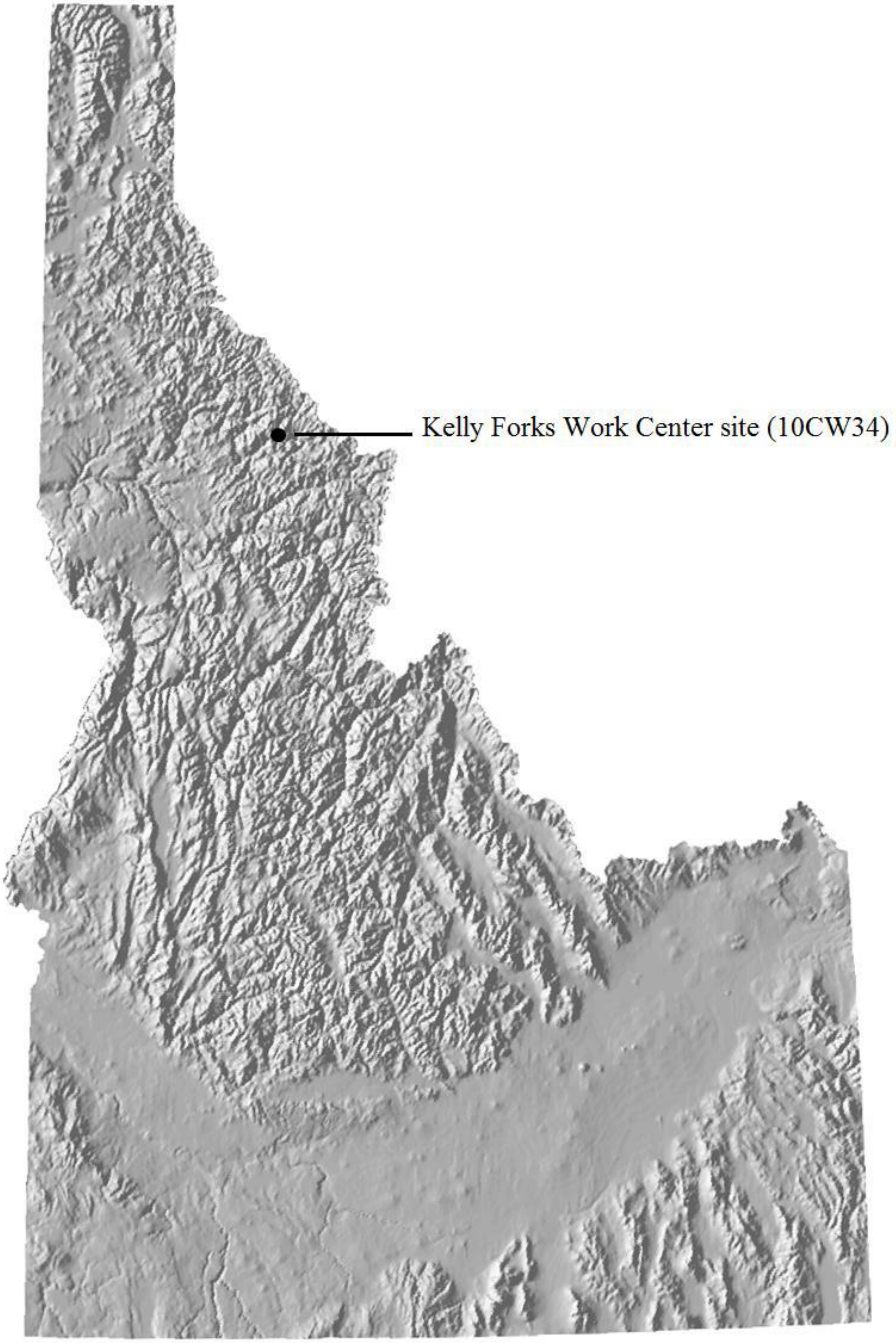
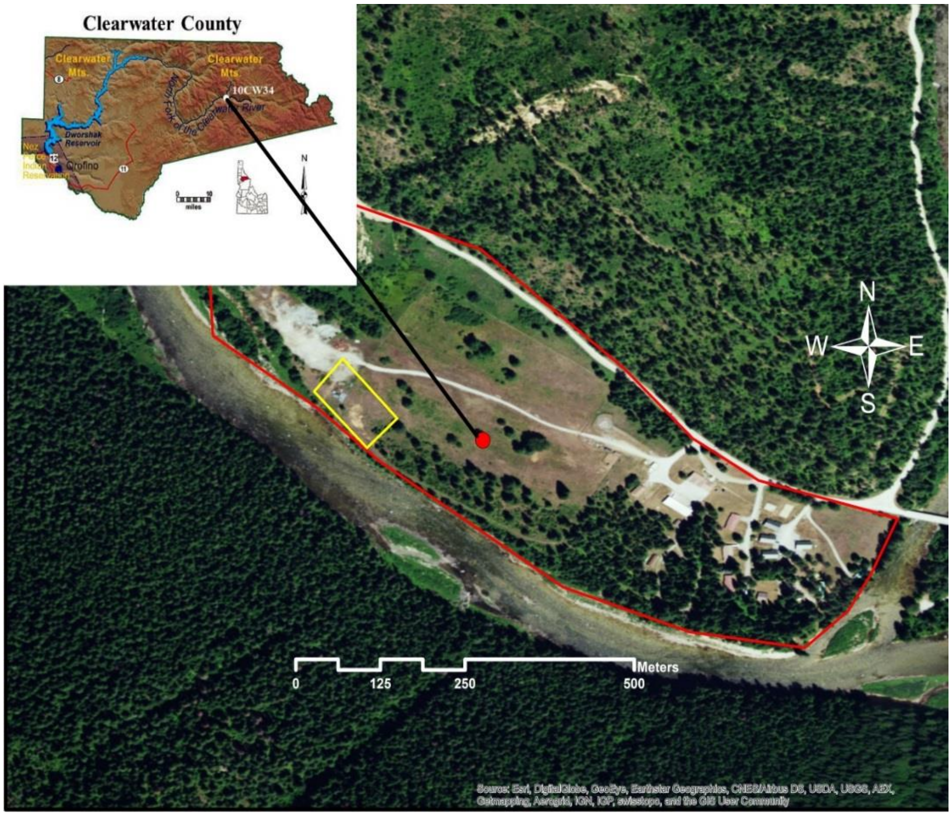


Figure 1.1 Location of the Kelly Forks Work Center Site (adapted from Longstaff 2013).



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 1.2 The Kelly Forks Work Center Site boundaries and location within Clearwater County, Idaho (Author and ArcGIS base maps).

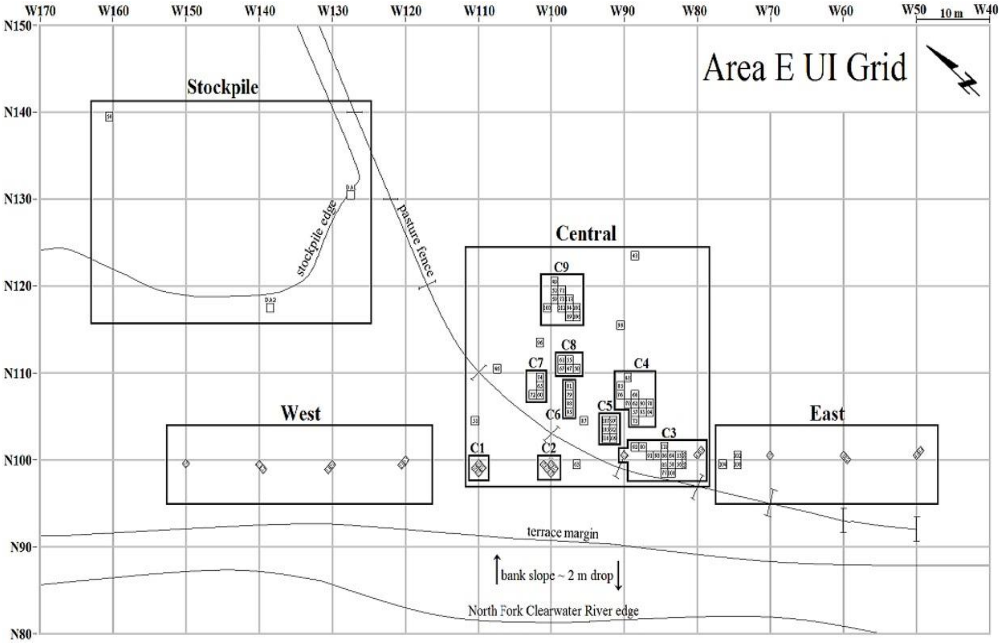


Figure 1.3 Area E, focus of intense analysis and three dimensional mapping (adapted from Longstaff 2013).

Research Objectives

The intent of this research and subsequent thesis is to conduct a comprehensive multivariate analysis of the lithic debitage assemblage associated with the 2010 – 2012 field excavations at the Kelly Forks Work Center Site. Lithic debitage analysis has been shown to be a good indicator of stone tool manufacturing behaviors, site activity foci, and patterns of mobility and exchange. However, there are methodological issues with debitage analysis, particularly when dealing with large complex lithic assemblages. Archaeologists have yet to devise an efficient, replicable, and statistically sound approach for these analyses. One of the goals of this study is to make a methodological contribution to the field of lithic analysis. Specifically, the objective is to determine if large assemblages deposited over long temporal spans can be analyzed using a combined approach of multivariate aggregate analyses and individual flake analysis of the application loads. Additionally, the material remains from 10CW34 present an excellent opportunity to investigate a residential base camp with repeated use during the seasonal rounds of the inhabitants of the Clearwater River drainage basin. The site's temporal longevity and proximity to Lolo Pass also makes it a candidate site to investigate inter-regional trade and exchange patterns throughout its occupation.

This study has four main goals:

1. To infer site activities and behavioral foci based on lithic debitage clusters and application load technologies.
2. To investigate trade, exchange, and mobility as associated with known Plateau cultural chronologies based on lithic debitage material remains.

3. To understand how traditional lands were utilized seasonally by the ancestors of the Nez Perce communities situated in the North Fork of the Clearwater River drainage basin.
4. To compare size-grade analyses to the individual flake analyses of the application load typologies to determine the correlation between these two attributes and examine the efficacy of this combined methodology.

In addition to these inquiries, the following supplemental goals were associated with this study to facilitate future debitage assemblage research and experimentation with spatial display:

1. To establish a comprehensive lithic debitage database for the Kelly Forks Site to be utilized for future study and comparison.
2. To display lithic debitage assemblages in three dimensions to identify activity clusters and patterns and to re-humanize large volumes of data entered onto spreadsheets.

The intended significance of this research is threefold. First, to my knowledge this study represents the first intensive lithic debitage analysis performed on a Clearwater River drainage site. Large debitage assemblages that have accumulated over long temporal spans are known to be problematic for archaeologists. The problem of mixed assemblages, compounded by the palimpsest effect of human activity, makes the identification of single episodic activities nearly impossible (Andrefsky 2001:4-5). Therefore the investigation of the overall assemblage using the combined approaches of aggregate and individual attribute analysis (application load technology) makes a methodological contribution to debitage analysis, particularly in the case of large excavated assemblages with mixed lithic reduction activities. Second, the results of this study will expand our knowledge of Columbia Plateau cultures utilization of lithic resources and how the availability of such resources may have further structured mobility, trade, and subsistence strategies. Third, the results of this study will provide a comprehensive debitage analysis of the Kelly Forks Work Center Site for future research and comparison.

Theoretical Considerations

Stone tools have played a vital role in the evolution of the genus *Homo* both physically and culturally. From the Oldowan tradition to the modern use of obsidian blades for surgical purposes, lithic technology has shaped our ability to extract and exploit resources and to adapt to the many environments that our genus has come to inhabit. The duration of this technology throughout our history is testament to its importance as both a tool for survival and catalyst for adaptive strategies. Therefore, the procurement, manufacture, and preconceived mental templates that produce these tools provide an evolutionary record and timeline that documents these physical and cultural adaptations.

As previously mentioned, the lithic debitage associated with prehistoric archaeological sites is often the most numerous artifact class recovered. This artifact class was once neglected, considered unimportant, and often discarded. This misguided perception of the unimportance of lithic debitage assemblages has changed significantly in recent decades. Lithic raw material fracturing characteristics and data generated through experimental archaeology have created a baseline for comparison to archaeological assemblages and is now considered a valuable analytical tool (Andrefsky 2001:2).

An initial discussion of lithic technological organization is necessary to infer broader implications of the analytical potential associated with lithic debitage. This discussion must consider such contexts as resource procurement strategies, concept and manufacture, tool form and function, maintenance and curation, and settlement and mobility patterns. To illustrate the importance of the theoretical framework associated with lithic technological organization, Andrefsky states:

> Lithic technological organization refers to the manner in which human toolmakers and users organize their lives and activities with regard to lithic technology…. In this context, the manner in which lithic tools and debitage are designed, produced, recycled and discarded is intimately linked to forager land use practices, which in turn are often associated with environmental and resource exploitation strategies (Andrefsky 2009:66).

To this end, the lithic technological organization of prehistoric hunting, foraging, and gathering communities was likely a factor to be considered in most of the survival decisions made on a daily basis (Andrefsky 2008:4).

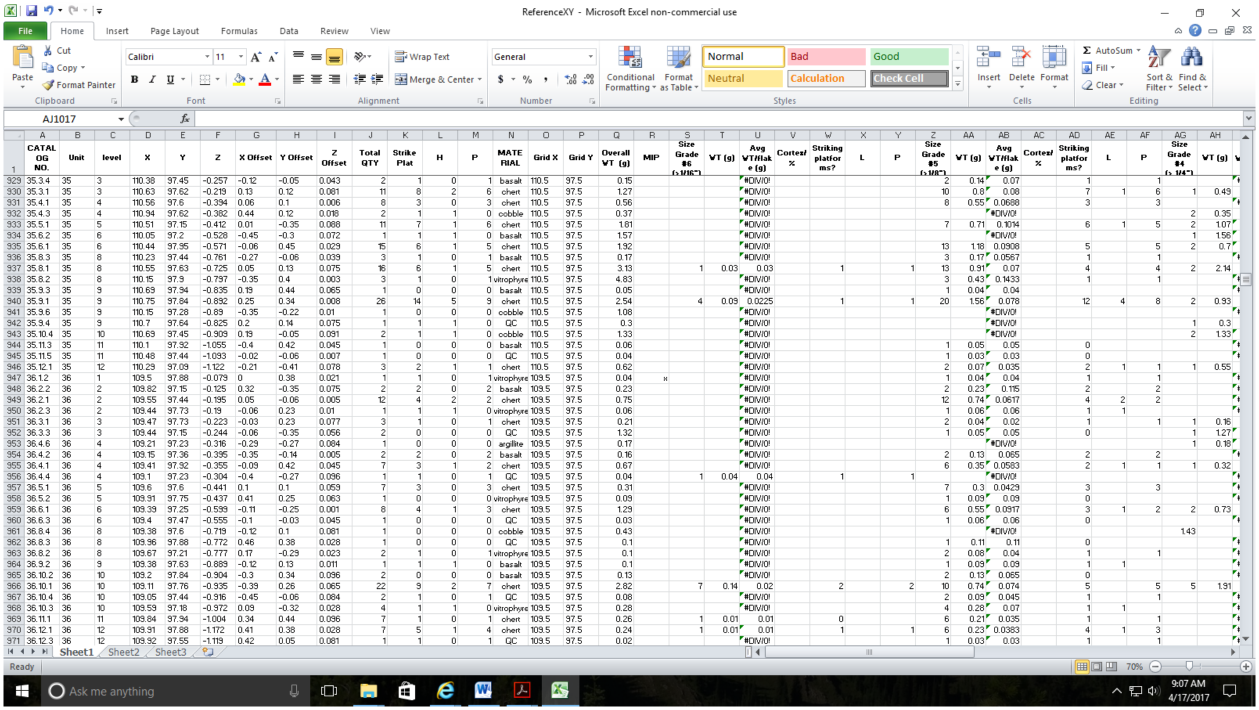
In archaeology, the lithic remains of a past culture are found in a static state. More than likely, the state in which stone tools and the associated manufacture, curation, and maintenance debris are deposited into the archaeological record is not in the same state that the tool or debitage started. Therefore the “life history” of a stone tool is dynamic and this is evidenced by the manufacture, curation, and maintenance debitage found on archaeological sites (Sappington 2016). The location of 10CW34 within the seasonal rounds, the lithic raw material sources available along these seasonal rounds, and the debitage assemblage recovered from the site testify to this reuse and repurposing of stone tools. The proximity to raw material sources dictates the extent to which curation and maintenance occurs. The use-life of tools is extended through curation and repurposing to prolong the usefulness of costly raw materials when procurement costs for these materials are high in a given location. Additionally, any serviceable or expedient flakes produced from the maintenance and curation activities are also collected and utilized and occasionally curated (Morrow and Jefferies 1989:29-30). The "life-history" of a stone tool is an integral part of the theoretical framework associated with lithic technological organization and the remaining debitage of these activities is the "photo album" or "scrap-book" that details this life history from birth (resource acquisition) through death (discard, loss, or end of serviceability).

Lithic debitage analysis has been generally relegated to three different methods of recording and observation. These are: aggregate, typological, and attribute analysis (Andrefsky 2001). All three of these methods rely on quantitative observation and analysis. The data generated from the aggregate observations of 15,763 lithic debitage artifacts were analyzed using descriptive statistics, measures of dispersion, and multivariate methods. The identified patterns were interpreted using the lithic technological organizational theoretical framework (Binford 1973; Kelly 1988; Nelson 1991; Shott 1986). To further bridge the analytical to the inferential, and thus make broader statements about past behaviors, treatises on experimental archaeology in lithic reduction with regards to application load technologies were referenced (Ahler 1989; Bradbury and Carr 1999; Crabtree 1972; Flenniken 1981; Newcomer 1971).This theoretical approach was used to determine which observations were relevant and also how the explanations of these were determined (VanPool and Leonard 2011).

The lithic technology organizational framework of analysis is very good for answering the questions of "how, what, and why" with regards to lithic and debitage assemblages. But there is one more very important question that often goes unasked when working with large volumes of quantitative data and that is, “so what?” (Kimball 2013). How can we archaeologists take the numerous columns and rows of data and re-humanize it so that we can attempt to answer the “so what” to put the people back onto the land and off of the spread sheet? In an attempt to accomplish this re-humanization and address the “so what,” I have spatially displayed the data in three dimensions to virtually put the people and their activities back onto the land.

It is said that a picture is worth a thousand words. In archaeology a good spatial representation of artifacts, ecofacts, features, and landscapes in both two dimensions and three dimensions is worth ten pages of text. In my opinion it is visually easier to grasp the context and significance of the overall “big picture” when displayed in this fashion. Patterns and clusters of activity are more easily discerned when displayed in a manner that gives visual context to the elements shown in their X, Y, and Z provenience. ArcGIS was the platform utilized to render the data into a three dimensional world in an attempt to re-humanize the many numbers, columns, and rows recorded on the spreadsheets.

The use of Geographic Information Systems (GIS) and the spatial display of landscape and archaeological data is difficult to confine to one theoretical paradigm. There has been an ongoing debate as to whether GIS is merely a tool or whether it can be considered its own “science” and thus support a theoretical aspect (Connolly and Lake 2006:3). The fact that GIS can display quantitative data and yet convert these data to a qualitative nature by simulating the environment in which it has been found is a powerful tool when displaying the spatial attributes of landscape and archaeological provenience. The use of GIS as a tool in this manner is a bridge from the positivist to the humanist and thus gives the viewer a virtual “ground” on which to stand and experience the phenomena. This sense of “being in the world” is one of the themes associated with landscape archaeological theory by providing the qualitative element of experience (Chapman 2009:129-130). This virtual experience then brings us closer to those individuals who sharpened their stone tools on the grounds where the North Fork of the Clearwater River and Kelly Creek converge. The use of GIS and spatial display in this analysis has been utilized both as a visual tool and in a landscape theoretical application to bridge the quantitative to the qualitative. Figure 1.4 shows the generated data in a very non-humanistic spread sheet format. Figures 1.5 - 1.7 illustrates this same generated data after it has been rendered in ArcGIS to display it visually and spatially in both two and three dimensions.



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935	35.6.1	35	6	110.44	97.95	-0.571	-0.06	0.45	0.029	15	6	1	5	chert	110.5	97.5	1.92				#DIV/0!					13	1.18	0.0908		5		5	2	0.7
936	35.8.3	35	8	110.23	97.44	-0.761	-0.27	-0.06	0.039	3	1	0	1	basalt	110.5	97.5	0.17				#DIV/0!					3	0.17	0.0567		1		1		
937	35.8.1	35	8	110.55	97.63	-0.725	0.05	0.13	0.075	16	6	1	5	chert	110.5	97.5	3.13		1	0.03	0.03		1		1	13	0.91	0.07		4		4	2	2.14
938	35.8.2	35	8	110.15	97.9	-0.797	-0.35	0.4	0.003	3	1	0	1	vitrophyre	110.5	97.5	4.83				#DIV/0!					3	0.43	0.1433		1		1		
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957	36.5.1	36	5	109.6	97.6	-0.441	0.1	0.1	0.059	7	3	0	3	chert	109.5	97.5	0.31				#DIV/0!					7	0.3	0.0429		3		3		
958	36.5.2	36	5	109.91	97.75	-0.437	0.41	0.25	0.063	1	0	0	0	vitrophyre	109.5	97.5	0.09				#DIV/0!					1	0.09	0.09		0				
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960	36.6.3	36	6	109.4	97.47	-0.555	-0.1	-0.03	0.045	1	0	0	0	QC	109.5	97.5	0.03				#DIV/0!					1	0.06	0.06		0				
961	36.8.4	36	8	109.38	97.6	-0.719	-0.12	0.1	0.081	1	0	0	0	cobble	109.5	97.5	0.43				#DIV/0!							#DIV/0!					1.43	
962	36.8.3	36	8	109.96	97.88	-0.772	0.46	0.38	0.028	1	0	0	0	QC	109.5	97.5	0.1				#DIV/0!					1	0.11	0.11		0				
963	36.8.2	36	8	109.67	97.21	-0.777	0.17	-0.29	0.023	2	1	0	1	vitrophyre	109.5	97.5	0.1				#DIV/0!					2	0.08	0.04		1		1		
964	36.9.2	36	9	109.38	97.63	-0.889	-0.12	0.13	0.011	1	1	1	0	basalt	109.5	97.5	0.1				#DIV/0!					1	0.09	0.09		1	1			
965	36.10.2	36	10	109.2	97.84	-0.904	-0.3	0.34	0.096	2	0	0	0	basalt	109.5	97.5	0.13				#DIV/0!					2	0.13	0.065		0				
966	36.10.1	36	10	109.11	97.76	-0.935	-0.39	0.26	0.065	22	9	2	7	chert	109.5	97.5	2.82		7	0.14	0.02		2		2	10	0.74	0.074		5		5	5	1.91
967	36.10.4	36	10	109.05	97.44	-0.916	-0.45	-0.06	0.084	2	1	0	1	QC	109.5	97.5	0.08				#DIV/0!					2	0.09	0.045		1		1		
968	36.10.3	36	10	109.59	97.18	-0.972	0.09	-0.32	0.028	4	1	1	0	vitrophyre	109.5	97.5	0.28				#DIV/0!					4	0.28	0.07		1	1			
969	36.11.1	36	11	109.84	97.94	-1.004	0.34	0.44	0.096	7	1	0	1	chert	109.5	97.5	0.26		1	0.01	0.01		0			6	0.21	0.035		1		1		
970	36.12.1	36	12	109.91	97.88	-1.172	0.41	0.38	0.028	7	5	1	4	chert	109.5	97.5	0.24		1	0.01	0.01		1		1	6	0.23	0.0383		4	1	3		
971	36.12.3	36	12	109.92	97.55	-1.119	0.42	0.05	0.081	1	1	0	1	QC	109.5	97.5	0.02				#DIV/0!					1	0.03	0.03		1		1		

Figure 1.4 Sample of Excel Spreadsheet data generated from aggregate analysis.

…….

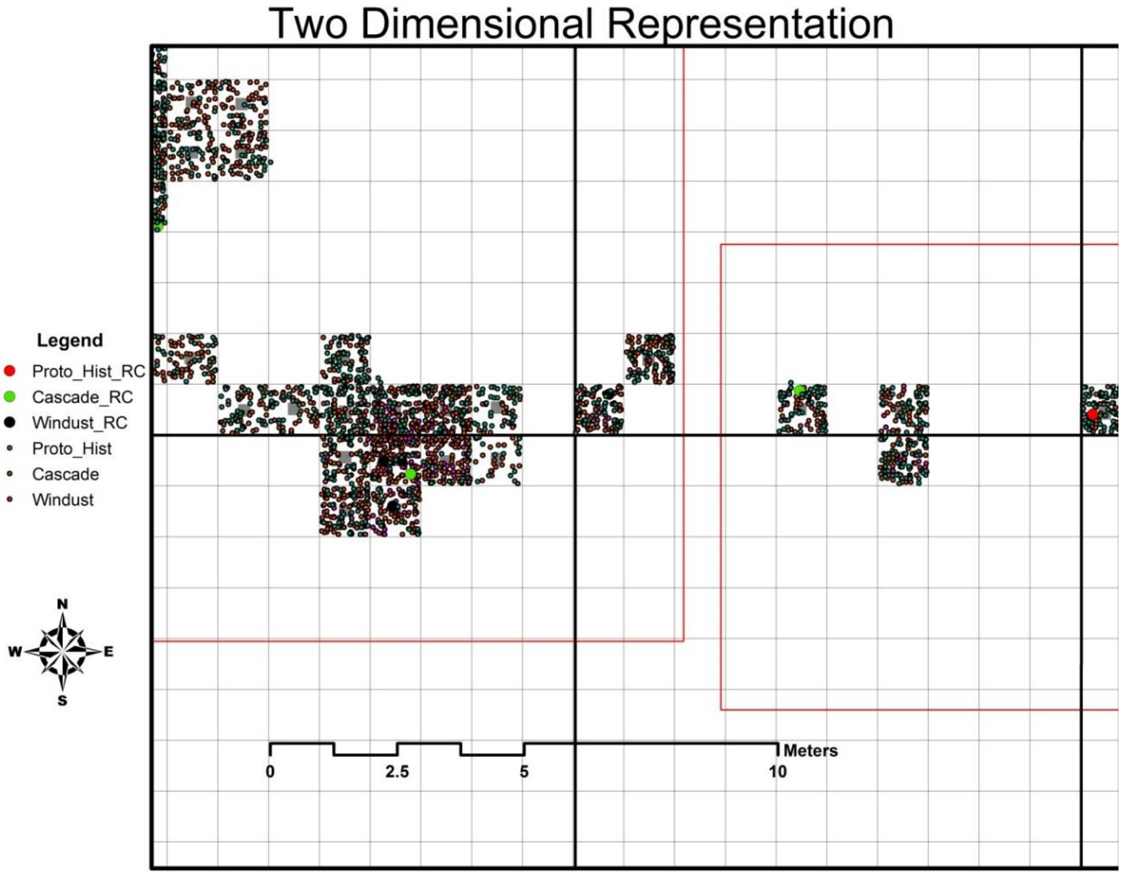

Figure 1.5 Two dimensional representations of the same data using ArcGIS.

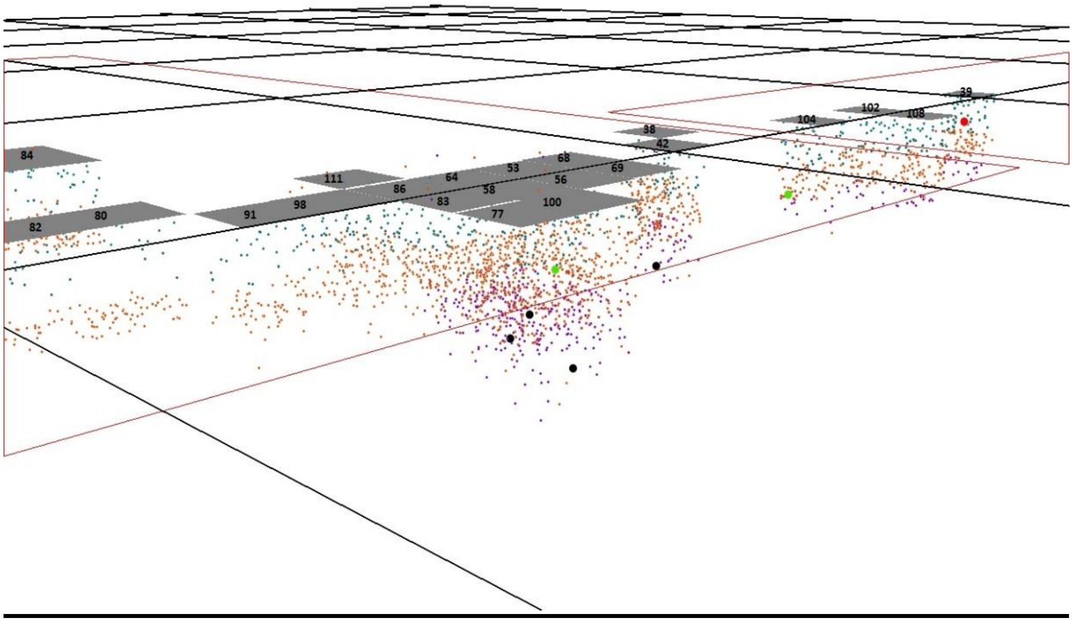

Figure 1.6 Three dimensional representations of the data shown in Figure 5 from a 30 degree viewing angle.

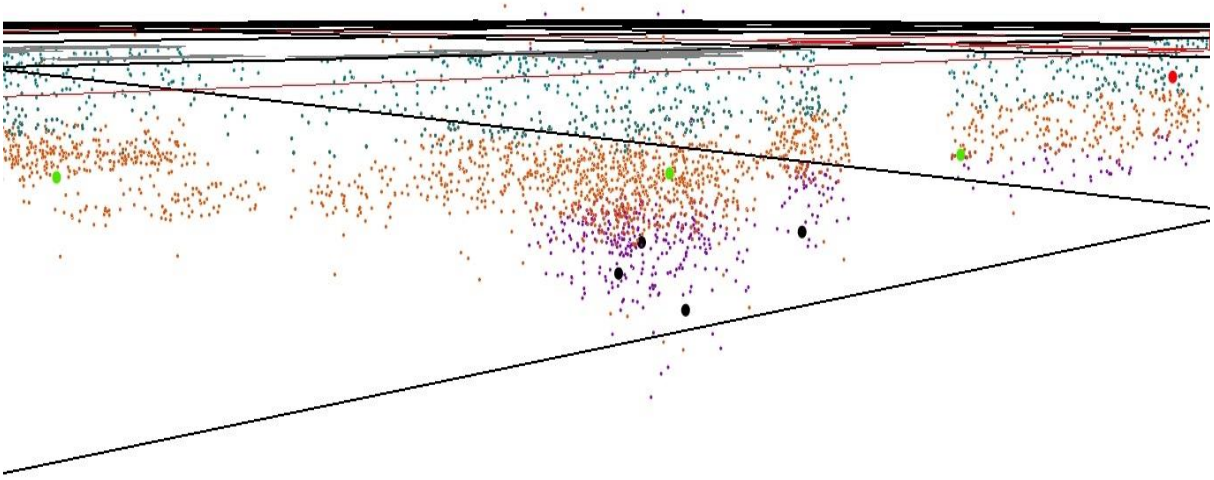

Figure 1.7 Three dimensional representations of the data shown in Figure 5 from an 8 degree viewing angle.

Professionals in many scientific fields tend to favor only one theoretical approach, either because that is how they were taught or because they have a professional investment in it. I am a firm believer that we should utilize all of the theoretical tools in our proverbial tool box to address the research questions to answer the “how, what, and why,” but also, and perhaps more importantly, to provide insights as to the “big picture,” and to answer the “so what.” Multiple theoretical approaches can be relevant when analyzing large data sets and are the archaeological and anthropological building blocks upon which we can give agency and voice to those individuals or cultures whose voices can no longer be heard. If we limit ourselves to one theoretical framework, we become chained to its parameters and lose our objectivity.

Chapter 2:

Methodology

The analysis of lithic debitage has taken many forms throughout recent history in attempts to answer the numerous behavioral, technological, and spatial questions associated with the prehistoric lithic tool technological organization. Lithic debitage is normally deposited at the site where the manufacturing activity occurred. It can therefore be looked at as one of the residual traces of behavior where and when these episodes of reduction occurred (Ahler 1989:86). Thus the debitage represents a behavioral "clue" left at the scene of the activity that can be analyzed in association with other "clues" remaining at the site to piece together what the daily life routines and behaviors of the prehistoric inhabitants were like. In the past thirty years, lithic debitage analysis has become an accepted analytical tool for prehistoric research into trade and mobility, site activities, settlement patterns, subsistence strategies, lithic tool manufacture, and the behaviors that can be associated with these manufacturing activities (Larson 2004:3-4).

The late Don Crabtree, renowned flintknapper and experimental archaeologist, recognized the diagnostic potential of lithic debitage in 1972 and said of this manufacturing by-product: "These debitage flakes are usually more diagnostic than flake scars for their size, thickness, shape and degree of curvature can reveal several manufacturing steps.… For this reason, a careful study of the flaking debris is a prime requisite in determining the manufacturing technique"

(Crabtree 1972:1).

An analysis of the lithic debitage and its context within the site and to other artifacts/ecofacts should be included to paint a complete picture when making behavioral inferences regarding a temporal component or culture associated with an archaeological site. This section on methodology will explore the various forms of debitage analysis methods, the history of debitage analysis, and a note on debates surrounding these forms of analysis. This section will end with the methods that have been chosen to analyze the 10CW34 assemblage and why these methodologies were employed.

*Individual Flake Analysis and Flake Aggregate Analysis***.** The analysis of lithic debitage is carried out in two manners; these are the individual flake analysis and flake aggregate analysis. The methodologies associated with these two different approaches will be examined later in this section of the thesis. Individual flake analysis focuses on specific attributes on each flake that are measured and recorded. The measurements of these attributes are related to discrete acts of lithic reduction (Ahler 1989:86). These attributes are often associated with technological, typological, and placement within the reduction sequence (Sullivan and Rozen 1985:755-760; White 1963). One of the advantages of individual flake analysis is the determination of discreet events from which we can then make larger inferences about behaviors. An obvious disadvantage of individual flake analysis, especially when analyzing large archaeological assemblages, is that it can be very tedious and time consuming (Odell 2004:121). Martin Magne cites that in his 1985 analysis of 1000 flakes that it took close to six-months to analyze, weigh, and measure this assemblage (Magne 1985:111). The individual flake analysis of the Kelly Forks Work Center assemblage was completed in just over three months' time but did not include a measurement of each flake.

Flake aggregate analysis focuses on the overall archaeological assemblage to infer group behaviors temporally and spatially within a site or landscape (Ahler 1989:101). Flake aggregate analysis is most commonly conducted by the size grading of the assemblage through nested sieves of descending mesh sizes. The size grading approach to aggregate analysis promotes replicability of results, efficiency for examining large assemblages, and takes advantage of the reductive nature of stone tools manufacture (Carr and Bradbury 2004:21). Disadvantages of flake aggregate analysis include mixed assemblages and the addition of broken or partial flakes in the analysis (Andrefsky 2006; Flenniken and Haggarty 1979; Sullivan and Rozen 1985).

Experimental Archaeology. In order to analyze archaeological debitage assemblages, a baseline set of data is required for comparison and reduction sequencing. This requirement fomented the need to determine how these flakes are made and the fracturing characteristics associated with the raw materials. This has been achieved through experimental archaeology by conducting experiments in flint knapping and lithic reduction analysis (Ahler 1989; Andrefsky 2006; Crabtree 1972; Dibble 1997; Flenniken 1981; Flenniken and Wilke 1989; Rasic and Andrefsky 2001; Root 1992; Shelley 1990; White 1963). These experimental exercises provide the bridging link, or middle range theory, to move from the analytical to the inferential. Experimental comparative assemblages are most often conducted using the same lithic raw materials that were found in the archaeological assemblage being studied (Andrefsky 2006:399). This makes sense in that the fracturing characteristics of the experimental materials should match those of the archaeological materials. Chert or cryptocrystalline silicates can pose a problem in this matching when there are numerous sources of this raw material in the region and when this variety of materials is found on site as evidenced in the 10CW34 assemblage (see Figure 8 below). Additionally, there are issues with geochemically sourcing cherts that are not seen when geochemically sourcing other raw materials such as obsidian (Odell 2004:31). There are also no profiles of Clearwater River drainage cherts to date with which to compare geochemical signatures for sourcing. There is, however, a technique that has gained recognition for identifying chert sources that exhibit similar attributes known as “Minimum Analytical Nodule Analysis” (MANA). This technique will be reviewed in a later section.

Generating an experimental assemblage for comparison to the Kelly Forks Work Center assemblage could not be accomplished because of the diversity of cryptocrystalline silicates found on the site, and the lack of known quarry sites from which these were sourced. Figure 2.1 shows examples of the diverse collection of chert found on the site.

Figure 2.1 An example of the diverse collection of cherts at 10CW34.

There are few known locations for cherts in the Clearwater River drainage and those that are known are on private property and were inaccessible to the author. The general location of some chert sources in the Clearwater River drainage were obtained from a local avocational historian and flint knapper Lawrence Clark. Mr. Clark declined to give specific locations as he considered these sources a “guarded secret,” not to be shared for fear of limiting his access and resource depletion (Lawrence Clark, personal communication 2016). The approximate location of these regional chert sources, as well as an argillite resource, in the Clearwater River drainage basin will be discussed in a later section of this thesis.

Data and analysis generated from previous lithic debitage experiments, regionally and globally, was used to infer broad lithic reduction strategies and analysis of the size grading schema for this investigation (Ahler 1989; Cotterell and Kamminga 1987; Crabtree 1972; Flenniken 1981; Root 1992, 1997; Sappington 1991, 1994). Particular attention was given to the Ahler (1989) and Root (1992, 1997) contributions because they both used Knife River Flint as their experimental material. This allowed for a comparison of their results to be used as a control group for other experimental comparative collections. Sappington’s contributions (1991, 1994) provided a Clearwater River drainage reduction sequence.

Accepted Methodologies

There are three recognized methodologies and a fourth that is somewhat controversial for analyzing lithic debitage within the professional archaeological community. These are the aggregate, typological, attribute, and the “interpretation free” analyses. Each of these will be reviewed for their strengths and weaknesses when applied to archaeological debitage assemblages. These methodologies are based on experimental archaeology that has scientifically established baseline comparative collections which identify technologies, application load processes, and stages of reduction. It is important to note that many analysts do not see the manufacture of lithic tools as a “stage” driven sequence, but one rather as a continuum (Schott 1996; Sullivan and Rozen 1985:755). For the purposes of this research, the stage driven reduction sequence was accepted and referenced. Additionally, the experimental comparative data sets that have been generated were done so under tight constraints and rigid scientific control. It is very unlikely that that the prehistoric tool manufacturer gave any thought to the future analysis of their discarded detritus (Magne 2001:29).

Aggregate and Mass Analyses. Aggregate or Mass Analysis (MA) is an effective methodology for looking at large assemblages of debitage when individual flake inspection and analysis is untenable given time and resource constraints. In this form of analysis, the entire assemblage is classified by predetermined criteria such as size, weight, raw material, or cortex content. Different classes can then be compared for similarities or differences within these populations to make interpretations about the individual criterion and the overall assemblage. Most often, aggregate analysis will focus on flake size distributions which are stratified by means of nested sieves of progressively smaller mesh or hardware cloth. Aggregate analysis offers advantages when working with large samples and eliminates the subjective measurements and observations to which the other methodologies are subject (Larson 2004:9). All of the debitage is included in this form of analysis; broken flakes and shatter and are not sorted out of the analysis. Aggregate analysis results are replicable by both skilled and unskilled technicians; the nested sieves are objective in their size sorting (Ahler 1989:85). Because lithic tool manufacture is a reductive process, this form of debitage analysis is good for determining the stage of production based on the size gradients and stratification.

From aggregate lithic debitage analysis, the reduction stages or point in the manufacturing process can be inferred. This is accomplished from ethnographic and experimental research into lithic tool manufacture and the subsequent statistical analysis of the size, shape, and attributes of the discarded flakes. These can then be associated with the various stages of reduction or manufacture and then compared to the archaeological assemblage. There have been numerous studies based on experimentation that have defined the various stages of reduction (Bradbury and Carr 1995; Crabtree 1972; Flenniken 1981; Henry et al. 1976; Sappington 1991; Stahle and Dunn 1982). These range from four to eight stages of reduction and have subtle differences that separate the authors' interpretation of what distinguishes each stage. These subtle differences can be argued elsewhere; what is important is that the different steps of reduction produce statistically different sized flakes. These different size gradings can then be analyzed to determine where in the manufacturing process the flake comes from. This size grading of debitage has been replicated in numerous experiments with consistent results (Andrefsky 2001:3). As can be expected, there are outliers and factors that can vary the results of these experiments. Some of these would be the individual knapper's techniques and the raw material being worked.

One disadvantages of aggregate analysis is that of the mixed debitage assemblage. Aggregate analysis of a mixed debitage assemblage, wherein several different reduction events have taken place, does not effectively discriminate between the individual episodes of manufacture. Additionally, the manufacture of different types of tools cannot be distinguished using aggregate analysis; only the manufacturing stage. Broken and partial flakes are also included in aggregate analysis and these can skew the count and weight data (Andrefsky 2001:5; Sullivan and Rozen 1985).

There has been some progress, however, in the analysis of mixed assemblages by using the least squares regression statistical model developed by Matt Root (1992, 1997). The technique of Minimum Analytical Nodule Analysis (MANA) has also proven to be an effective analytical tool for determining discreet events in large, mixed assemblages. MANA analysis is a form of refitting that identifies similar attributes of raw materials such as color, cortex, texture, and inclusions and then categorizes these flakes based on these visual attributes into groups that may have come from the same nodule (Larson 2004; Larson and Kornfeld 1997; Odell 2004:31). The 10CW34 debitage assemblage represents an excellent candidate for a future MANA analysis because of the mixed chert types. This form of analysis could work towards distinguishing discreet reduction/curation episodes on the site and further define the spatial use and site activity centers on this landscape.

Typological Analyses. Typological debitage analysis requires an inspection of each flake or a representative sample of the assemblage for a specific function or technology. Since there are innumerable possible typologies to analyze, the researcher must decide what is needed for their specific research or assemblage. In typological analysis, the debitage is separated and analyzed based on one or more identifiable characteristics which are based on particular research goals. Initially, this typological form of analysis was limited to the designation of flakes as primary, secondary, and tertiary (White 1963) and many of the typological analyses today are loosely based on this initial typology. Experimentation in flint knapping and lithic tool production in recent years has yielded insights into the manufacturing processes and the corresponding flake typologies (Bradbury and Carr

1995:100). Debitage analysis based on these experimental assemblages has led to numerous typologies that can immediately infer behaviors based on the flake type. An example of this would be that if notching flakes, channel flakes, and bifacial thinning flakes are found in the debitage assemblage, then we could infer that specific types of points were being manufactured on the site. Bill Andrefsky identifies four typological approaches to debitage analysis: application load typologies, technological typologies, cortex typologies, and free standing typologies (Andrefsky 1998:114).

Application load typologies identify the tool type (indenter) used to detach the flake from the objective piece or core. Hard hammer percussion detached flakes tend to have pronounced bulbs of percussion with some crushing on the striking platform and minimal lipping. Soft hammer percussion also produces a bulb of percussion but not as pronounced as hard hammer and depending on the elasticity of the stone, lipping occurs at point of contact with soft hammer percussion (Crabtree 1972:44). Pressure flakes generally tend to be smaller but it must be noted that all stages of reduction will produce small flakes. However, when these small flakes are diagnostic and complete, including prepared surface, feathered termination, and bulb of percussion, it is most likely that they are the result of a later stage in the reduction sequence usually associated with pressure flaking (Sappington 1991:70-72).

Technological typological analysis focuses on a specific characteristic of stone tool manufacture whether it is where on the objective piece the flake came from (e.g., the notching flake referenced previously), where in the reduction process (bifacial thinning flake), or how the flake was produced (such as the bipolar flake). Flake typologies based on tool technologies can be useful when inferring what tools where used on a site. Examples of this would be scrapers or other unifacially worked tools. Flake debris from retouching these types of tools would have prepared striking platforms on the flat or smooth ventral surface with little evidence of cortex on the dorsal surfaces (Andrefsky 1998:125).

The cortex typology or triple cortex typology is most often associated with the aforementioned primary, secondary, and tertiary flake classification schema. The primary flake has a dorsal side that is predominantly covered with cortex and is associated with the early stages of reduction processes such as core reduction. Secondary flakes have some residual cortex on their dorsal (surface usually less than 50% coverage) and are associated with core reduction and/or blank preparation. Tertiary flakes are those flakes that exhibit no cortex on their dorsal surface and are associated with the later stages of reduction such as bifacial thinning or unifacial/bifacial retouch (White 1963).

The free-standing typological analysis narrows the characteristic criteria of the flakes into categories that make no inferences or interpretations about the flake whether it be stage of reduction, application load type, or the tool that was produced. This form of debitage analysis examines physical attributes such as raw material, length, weight, the presence of cortex and other characteristics of the flake with no regard to technology or function. These physical attributes can then be evaluated in relation to each other to make inferences about the assemblage. An example would be the relation of cortex presence to the size of the flakes (Andrefsky 1998:127). Sullivan and Rozen’s (1985) treatise on “interpretation-free” analysis of debitage assemblages is considered the genesis of this form of typological debitage analysis.

The most significant and repeated criticism of the typological debitage analysis is the subjectivity that is introduced by the analyst. One analyst may measure and record the bulb of percussion using one method while another analyst uses an entirely different method and their results do not match. There is a lack of standardized methods and terminology (Sullivan and Rozen 1985). This is particularly true of the technological and application load typologies. It must be noted here that the application load typological analysis of the Kelly Forks Work Center Site debitage assemblage was conducted solely by the author. Therefore any subjectivity in this analysis was consistent throughout the study.

The triple cortex typology is additionally troublesome in that there is no clear definition as to the amount or percentage of cortex coverage on the dorsal surface in order to classify a flake as primary or secondary. This is a subjective measurement determined by the analyst. Additionally, the use of the cortex typological classification and analysis assumes that the raw material sources were from alluvial or colluvial secondary deposits such as cobbles. This can be problematic when analyzing debitage assemblages whose raw material sourcing was from outcroppings or bedrock deposits where no geological cortex has formed (Sappington 1991:72). The free-standing typologies, unlike the other three typological analyses previously reviewed, are considered objective and replicable (Andrefsky 2001:7).

Attribute Analysis. Debitage attribute analysis examines a specific attribute(s) across an entire assemblage to make inferences about the population. Like typological analysis, there are a near infinite number of attributes that can be targeted, but this is not done on an individual flake basis. Much like aggregate analysis, the entire assemblage is examined. However, this form of analysis focuses on the target attribute(s) regardless of flake size or combined weights (Andrefsky 2001:9). A common form of debitage attribute analysis is the presence of a prepared striking platform type to determine the application load tool used. The entire population would be analyzed for those flakes that have a prepared striking surface. Those striking surfaces would then be analyzed for the type application load tool used (Dibble 1997:153). Like aggregate analysis, attribute analysis can be an indicator of trends within an assemblage. Like typological analysis, the subjectivity introduced by the researcher with their measurements is the most often cited critique of this methodology. This can result in recorded observations that are not replicable by other researchers or often even by the original analyst.

Interpretation Free Analysis. The interpretation free analysis of lithic debitage was first proposed by Sullivan and Rozen in 1985. The premise of their article, titled: "Debitage Analysis and Archaeological Interpretation," was the standardization of debitage analysis through an objective and replicable classification of debitage attributes. In their article, Sullivan and Rozen cite the replicability and reliability issues that have been associated with the typological forms of analysis as well as the "stage driven" reduction sequencing that identify specific flake classes as the main problems. Their solution to these problems is the interpretation-free and mutually exclusive categories for debitage classification. The interpretation-free classification proposal presented in their paper consists of "three dimensions of variability, each with two naturally dichotomous attributes" that then define four mutually exclusive and interpretation-free debitage categories (Sullivan and Rozen 1985:758). These are: complete flakes, broken flakes, flake fragments, and debris (Figure 2.2).

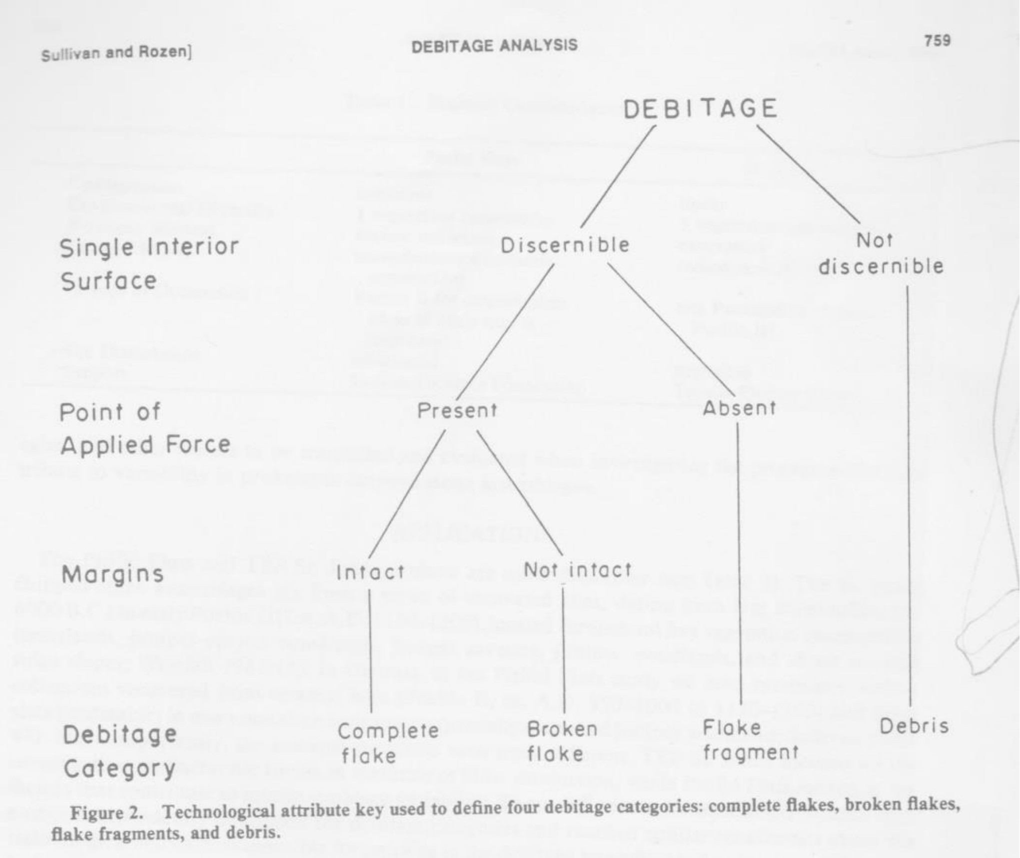

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Figure 2. Technological attribute key used to define four debitage categories: complete flakes, broken flakes, flake fragments, and debris.

Figure 2.2 Sullivan and Rozen's Interpretation-Free Schema (1985:759).

These four flake categories do not imply a technological conclusion, application load, or reduction stage sequence and are therefore interpretation-free according to the authors. Using these four debitage categories, the authors compare two different site types in the American Southwest and present their conclusions regarding their findings and how they are related to the debitage variation and patterning associated with these sites (1985:773). The criticisms and critiques of this paper and the methodology will be discussed later in this section.

The History of Debitage Analysis

The history of debitage analysis is likely to have begun when the first lithic scatter was found and questions were asked as to where these chipped flakes came from and what they meant. For the purposes of this thesis, based on the methodologies discussed above, this history of debitage analysis will begin with A.M. White's "triple cortex typology" (1963). White's treatise on the triple cortex typology was one of a number of papers published in *Miscellaneous Studies in Typology and Classification* (1963) during the nascent years of the "New Archaeology" and reflects the close association with the systemic analysis and interpretation of this period. The accepted scientific methodology of this time relied heavily on statistical sampling combined with the rigorous recording of empirical observations to determine cultural processes of the past (Larson 2004:3). This scientific paradigm is very good for explaining the "how," but comes up lacking when trying to explain the "who" and "why" (Sappington 2015).

The resulting scholarly contributions from the "New Archaeology" era of debitage analysis mostly focused on establishing lithic production models based on the stages of reduction and their associated processes (Newcomer 1971). Schiffer (1972) placed lithic debitage within the systemic and archaeological contexts while Henry et al. (1976) focused on the size grading of debitage produced by the different application loads (hard/soft hammer percussion; pressure flaking). These approaches focused on the individual flake or typological analysis. In 1972, Stan Ahler coined the term "Mass Analysis" when comparing several large experimental data sets and continued this approach when analyzing large archaeological assemblages in the mid-1970s (Ahler 1989:95).

As the practice and acceptance of lithic debitage analysis and replication continued, glaring inconsistencies became evident in the application of the methodologies, particularly the typological debitage analysis. As has been previously mentioned, these inconsistencies in replicability and reliability, measurement techniques, and inconsistent terminology plagued typological debitage analysis. Because of a lack of standards, some within the debitage analysis community questioned their methods and as a result, conducted a self-reflection and review of their practices. The genesis of this self-reflection was Sullivan and Rozen's (1985) article.

*Historic Debate Regarding Methodologies***.** As is the case with most other methodologies, theories, and hypotheses within the archaeological community, the history of debitage analysis is replete with robust debate as to the efficacy of one methodology versus the other, as to whether one form is legitimate for a particular assemblage, and so forth (Larson 2004:4). This form of archaeological discourse is common among scholars and has served to promote a better understanding and application of these methodologies. The aforementioned Sullivan and Rozen article ruffled the feathers of some of the leading proponents of typological debitage analysis and started a heated debate as to the efficacy of the Sullivan and Rozen proposal (Andrefsky 2001:2).

Responses to this article and the "four interpretation-free" debitage typologies ranged from partial agreement to flat out rejection of the premises proposed. Amick and Mauldin (1989:166) agree with the lack of uniform terms and measurements, but feel that typologies free of interpretation will not increase the knowledge base when applied to archaeological assemblages. Ahler (1989:87) argues that this typology scheme has no theoretical grounding and states of this methodology: "The application of this typology to experimental data indicates that it has limited power for assessing variation in knapping behavior." Sullivan and Rozen also reject that reduction sequences are "stage driven" and suggest that they should instead be viewed as a continuous process free of the previously held notion of discrete stages of reduction (1985:755). This flew in the faces of those who relied on a traditionally held notion that flakes with certain attributes could be identified with specific stages of reduction. Ensor and Roemer (1989:177) take issue with the continuum model proposed by Sullivan and Rozen and state that debitage should be referenced to steps or stages so as to separate and define the manufacturing processes. They cite the use of the different hammer types, hard and soft, as discrete steps or stages in this process. The point of presenting the Sullivan and Rozen paper in this section, as well as the counter-arguments which resulted from their methodology, are the improved practices and methodologies that it generated within the lithic debitage community (Andrefsky 2001:2).

The aggregate debitage analysis or MA has also received scrutiny in recent years as to its efficacy within the field as well. In 2006, Bill Andrefsky authored a critique of MA titled: "The Application and Misapplication of Mass Analysis in Lithic Debitage Studies." In this article, Andrefsky cites the problems associated with MA when analyzing large archaeological assemblages, particularly those of the mixed assemblage and the separation of manufacturing episodes. Additionally, Andrefsky points out that differences in flint knapping styles (as observed in modern experimental cases) as well as raw material variability and fracture properties will potentially skew the data from this type of analysis. As a result, inferences as to the type of tool produced and lithic technology employed cannot be determined from MA, according to Andrefsky (Andrefsky 2006:392). Bradbury and Carr (2009) challenge Andrefsky's assertions in their response titled "Hits and Misses when

Throwing Stones at Mass Analysis." They point out that MA size grade analysis is useful when used as part of a multivariate analysis (2009:2788). To this end, aggregate analysis in conjunction with the identification of statistically significant attributes can be considered an initial starting point when analyzing an archaeological assemblage to making informed inferences (2009:2795).

Chosen Methodologies

When first presented with the debitage analysis of the Kelly Forks Work Center Site as a potential thesis topic, I gladly accepted and started to review the literature on various analytical approaches. Initially, the prospect of this undertaking seemed a very achievable project with access to the collection readily available. However, since spring 2016, I have come to realize how complicated an analysis of this magnitude is, and also how important the debitage analysis of a prehistoric site is, and the implications that are a result of the analysis of this artifact class. There are two recurring themes in most of the literature: (1) debitage is often the most numerous artifact class to be recovered from a prehistoric archaeological site and (2) where lithic debitage lands is most likely where the activity that produced it occurred. We can therefore tie specific behaviors to where the debitage was recovered. As each journal article or book on the subject of debitage analysis, experimental archaeology, or trade and mobility was read, there were several more articles cited that would also need to be read. The myriad of academic publication "rabbit holes" that this led me down was at first overwhelming. As I continued to review the literature, my understanding of the theoretical considerations, methodologies, and interpretations associated with debitage analysis increased to the point where I felt confident to conduct the analysis.

During this research, it has also become apparent how unique the Kelly Forks Work Center Site is to the Clearwater River drainage and to Columbia Plateau prehistory. In a recent conversation with the Idaho State Historic Preservation Officer, Dr. Ken Reid, the importance of 10CW34 was discussed and affirmed (Ken Reid, personal communication 2016). The intact strata and calibrated radiocarbon dates indicate the continuous occupancy of the site for the last thirteen-thousand years. There are very few sites in the Clearwater region and Columbia Plateau that exhibit these unique archaeological site conditions (Sappington 2017). Because of the significance of the site, one of the outcomes of this research was the generation of a comprehensive debitage data base for future research and comparison.

Given the size of the lithic debitage assemblage associated with 10CW34, consideration of the scale of the analysis had to be considered when determining the best approaches for its analyses (Johnson 2001:16). The meticulous mapping and cataloguing of the 10CW34 assemblage during the excavation and throughout the initial analysis make this assemblage an excellent candidate for an intense lithic debitage study (Longstaff 2013). In order to accomplish this and the research goals previously stated, a two pronged analytical approach was employed: (1) a multivariate aggregate analysis and (2) an application load typological analysis.

These two approaches were chosen because it was deemed that they were the best methodologies to achieve the stated research goals given the resource and time constraints associated with the assemblage analysis. Additionally, the two methodologies were compared to determine if the aggregate size-grade analysis and the individual application load typology analysis exhibited a positive or negative correlation between these two attributes. The two-pronged analytical approach was also to be tested to see if it could affirm or refute the aforementioned methodological arguments and to evaluate its efficacy as an analytical tool.

There are two irrefutable physical laws that apply to stone tool manufacture. First, this is a reductive process that most often utilizes material with known fracturing patterns and characteristics. The resulting detached flakes are of a predictable size and shape, and therefore the manner and placement of the application load (ex. soft hammer percussion vs. applied pressure) produces predictable variations in the resulting detached flakes size and shape (Ahler 1989; Sappington 2016b). The combined analytical approach employed for this research addresses both of these stated laws. The multivariate aggregate methodology separates and sorts the resulting detached flakes by size. This approach reflects the reductive nature of stone tool manufacture. The application load typological analysis examines the detached flakes for evidence of the application load that was applied to remove it. These observations infer the manner in which the flake was detached from the objective piece. Both of these complement each other and it was hoped that the resulting data generated would reflect this correlation between the physical laws and the methodologies utilized.

The individual flake analysis conducted during this research also facilitated the inspection of each flake for the presence of residual cortex. Residual cortex can be an indicator of reduction stage. The general rule that refers to the reductive nature of stone tool manufacture would imply that the less cortex present, the more advanced the reduction stage. White’s (1963) triple cortex typology of detached flakes references the amount of cortex present as an indicator of reduction stage. Additionally, the presence of cortex on detached flakes can also be indicative of mobility, exchange, and site catchment (Dibble et al. 2005:545).

There are three recognized behavioral and taphonomic factors that were considered at the outset of this analysis that likely altered the spatial and temporal context of some portions of the assemblage. First, it was assumed that detached flakes which are large enough to have been utilized were so used and are therefore no longer in the context from when they were struck (Ahler 1989). Expedient flake tools that were produced as the result of a reduction episode were the most numerous of the stone tools recovered at 10CW34. Longstaff observed that: “The majority (n=186, 67%) of flake tools are minimally modified on one margin side only, an indication that flake tools were frequently selected for immediate use and discarded” (2013:222). Given the average size of the individual debitage flakes in the collection, it is obvious that the larger flakes that were detached were used as tools and deposited into the archaeological record elsewhere from where they were produced. The above claim will be evaluated in the analysis portion of this thesis. Second, sites that exhibit continued use and occupation will likely have a lot of foot and animal traffic. This continuous traffic results in the trampling of lithic artifacts, causing breakage, edge wear, and movement both vertically and horizontally (Flenniken and Haggarty 1979). The concentrations of material remains (mostly debitage) at 10CW34 would indicate that there was quite a bit of foot traffic and thus we can expect some of the spatial displacement that Flenniken and Haggerty observed in their experiments. Third, refuse disposal, while not common, may have occurred at 10CW34. Lithic debitage is sharp and work areas may have been cleaned to prevent the numerous cuts and pricks that are associated with debitage and tool manufacture. This would represent the removal of debitage from its primary context, or where it was produced, to a secondary context such as a midden or designated disposal area (Root 2004:86). The observation that lithic debitage is most likely found where the manufacturing episode occurred has been and will continue to be cited in this thesis. Most archaeological assemblages, including that from 10CW34, support this statement. Recognition that there are mechanisms that may alter the spatial and temporal context of portions of the assemblage is necessary to counter-argue the discovery of patterns or clusters to provide an alternate means for its placement.

Multivariate Aggregate Analysis. The multivariate aggregate analysis conducted on the debitage assemblage from 10CW34 was patterned after Stanley Ahler's 1989 *Mass Analysis of Flaking Debris: Studying the Forest Rather than the Tree*. Ahler cites examples of multivariate aggregate analyses from archaeological sites that would be considered either the result of sedentary village or camp site settlement usage. This study focuses on those sites with long term occupations or semi-sedentary occupations whose lithic raw material sources are non-local. In sites such as these, flakes from across the reduction sequence spectrum were observed with the emphasis on late sequence tool production and curation. Additionally, a mixture of raw materials and numerous reduction episodes are represented in the assemblages (Ahler 1989:106-112). The assemblage analyzed by Ahler was chosen because it is very similar to the debitage assemblage from 10CW34. Additionally, the experimental data from Ahler's analysis will be referenced for size-graded reduction sequencing. This study used size grade distributions of the various raw materials, counts, and weights to determine early, mid, and late production stages (Figure 2.3).

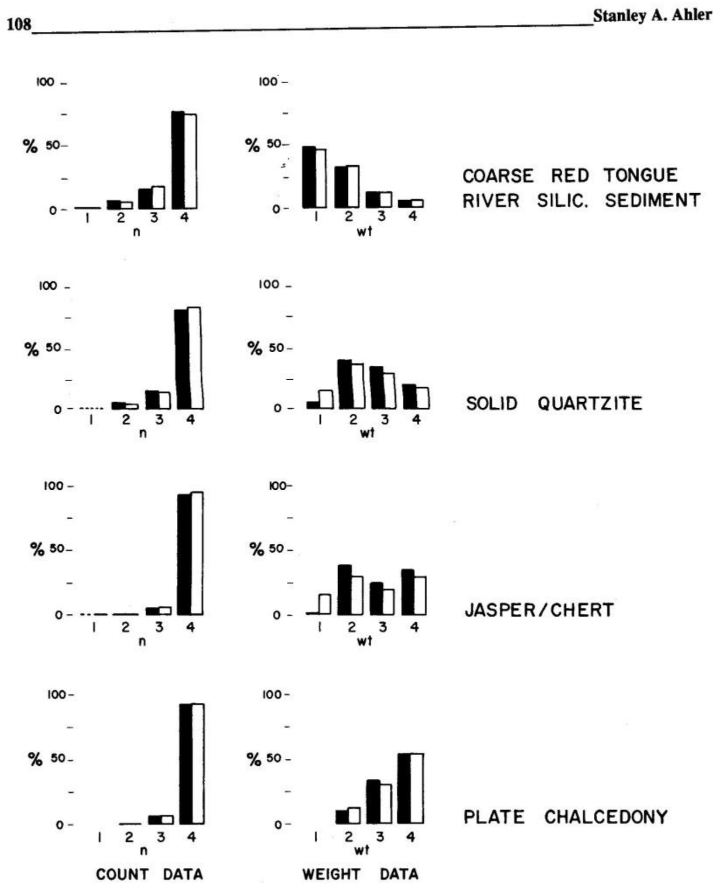


Figure 2.3 Size grading, count, and weight measurements (adapted from Ahler 1989:108).

From these measurements, site behavioral activities are inferred based on flake placements of the various raw materials, their given size, count, and weight distributions (1989:109). Bradbury and Carr also advocate Ahler's multivariate methodology above citing the importance of size grading, count, and the average weight of flakes in each size grade for an effective multivariate approach (Bradbury and Carr 2009:2794).

The aggregate debitage analysis that was performed on the 10CW34 assemblage was multivariate in that the examinations of detached flakes were segregated by raw material, unit, and level. These were then passed through six nested sieves and were at times hand manipulated in order to get accurate counts and weights. The sizes of the mesh in the

Hogentogler sieves were 2” (50 mm), 1” (25.4 mm), ½” (12.5 mm), ¼” (6.3 mm), No. 6 (3.35 mm), and No. 12 (1.7 mm). The use of smaller sieves is not standard procedure in aggregate analysis because most field screening does not recover artifacts smaller than ¼” (Carr and Bradbury 2004:27). The screening at 10CW34 was through 1/8” mesh and many small flakes were recovered. Therefore the addition of smaller sieves was included in this analysis. Figure 2.4 illustrates the nested sieves and their designated numbers 1-6. Most flakes will pass through the sieves with moderate shaking. However, Figure 2.5 illustrates a screen that would have to have some of the flakes hand manipulated through the screen after moderate shaking to insure that the flakes were size graded correctly.

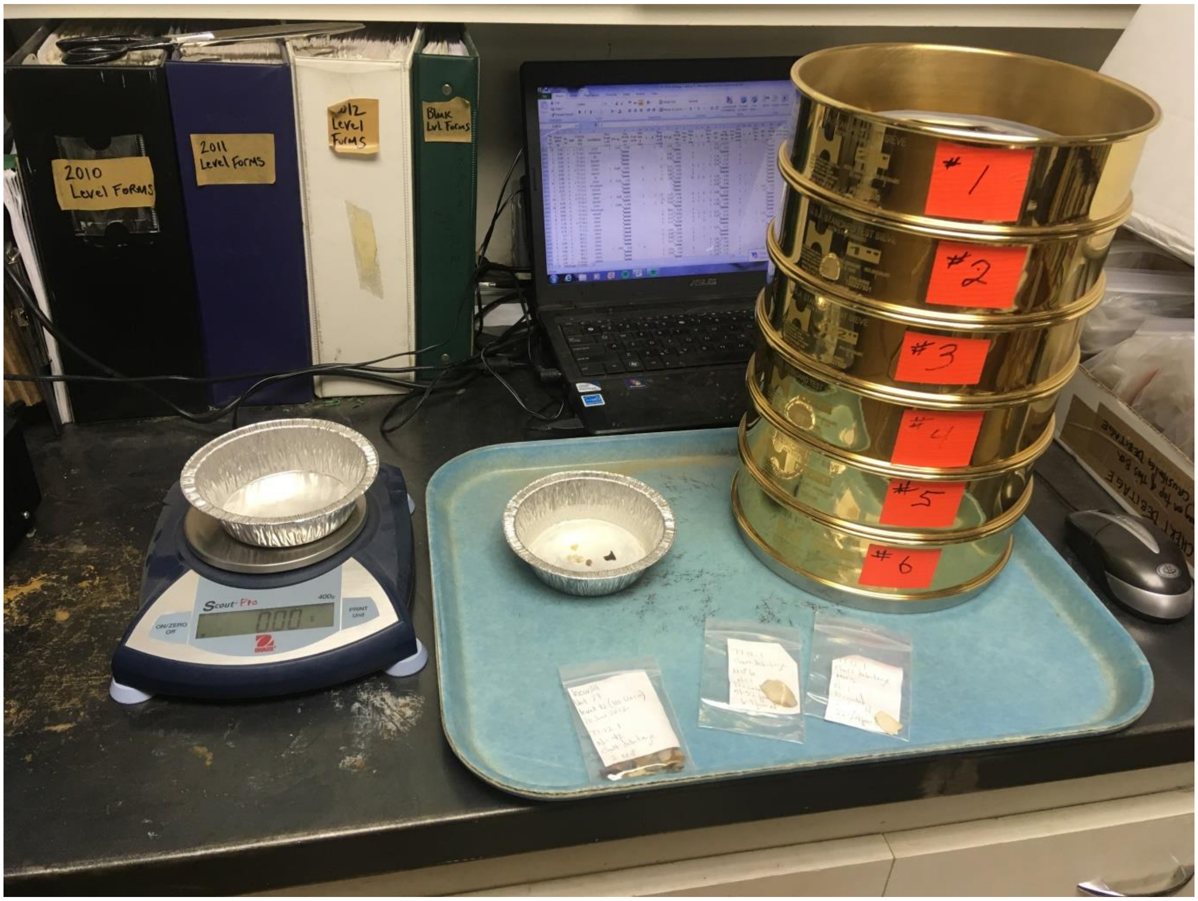


Figure 2.4 The six nested sieves stacked and ready for moderate shaking to sort the flakes.

Figure 2.5 Some of these flakes in sieve #5 had to be hand manipulated for proper sorting.

The lithic debitage from 10CW34 had been previously separated into individual bags by raw materials, unit, and level. This preliminary "sorting" and the accompanying Excel spreadsheet facilitated an efficient analysis. The debitage was then put into the sieves and was shaken to pass through the mesh, if needed; some were hand manipulated to the proper sieve. The debitage in each sieve was then inspected for residual cortex and evidence of an application load either percussive or pressure. The debitage from each sieve was then counted, weighed, and recorded in Excel. One of the advantages of this methodology is the replicability and objectivity that comes with size-grading through nested sieves.

Application Load Typological Analysis. This form of individual flake analysis was chosen to examine the physical property associated with lithic reduction in that the manner and placement of the application load (ex. soft hammer percussion vs. applied pressure) produces predictable variations in the resulting detached flakes size and shape (Cotterell and Kamminga 1989; Crabtree 1972). The tool type and application force exerted on an objective piece in order to detach a flake are related to specific steps within the reduction sequence. Generally speaking, the application of pressure is not used to reduce a core in the manufacture of a preform and similarly, hard hammers are not used for margin shaping, curation, and or retouching (Sappington 2016b). The identification of the application load typologies in this assemblage infers the manufacturing and curation activities that were carried out on the site. The lack of exhausted cores (n=1) and cortical flakes (n=19) in the 10CW34 assemblage indicate that most of the lithic reduction was related to mid to late stage reduction processes and tool curation (Longstaff 2013).

There are three accepted forms of application load typologies recognized by lithic analysts: (1) hard hammer percussion, (2) soft hammer percussion, and (3) pressure flaking. The means used to identify these application loads were based on visual inspection of each of the flakes under a lighted magnifying glass. Preliminary identification was based on the recognition of a prepared striking platform in conjunction with the presence (or absence) of a bulb of force and a smooth ventral surface. The dorsal surface was examined for a leading ridge on those flakes thought to be from the application of pressure. Those flakes that exhibited these attributes were then further scrutinized for the diagnostic markers associated with the application load typology. Cotterell and Kamminga (1989:676) identify the tool that detaches the flake as the “indenter” (Figure 2.6). In prehistoric tool kits these have mostly been found to be rounded cobbles, antler billets, antler tines, and some hardwoods (Andrefsky 1998:14).

Figure 2.6 Prehistoric Indenters: A. Hammerstone B. Antler Tine C. Elk Billet.

The fracturing mechanics and properties of the raw materials will be touched on briefly to provide reference for the formation of detached flakes. These physical characteristics of the raw materials have a direct correlation to the shape and attributes of the detached flakes as associated with the application loads. The desired raw materials for lithic tool manufacture are those materials that fracture conchoidally. A conchoidal fracture is a curved fracture like a conch shell, as the name implies. These conchoidal fractures are predictable and to some extent controllable based on the angle of attack, force, and composition of the indenter when applied to the objective piece. The example most often cited to describe this type of fracture is that of a BB hitting a pane of glass. The resulting detached flake or shard in this case, is called a Hertzian Cone (Whittaker 1994:12). This example is illustrated in Figure 2.7.

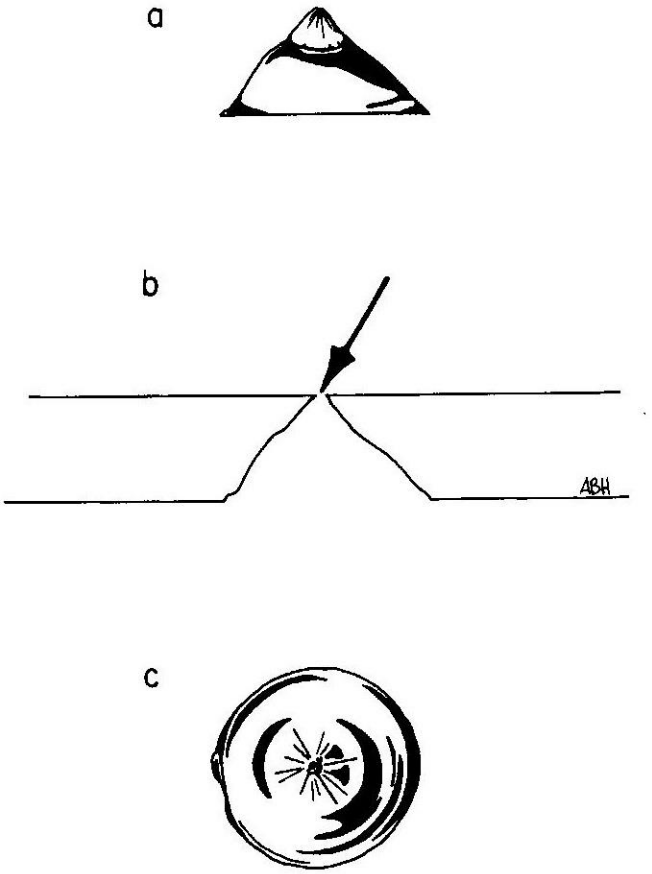


Figure 2.7 The Hertzian Cone principle as demonstrated in window glass.

The raw materials that possess the best conchoidal fracturing characteristics are homogeneous, brittle, and elastic. These tend to have a high silicate (SiO2) content and have formed as amorphous or cryptocrystalline (sometimes referred to as microcrystalline) structures. These include the volcanic glasses such as obsidian, rhyolite, and andesite in the amorphous category and the cherts, argillites, quartzites, and vitrophyre in the cryptocrystalline materials (Odell 2004:21). Basalts and other fine grained mafic materials are also capable of conchoidal fracture, but are not considered amorphous or cryptocrystalline in structure (Sappington 2016b).

Hard hammer percussion flakes are made when a hammer, usually a rounded cobble, strikes the objective piece with moderate to heavy force (Figures 2.8 and 2.9). Hard hammer percussion flakes exhibit pronounced bulbs of force, can have a crushed platform area, and rarely exhibit lipping (Andrefsky 1998:119; Crabtree 1972:44).

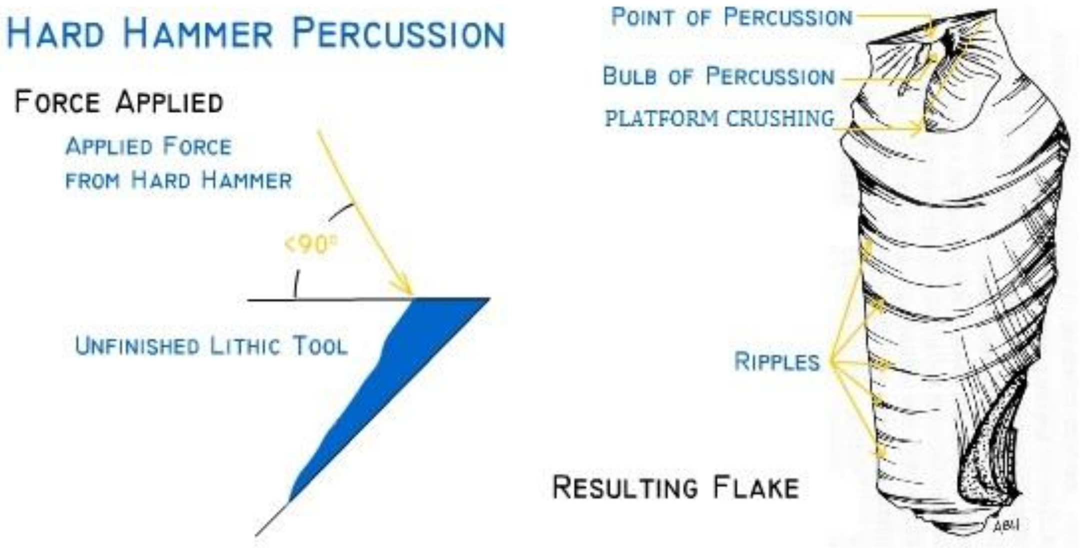


Figure 2.8 Hard hammer percussion mechanics and resulting detached flake (adapted from Whittaker 1994).

The flakes produced by hard hammer percussion are usually associated with the early stages of the lithic reduction sequence. These would include core reduction, formation of blanks or preforms, and the initial shaping of the tool (Sappington 2016b).

The diagnostic attributes of flake morphology as associated with a specific application load discussed in this section are not mutually exclusive. Flakes exhibiting hard hammer percussion markers have been produced from soft hammer percussion and vise-versa. However, statistically, the ascribed attributes associated with an application load type are good indicators of the method of detachment (Odell 2004:59).

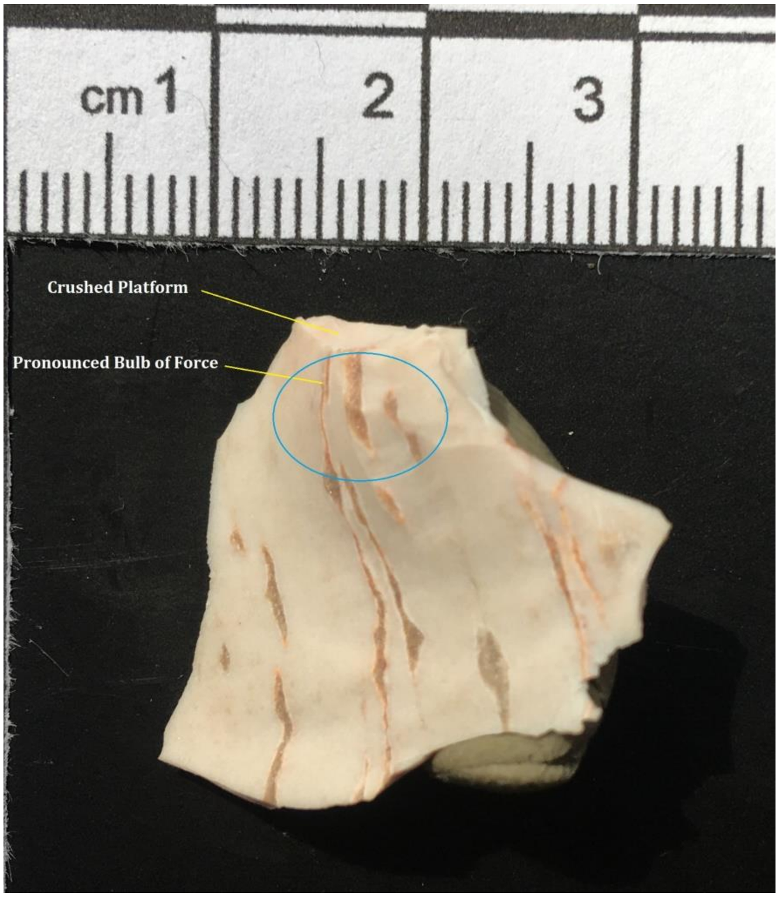


Figure 2.9 Hard hammer percussion flake.

Soft hammer percussion flakes are made when the indenter is of a softer material than the raw material of the objective piece. These are usually identified as moose, elk, or deer antler billets when found on prehistoric archaeological sites. Large mammal long bones have also been recognized as soft hammer indenters (Wenzel and Shelley 2004:123). Modern flintknappers and experimental archaeologist will also use “copper boppers” as soft hammers. The diagnostic markers associated with soft hammer percussion are a diffuse bulb of force or the absence of a bulb of force, pronounced lipping, and occasionally eraillure flakes (Crabtree 1972:74). Lipping is described as a protrusion of the edge of the striking platform over the ventral surface. Mark Newcomer describes the forces, the indenter, and the placement of the applied load that result in the formation of a "lip":

> "With the soft hammer, however, the blow lands directly on the edge of the handaxe, and this edge actually penetrates the face of the hammer and spreads the force of the blow over several millimeters, diffusing the bulb of percussion of the flake and preventing the formation of a cone of percussion. Although the blow lands on the edge, the fracture plane begins several millimeters back from the edge of the handaxe, and the flake is pulled or torn off, and the lip formed" (Newcomer 1971:89).

Flakes produced from soft hammer percussion are usually associated with the mid to late stages of the lithic reduction sequence (Sappington 2016b). Figure 2.10 illustrates the mechanics of soft hammer percussion flake detachment and the expected resulting attributes. Figures 2.11 – 2.14 provide examples of flakes from 10CW34 that exhibit these attributes.

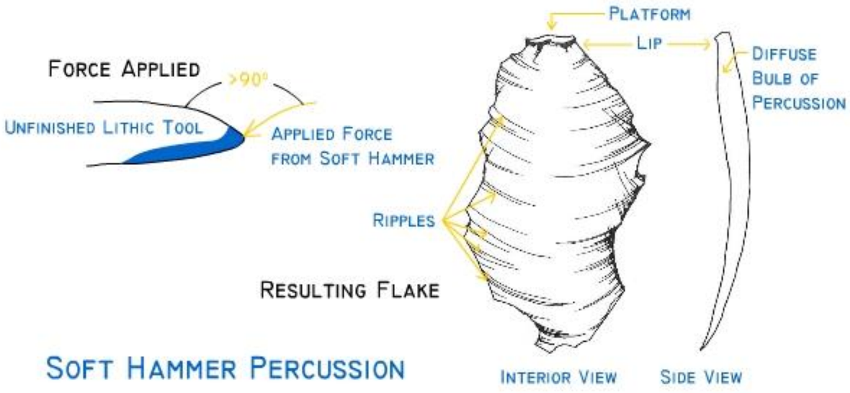


Figure 2.10 Soft hammer percussion mechanics and resulting detached flake (adapted from Whittaker 1994).

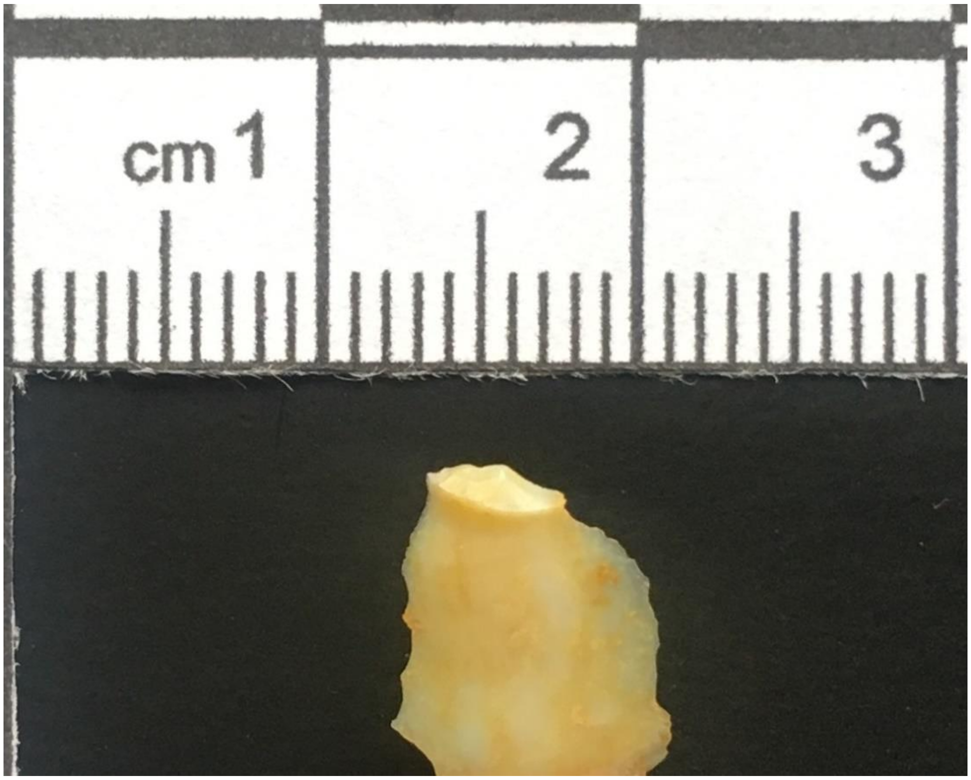


Figure 2.11 Chert soft hammer percussion flake with pronounced lipping. Ventral surface (from 10CW34, Unit 86, Level 9).

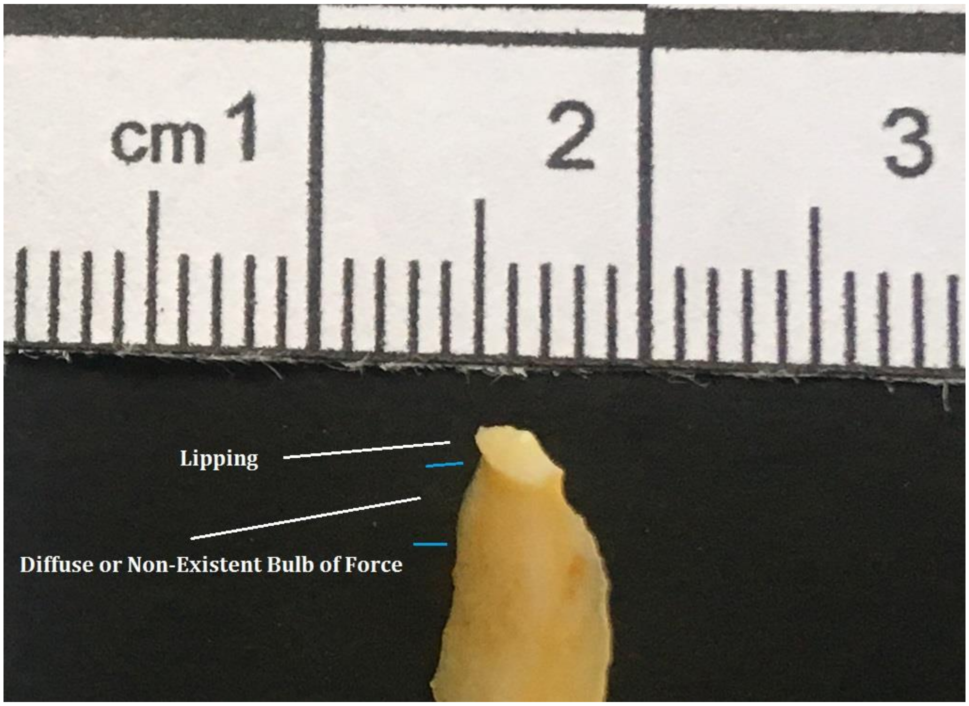


Figure 2.12 Profile view to emphasize pronounced lipping and diffuse bulb of force.

Figure 2.13 Basalt soft hammer percussion flake with pronounced lipping. Ventral surface (from 10CW34, Unit 52, Level 3).

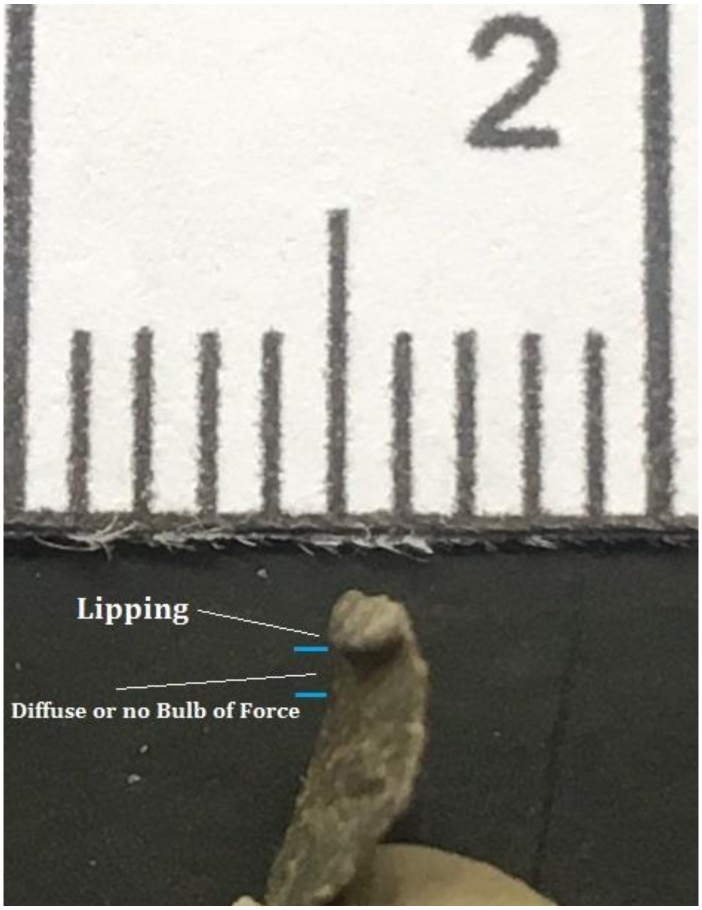


Figure 2.14 Basalt flake profile view.

Pronounced lipping identified on the flakes of the 10CW34 assemblage was classified as being soft hammer percussed. As was previously cited, the diagnostic attributes of application load typologies are not mutually exclusive, but there are statistical grounds to make such inferences (Andrefsky 1998:119; Cotterell and Kamminga 1989:690).

Pressure flakes are made when the indenter is precisely placed on the edge or margin of the objective piece or just slightly above the margin on the opposite face from which you want the flake to detach (Figure 2.15). An inward and then downward pressure is applied to detach the flake (Whittaker 1994:129). Pressure flaking indenters are usually made of bone or antler tine when found on prehistoric archaeological sites. Modern flintknappers and experimental archaeologists sometimes use hard copper wire affixed to a dowel or handle as the indenter (Odell 2004:61).

Figure 2.15 Pressure flaking mechanics (adapted from Whittaker 1994).

The diagnostic markers of pressure flakes can include visual characteristics on both the dorsal and the ventral surfaces of the flake. Ideally, when aligning the indenter to remove a pressure flake, a ridge is chosen on what will be the dorsal side of the detached flake. This is done for two reasons, the first reason being that when a pressure flake is aligned with a ridge on the dorsal side of the detached flake, the potential distance and shape of the flake can be defined by the characteristics of the ridge. Detached pressure flakes can and will follow a ridge because the mass of the ridge can guide the propagation of the fracture. Figure 2.16 is an example of the fracture following the contours of a dorsal ridge. The alignment of the indenter on a dorsal ridge promotes a greater and defined travel of the fracture simply by using the mass of the ridge and the applied force (Crabtree 1972:15-20; Root 2004:74; Sappington 2016b; Whittaker 1994:147). The second reason is that the removal of this ridge will create two smaller ridges laterally that can be utilized for further shaping and/or sharpening of the tool edge or margin (Sappington 2016b).

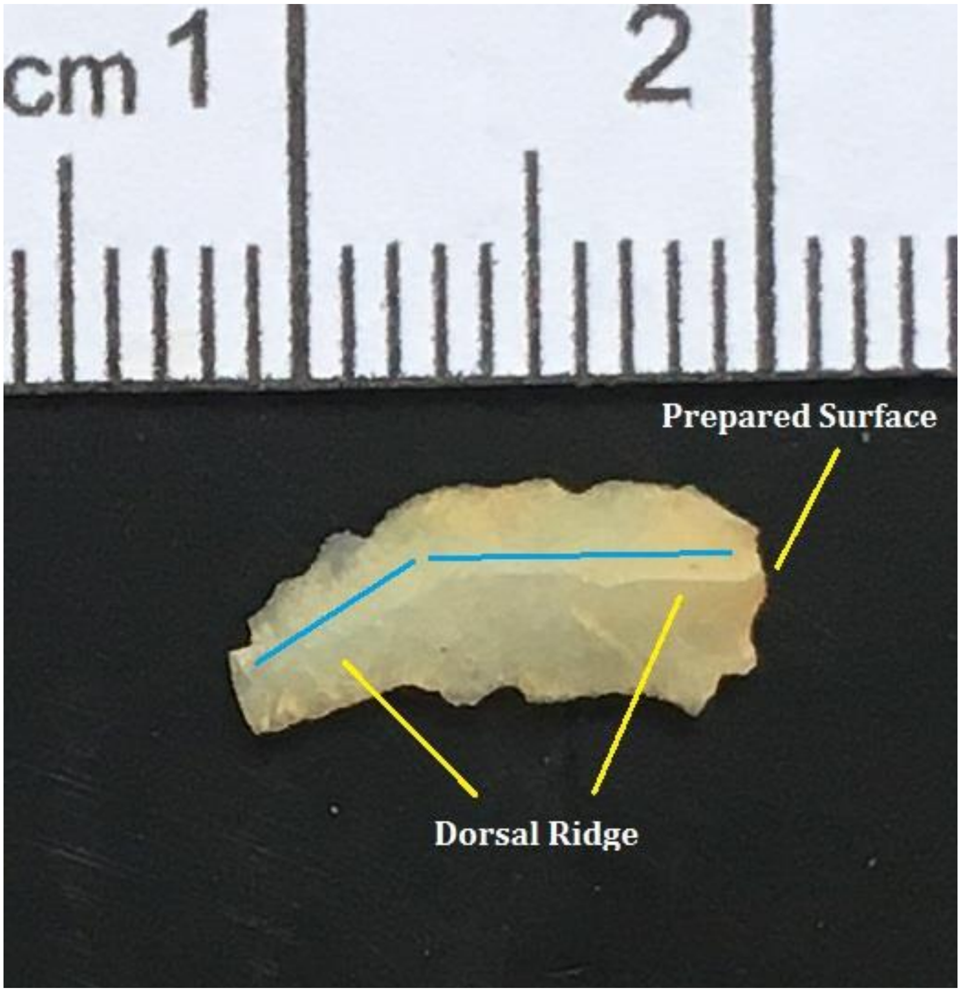


Figure 2.16 The dorsal surface (with ridge) of a detached pressure flake (from 10CW34, Unit 105, Level 10).

The ventral surface of a pressure flake has a bulb of percussion that falls between the pronounced effect of a hard hammer strike and the diffuse effect of a soft hammer strike that was previously discussed. Because pressure flakes tend to be smaller, this measure of the bulb of percussion is relative to the size of the flake (Ahler 1989:91; Root 1992:87). A scar or flake sometimes occurs on the bulb of percussion's surface of many of the flakes produced in lithic tool manufacture. These have been termed "eraillure" flakes and have been seen to occur as a result of all of the application load types (hard/soft hammer; pressure). However, eraillure scars are most commonly seen on pressure flakes: "…since eraillures are a common feature of pressure flaking, and can be formed in very slowly moving fractures such as are produced by the inward tangential loading method…While no direct explanation for the formation of this feature can be offered as yet, certain observations can be made about its formation" (Faulkner 1972:159).

The presence of eraillure scars on the bulb of percussion of suspected pressure flakes was not deemed a mutually exclusive feature attributed to pressure flakes. However, because eraillure scars are most often seen on these types of flakes, the presence of this feature was used as one of several identifying attributes associated with a pressure flake. As previously noted, those flakes deemed by the author to be the result of soft hammer percussion had diffuse or non-existent bulbs of percussion and the identification of eraillure scars on these was much more difficult due to the lack of this ventral surface feature. The occurrence of an eraillure scar on a detached flake is not visually represented on the negative image surface of the objective piece (Whittaker 1994:15).

The presence of the diagnostic attributes on both the dorsal and ventral surfaces was used to identify the flake as having been removed by means of pressure (Figure 2.17). These observed attributes are not mutually exclusive to pressure flakes, but when observed in conjunction with a prepared platform of close to 90 degrees to the flake's long axis, these were deemed pressure flakes (Daugherty et al. 1987:92-104; Sappington 1991:70).

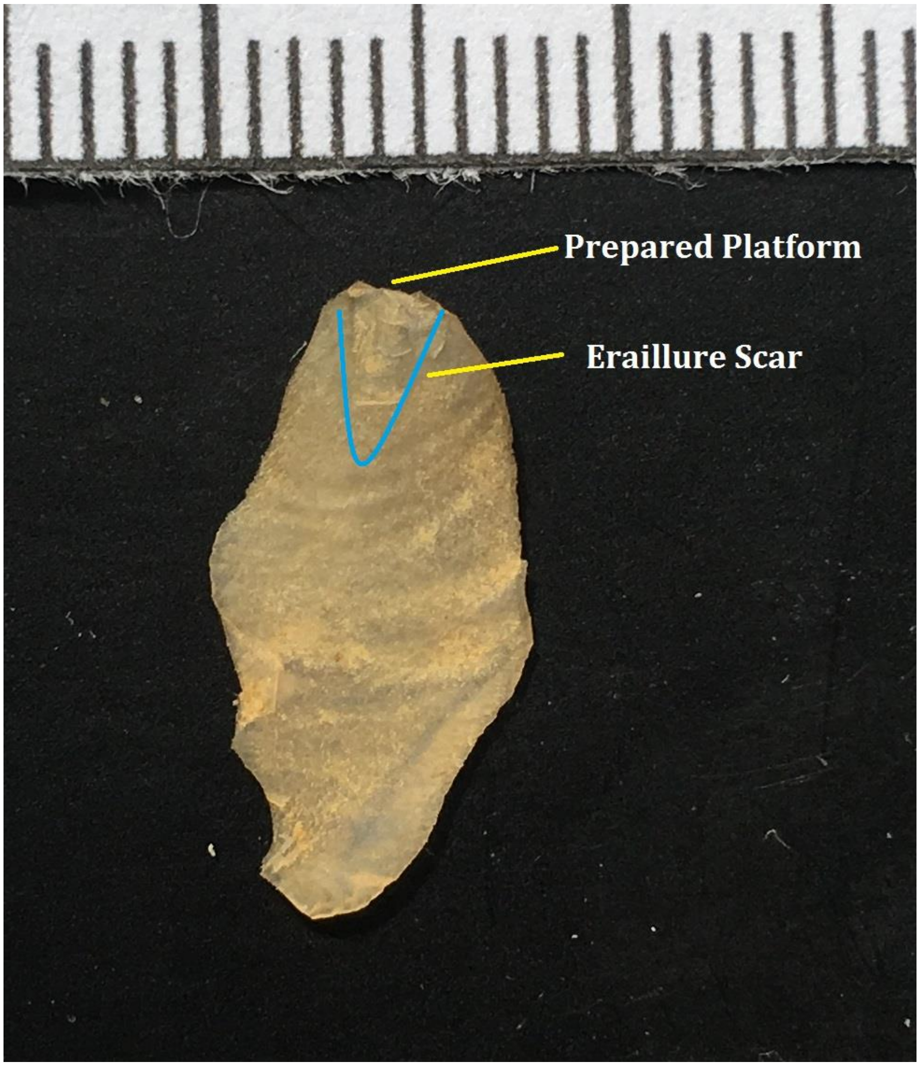


Figure 2.17 The ventral surface of a pressure flake with an eraillure scar (from 10CW34, Unit 100, Level 15).

The angle of attack (AoA) of the application load will differ significantly depending on the indenter used and the desired size of the detached flake. The AoA of the indenter will also then affect the placement and angle of the prepared surface with respect to the long axis of the flake. The soft hammer detached flakes evidence prepared surface angles of less than 90 degrees to the long axis (referenced to the ventral surface of the flake) whereas the pressure flakes exhibit prepared surface angle of close to 90 degrees to the long axis of the flake.

Figure 2.18 illustrates an example of the AoA from a soft hammer percussion strike. The prepared surface was clearly above the margin on the detached flake. The angle

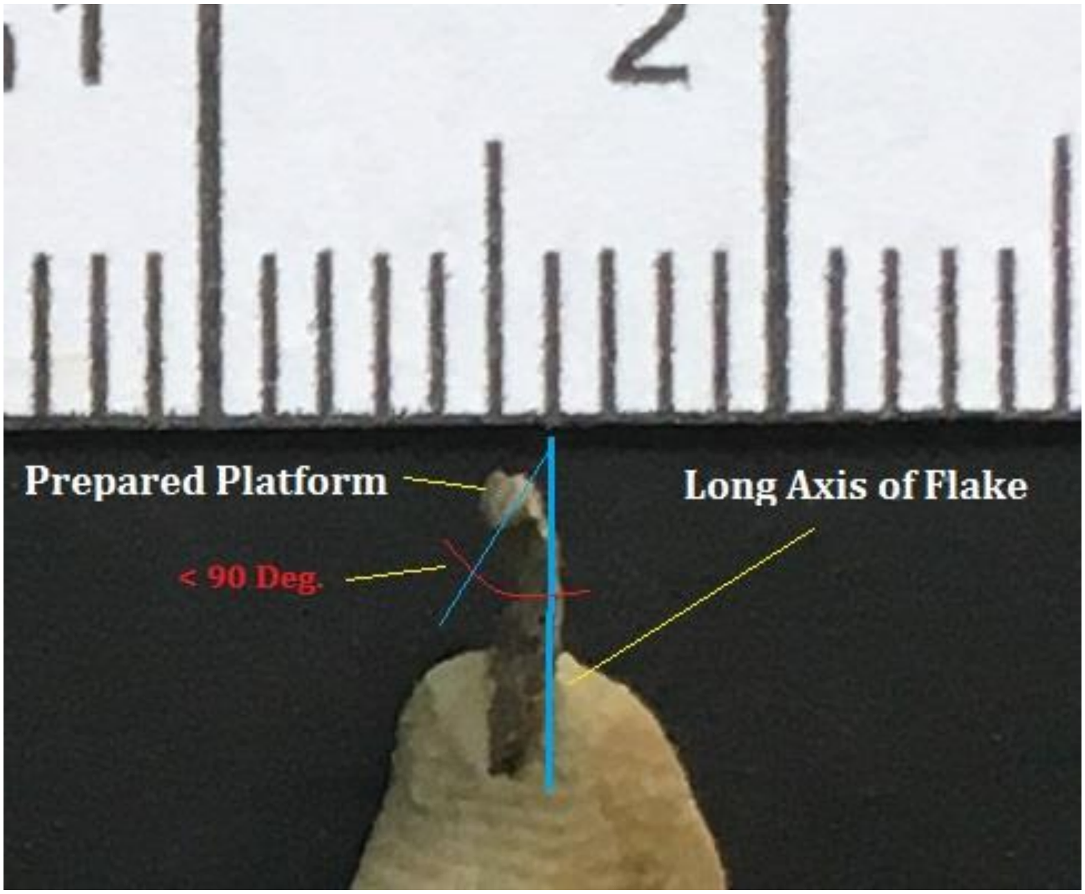


Figure 2.18 Prepared platform of less than 90 degrees to the long axis (ventral surface) of the flake (from 10CW34, Unit 52, Level 3).

of the prepared surface with regards to the long axis of the detached flake is less than 90 degrees to the ventral surface. This observation was typical to those flakes that were deemed as having been the result of a soft hammer percussion application load.

Figure 2.19 provides an example of the placement of the prepared surface of a pressure flake. The nature and intent of pressure flake removal is generally for the sculpting and maintaining of a sharp edge on the objective piece. This is achieved by the precise placement of prepared surface, and subsequently the indenter on or slightly above the margin (Andrefsky 2001:7; Odell 2004:61; Whittaker 1994:129).

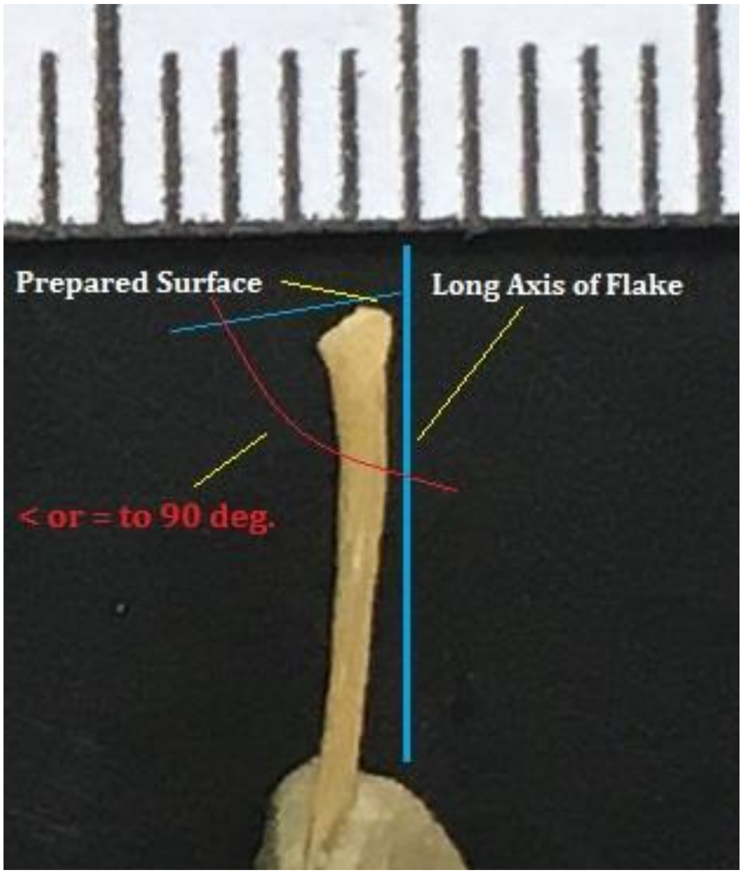


Figure 2.19 Prepared platform of less than, or equal to, 90 degrees to the long axis (ventral surface) of the flake (from 10CW34, Unit 105, Level 10).

The observations described to distinguish the difference between hard hammer percussion flakes, soft hammer percussion flakes, and pressure flakes are consistent with those observations noted and recorded by Ahler (1989:91) and Sappington (1991:70, 2016b) on debitage assemblages in an archaeological context. Recognition of these application load typologies, as evidenced on the individual flakes, were consistent with those observations made from numerous replicative and experimental archaeology studies conducted over the previous fifty years (Ahler 1989; Bamforth and Finley 2008; Bradbury and Carr 1995; Crabtree 1972; Cotterell and Kamminga 1987; Flenniken 1983; Henry et al. 1976; Newcomer 1971; Sappington 2016; White 1963; and Whittaker 1994). Methodology for the aggregate nested screen analysis was based on Ahler's (1989) previously cited paper on multivariate aggregate analyses and how these can be used when analyzing archaeological assemblages. Statistical justification of the classification of the nested screen aggregate analysis of the assemblage was based on Carr and Bradbury's 2004 analysis wherein a 67.7% rate of accuracy was achieved in 65 experiments (2004:31).

GIS Projection. Without the visual display of numerical data, be it in chart, graph, or virtual representation, trends and patterns often go unrecognized when dealing with large data sets (Vanpool and Leonard 2011:18). The visual display of the generated data from debitage assemblage from the excavations at 10CW34 was accomplished using the ArcGIS 10.3 software platform. The data was imported using the "Add XY Data" feature of the program. This is a feature by which X, Y, and Z values of the data are imported from Excel or other spreadsheet files and then plotted in a virtual three-dimensional spatial representation of the landscape, site, feature, or test unit. The data must first be formatted in order to be imported in to ArcGIS and perhaps more importantly, a system of projected coordinates must be established in ArcGIS to render the three-dimensional virtual world into recognizable measurements (Connolly and Lake 2006:87).

These projected coordinate systems usually use measurements such as degrees, minutes, seconds, UTM coordinates, or the Military Grid Reference System (MGRS). These are viable and very useful measurement systems when looking at the larger landscape, however, they prove cumbersome when working in a smaller area. The problem lies in the way that ArcGIS renders the virtual space when working with these projected coordinate systems; it renders the whole of the world regardless of the space in which you are working, this can significantly slow down the processing speed of the computer as well as create errors when working in a detailed area (Connolly and Lake 2006:263-64). Therefore, a virtual world with a projection coordinate system based on 1 x 1 m squares was created (Figures 2.20 and 2.21). The reason 1 x 1 m was used as the measurement system should be obvious based on the arbitrary grid system established by Sappington and Longstaff in 2010 as well as the test units being 1 x 1 m and the depths below surface being recorded in centimeters below surface (Longstaff 2013).

The individual flakes have a provenience consisting of an XY coordinate associated with a test unit within the 1x1 meter grid and an arbitrary 10 cm level below surface (cmbs). For example, the chert debitage excavated from test unit 77, level 10, would have the XY coordinate of X=85, Y=98 on the arbitrary grid system established in 2010. With some rare exceptions, the debitage was not “piece plotted” within the 1 meter test units. Therefore to simply plot all the debitage to X=85, Y=98, ArcGIS would put all of the debitage in the center of that test unit. In order to display the data in a comprehensible manner, a random

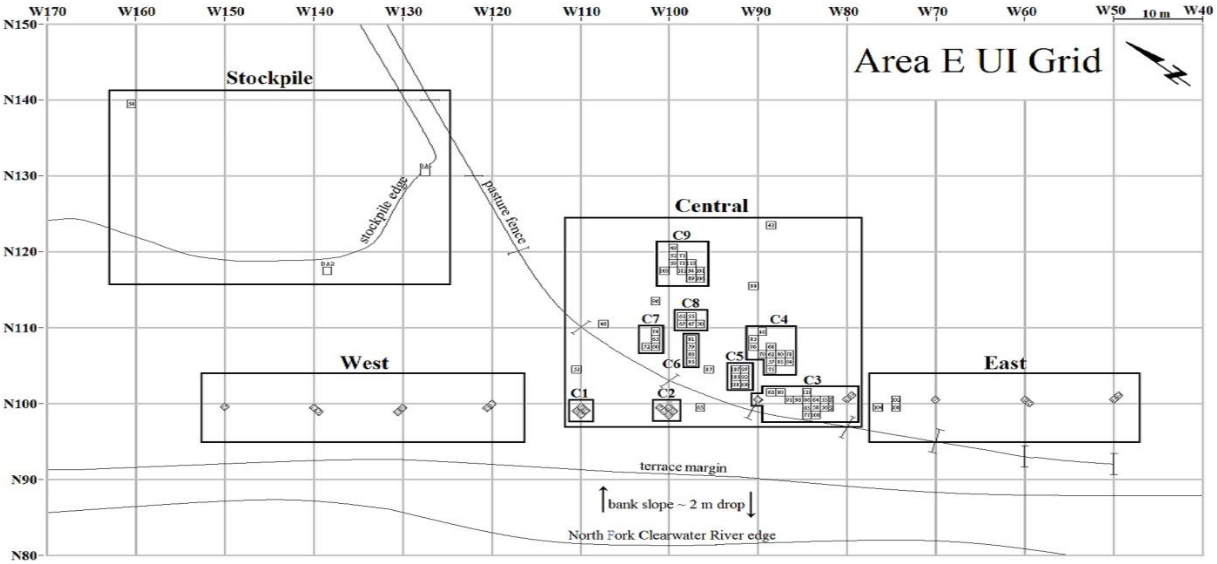


Figure 2.20 Arbitrary grid reference system established by Sappington and Longstaff in 2010 (adapted from Longstaff 2013).

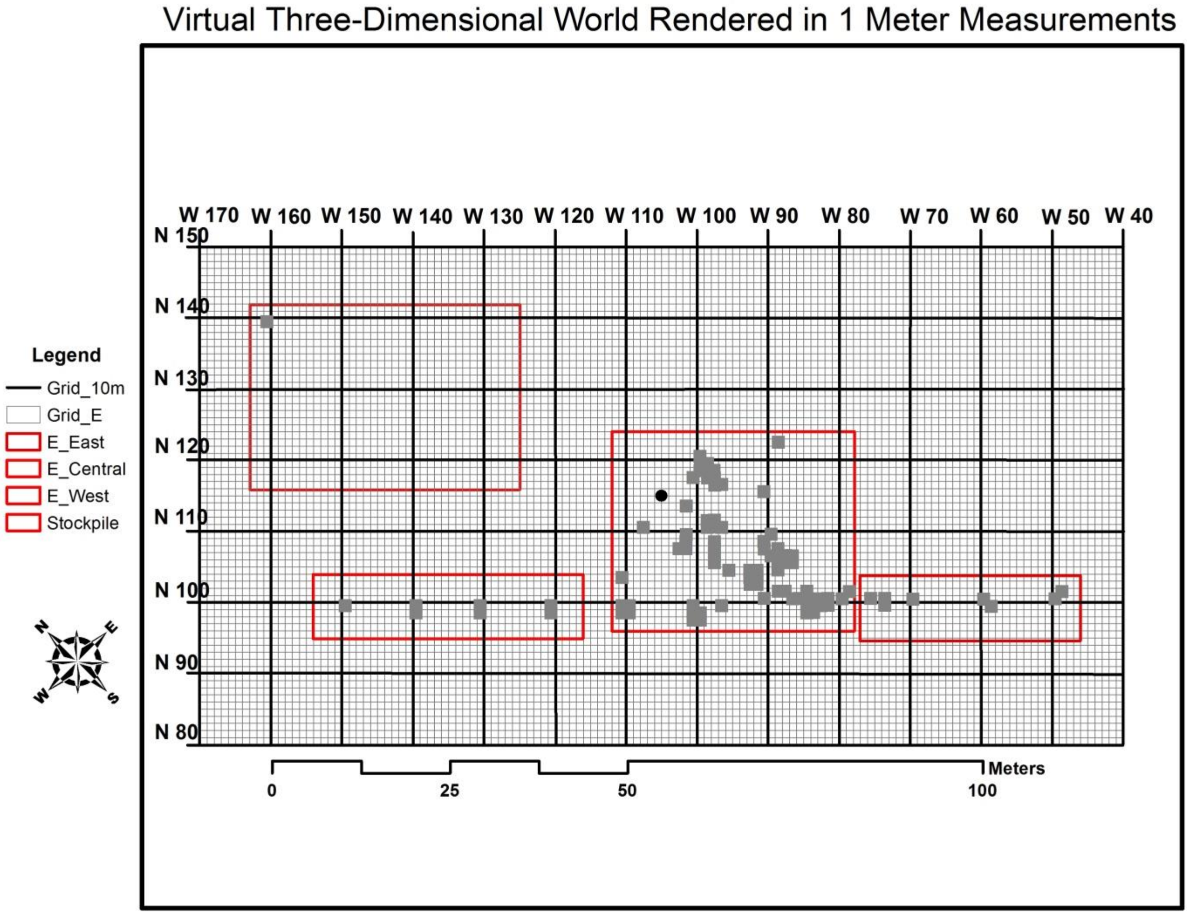


Figure 2.21 Virtual Three-Dimensional World rendered in 1 x 1 m (created by the author).

offset from the center of the XY coordinate was generated which either added or subtracted 0-50 centimeters within the 1 meter test unit. So the center of test unit 77 has an XY coordinate of X=85.5, Y=98.5. A randomly generated X offset of -16 cm would now place the X coordinate at X=85.34 and a randomly generated Y offset of 34 cm would put the new Y coordinate at Y=98.84. The individual flake was then plotted at X=85.34, Y=98.84 in ArcGIS. The depth for the flake was given as an arbitrary 10 cm level. Level 10 indicated in the example would be from 90.01 to 100 cmbs. In order to spread the flakes out within the arbitrary 10 cm level, the level was multiplied by -.1 thus making it a depth below the surface. Level 10 then became -100 cmbs. This was the very bottom of level 10 and to plot all the flakes at this level would have created a “floor” every 10cmbs. A randomly generated Z offset of .0XX was then added to the -100 cmbs to place the flake within the arbitrary 10cm level. If the randomly generated Z offset was .034, the Z depth would then be 96.6 cmbs, placing this flake randomly within the arbitrary 10 cm level. Thus the now plotted flake has an X=85.34, Y=98.84 horizontal placement at a Z depth of 96.6 cmbs. This was done for visual display purposes and can be justified by the palimpsest effect of human activity (Beardsell 2013:2) as well as those effects previously evidenced in Flenniken and Haggerty’s trampling experiments (1979).

Chapter 3:

Analyses

The analysis of this assemblage will be presented in two sections. The first will be the multivariate aggregate analysis of the entire debitage assemblage through nested sieves. The second will be the application load typological analysis resulting from the individual flake analysis. There will be some overlap in these analyses in order to compare the findings to achieve the stated research goal: *To compare nested sieve size-grade analysis to the individual flake application load typology analysis to determine the correlation between these two attributes and examine the efficacy of this combined methodology*. Further, the general assumption is that all detached flakes which could be utilized were removed from the archaeological context of the manufacturing episode (Ahler 1989:99).

The radiocarbon dates associated with 10CW34 will be referenced for cultural phases in association with their depth below surface and the arbitrary levels from which they came (Longstaff 2013:338-356). These radiocarbon dates are not mutually exclusive to the arbitrary levels and there is some overlap. However, with the exception of one radiocarbon date to its arbitrary level, the strata appear to have been intact when the site was excavated. The following are the cultural phases and their association to the arbitrary levels:

Paleoindian/Windust Phase (13,740 to 9520 cal. BP): levels 14-20 (140-200 cmbs)

Cascade/Hatwai Phase (8990 to 4440 cal. BP): levels 6-14 (60-140 cmbs)

Ahsahka and Kooskia Phases (1380 and 280 cal. BP.): levels 1-7 (surface-70 cmbs)

There is a noticeable gap of approximately three-thousand years between 1380 and 4440 cal. BP. There are many natural and taphonomic factors that could cause this gap in the radiocarbon dating timeline. Natural causes such as floods, fires, and drought and taphonomic processes such as bioturbation could also have affected the radiocarbon dating timeline. It is also important to recognize that only 1% of the alluvial terrace upon which the site resides was excavated. While there is not radiocarbon dating evidence of continuous seasonal occupation from 13,540 to 280 cal. BP, it is generally recognized that there was not a three-thousand year gap in occupation from 4440 to 1380 cal. BP (Lee Sappington, personal communication 2017).

Multivariate Aggregate Analyses

This section will examine the findings of the nested screen size-grading analysis. The methodology focuses on generation of assemblage level summary statistics from which inferences are made based on the premise that the manufacture of stone tools is a progressively reductive sequence. This methodology is effective for analyzing large assemblages and can be replicated (Carr and Bradbury 2004:21). There were, however, some initial subdivisions of the assemblage as received. These separations were by: materials, unit, and level. These variates were analyzed separately but were also included in the mass analysis of the assemblage.

The stage reduction sequence used for this analysis is based on the four stage reduction sequence from Sappington (1991). This stage driven reductive sequence is described as follows:

> **Stage 1:** *Core reduction* is represented by primary and secondary decortication flakes with primary geological cortex and interior flakes.
>
> **Stage 2:** *Blank preparation* involved modification of flake-blank margins in anticipation of bifacial reduction. Blank preparation flake types include bulb removal, alternate, and edge preparation.

> **Stage 3:** *Percussion bifacial thinning* is represented by margin removal flakes, early-thinning, and late thinning flakes. These kinds of flakes are produced from percussion thinning of prepared flake blanks into bifacial blanks.
>
> **Stage 4:** *Pressure bifacial thinning* is represented by early and late pressure flakes… These flake types are associated with pressure reduction of bifacial blanks into bifacial preforms and bifacial tools, especially projectile points (Sappington 1991:72).

Those flakes that were a result of the modification of unifacial and expedient flake tools would also be included in this stage driven sequence.

The distribution of flakes from the size-graded nested sieves with reference to the stage driven sequence is not mutually exclusive. Because of the reductive nature of stone tool manufacture, it is inferred that larger flakes come from earlier stages whereas smaller flakes come from later stages. For the purposes of this analysis, those diagnostic flakes associated with **Stage 1** (*Core reduction*) were expected to be collected in sieves #1 - #3 (>50 mm - > 12.5 mm). It must be noted here that the hard and soft hammer percussion normally associated with this stage often produces non-diagnostic small flakes known as shatter and these would be collected in the smaller sieves (Sappington 2016b). Those flakes associated with **Stage 2** (*Blank preparation*) would expect to be collected in sieves #2 - #5 (>25.4 mm - >3.35 mm). **Stage 3** (*Percussion bifacial thinning*) flakes would expect to be collected in sieves #3 - #6 (12.5 mm – 1.7 mm), and **Stage 4** (*Pressure bifacial thinning*) flakes would expect to be collected in sieves #4 - #6 (6.3 mm – 1.7 mm). There are many variables that that would affect the size of the flakes within the assemblage such as the desired size of the objective piece or tool. As has been previously stated in this thesis, all of the application load technologies are capable of producing flakes that are not within their expected size or shape range. However, the flakes produced during the various stages will statistically fall within the size grades cited above.

The screens used for these analyses were Hogentogler geologic nested sieves (brass) and these conform to all ASTM E-11, AASHTO T-27 & M-27, NIST, ISO 3310-1, and BS410 specifications (Hogentogler 2017). It is important to note that the mesh opening on these screens measure to the exact specification, i.e., the 1 inch mesh screen measures a 1 inch length by 1 inch width opening. The diagonal, or hypotenuse, then measures 1.414 inches. The application of the hypotenuse measurement must be considered relevant on all sieve size grades.

Table 3.1 gives the numbers and proportions from the data generated as a result of the multivariate aggregate analysis of the lithic debitage assemblage from 10CW34. Figures 3.1 through 3.4 provide pie chart and distribution curve charts for the data from Table 3.1. The methodologies used to measure and record this data set have already been discussed and are consistent with those procedures recognized and accepted by experts within the lithic debitage research community (Ahler 1989; Carr and Bradbury 2004; Henry et al, 1976; Larson 2004; Newcomer 1971; Sappington 2016b; Stahl and Dunn 1982). Table 1 represents all debitage from the excavations and includes all the raw materials identified to include metamorphic cobbles. The numbers recorded in this analysis do not match those numbers as reported by Longstaff in 2013. This is because the 2013 report includes the debitage from excavations prior to 2010 (Longstaff 2013). The debitage from these previous excavations was not included in this analysis because the provenience associated with their collection could not be verified as accurate (Lee Sappington, personal communication 2016).

Variate	Total # Debitage:	Total Weight (g)	Avg Wt/flake (g)	Percentage %
Assemblage	15763	7165.939	0.455	100
Size Grade #1: (>50 mm)	5	642.08	128.416	0.03%
Size Grade #2: (>25.4 mm)	79	2150.41	27.220	0.50%
Size Grade #3: (>12.5 mm)	548	2162.551	3.946	3.48%
Size Grade #4: (>6.3 mm)	3428	1481.069	0.432	21.70%
Size Grade #5: (>3.35 mm)	10779	715.874	0.066	68.40%
Size Grade #6: (>1.7 mm)	924	13.955	0.015	5.90%
Total	15763	7165.939	0.455	100.01%

Table 3.1 Overall counts, weights, and percentages of the assemblage and size-grade variates.

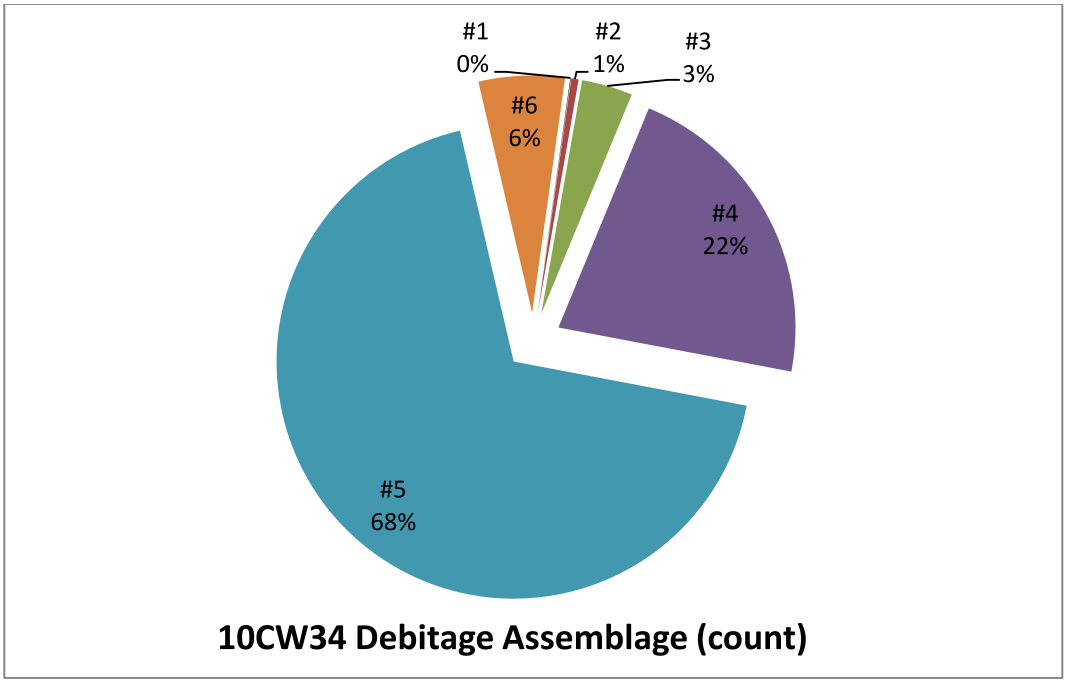


Figure 3.1 Pie chart from the entire debitage assemblage showing the distribution of flakes (count) in the nested sieves.

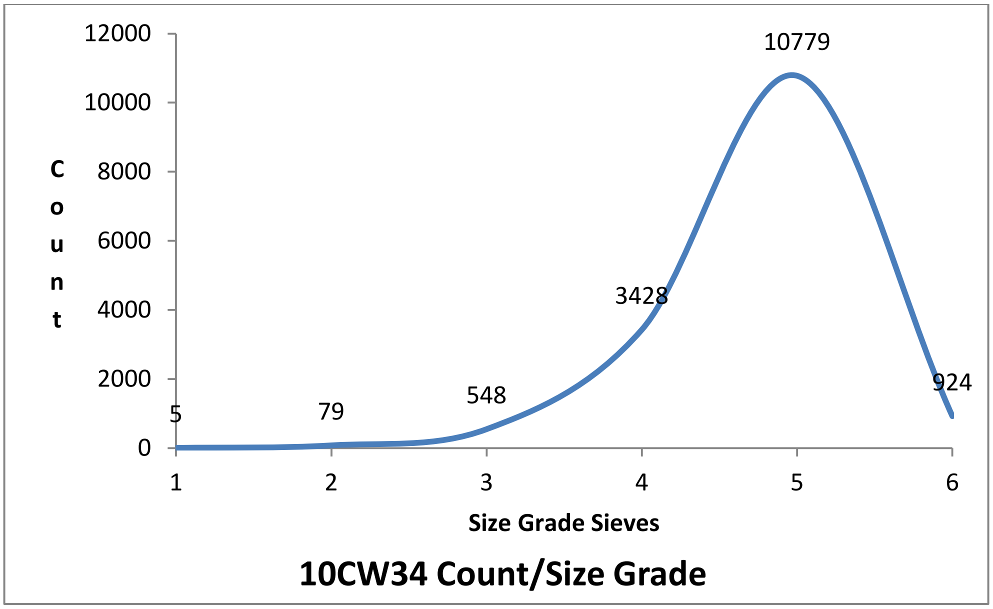


Figure 3.2 Distribution curve (left-skewed) of the size-graded counts from the entire debitage assemblage.

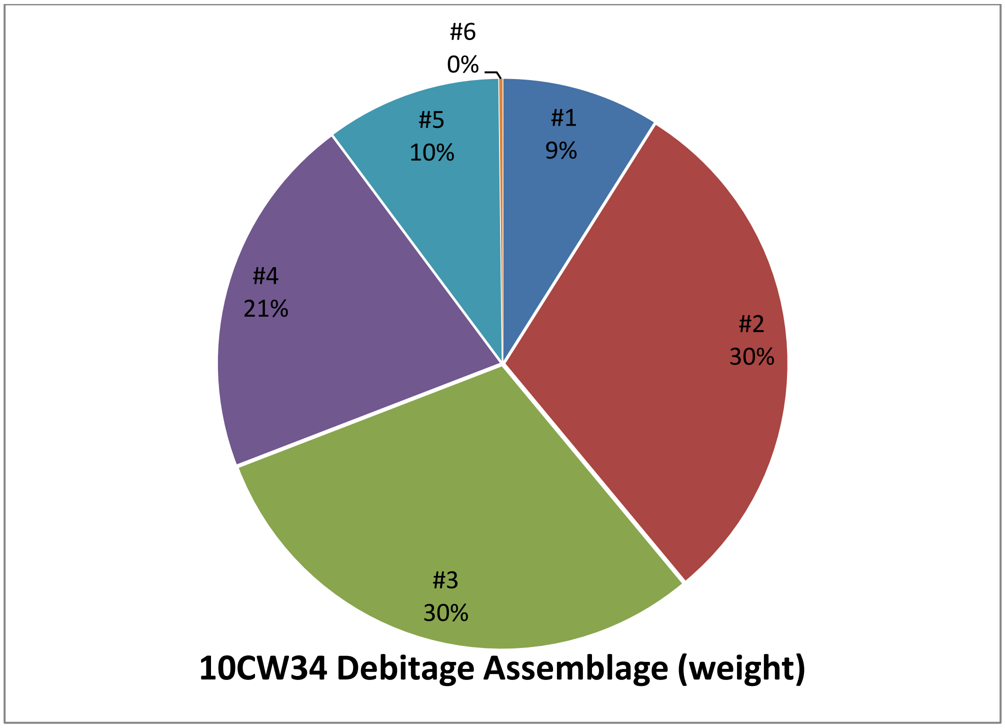


Figure 3.3 Pie chart of the overall weight distribution across the size-grades.

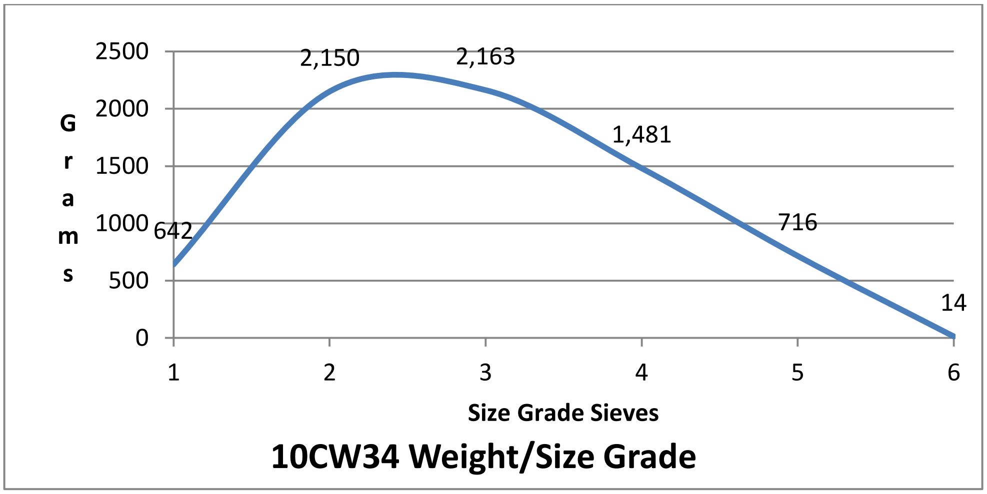


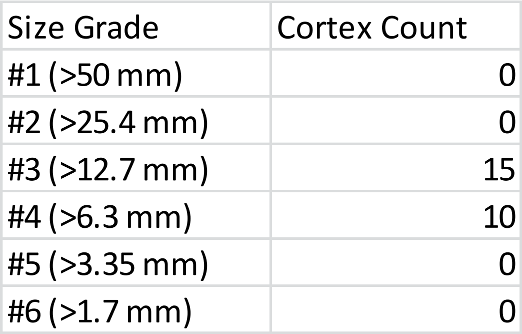
Figure 3.4 Distribution curve (right-skewed) of the size-graded weights from the entire debitage assemblage.

Cortex. The presence of dorsal cortex on debitage and flakes associated with an archaeological assemblage can be indicative of several probabilities. Dorsal cortex on larger flakes indicates core reduction sequences or early stage preform shaping (Andrefsky 2001:11). The presence of significant cortex can also infer local quarry sites that are within the sites catchment (Bettinger 1982:113, Sappington 1994:393). The presence of cortex identified on the flakes from the 10CW34 debitage assemblage was negligible (n=25) and represented less than two tenths of one percent (0.16%). Those flakes identified with residual cortex were found in only two of the of the size grades: n=15 in the #3 size grade (>12.5 mm) and n=10 in the #4 size grade (>6.3 mm). These numbers differ significantly with the cortex presence in the assemblage as reported by Longstaff (2013:268). There are two reasons for these discrepancies: the first is the subjective nature of determining cortex. Carr and Bradbury note that between analysts, there are often major differences in the identification and recording of cortex. This can often be the result of the "unweathered staining" of flake surfaces misidentified as cortex (2004:29). The second discrepancy between the Longstaff 2013 cortex analysis and the analysis presented by the author was the inclusion of cobble as having cortex in the 2013 analysis. This analyst/author felt there was not enough of a difference in color, texture, or composition of cobble surfaces to classify the cobble exterior surfaces as cortex. In the examples below, Figure 3.5 shows a chemically produced cortex which has a noticeable texture and composition difference, whereas Figure 3.6 shows a color difference that is the result of unweathered staining.

Figure 3.5 Cortex identified on a chert flake.

Figure 3.6 An example of unweathered staining often misidentified as cortex. The exterior texture and composition are the same as the interior surfaces.

The fact that there were no flakes with dorsal cortex in either size grading #1(>50 mm) or #2 (>25.4 mm) is likely the result of two factors (Table 3.2). The first being that flakes from these size groups would have been large enough to be utilized as tools and were repurposed for other tasks and were thus removed from the manufacturing context (Ahler 1989:99; Longstaff 2013), and the second would be that there was very little core reduction and early stage tool manufacture occurring on the site. The distribution of flakes across the size grading's and utilized flake count (n=186) from 10CW34 supports this hypothesis. White's (1963) triple cortex typology explains the lack of cortical flakes in size gradings #5 (>3.35 mm) and #6 (>1.7 mm). The flakes from these size-grades and their method of detachment (application load) suggest that these are tertiary flakes from the later stages of tool production.



Size Grade	Cortex Count
#1 (>50 mm)	0
#2 (>25.4 mm)	0
#3 (>12.7 mm)	15
#4 (>6.3 mm)	10
#5 (>3.35 mm)	0
#6 (>1.7 mm)	0

Table 3.2 Flakes identified with dorsal cortex by size grading.

However, it must be noted that Root (2004) observes that smaller nodules produce more cortex than do larger nodules when examining small flakes. Therefore the flakes placement in the reduction sequence cannot accurately be identified based on cortex coverage (2004:69). Because there were no small flakes identified as having dorsal cortex, this was not a factor in the analysis of the size grading of this assemblage. Additionally, a cursory examination of cherts recently sourced (in the lithic sourcing section below); indicate that these are likely from raw material outcroppings and not from nodules. Chert and other raw materials extracted from outcroppings tend to exhibit much less residual cortex than those flakes produced from nodules (Sappington 1991:39, 72).

*Overall Material Comparison***.** There were seven lithic material types utilized and identified at 10CW34: argillite, basalt, chert, metamorphic cobble (cobble), obsidian, quartz crystal (QC), and vitrophyre. The percentage distribution of these raw materials by count and weight are represented in Figures 3.7 through 3.9.

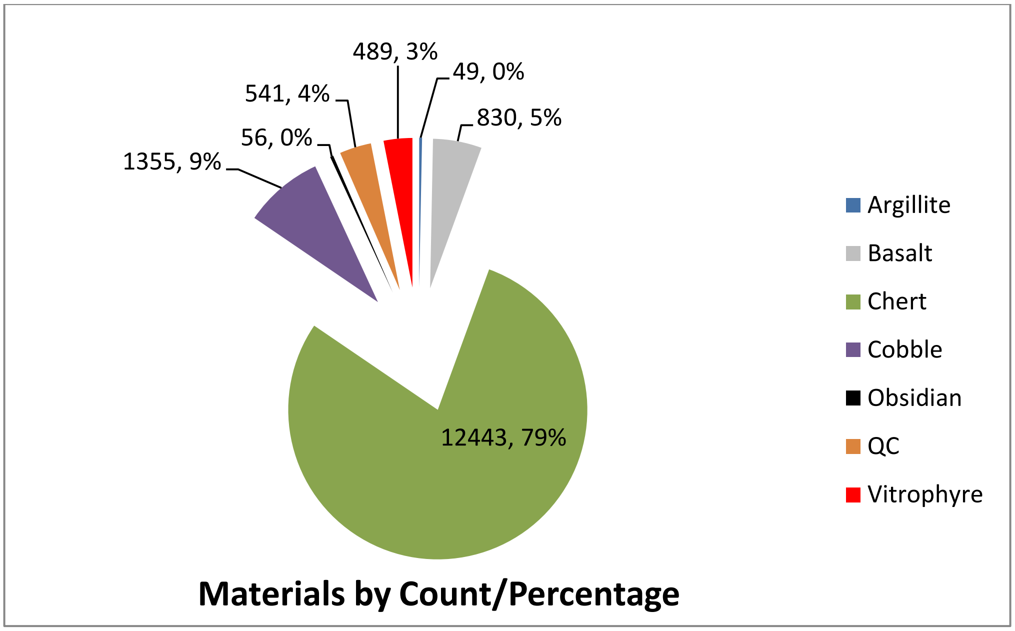


Figure 3.7 Pie chart from the entire debitage assemblage showing the numerical distribution of flakes based on raw material types.

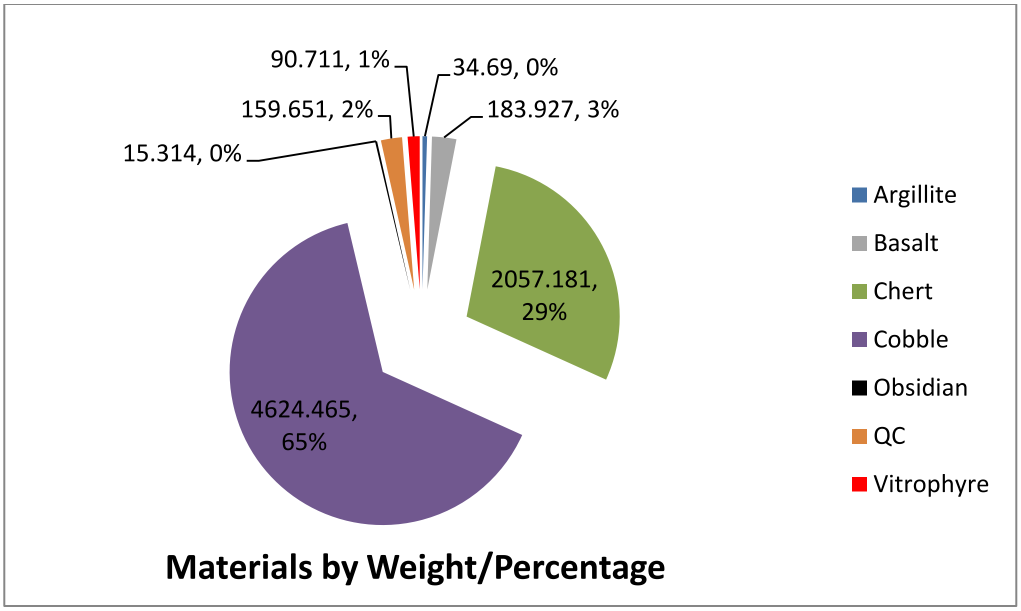


Figure 3.8 Pie chart from the entire debitage assemblage showing the weight distribution of flakes based on raw material types.

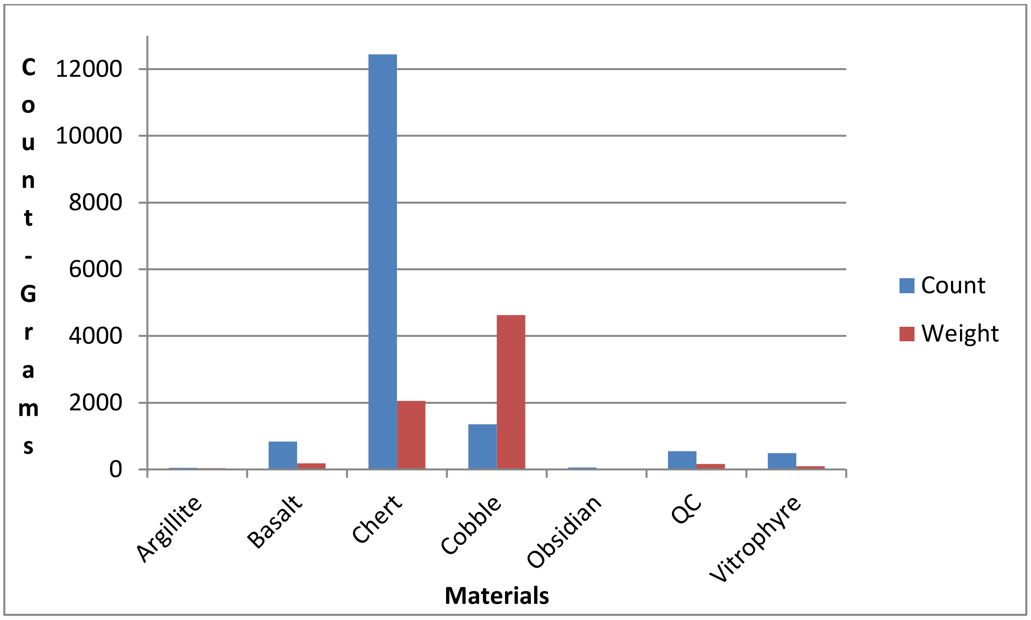


Figure 3.9 Bar chart displaying count to weight ratios of the raw materials.

These materials vary from the local (argillite, basalt, cherts, cobble, QC, and vitrophyre) to the exotic (obsidian). The sourcing of these materials is discussed in a later section of this thesis. The inclusion of metamorphosed cobble significantly skews the data in both the size-grade counts and the weight counts. Figures 3.8 and 3.9 above show the skewing of the overall weight data by the inclusion of cobble while Table 3.3 displays the skewing of the overall count data by the inclusion of the cobble.

Material	#1	#2	#3	#4	#5	#6
Argillite	0	0	7	15	26	1
Basalt	0	0	25	246	540	19
Chert	0	2	203	2377	9014	847
Cobble	5	77	291	538	442	2
Obsidian	0	0	0	8	41	7
QC	0	0	11	135	376	19
Vitrophyre	0	0	11	109	340	29

Table 3.3 Size grade counts by material. Note the cobble presence in size grades #1 and #2 with respect to the other materials and the chert presence in size grades #4, #5, and #6.

The chert flake count in size grades #4, #5, and #6 also skews the data. However, this is to be expected given the local availability of the lithic raw materials and the fracturing characteristics and edge retention qualities of cryptocrystalline silicates. Lithic raw material ratios of similar sites in the Clearwater River drainage also show similar skewing with regards to the presence of chert.

The numbers from the area E size grade analysis with regards to both count and weight are similar to the results from the sample analysis conducted by Longstaff in 2013 (2013:257). This correlation lends validity to both the Longstaff sample analysis (2013) and the overall aggregate analysis conducted by the author. Additionally, the confidence in the statements that flake aggregate analysis reliable observations is supported by these analyses (Larson 2004:8).

Argillite. Argillite is a "fine grained, metamorphosed, sedimentary rock with a fairly consistent crystalline structure and predictable fracture planes" (Huntley et al. 2010:1-2). Argillite is formed from a shale or siltstone under low pressure without the inclusion of quartz, or the process known as silicification. Argillite is generally considered as having a dull luster unless metamorphosed under high temperatures, when this occurs, argillite can develop a glassy sheen (Andrefsky 1998:58). Argillite is considered a semi-local raw material and can be sourced in the Clearwater River drainage (Figure 3.10).

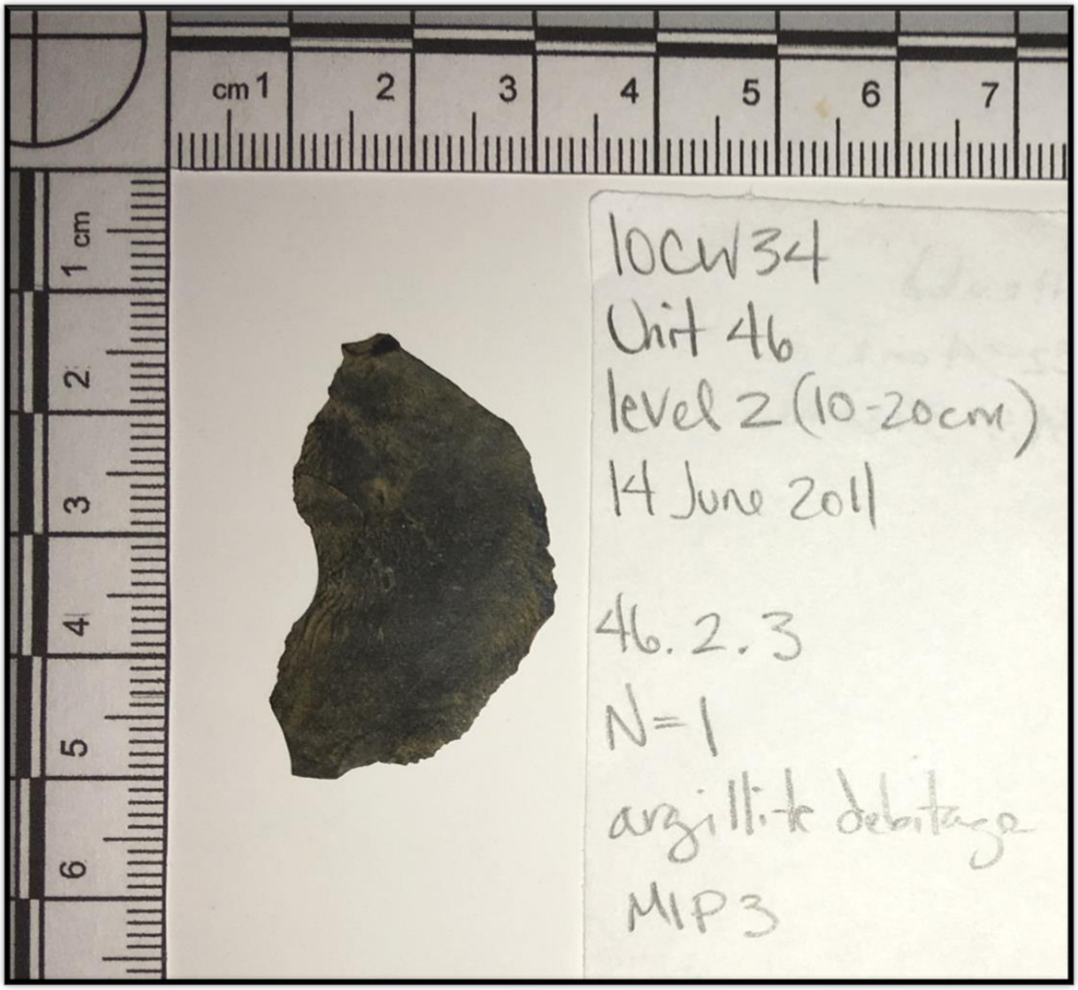


Figure 3.10 Argillite flake from 10CW34.

Argillite represents 0.3 % of the assemblage and was recovered from arbitrary levels 1-16. Based on the radiocarbon dates associated with 10CW34, this represents the use of argillite from the protohistoric period through the Windust cultural phases (Table 3.4 and Figure 3.11).

Argillite	Count	Weight	Weight/Flake
#1	0	0	0.000
#2	0	0	0.000
#3	7	26.67	3.810
#4	15	5.54	0.369
#5	26	2.47	0.095
#6	1	0.01	0.010
total	49	34.69	0.708

Table 3.4 Argillite flake count and weight per size-graded sieves.

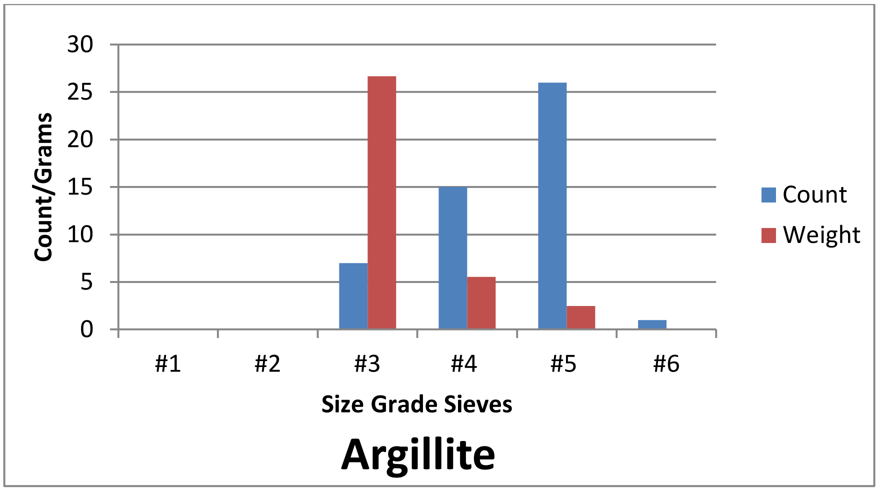


Figure 3.11 Argillite bar chart displaying count to weight ratios in the size-graded sieves.

This percentage is low considering semi-local sources of argillite in the region and the quality of this raw material. Argillite sources near Kooskia, ID (10IH1771) and along the lower Lochsa and Selway rivers were utilized in these areas and are found in archaeological contexts as well as in surface collections in pre-contact occupation areas (Danner 2017; Sappington 1991:39; Cindy Schacher, personal communication 2017; surveys conducted by the author). The low percentage of argillite in the assemblage may be the result of the location of 10CW34 on the North Fork of the Clearwater River. There are no known or recorded sources for argillite along this fork of the river. Therefore, the limited presence of argillite at 10CW34 could be indicative of the trails and routes used seasonally to access the site. Other locally available raw materials such as cherts have been sourced along this section of the river. These local and route accessible raw materials were likely gathered and utilized during the seasonal migrations to the site as a matter of logistics and convenience. This hypothesis will be further explored in the mobility section of this thesis.

Basalt. Basalt is an igneous rock that has very little silica content and is comprised of mostly feldspar. When basalt cools rapidly, the different minerals do not have time to separate into individual crystalline formations and the resulting raw material is considered a "fine grained" basalt (Figure 3.12). It is recognized as a homogeneous material that will fracture conchoidally (Whittaker 1994:69). This is a very hard raw material that is difficult to work, but holds its edge once flaked (Sappington 2016b). Basalt is considered a local material and represents 5.3% of the assemblage (Table 3.5 and Figure 3.13) and was recovered from arbitrary levels 1-16. Based on the radiocarbon dates associated with 10CW34, this represents the use of basalt from the protohistoric period through the late Windust cultural phases.

Leonhardy and Rice (1970:9) recognize basalt as a raw material that was heavily utilized during the Cascade cultural phase (8990 to 4440 cal. BP) in the lower Snake River region. The debitage assemblage from 10CW34 does not reflect this trend found elsewhere in the Plateau Cultural area. Basalt as a percentage of 5.3% of the overall assemblage remains relatively consistent through those arbitrary levels (6-14) identified with

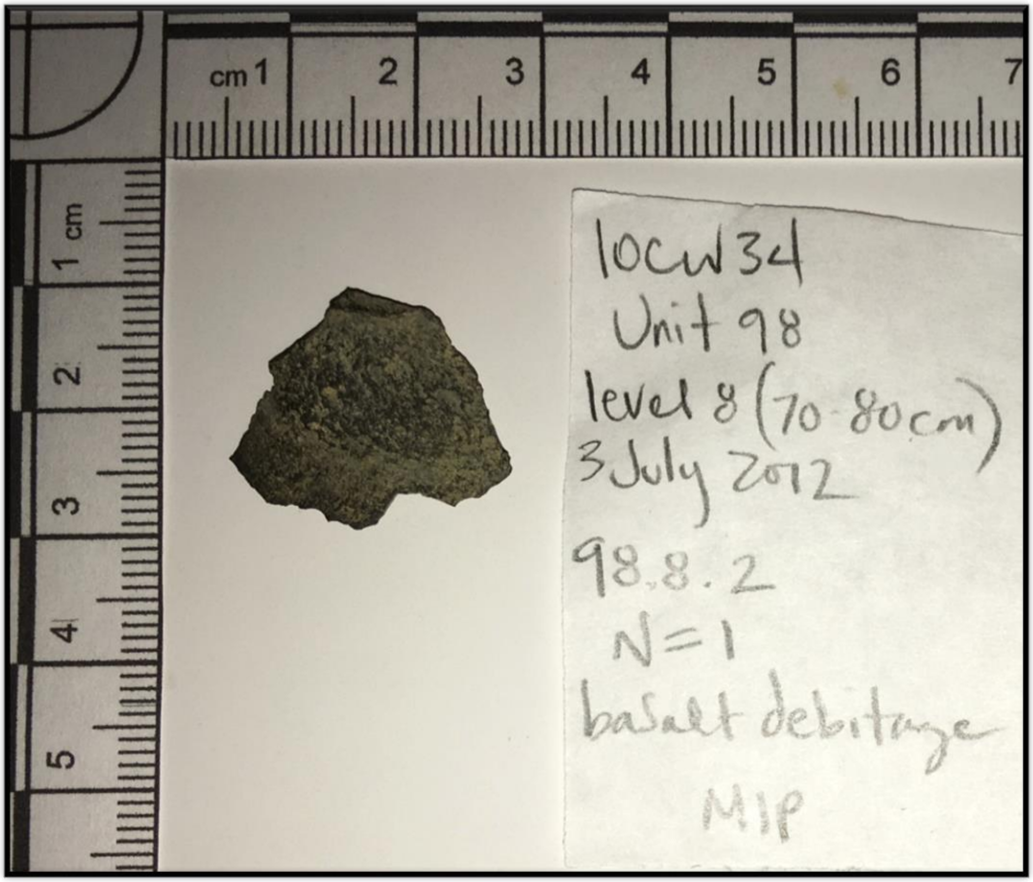


Figure 3.12 Basalt flake from 10CW34.

the Cascade Phase. This is likely a result of the local geological formations which are not basaltic in nature but rather are representative of the Precambrian metamorphosed quartzite, schists, and gneisses which dominate the area local to 10CW34 (Longstaff 2013:18). Test unit 65 does show some concentration of basalt debitage in levels 7, 8, and 9 with statistical deviation from all other test units in these levels. In level 7, there were four basalt flakes recovered, five basalt flakes from level 8, and seventeen basalt flakes from level 9. This concentration does not rise to the level of significance and is most likely the result of one reduction episode with the vertical displacement being the result of turbation from human and other activities.

Basalt	Count	Weight	Weight/Flake
#1	0	0	0
#2	0	0	0
#3	25	51.951	2.078
#4	246	95.400	0.388
#5	540	36.428	0.067
#6	19	0.148	0.008
total	830	183.927	0.222

Table 3.5 Basalt flake count and weight per size-graded sieves.

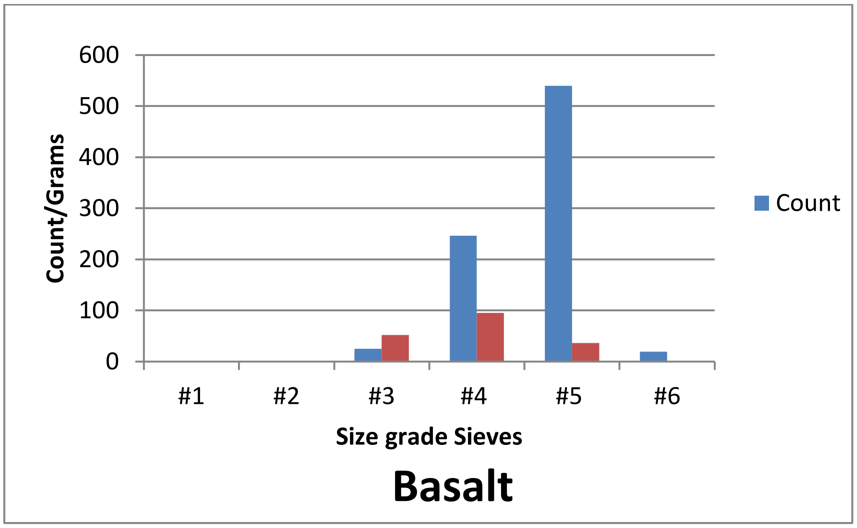


Figure 3.13 Basalt bar chart displaying count to weight ratios in the size-graded sieves.

Cherts. Cherts occur in the Clearwater River drainage as nodular cobbles and as interbedded inclusions in limestone and chalks (outcroppings). Silica precipitates into the limestone and replaces the calcium carbonate. The result is a very strong, fine grained material often referred to as “cryptocrystalline” in structure (Odell 2004:20). The term "chert" includes those materials also referred to as flint, opal, chalcedony, jasper, and other cryptocrystalline silicates (Sappington 1991:39). Cherts are considered a local material and represent 79% of the assemblage (Figure 3.14). Cherts were recovered from all arbitrary levels (1-20) and this represents the use of chert from the protohistoric period through the Paleoindian/Windust cultural phases.

Figure 3.14 Chert Debitage from 10CW34.

Cherts often represent the most often utilized raw material on many prehistoric sites in North America when there is a local or semi-local source available. This is due to the high silica content, the desirable fracturing characteristics, and relative hardness which enable the finished tool to hold an edge (Whittaker 1994:67). The debitage assemblage from 10CW34 is representative of this trend. There is not one specific source for quality chert in the

Clearwater River drainage, but rather, there are many. The many sources of this raw material's regional availability will also be discussed in the sourcing section of this thesis.

The numerical, temporal, and spatial distribution of chert flakes from the excavated units at 10CW34 infers chert as both a relatively available and desirable raw material by those who occupied this site. The concentration of chert flakes in the #4 and #5 size grades would indicate that these tools were in finished form when they arrived at the site and these concentrations of debitage are the result of curation and maintenance activities (Table 3.6 and Figure 3.15).

Chert	Count	Weight	Weight/Flake
#1	0	0	0
#2	2	26.120	13.060
#3	203	525.830	2.590
#4	2377	918.389	0.386
#5	9014	573.830	0.064
#6	847	13.012	0.015
Total	12443	2057.181	0.165

Table 3.6 Chert flake count and weight per size-graded sieves.

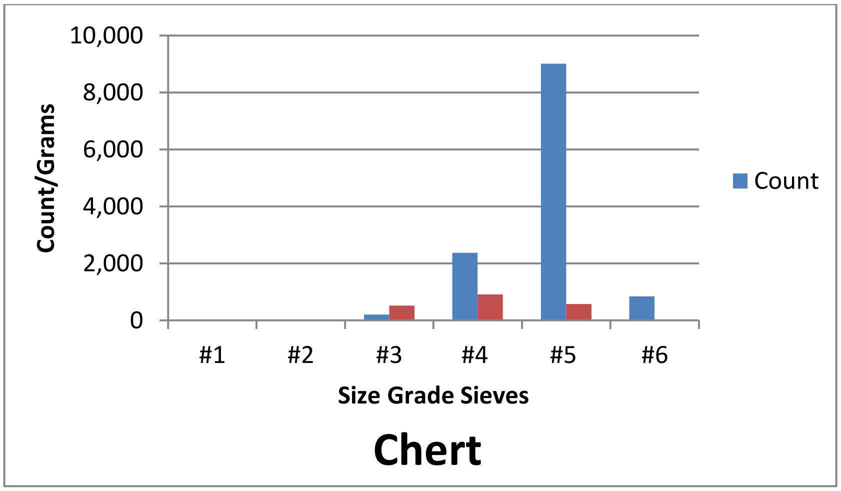


Figure 3.15 Chert bar chart displaying count to weight ratios in the size-graded sieves.

Metamorphic Cobble. Metamorphic cobble (cobble) flakes recovered at 10CW34 are considered “fine grained” with a high silicate content. These materials were likely sourced from the river adjacent to the site. Longstaff reports that a good portion of the cobble was identified as flake tools, cobble tools, and fire-cracked rock (Longstaff 2013:191). The inclusion of the metamorphic cobble debitage in the assemblage skews the weight and distribution counts significantly. These tools and the resulting debitage are considered expedient and local to the site. The use of river cobble material in this manner is consistent throughout the Clearwater River drainage (Sappington 2017). Cobble is considered a local material and is most likely sourced at the site. Cobble represents 8.6% of the assemblage Cobble debitage was recovered from arbitrary levels 1-18 and this represents the use of local cobble from the protohistoric period through the Paleoindian/Windust cultural phases.

The cobble debitage of the 10CW34 assemblage makes up 100% of the size grade 1 and 98% of the size grade 2 samples (Figure 3.16). While representing only 8.6% of the overall count, the cobble debitage constitutes 65% of the overall weight of the assemblage. The size, count, and weight ratios of the cobble flakes in the assemblage are clear evidence of the outlying nature of the flakes and therefore their placement within the early stages of reduction (Table 3.7 and Figure 3.17). The presence of these large flakes is consistent with the expedient manufacture and use of this locally available raw material. The initial reduction process for this raw material was likely achieved through bipolar percussion (Keeler 1973:49). Bipolar percussion is the process by which a nodule or core is placed on a hard surface which serves as an anvil and then struck with a hard hammer. The shock wave travels through the objective piece and is returned through the base of the objective piece as a result of the hard surface upon which the core or nodule has been placed. This method is ideal for rounded cobbles because of the lack of edges from which a flake can be struck (Whittaker 1994:115).

Figure 3.16 Cobble flake from 10CW34.

When those raw materials that have the characteristics associated with conchoidal fracture are produced using bipolar percussion, there are diagnostic markers that are not evident on the cobble debitage. Diagnostic markers of conchoidally fracturing materials would include diffuse bulbs of percussion on both the striking surface and the anvil surface. Additionally, application force ripple marks will be evident from both the striking surface and the anvil surface; these can often meet in the center of the objective piece (Andrefsky 1998:20-28). Because of the nonhomogeneous nature of the cobble mineral structure, these diagnostic markers of bipolar percussion are not evident on cobble debitage.

Cobble	Count	Weight	Weight/Flake
#1	5	642.080	128.416
#2	77	2124.290	27.588
#3	291	1482.730	5.095
#4	538	332.320	0.618
#5	442	43.040	0.097
#6	2	0.005	0.003
Total	1355	4624.465	3.413

Table 3.7 Cobble flake count and weight per size-graded sieves.

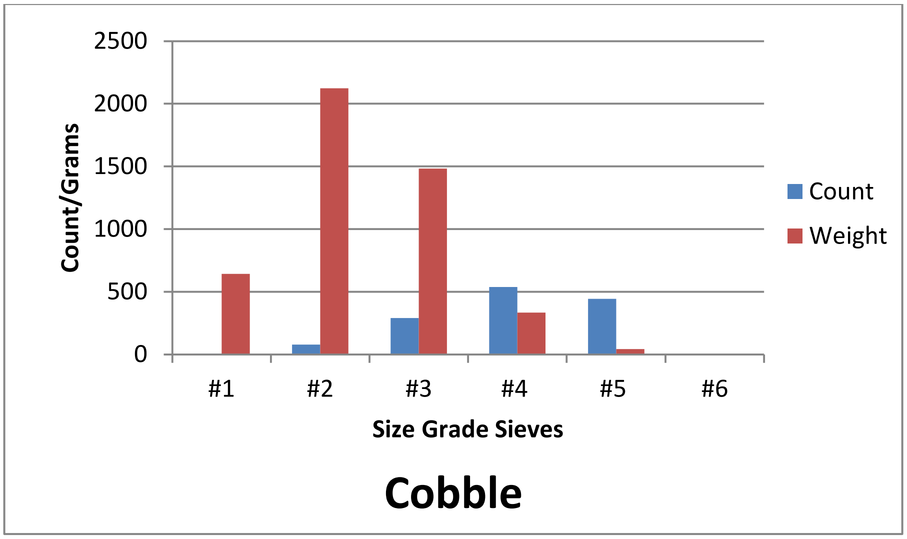


Figure 3.17 Cobble bar chart displaying count to weight ratios in the size-graded sieves.

Obsidian. Obsidian is an ideal raw material for the manufacture of stone tools because it can be worked by the manufacturer to fracture in the manner in which the tool maker desires (Andrefsky 1998:24). This is because of it chemical composition. Obsidian is an igneous rock referred to as volcanic glass. It is a natural glass formed when the extreme rapid cooling of lava or magma prevents the formation of precipitate mineral crystals. This cooled material remains in a near perfect homogeneous form and therefore fractures conchoidally in a predictable manner not seen in many of the other raw materials suited for stone tool manufacture. However, these characteristics also make obsidian a very brittle material and it is prone to breaking during manufacture if the knapper is not careful (Whittaker 1994:69). Obsidian recovered from the excavations at 10CW34 (Figure 3.18) is considered an exotic material and has been sourced to known obsidian sources southern Idaho and eastern and central Oregon (Longstaff 2013:373-379). Obsidian represents less than 1% (0.3%) of the assemblage (Table 3.8 and Figure 3.19). Obsidian debitage was recovered from arbitrary levels 1-12 and this represents the use of obsidian from the protohistoric period through the Cascade cultural phase.

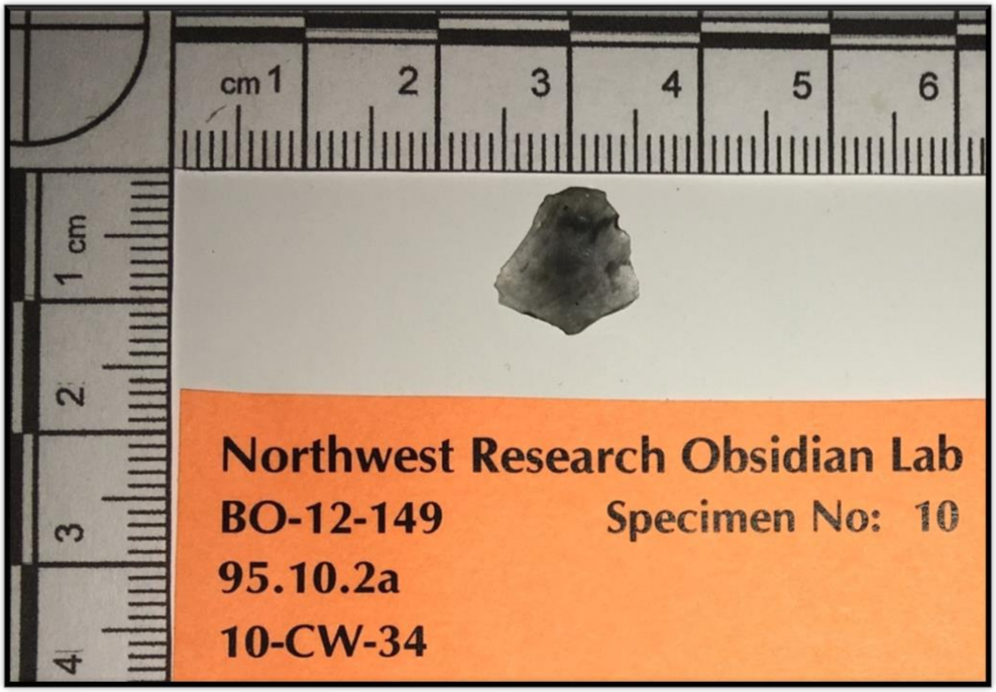


Figure 3.18 Obsidian flake from10CW34.

Obsidian	Count	Weight	Weight/Flake
#1	0	0	0
#2	0	0	0
#3	0	0	0
#4	8	13.870	1.734
#5	41	1.380	0.034
#6	7	0.064	0.009
Total	56	15.314	0.273

Table 3.8 Obsidian flake count and weight per size-graded sieves.

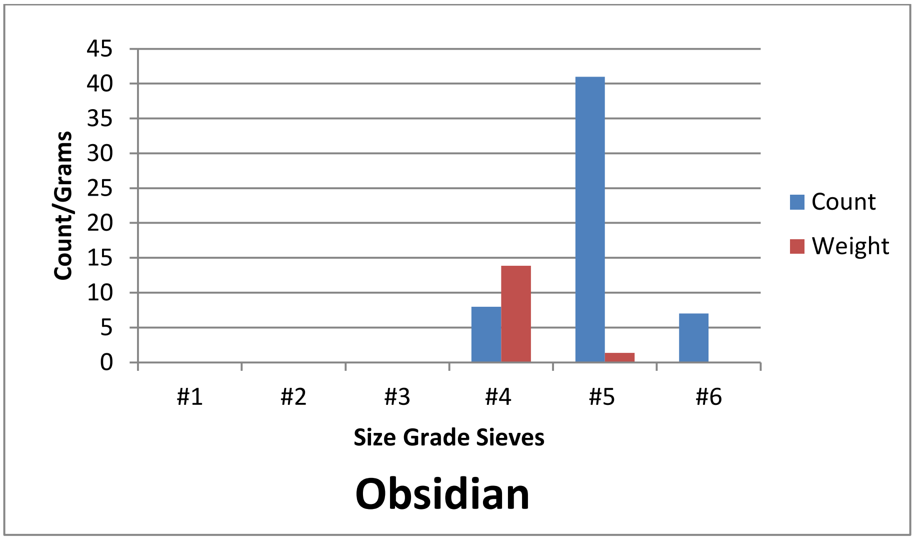


Figure 3.19 Obsidian bar chart displaying count to weight ratios in the size-graded sieves.

Obsidian is considered a highly desired raw material by modern knappers and prehistoric tool makers alike because of the fracturing qualities mentioned above. Obsidian is not local to the 10CW34 site catchment or within the known seasonal rounds of the ancestral Nez Perce (Longstaff 2013:51-54). Obsidian was recognized not only for its exceptional tool making qualities, but also for its value as a status indicator. An example of the value placed on obsidian by prehistoric cultures is the obsidian found in the Hopewell Mounds in Ohio which have been sourced to quarries in Yellowstone Park (Whittaker 1994:69). The obsidian flakes recovered in the excavations at 10CW34 are generally small and most are diagnostic. All of the obsidian flakes fall within the size grades 4, 5, and 6 and of these, 85% show evidence of prepared platforms and attributes that are associated with pressure flaking. This would indicate that the tools from which these flakes were detached were complete when they arrived at the site and that the recovered flakes were a result of curation or maintenance.

Quartz Crystal. Quartz crystal is a clear (or sometimes colored) igneous mineral that grows in cooling rock. By nature, quartz crystal is a nearly pure silicate (SiO2) and is considered mega quartz because of the high silica content. It is from this raw material that the cryptocrystalline silicates are based (Grisham 2015:8-9). Quartz crystal is much more brittle than chert or basalt and therefore has a tendency to shatter during tool manufacture (Beardsell 2013:89). Because of this, quartz crystal is not a favored raw material among modern knappers. Quartz crystal is found locally to 10CW34 (Figure 3.20) and the region due to the geologic formations from which Idaho’s central mountains were formed (Grisham 2015:25-29). Quartz crystal represents 3.4% of the assemblage (Table 3.9 and Figure 3.21). Quartz crystal debitage was sorted into size grades 3-5. This would indicate that earlier stages of reduction were associated with this raw material. This is consistent with the local availability of this resource. Much of the quartz crystal gathered in size grade #3 and #4 appeared as shatter which is expected given the fracturing characteristics of quartz crystal. Quartz crystal debitage was recovered from arbitrary levels 1-19 and this represents the use of quartz crystal from the protohistoric period through the Paleoindian/Windust cultural phase.

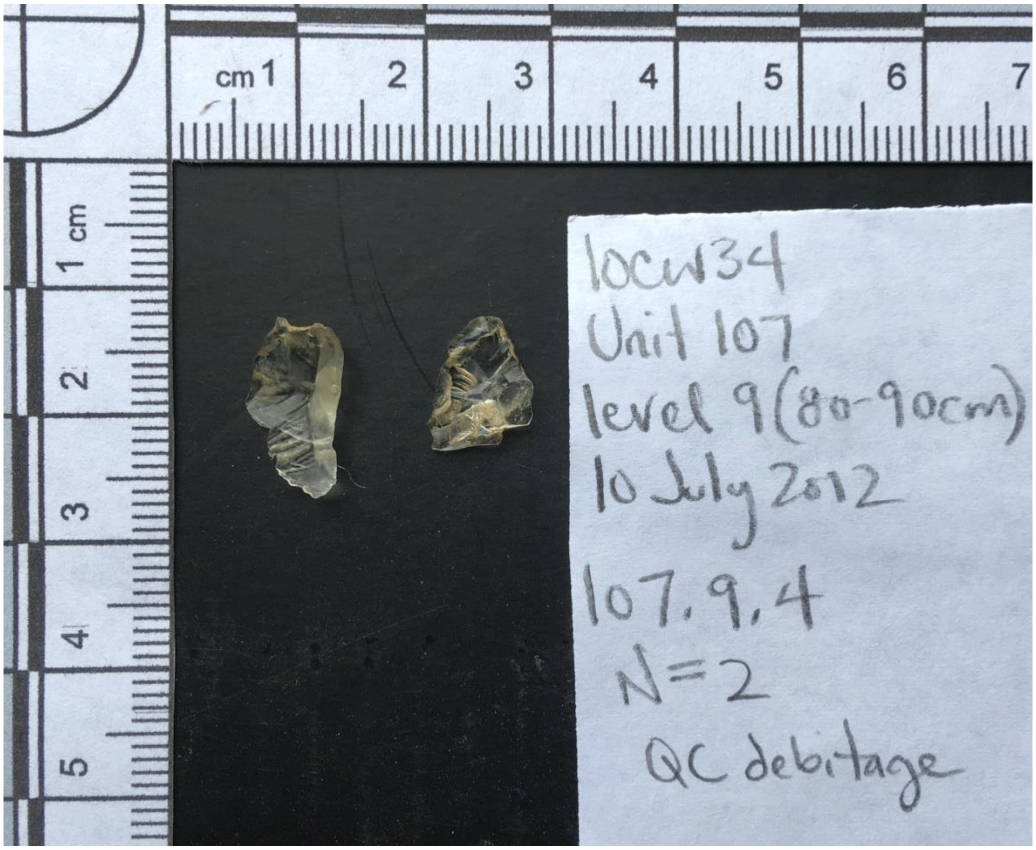


Figure 3.20 Quartz crystal flakes from 10CW34.

QC	Count	Weight	Weight/Flake
#1	0	0	0
#2	0	0	0
#3	11	44.360	4.033
#4	135	78.730	0.583
#5	376	36.234	0.096
#6	19	0.327	0.017
Total	541	159.651	0.295

Table 3.9 Quartz crystal flake count and weight per size graded-sieves.

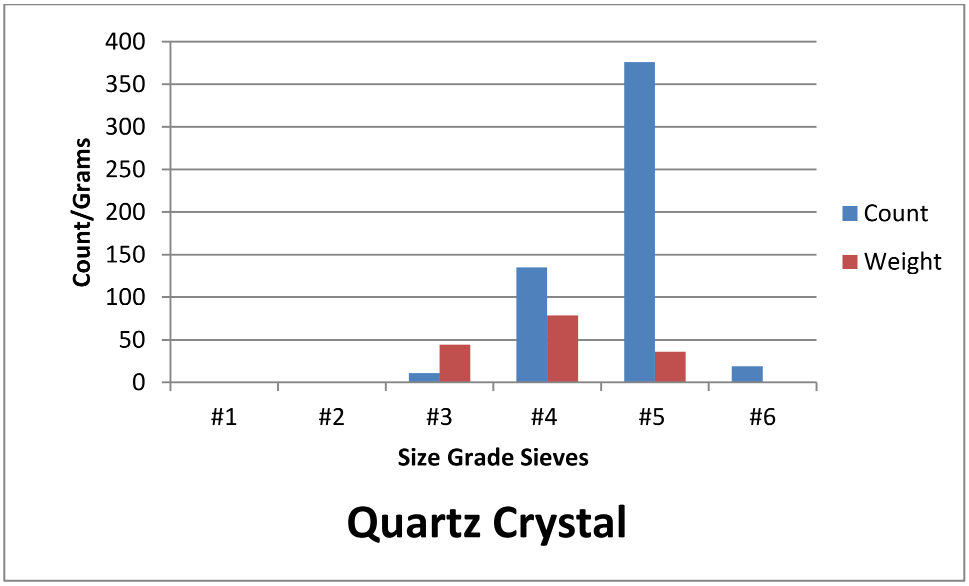


Figure 3.21 Quartz crystal bar chart displaying count to weight ratios in the size-graded sieves.

The analysis of the quartz crystal was particularly difficult in determining the striking platform and bulb of percussion because of the unique fracturing characteristics of the material. Robert Beardsell describes the problems inherent with the irregular fracturing mechanics of quartz crystal and the resulting tools in his 2013 dissertation as follows:"…that this tendency has led to an a priori assumption that 'crude looking' artifacts are inevitable when 'coarse' materials such as quartz are used. Archaeologists therefore often believe that quartz, when it was used, was used reluctantly and only in the absence of finer grained, more easily worked raw materials such as flint or chert" (Beardsell 2013:91).

The difficulties of knapping quartz crystal and quartzite are also encountered when analyzing the debitage and tools made from this raw material. Additionally, because of the pure nature of the silica from which it is composed, sourcing quartz crystal poses difficulties because of the lack of impurities that can be identified in the material (Grisham 2015:23-24).

Vitrophyre. Vitrophyre is an igneous raw material that is a form of obsidian but has cooled more slowly than obsidian and thus has large (relative) phenocryst formations within (Sappington 2016b). Vitrophyre is considered a semi-local resource to 10CW34 (Figure 3.22) and some of the flakes from the assemblage have been sourced to Montana Creek in Montana twenty-five miles away (Longstaff 2013:194). Vitrophyre can be sourced just as obsidian can be sourced by identifying the impurities to a source. Additional sources have been noted near the confluence of the Lochsa and Selway rivers (Sappington 1991:39). Vitrophyre represents 3% of the assemblage (Table 3.10 and Figure 3.23). Vitrophyre debitage was recovered from arbitrary levels 1-19 and this represents the use of vitrophyre from the protohistoric period through the Paleoindian/Windust cultural phase.

Figure 3.22 Vitrophyre flake from 10CW34.

Vitrophyre	Count	Weight	Weight/Flake
#1	0	0	0
#2	0	0	0
#3	11	31.010	2.819
#4	109	36.820	0.338
#5	340	22.492	0.066
#6	29	0.389	0.013
Total	489	90.711	0.186

Table 3.10 Vitrophyre flake count and weight per size-graded sieves.

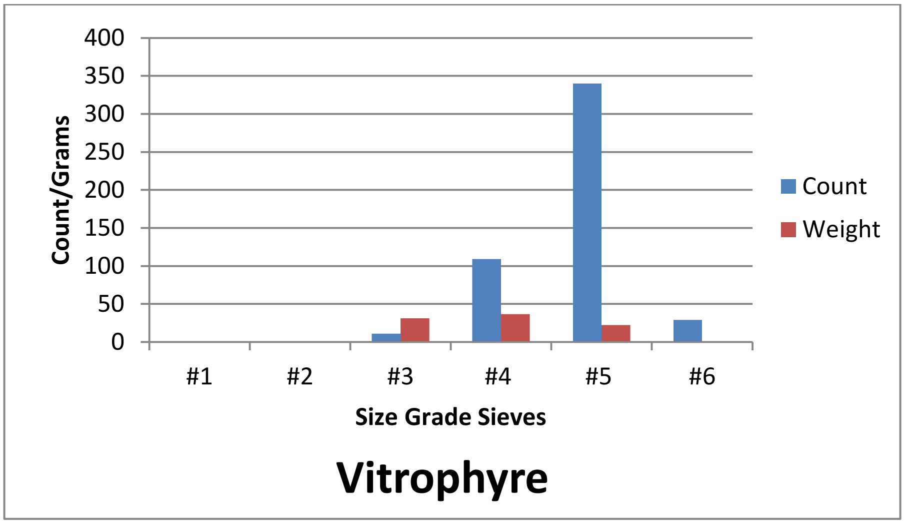


Figure 3.23Vitrophyre bar chart displaying count to weight ratios in the size-graded sieves.

The theoretical basis for aggregate analysis relies on this irrefutable law of stone tool manufacture: this is a reductive process that most often utilizes material with known fracturing patterns and characteristics. The resulting detached flakes are of a predictable size and shape (Ahler 1989:89). However, it must be acknowledged that all reduction stages produce small flakes and therefore there will most always be more of the smaller flakes than there will be larger flakes in an assemblage; be it either experimental or from the archaeological record (Henry et al. 1976:59-60). Simple physics states that we can expect larger flakes to weigh more than smaller flakes when struck from the same raw materials (Figure 3.24). Because of this, a size distribution based on total weight (proportionally) across the size grades will show size differences that may not be seen in just the size graded flake count (Ahler 1989:90). So a combined analysis of the size variations by both relative weights across the size grades as well as relative counts across the size grades was performed. Results of the aggregate analysis support the statement that the resulting detached flakes from a specific point(s) in the reduction sequence are of a predictable size and shape. These also will reflect the initial size of the objective pieces being worked. The data generated from the multivariate aggregate analysis infers that the vast majority of the reductive behaviors at 10CW34 were related to late stage tool production and curation activities. A comparison of the assemblage from 10CW34 was made to two experimentally generated assemblages to affirm these results. Additionally, the application load typological analysis below confirms and correlates these conclusions.

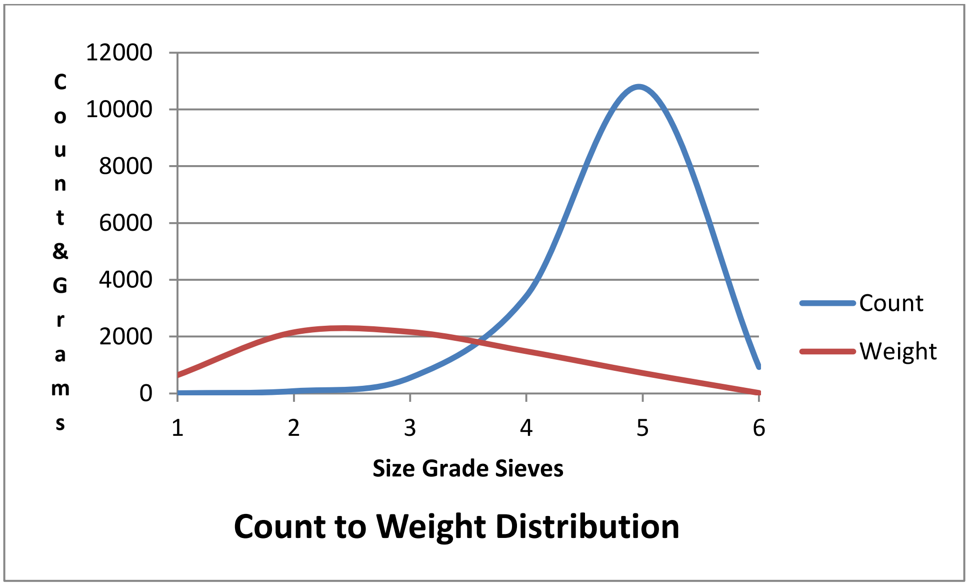


Figure 3.24 Overall count to weight distribution.

Experimental Data Comparison

The experimental data sets used as a reference for this analysis come from two different research studies. Both were performed using Knife River Flint and this is why they were chosen. The first experimental data set comes from Ahler's previously cited 1989 experimental debitage assemblage comparison to archaeological debitage assemblages. The second is from Root's 1992 Dissertation titled: *The Knife River Flint Quarries: The Organization of Stone Tool Production.* The purposes behind the experimental data sets are different, but the size-graded sieves and data collected from each is similar. Both experiments used 4 nested sieves designated size grades 1-4. Size grade #1 for both experiments were 1 inch or 25.4 mm, size grade #2 were ½ inch or 12.7 mm, size grade #3 for Ahler's experiment was 1/4 inch and Root used 5.6 mm, and size grade #4 was 1/8 inch for Ahler and 2.54 mm for Root (Ahler 1989:99; Root 1992:213). There is a slight size difference for size grades #3 and #4 between the two experiments, but these are not statistically significant. The size grade sieves used for the analysis of the 10CW34 assemblage are also similar to these with the addition of a 2" (50 mm) sieve designated #1 and a 1.7 mm sieve designated #6. The sieves designated #2 through #5 used in the 10CW34 analysis represent the size grades #1 - #4 in the experimental comparison assemblages.

The experimental data from Root 1992 comes from tables 6.1 and 6.2 (pp. 214-215). Root's experimental data was based on a quarry site and there were numerous variables that were incorporated into this data. Much of the data included hard-hammer core reduction and bipolar core reduction. These reduction strategies were considered in limited use at 10CW34 given that there is neither a quarry site nearby nor a quality source of chert in the vicinity. Additionally, Root collected data from "novice," "skilled," and "expert" knappers. The data that was selected for comparison from the Root experimental data was from three categories: Biface Thinning (skilled), Biface Edging (skilled), and Small Tool production. The data from these categories was selected as the comparison data because the reduction stages and application loads described by Root most closely matched the suspected reduction stages and application loads of the 10CW34 assemblage (Root 1992:80-83).

Ahler's experimental data (1989:Table 2) was based on experiments that started with core reduction and cobble testing through the completion of bifacial tools. The data that were selected from the Ahler experimental data was from three categories: SH Stage 3-4 Thinning, SH Stage 5 Thinning, and Pressure Stage 5 Shaping. The data from these categories was selected as the comparison data because the reduction stages and application loads described by Ahler most closely matched the suspected reduction stages and application loads of the 10CW34 assemblage (Ahler 1989:90-92).

As was previously mentioned, generating an experimental set of data for comparison to the 10CW34 assemblage would prove problematic given the many varieties and sources of chert in the assemblage. The two experimental assemblages that were chosen for this comparison were selected because they were produced from the same raw materials and the reduction stages and application loads were recorded. The analysis of the 10CW34 chert assemblage size-grading indicates that later stage reduction and curation activities generated most of the debitage. Table 3.11 and Figure 3.25 shows a comparison of the count percentages from the experimental assemblages to the similar size grade data recorded from 10CW34. The count distributions from the experimental data sets match fairly well to the 10CW34 distributions. Knowing the experimental assemblage's reduction stage and application load supports the hypothesized application loads and reduction strategies employed at 10CW34.

Assemblage Percentage: **Count**	Size Grade **#1** Experimental (#2 10CW34)	Size Grade **#2** Experimental (#3 10CW34)	Size Grade **#3** Experimental (#4 10CW34)	Size Grade **#4** Experimental (#5 10CW34)
Ahler (1989)	< 1%	2.1%	12.2%	86.1%
Root (1992)	< 1%	2.8%	18.3%	78.0%
10CW34 (Chert)	< 1%	1.8%	20.4%	77.7%

Table 3.11 Count percentage comparison of experimental data sets of Knife River Flint to the chert assemblage from10CW34.

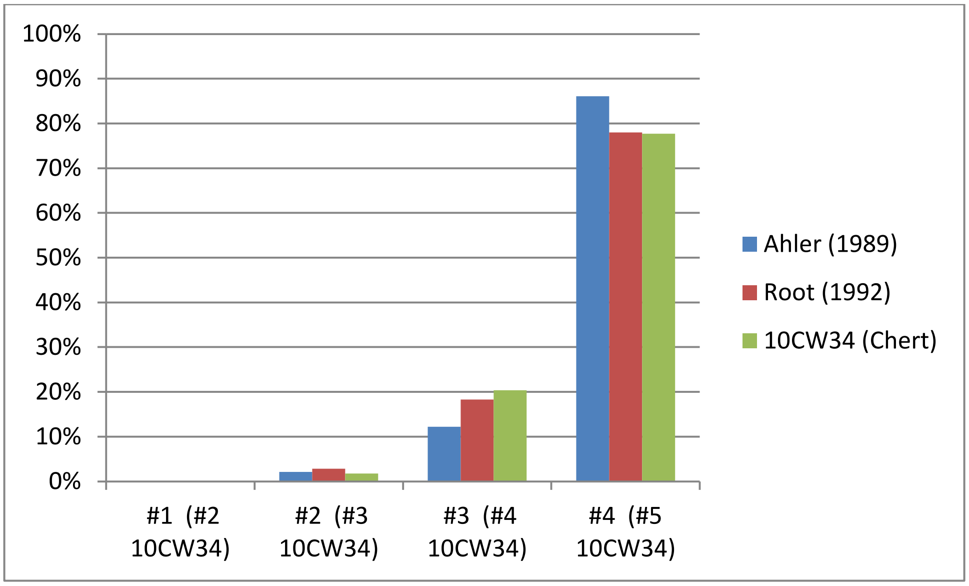


Figure 3.25 Bar chart of the experimental count size-grade distributions to 10CW34.

The weight distributions between the experimental comparative data sets and the data from 10CW34 did not match as well as the count data (Table 3.12 and Figure 3.26). There could be several reasons for the discrepancy between the experimental data sets and the 10CW34 data. Larger flakes that could have been used as expedient flakes may not have been removed from the experimental data sets as it is assumed that they were from 10CW34. Additionally, these data sets were “managed” with the intent of analyzing them when collected and size graded, so there was careful handling of the debitage from the experiments. The debitage that fell on the ground at Kelly Forks was most likely stepped upon, crushed, moved, and otherwise uncared for. It is unlikely that the prehistoric toolmakers at 10CW34 gave any thought to the future analysis of their waste flakes.

Assemblage Percentage: **Weight**	Size Grade **#1** Experimental (#2 10CW34)	Size Grade **#2** Experimental (#3 10CW34)	Size Grade **#3** Experimental (#4 10CW34)	Size Grade **#4** Experimental (#5 10CW34)
Ahler (1989)	3.6%	35.3%	42.2%	18.9%
Root (1992)	9.6%	38.6%	37.4%	14.4%
10CW34 (Chert)	1.3%	25.7%	45.0%	28.0%

Table 3.12 Weight percentage comparison of experimental data sets of Knife River Flint to the chert assemblage from10CW34.

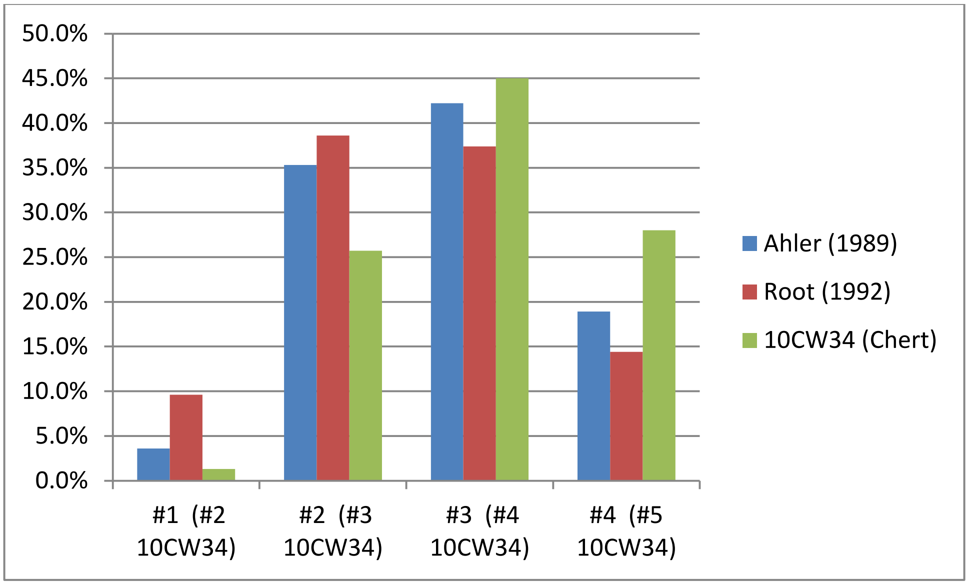


Figure 3.26 Bar chart of the experimental weight size-grade distributions to 10CW34.

Ideally, an experimental comparative collection of debitage is generated from the raw materials that make up the archaeological assemblage being studied. This gives a known and controlled comparative collection from which to make inferences about reduction strategies, site activities, and mobility strategies. In this analysis, there was no experimental data set from which to make these inferences. These comparative data sets were chosen because of the tight control with which were produced and the numerous archaeological sites where this raw material has been recovered (Root 1992:45-57).

Application Load Typological Analyses

There were three application load typologies identified within the Kelly Forks Work Center Site debitage assemblage. These were hard hammer percussive (HH), soft hammer percussive (SH), and pressure flaking with the vast majority of identified application loads falling in the soft hammer percussive and pressure flaking classification. It must be noted that there were no *bipolar* flakes identified in the assemblage of raw materials that are known to conchoidally fracture (argillite, basalt, chert, obsidian, QC, and vitrophyre). However, it is most likely that some cobble flakes and tools from 10CW34 were produced using this technology given the density and fracture characteristics of the metamorphic cobble in the assemblage.

The methods, identified attributes, and observations used to determine the application load and therefore the indenter used to detach those flakes have already been discussed and will not be reiterated here. Of the 15,763 flakes in the assemblage, 6,599 (42%) were identified as diagnostic. Table 3.13 identifies the diagnostic flake distribution and the application loads within each size grade. The distribution of the application loads supports the statement that the manner and placement of the application load (ex. soft hammer percussion vs. applied pressure) produces predictable variations in the resulting detached flakes size and shape (Ahler 1989:89; Sappington 2016b). This statement is statistically supported by the two-tailed T-tests and the analysis of variance (ANOVA) tests performed on the assemblage. The diagnostic flakes identified in the size grades is what is to be expected from a site where the majority of the reduction activities are related to late stage reduction, SH margin shaping, pressure margin shaping (margin retouch), and tool curation.

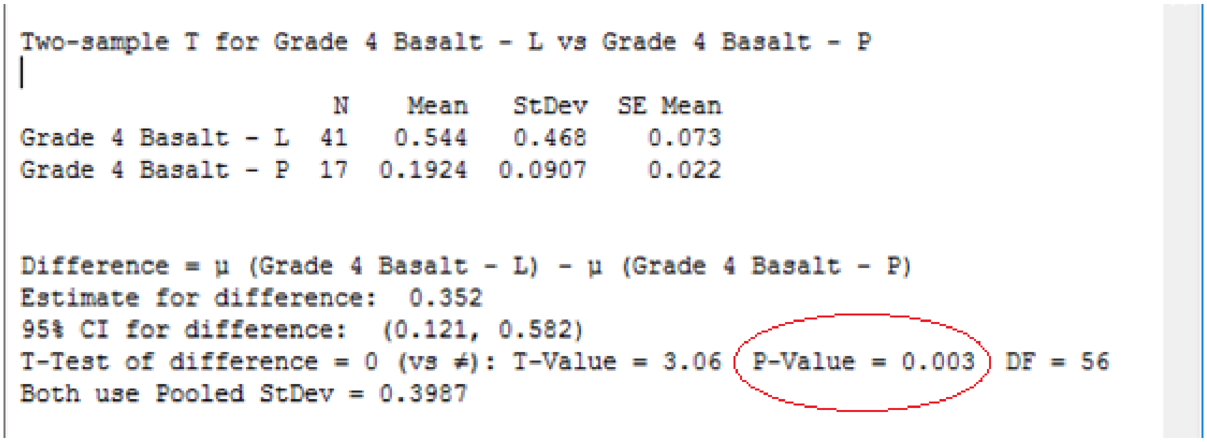
Sieves	Diagnostic	SH Percussion	Pressure	Percentage
Size Grade #1: (>50 mm)	0	0	0	0.00%
Size Grade #2: (>25.4 mm)	6	6	0	0.09%
Size Grade #3: (>12.5 mm)	140	135	5	2.12%
Size Grade #4: (>6.3 mm)	1206	860	346	18.28%
Size Grade #5: (>3.35 mm)	4867	1351	3516	73.75%
Size Grade #6: (>1.7 mm)	380	18	362	5.76%
Total	6599	2370	4229	

Table 3.13 Diagnostic flake distribution and application load in the size-graded sieves.

The statistical analyses for this thesis were conducted using the “Minitab” statistical software platform under the guidance and tutelage of James L. Polito, holder of a “Six Sigma Black Belt” in statistical analyses. The determination of which statistical analysis best suited this research comes from VanPool and Leonard’s *Quantitative Analysis in Archaeology* (2011:109-129, 153-161).

Two Tailed T-Tests. The first of the statistical tests of the application typological analysis consisted of a two-tailed T-test to test the hypothesis that SH flakes will generally be thicker because of the non-marginal detachment point and will therefore weigh more than pressure flakes (Ahler 1989:91). These T-tests were conducted to determine if there was a statistically significant difference between the weights of those flakes identified as soft hammer percussive (L) and pressure (P) flakes within the same size grading. The confidence interval for these tests was 95%. Data points were selected randomly from the raw material size grading’s that contained either flakes identified as soft hammer percussion (L) or pressure (P). The results of the two-tailed T-tests are shown in Figures 3.27 through 3.32 below.

Exhibit #1 – Grade #4 Basalt: P-value = 0. 003 < 0.05; **Samples are statistically different**



```
Two-sample T for Grade 4 Basalt - L vs Grade 4 Basalt - P

                     N    Mean    StDev  SE Mean
Grade 4 Basalt - L  41   0.544    0.468    0.073
Grade 4 Basalt - P  17  0.1924   0.0907    0.022


Difference = μ (Grade 4 Basalt - L) - μ (Grade 4 Basalt - P)
Estimate for difference:  0.352
95% CI for difference:  (0.121, 0.582)
T-Test of difference = 0 (vs ≠): T-Value = 3.06  P-Value = 0.003  DF = 56
Both use Pooled StDev = 0.3987
```

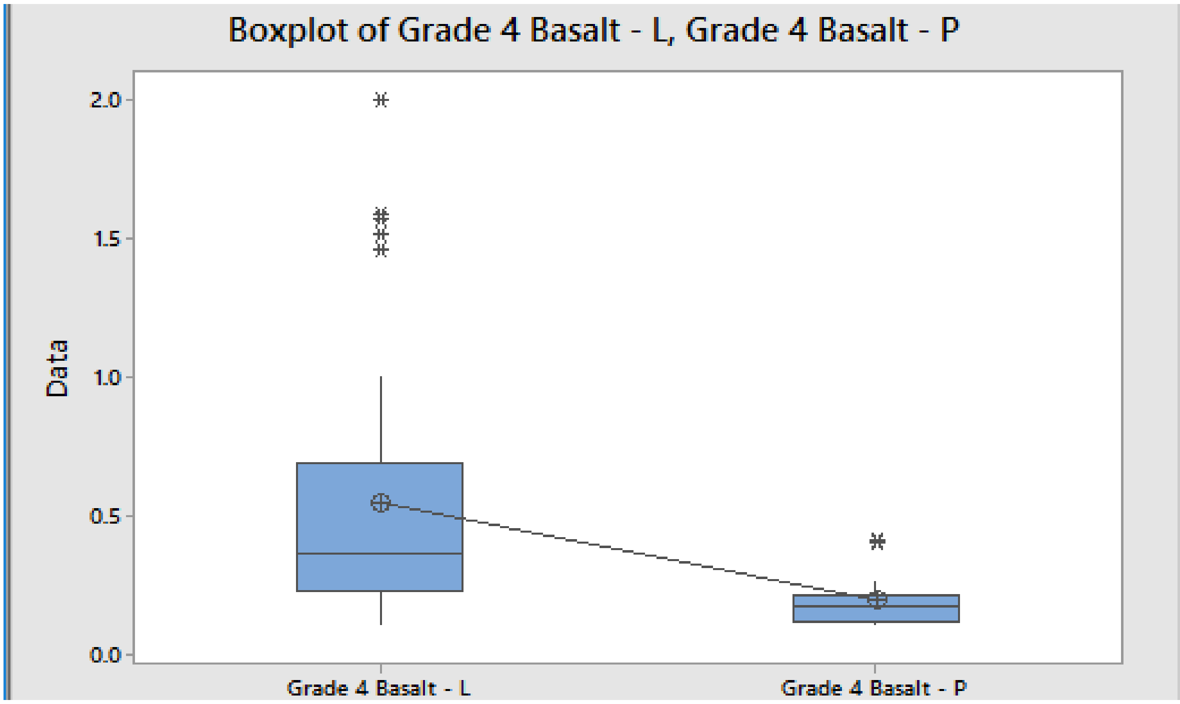
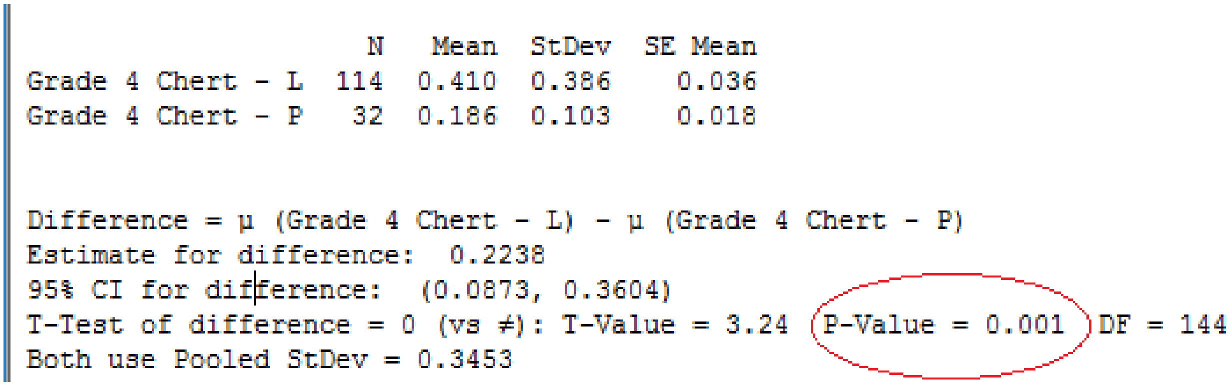


Figure 3.27 Box plot of two tailed T-test of sieve #4 basalt SH (L) and pressure (P) flakes.

Exhibit #2 – Grade #4 Chert: P-value = 0.001 < 0.05;

Samples are statistically different



```
                    N    Mean   StDev  SE Mean
Grade 4 Chert - L  114  0.410  0.386    0.036
Grade 4 Chert - P   32  0.186  0.103    0.018


Difference = μ (Grade 4 Chert - L) - μ (Grade 4 Chert - P)
Estimate for difference:  0.2238
95% CI for difference:  (0.0873, 0.3604)
T-Test of difference = 0 (vs ≠): T-Value = 3.24  P-Value = 0.001  DF = 144
Both use Pooled StDev = 0.3453
```

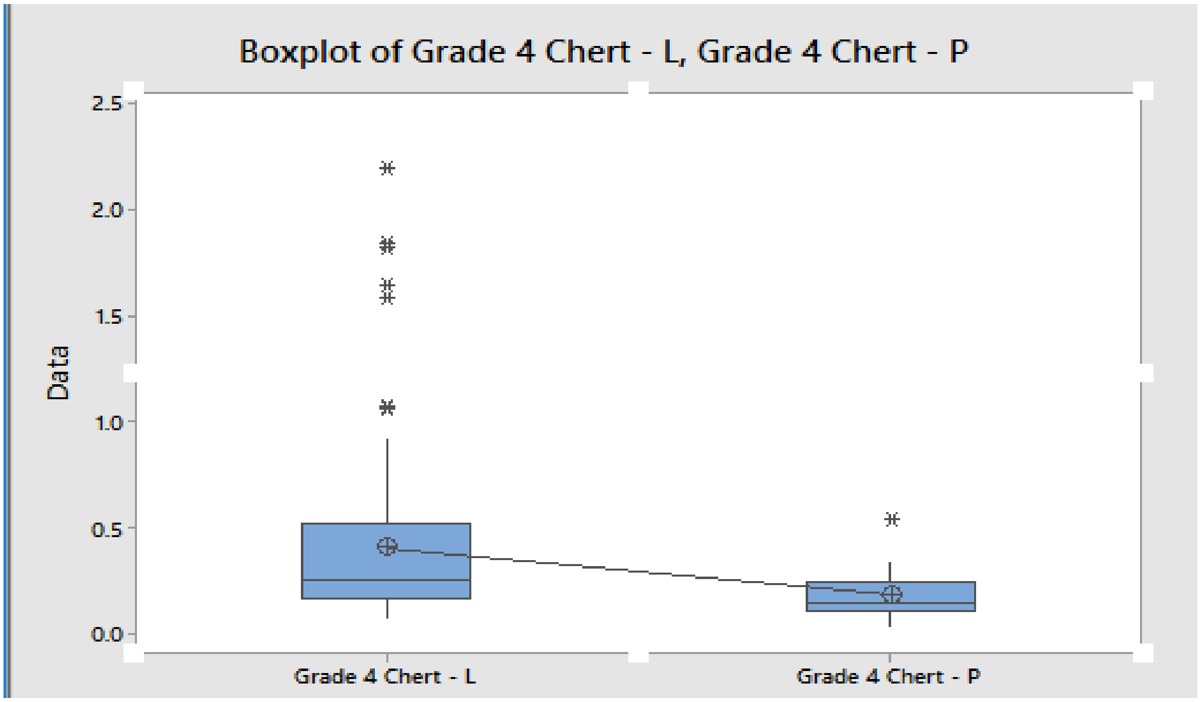
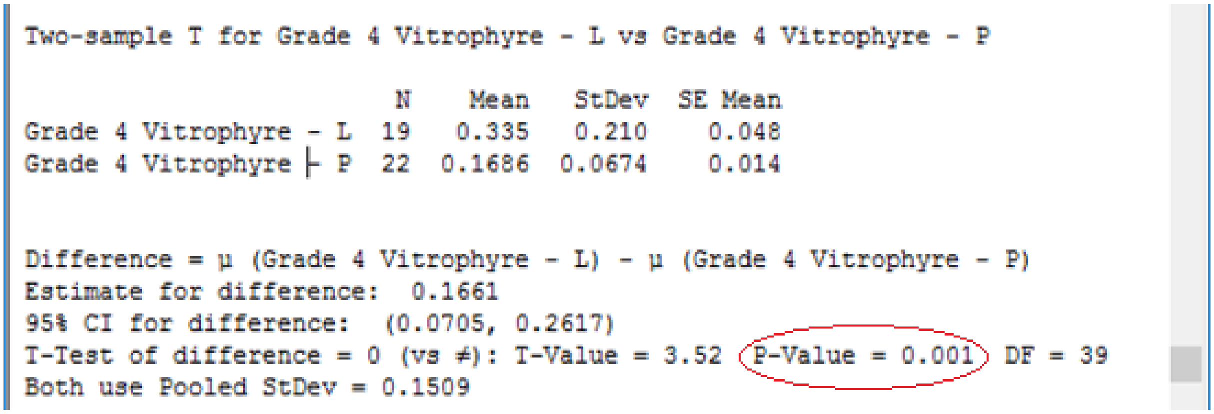


Figure 3.28 Box plot of two tailed T-test of sieve #4 chert SH (L) and pressure (P) flakes.

Exhibit # 3 Grade #4 - Vitrophyre: P-value = 0. 001 < 0.05;

Samples are statistically different



```
Two-sample T for Grade 4 Vitrophyre - L vs Grade 4 Vitrophyre - P

                         N    Mean   StDev  SE Mean
Grade 4 Vitrophyre - L  19   0.335   0.210    0.048
Grade 4 Vitrophyre - P  22  0.1686  0.0674    0.014


Difference = µ (Grade 4 Vitrophyre - L) - µ (Grade 4 Vitrophyre - P)
Estimate for difference:  0.1661
95% CI for difference:  (0.0705, 0.2617)
T-Test of difference = 0 (vs ≠): T-Value = 3.52  P-Value = 0.001  DF = 39
Both use Pooled StDev = 0.1509
```

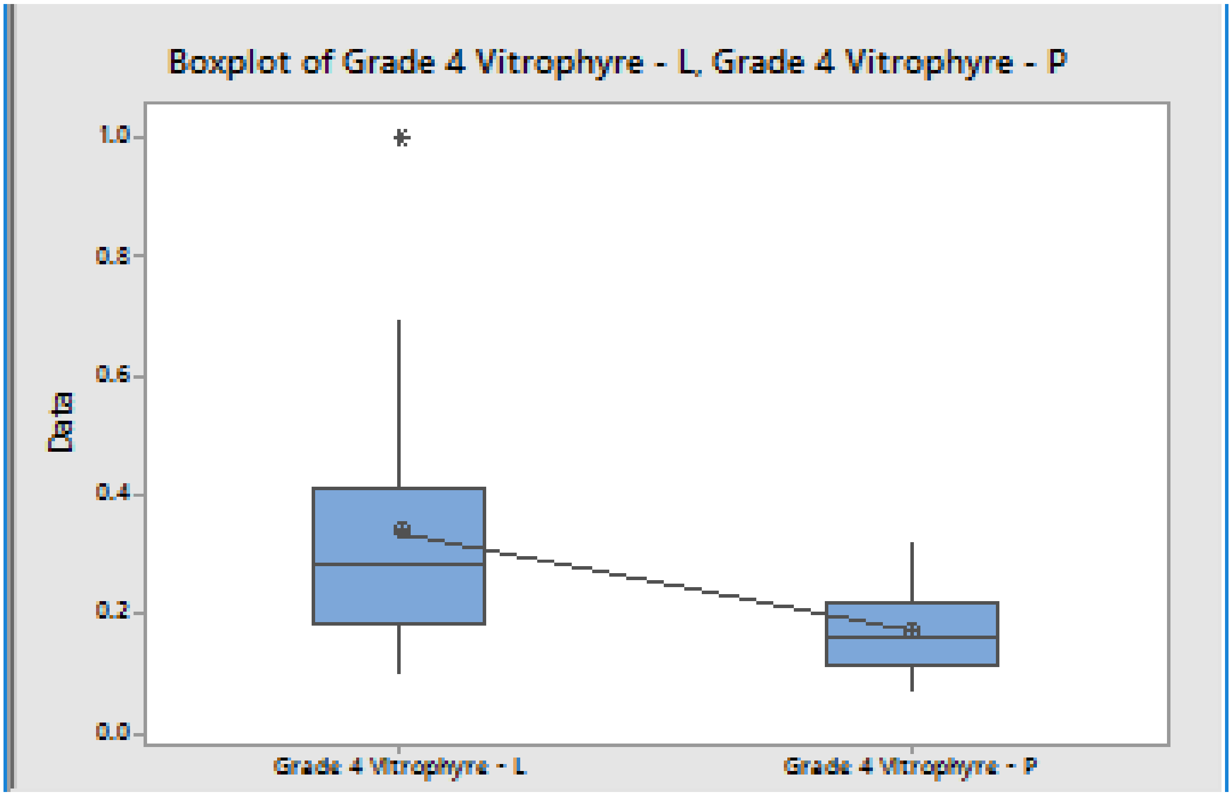
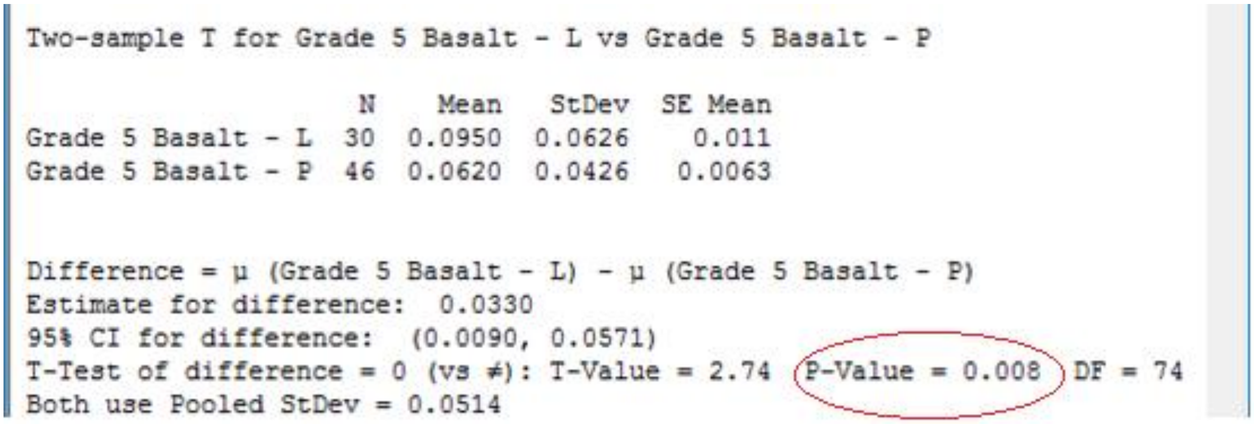


Figure 3.29 Box plot of two tailed T-test of sieve #4 vitrophyre SH (L) and pressure (P) flakes.

Exhibit #4 – Grade #5 Basalt: P-value = 0.008 < 0.05;

Samples are statistically different



```
Two-sample T for Grade 5 Basalt - L vs Grade 5 Basalt - P

                    N    Mean   StDev  SE Mean
Grade 5 Basalt - L  30  0.0950  0.0626    0.011
Grade 5 Basalt - P  46  0.0620  0.0426   0.0063


Difference = μ (Grade 5 Basalt - L) - μ (Grade 5 Basalt - P)
Estimate for difference:  0.0330
95% CI for difference:  (0.0090, 0.0571)
T-Test of difference = 0 (vs ≠): T-Value = 2.74  P-Value = 0.008  DF = 74
Both use Pooled StDev = 0.0514
```

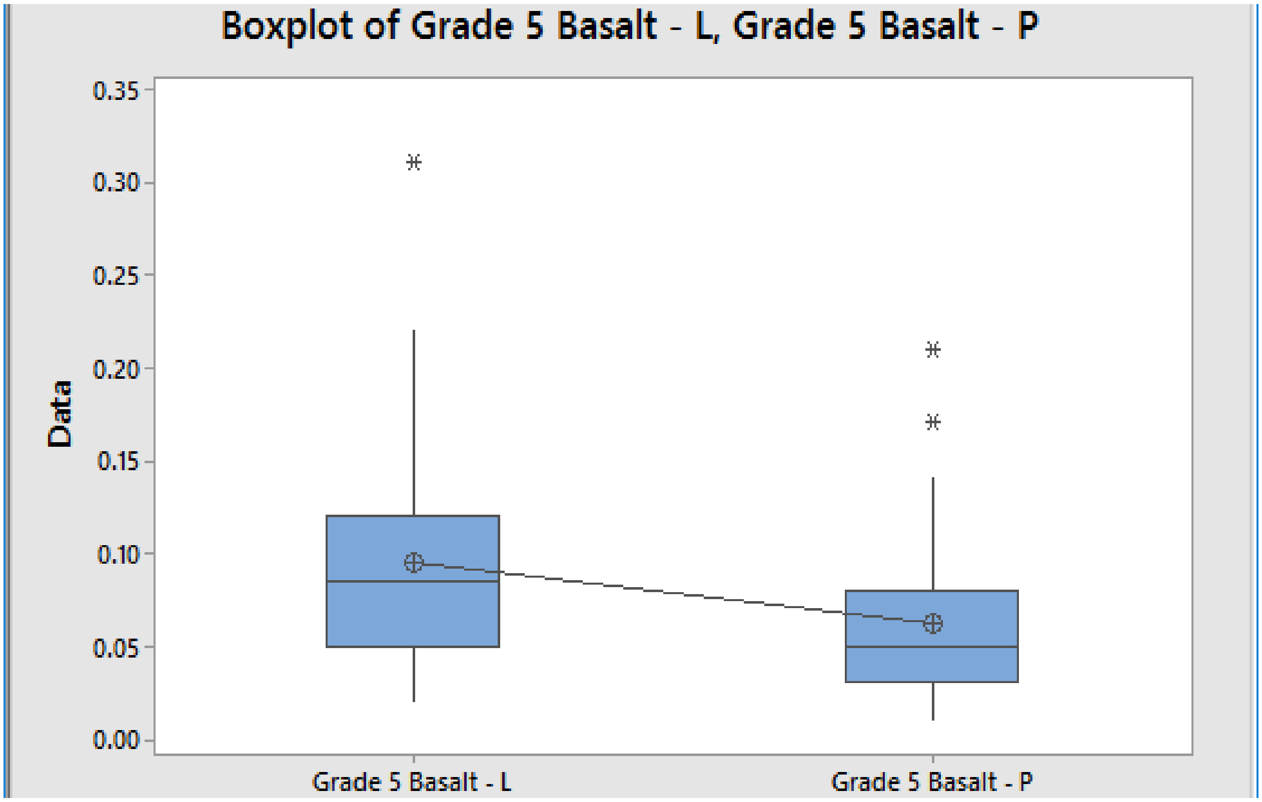
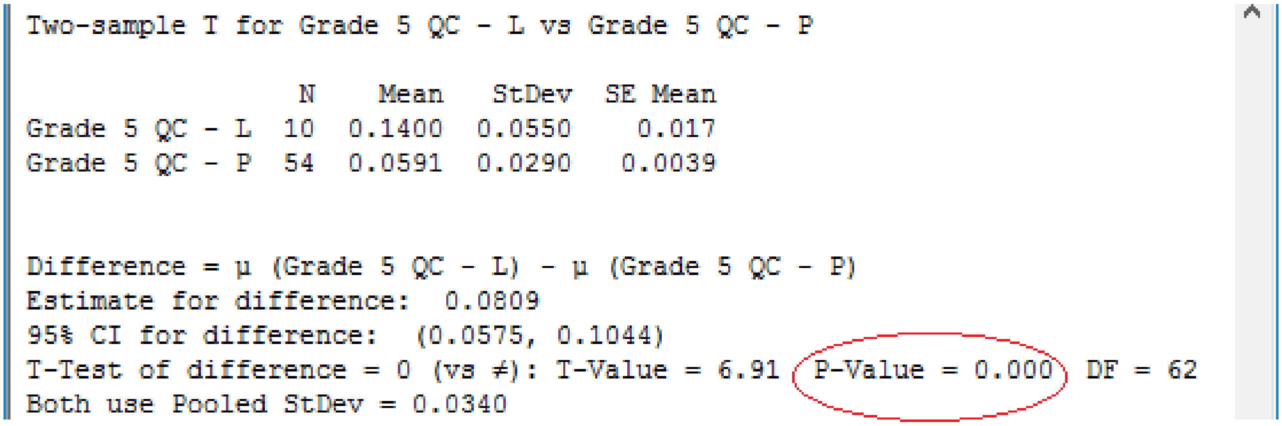


Figure 3.30 Box plot of two tailed T-test of sieve #5 basalt SH (L) and pressure (P) flakes.

Exhibit #5 – Grade #5 QC: P-value = 0. 000 < 0.05;

Samples are statistically different



```
Two-sample T for Grade 5 QC - L vs Grade 5 QC - P

                  N    Mean   StDev  SE Mean
Grade 5 QC - L   10  0.1400  0.0550    0.017
Grade 5 QC - P   54  0.0591  0.0290   0.0039


Difference = μ (Grade 5 QC - L) - μ (Grade 5 QC - P)
Estimate for difference:  0.0809
95% CI for difference:  (0.0575, 0.1044)
T-Test of difference = 0 (vs ≠): T-Value = 6.91  P-Value = 0.000  DF = 62
Both use Pooled StDev = 0.0340
```

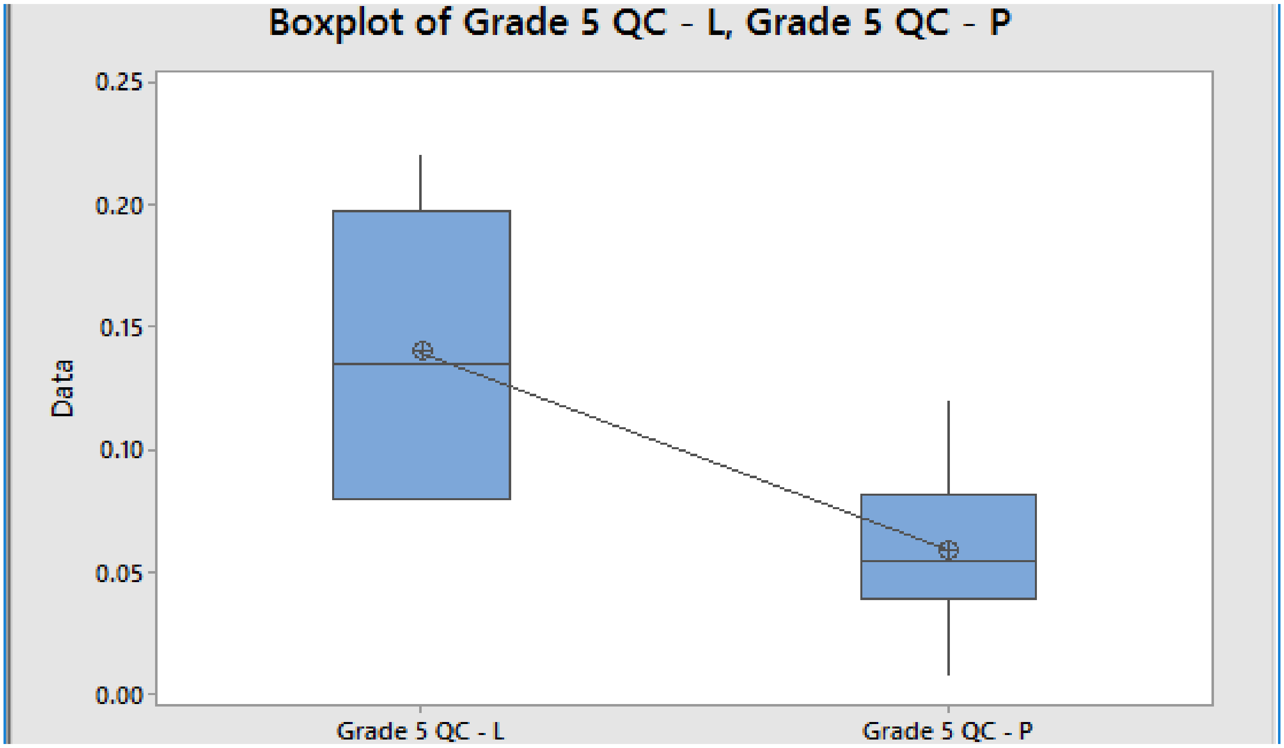
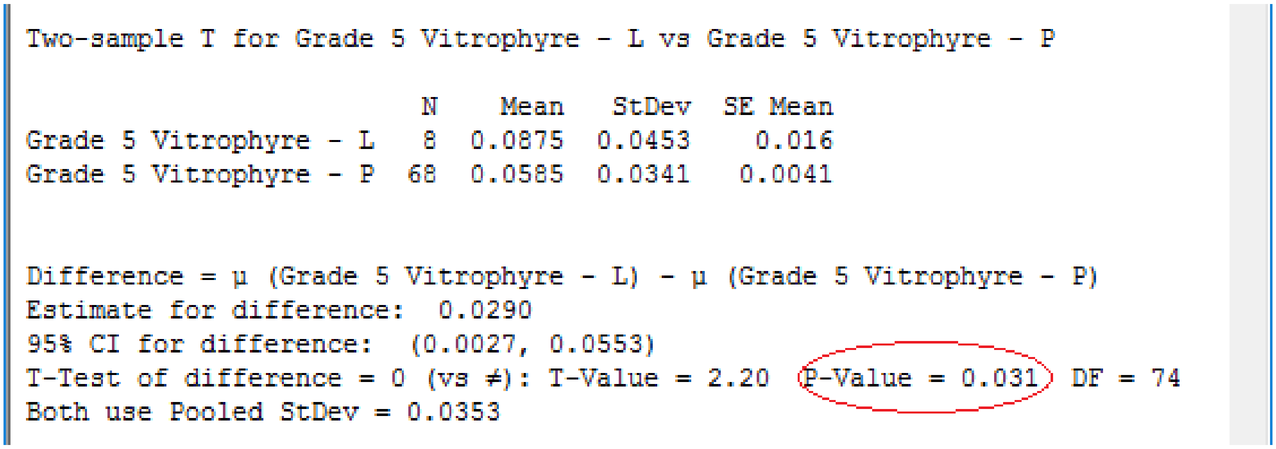


Figure 3.31 Box plot of two tailed T-test of sieve #5 QC SH (L) and pressure (P) flakes.

Exhibit # 6 - Grade #5 - Vitrophyre: P-value = 0.031 < 0.05; **Samples are statistically different**



```
Two-sample T for Grade 5 Vitrophyre - L vs Grade 5 Vitrophyre - P

                          N    Mean   StDev  SE Mean
Grade 5 Vitrophyre - L    8  0.0875  0.0453    0.016
Grade 5 Vitrophyre - P   68  0.0585  0.0341   0.0041


Difference = µ (Grade 5 Vitrophyre - L) - µ (Grade 5 Vitrophyre - P)
Estimate for difference:  0.0290
95% CI for difference:  (0.0027, 0.0553)
T-Test of difference = 0 (vs ≠): T-Value = 2.20  P-Value = 0.031  DF = 74
Both use Pooled StDev = 0.0353
```

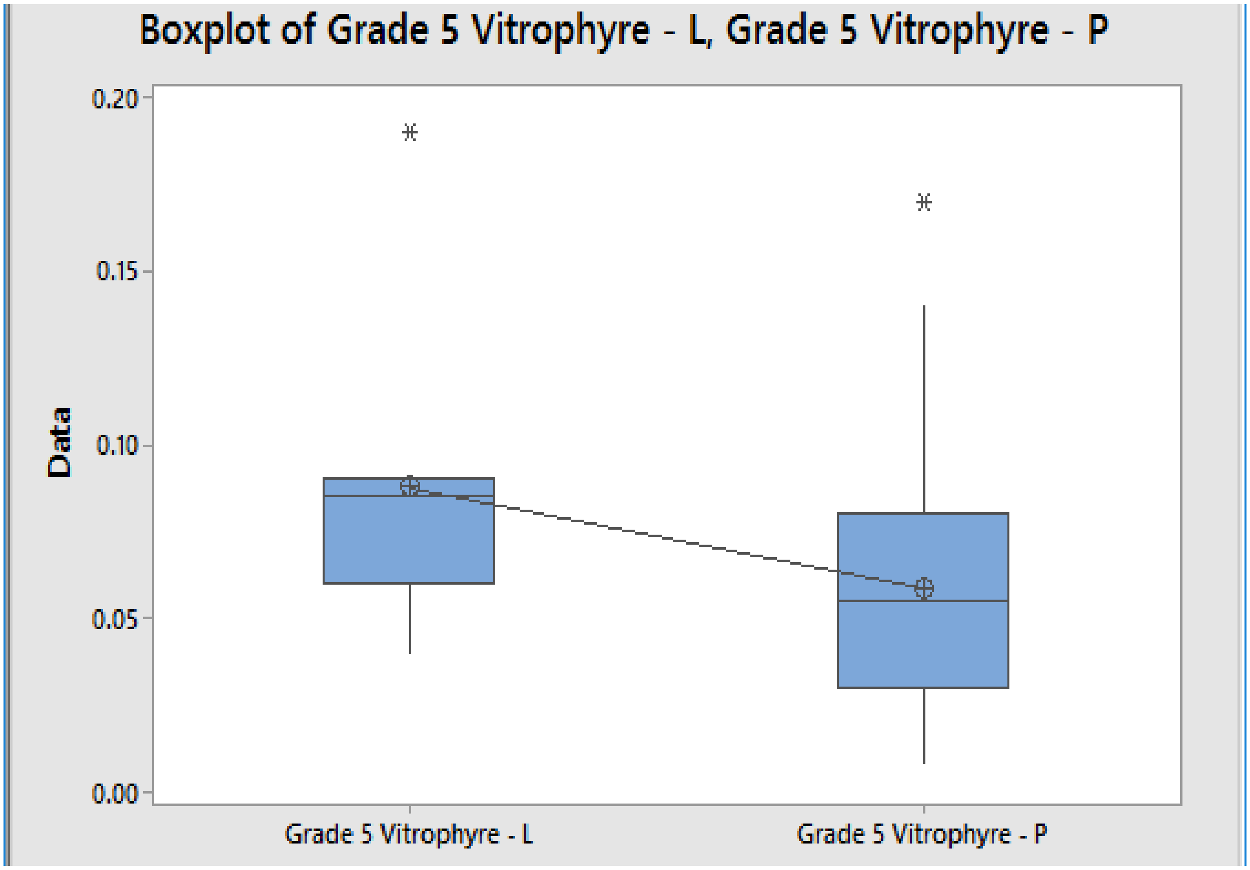


Figure 3.32 Box plot of two tailed T-test of sieve #5 vitrophyre SH (L) and pressure (P) flakes.

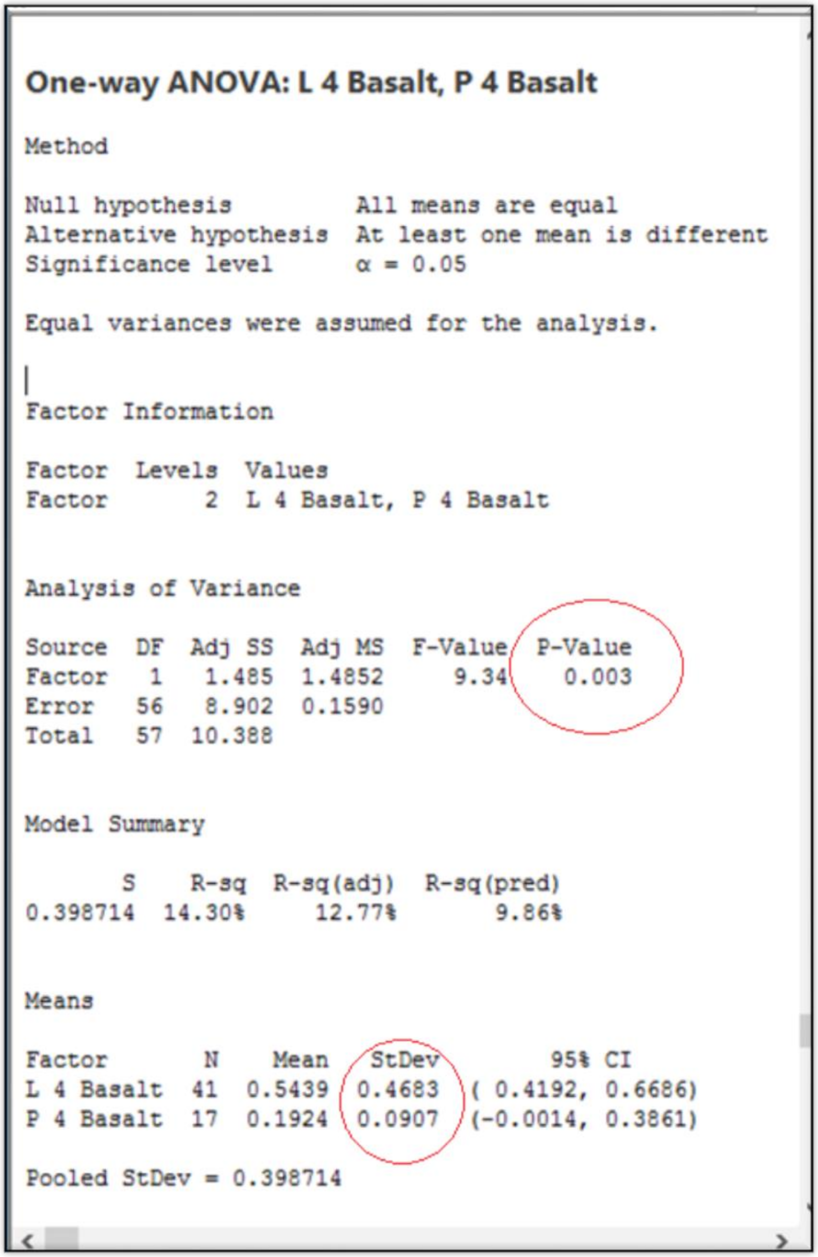
The two tailed T-tests above confirm that there is a significant statistical difference in the weights of soft hammer percussive flakes and pressure flakes that were gathered in the same size grades. This test lends validity to the methodologies employed and also the author’s ability to distinguish between the attributes associated with soft hammer percussion and pressure flaking.

ANOVA. The second of the statistical tests of the application typological analysis consisted of an analysis of variance test or ANOVA. As the name implies, this process tests the variance of the two variables (L and P) and compares these variances to see if there is a significant statistical difference in their standard deviation. Because of the controlled nature of the pressure flake as compared to the relative randomness of the soft hammer percussive flake, one would expect more variance in those flakes identified as SH flakes. The mechanisms that detach a pressure flakes are much more controlled than the detachment of a SH flake. Pressure indenters are placed precisely where they are intended to detach the flake and a more controlled amount of force is applied. Additionally, if a dorsal ridge is the focal point of an applied pressure indenter, the resulting detached flakes will be similarly sized from similarly sized objective pieces. In contrast, SH percussion does not always strike where the manufacturer intended and the resulting detached flakes will have more variance than the controlled pressure detached flake.

The ANOVA tests that were conducted supports the hypothesis and the results statistically show that SH flakes normally show more variance in their standard deviation with respect to weight (and thus shape) within a size grade. The confidence interval for these tests was 95%. The results of the ANOVA tests are shown in Figures 3.33 through 3.38.

Exhibit #1 – Grade #4 Basalt: P-value = 0. 003 < 0.05;

Standard deviation (St. Dev.) of L4 Basalt is greater than 5 times the St. Dev. for P4 Basalt

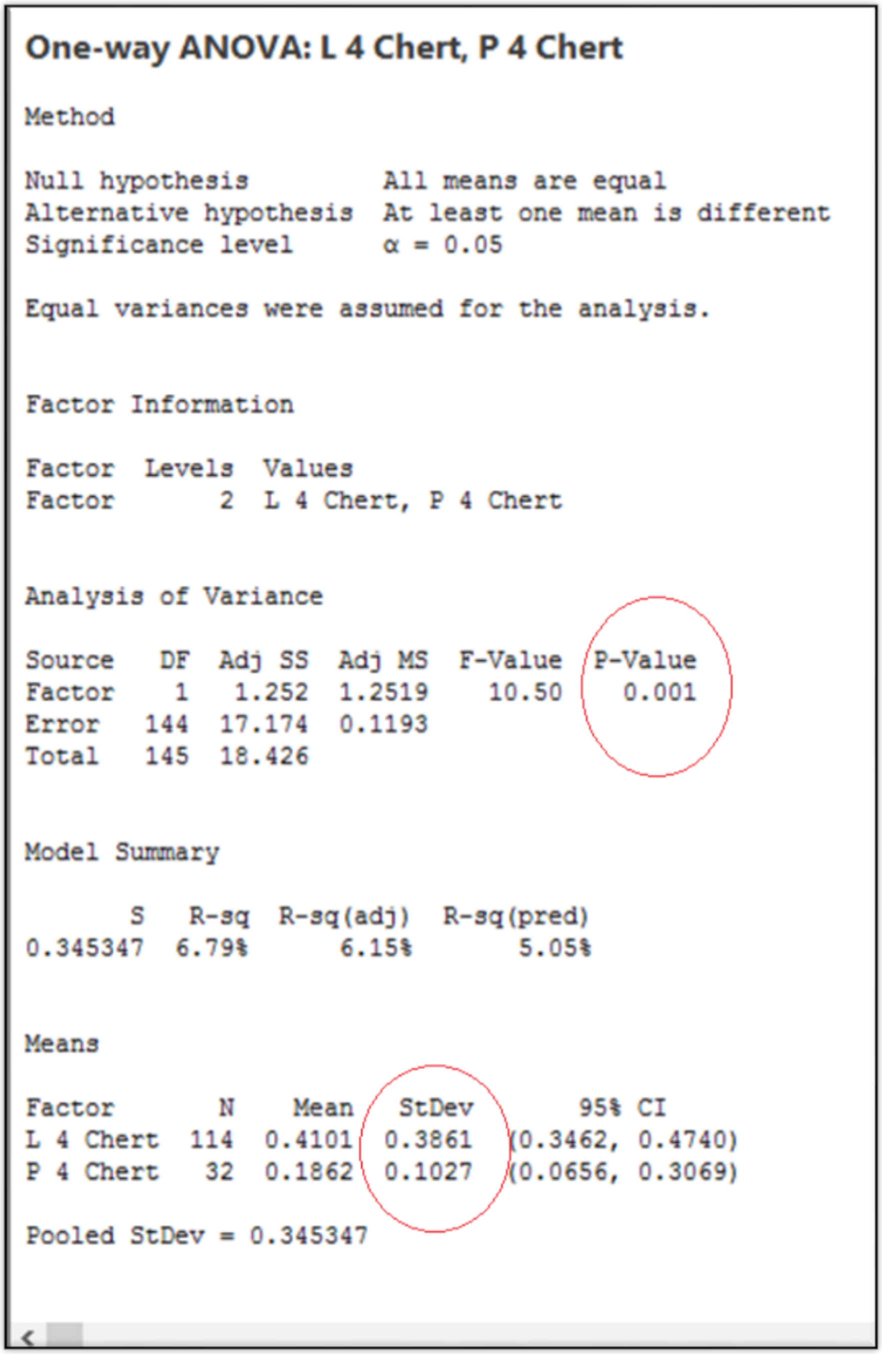


```
One-way ANOVA: L 4 Basalt, P 4 Basalt

Method

Null hypothesis          All means are equal
Alternative hypothesis   At least one mean is different
Significance level       α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 4 Basalt, P 4 Basalt


Analysis of Variance

Source  DF  Adj SS  Adj MS  F-Value  P-Value
Factor   1   1.485  1.4852     9.34    0.003
Error   56   8.902  0.1590
Total   57  10.388


Model Summary

       S    R-sq  R-sq(adj)  R-sq(pred)
0.398714  14.30%     12.77%       9.86%


Means

Factor       N    Mean   StDev        95% CI
L 4 Basalt  41  0.5439  0.4683  ( 0.4192, 0.6686)
P 4 Basalt  17  0.1924  0.0907  (-0.0014, 0.3861)

Pooled StDev = 0.398714
```

Figure 3.33 ANOVA tests of #4 basalt SH (L) and pressure (P) flakes.

Exhibit #2 – Grade #4 Chert: P-value = 0.001 < 0.05;

Standard deviation (St. Dev.) of L4 Chert is **greater than 3 times** the St. Dev. for P4 Chert



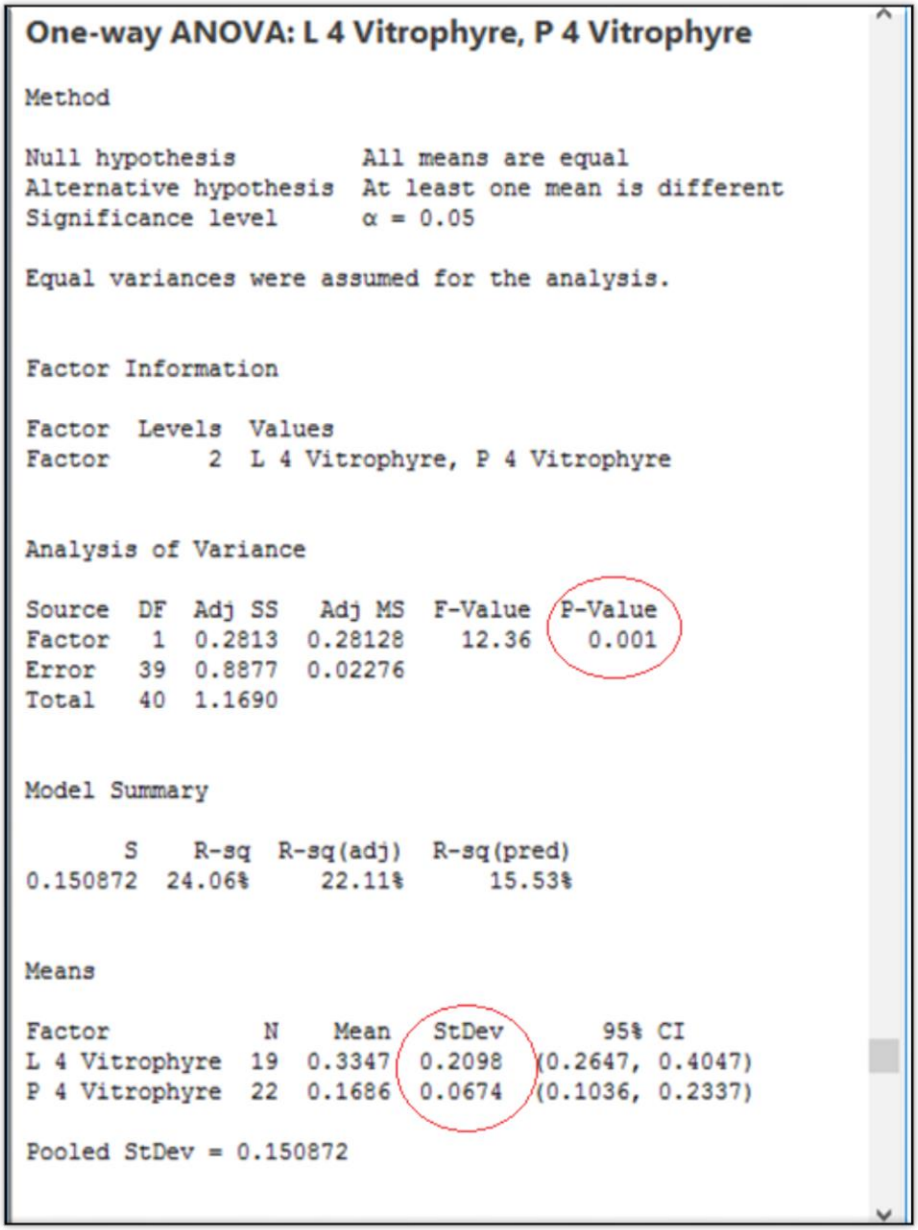
One-way ANOVA: L 4 Chert, P 4 Chert

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 4 Chert, P 4 Chert


Analysis of Variance

Source   DF  Adj SS  Adj MS  F-Value  P-Value
Factor    1   1.252  1.2519    10.50    0.001
Error   144  17.174  0.1193
Total   145  18.426


Model Summary

       S   R-sq  R-sq(adj)  R-sq(pred)
0.345347  6.79%      6.15%       5.05%


Means

Factor       N    Mean  StDev       95% CI
L 4 Chert  114  0.4101  0.3861  (0.3462, 0.4740)
P 4 Chert   32  0.1862  0.1027  (0.0656, 0.3069)

Pooled StDev = 0.345347
```

Figure 3.34 ANOVA tests of #4 chert SH (L) and pressure (P) flakes.

Exhibit # 3 - Grade #4 - Vitrophyre: P-value = 0. 001 < 0.05;

Standard deviation (St. Dev.) of L 4 Vitrophyre **is greater than 3 times** the St. Dev. for P 4.

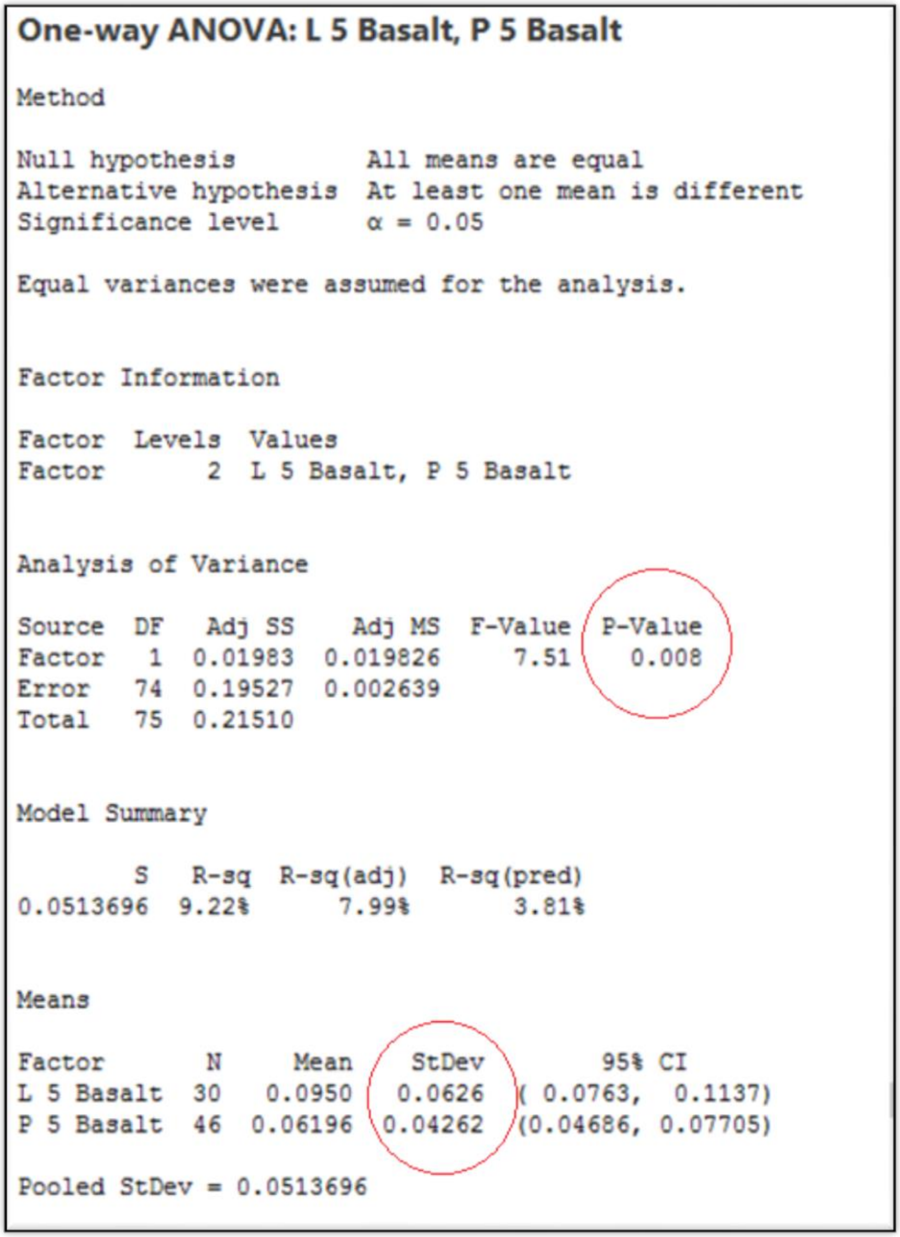


```
One-way ANOVA: L 4 Vitrophyre, P 4 Vitrophyre

Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 4 Vitrophyre, P 4 Vitrophyre


Analysis of Variance

Source  DF  Adj SS   Adj MS  F-Value  P-Value
Factor   1  0.2813  0.28128    12.36    0.001
Error   39  0.8877  0.02276
Total   40  1.1690


Model Summary

       S    R-sq  R-sq(adj)  R-sq(pred)
0.150872  24.06%     22.11%      15.53%


Means

Factor           N    Mean   StDev       95% CI
L 4 Vitrophyre  19  0.3347  0.2098  (0.2647, 0.4047)
P 4 Vitrophyre  22  0.1686  0.0674  (0.1036, 0.2337)

Pooled StDev = 0.150872
```

Figure 3.35 ANOVA tests of #4 vitrophyre SH (L) and pressure (P) flakes.

Exhibit #4 – Grade #5 Basalt: P-value = 0.008 < 0.05;

Standard deviation of L 5 Basalt **is about 50% greater** than the Std. Dev. for P 5 Basalt.

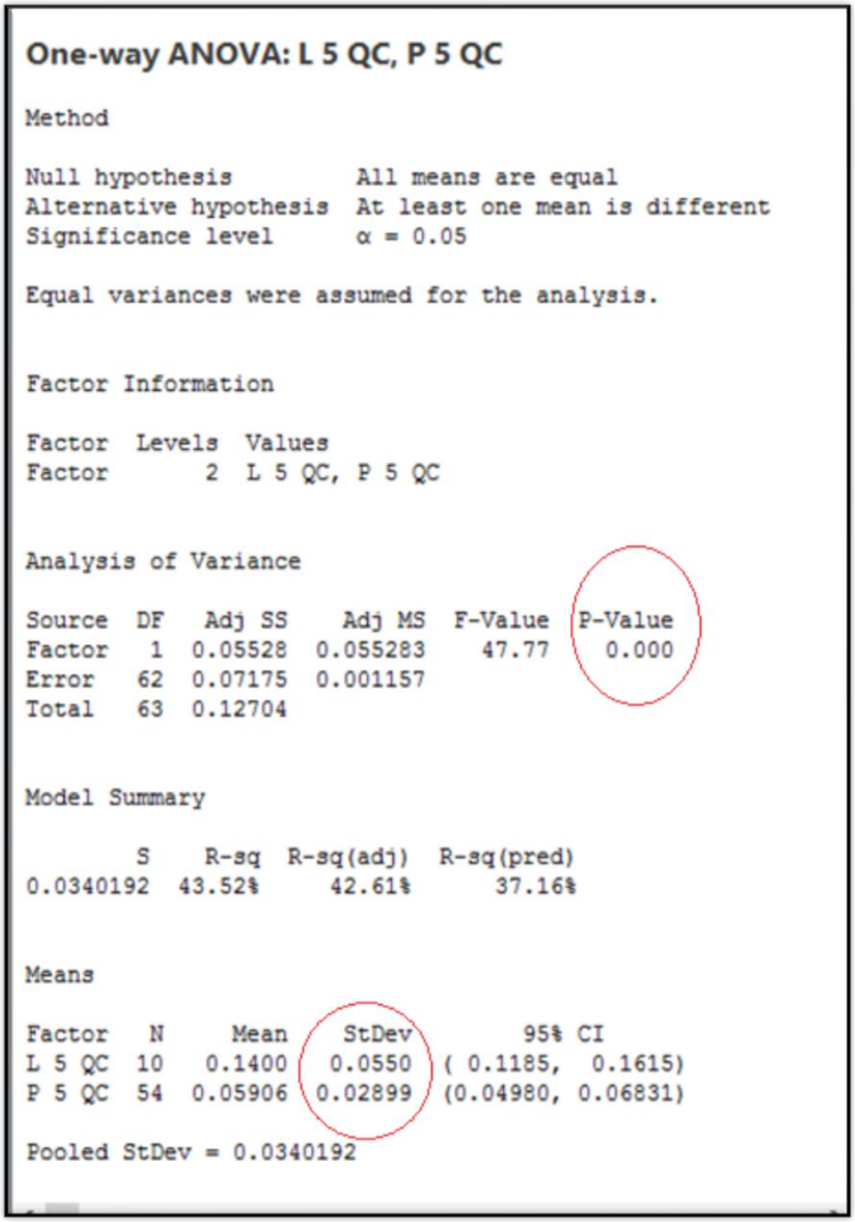


```
One-way ANOVA: L 5 Basalt, P 5 Basalt

Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 5 Basalt, P 5 Basalt


Analysis of Variance

Source  DF   Adj SS    Adj MS  F-Value  P-Value
Factor   1  0.01983  0.019826     7.51    0.008
Error   74  0.19527  0.002639
Total   75  0.21510


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0.0513696  9.22%      7.99%       3.81%


Means

Factor       N     Mean    StDev         95% CI
L 5 Basalt  30   0.0950   0.0626  ( 0.0763,  0.1137)
P 5 Basalt  46  0.06196  0.04262  (0.04686, 0.07705)

Pooled StDev = 0.0513696
```

Figure 3.36 ANOVA tests of #5 basalt SH (L) and pressure (P) flakes.

Exhibit #5 – Grade #5 QC: P-value = 0. 000 < 0.05;

Standard deviation (St. Dev.) of L 5 QC is **nearly 2 times** the St. Dev. for P 5 QC



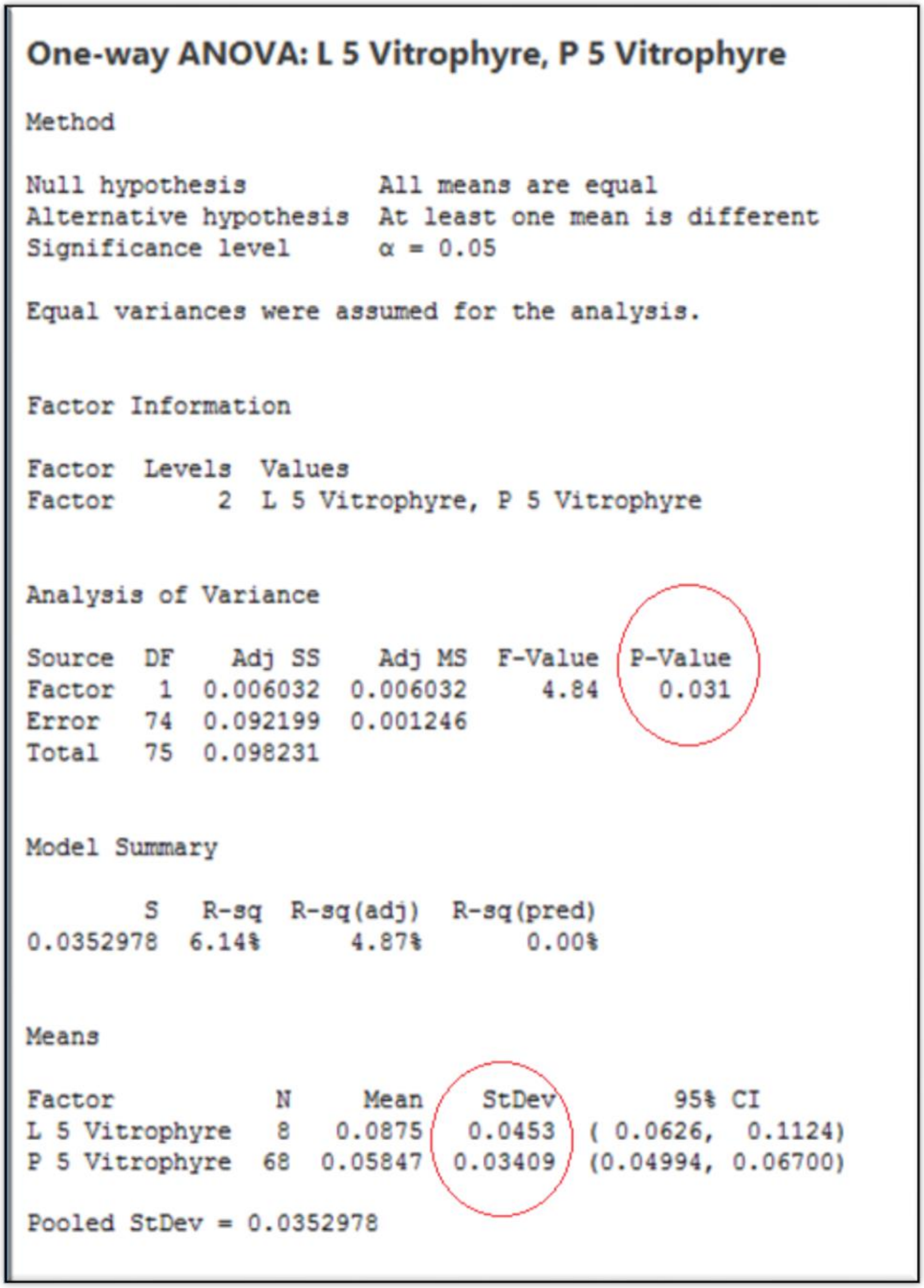
One-way ANOVA: L 5 QC, P 5 QC

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 5 QC, P 5 QC


Analysis of Variance

Source  DF   Adj SS    Adj MS  F-Value  P-Value
Factor   1  0.05528  0.055283    47.77    0.000
Error   62  0.07175  0.001157
Total   63  0.12704


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0.0340192  43.52%     42.61%      37.16%


Means

Factor   N     Mean    StDev        95% CI
L 5 QC  10   0.1400   0.0550  ( 0.1185,  0.1615)
P 5 QC  54  0.05906  0.02899  (0.04980, 0.06831)

Pooled StDev = 0.0340192
```

Figure 3.37 ANOVA tests of #5 QC SH (L) and pressure (P) flakes.

Exhibit # 6 - Grade #5 - Vitrophyre: P-value = 0.031 < 0.05;

Standard deviation of L5 Vitrophyre is **33% greater than** the Std. Dev. for P5 Vitrophyre.



One-way ANOVA: L 5 Vitrophyre, P 5 Vitrophyre

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       2  L 5 Vitrophyre, P 5 Vitrophyre


Analysis of Variance

Source  DF    Adj SS    Adj MS  F-Value  P-Value
Factor   1  0.006032  0.006032     4.84    0.031
Error   74  0.092199  0.001246
Total   75  0.098231


Model Summary

        S    R-sq  R-sq(adj)  R-sq(pred)
0.0352978  6.14%      4.87%       0.00%


Means

Factor           N     Mean    StDev        95% CI
L 5 Vitrophyre   8   0.0875   0.0453  ( 0.0626,  0.1124)
P 5 Vitrophyre  68  0.05847  0.03409  (0.04994, 0.06700)

Pooled StDev = 0.0352978
```

Figure 3.38 ANOVA tests of #5 vitrophyre SH (L) and pressure (P) flakes.

The ANOVA analysis of the samples above support the hypothesis that there will be greater variance in the standard deviation of the SH flakes than those of the pressure detached flakes. This is due to the less precise nature of the application load of the soft hammer percussion and therefore the size and weight of the flakes is not as controlled resulting in greater variance. This test lends validity to the methodologies employed and also the author’s ability to distinguish between the attributes associated with soft hammer percussion and pressure flaking.

The application load typological analysis supports the data generated from the multivariate aggregate analysis in that the identified diagnostic flakes fall into the category of soft hammer edge shaping and pressure edge shaping. Both of these reductive actions will produce intentionally smaller flakes and these will be collected in the smaller sized sieves. The combined use of the two methodologies supports the theoretical basis for the methods and their use in the analyses of the assemblage. The multivariate aggregate methodology separates and sorts the resulting detached flakes by size. This reflects the reductive nature of stone tool manufacture. The application load typological analysis examines the detached flakes for evidence of the application load that was applied to remove it. These observations infer the manner in which the flake was detached from the objective piece. Both of these methodologies complement each other and the resulting data generated reflect this correlation between the physical laws and the methodologies utilized.

Chapter 4:

Lithic Sourcing at 10CW34

The raw materials from which the objective pieces are made of (and subsequent debitage scatters) are diagnostic when inferring mobility, exchange, and site catchment (Odell 2004:196). Therefore, recognizing and recording the raw materials with knowledge of local and regional sources and quarries are critical when making these inferences. The sourcing of these raw materials has proven a valuable tool when analyzing the behaviors associated with mobility and exchange and the prehistoric use of the regional tool stone geography (Ozbun 2015:2).

The lithic technological organization of prehistoric hunting, foraging, and gathering communities was likely a factor to be considered in nearly all of the economic and survival decisions made on a daily basis (Andrefsky 2008:4). The procurement of raw materials and the cost of this procurement were either incorporated into the seasonal rounds of Plateau hunter-gatherers or were achieved through exchange. If these raw materials were obtained via means of exchange, then we can assume that there were inter-group social interactions. This speaks to the economic value being placed on this raw material and a determination of whether they were used for utilitarian purposes or as luxury/status indicators (Ericson 1982:147).

The sourcing of lithic raw materials requires knowledge of the geological formations of the desired stone of the region under study as well as from those regions where exotic materials are imported. Additionally, a study of the recent geomorphology of these regions can indicate potential source sites that are no longer accessible or visible (Odell 2004:41). The sourcing of lithic raw materials is accomplished by two methods: visual characterization and geochemical analysis. Visual characterization is a simple method of identification that can be done in the lab as well as in field environments. The use of low power magnification such as a hand lens can be used to identify texture, color, phenocrysts or inclusions, and other visual characteristics. These attributes can then be contrasted to those specimens from a comparative collection. The use of an ultraviolet light has also been used to compare and contrast archaeological specimens to comparative collection samples (Odell 2004:28-31).

A cursory examination of the various geochemical analysis options will be reviewed for their theoretical operation as well as their respective strengths and weaknesses. The geochemical analyses of raw materials are most often used to identify levels and presence of impurities rather than the base elements of the materials. These impurities are then matched to known lithic “signature” profiles from the area or region. When geochemical sourcing was first introduced, instruments such as the mass spectrometer were used to determine the chemical composition of lithic materials by means of ionization. The use of mass spectrometry has fallen out of favor because of the destructive nature of these processes (Sappington 2016b).

The use of non-destructive methods has improved in recent years and the instruments used to perform these analyses have become portable in some cases and have been used to source lithic artifacts *in-situ* (Bruker Sales Representative, personal communication 2012). Portable X-ray fluorescence (pXRF) is an example of this technology. X-ray fluorescence works on the principle known as Bragg’s formula. A sample is irradiated with a beam of X-rays which excites electrons in the inner orbits to higher orbits. A higher orbiting electron then falls into the place of the ejected electron and emits a photon as a result. These photons are fluorescent and the wavelength emitted is specific to an element. These elements are then identified and ratios are determined. Advantages of XRF are the portability previously mentioned, cost, and its non-destructive nature. However, one of the disadvantages of XRF is that this process only analyzes the surface of the specimen. If there is cortex, animal or plant residue, or a weathered surface, the returns will reflect these surface contaminants. Additionally, XRF cannot detect elements that have an atomic weight of less than 22 unless placed in a vacuum (Odell 2004:34-35).

Another non-destructive method of geochemical analysis is instrumental neutron activation analysis (INAA). This form of analysis inundates the sample with neutrons from a nuclear source that converts some of the elements of the sample into radioactive isotopes. These radioactive isotopes then decay at a known rate and the elements are identified and ratios are determined. This form of analysis is more precise than XRF and can analyze very small samples. Drawbacks to this method are the expense as well as those elements that have long half–lives when irradiated (Kendall and MacDonald 2015:52-53).

Samples of the obsidian and vitrophyre (n=75) debitage from the Kelly Forks Work Center Site were sourced in the Northwest Research Obsidian Studies Laboratory (NWROSL) using X-ray fluorescence. Obsidian sources in southern Idaho and central/eastern Oregon were identified with the majority of obsidian being sourced to Timber Butte in Idaho (n=25) which is ca. 150 miles-in a straight line-from the site (Figure 4.1). The vitrophyre that was identified was sourced to Montana Creek in Montana roughly 25 miles from the site (Longstaff 2013). Six out of the eleven vitrophyre samples were returned as “unidentified.” There is a vitrophyre source that was identified on the Lochsa River and some of these may have come from this area (Sappington and Carley 1987).

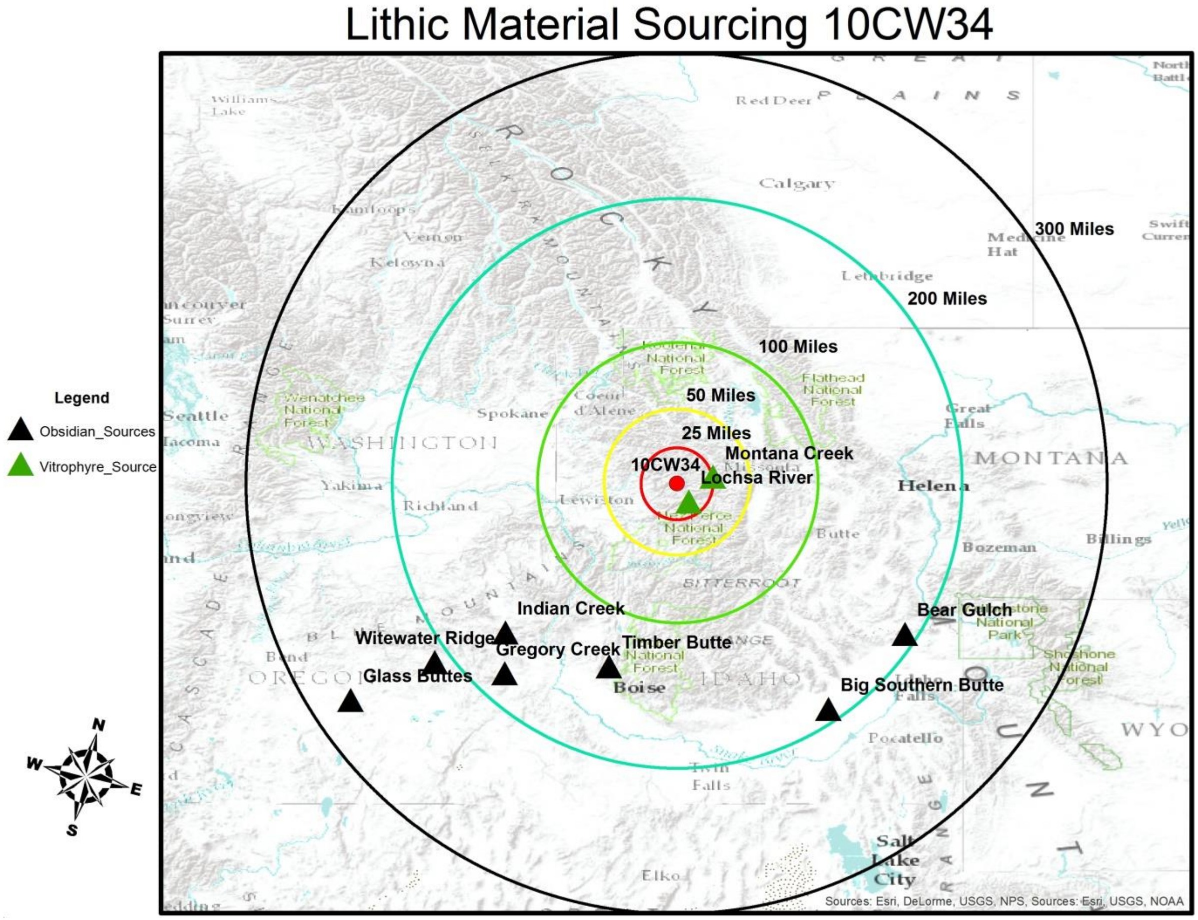


Figure 4.1 Obsidian and vitrophyre sourcing for 10CW34.

Sourcing cherts can be challenging at best. Because of the genesis of this type of stone, sources located close to each other can have very different geochemical signatures and therefore numerous reference samples would need to be taken to create a geochemical profile of an area (Sappington 2017). 10CW34 illustrates these difficulties because of the numerous chert sources in the Clearwater River drainage. These raw materials vary in color, texture, and their geomorphology. The hunter-gatherers who curated their tools at 10CW34 likely utilized many of these raw material sources during their seasonal rounds and had a diverse assortment of cherts in their tool kits. The numerous colors and textures of the cherts in the 10CW34 debitage assemblage is evidence of this. In order to source these, the analyst would have to know all of the various routes used for the seasonal rounds as well as the locations of individual outcroppings and nodule concentrations. Figure 4.2 is a representative sample of the heterogeneous nature of the 10CW34 chert assemblage. This collection of cherts is from an arbitrary 10 cm level of a 1 x 1 m test unit.

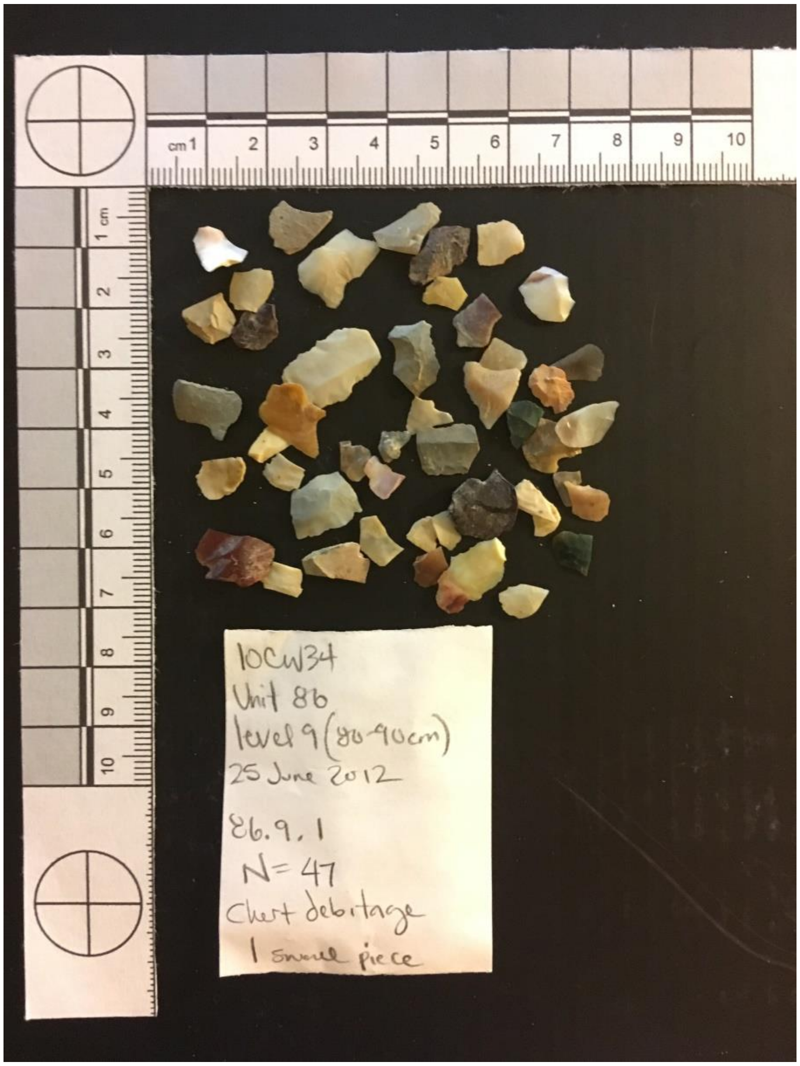


Figure 4.2 Chert variability within the assemblage.

The variability of the raw materials in Figure 4.2, and also size of the flakes, indicates that there is no singular source for quality chert within the site catchment. If there were such a quarry site located in proximity to 10CW34, we would expect to see a more homogeneous raw material assemblage and larger flakes associated with core reduction and early stage tool production (Pecora 2001:174).

The identification and mapping of chert sources in the Clearwater River should be a continuous endeavor by archaeologists, geologists, and the avocational members of these fields. Establishing a data base of the known chert sources in this region would enhance our knowledge of lithic procurement and use in the region to then further our understanding of the lithic technological organization of its prehistoric inhabitants. Figure 4.3 denotes several chert sources located in the Clearwater River drainage. Figures 4.4 through 4.9 show the variation of colors and textures of the chert from recently identified chert sources.

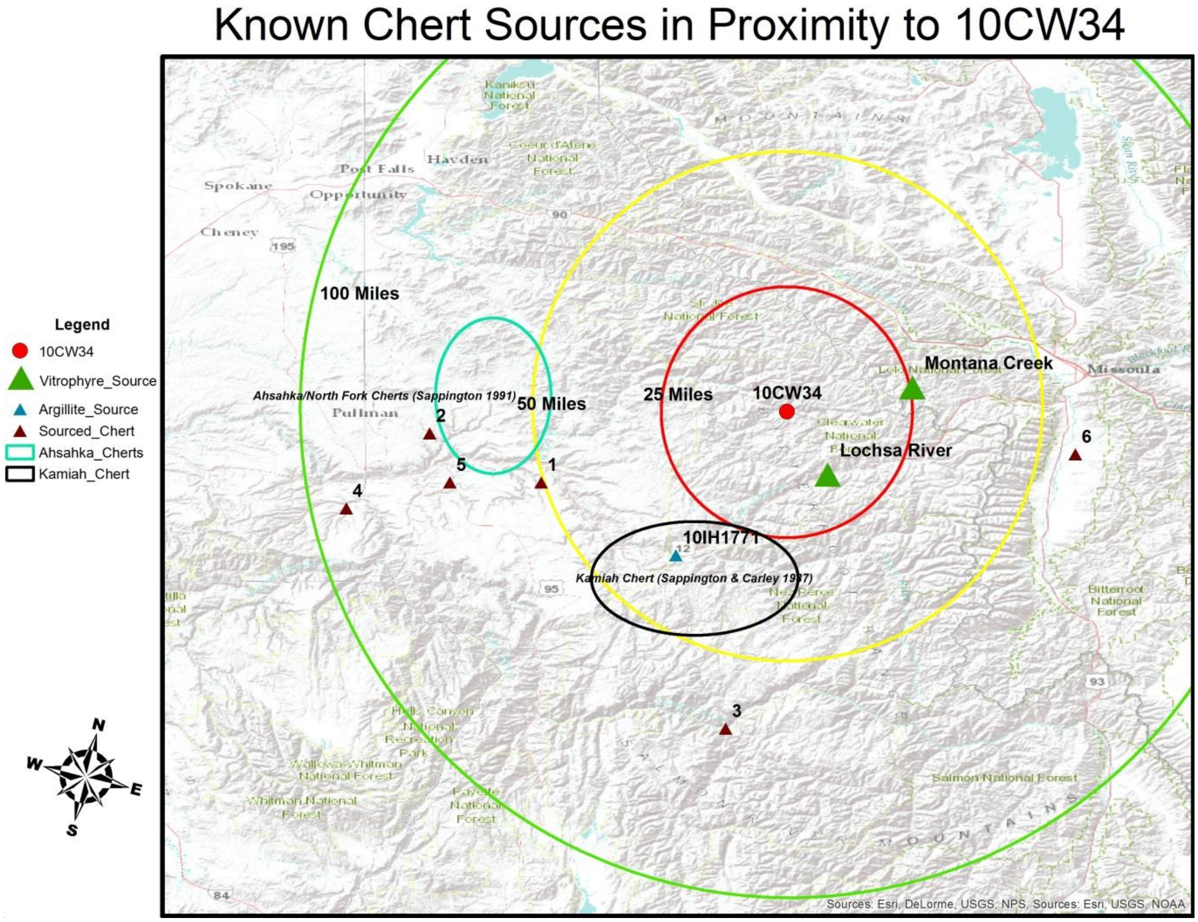


Figure 4.3 Sourced chert within 100 miles of 10CW34

Figure 4.4 #1. Little Canyon Creek (Jared Norman, personal communication 2015).

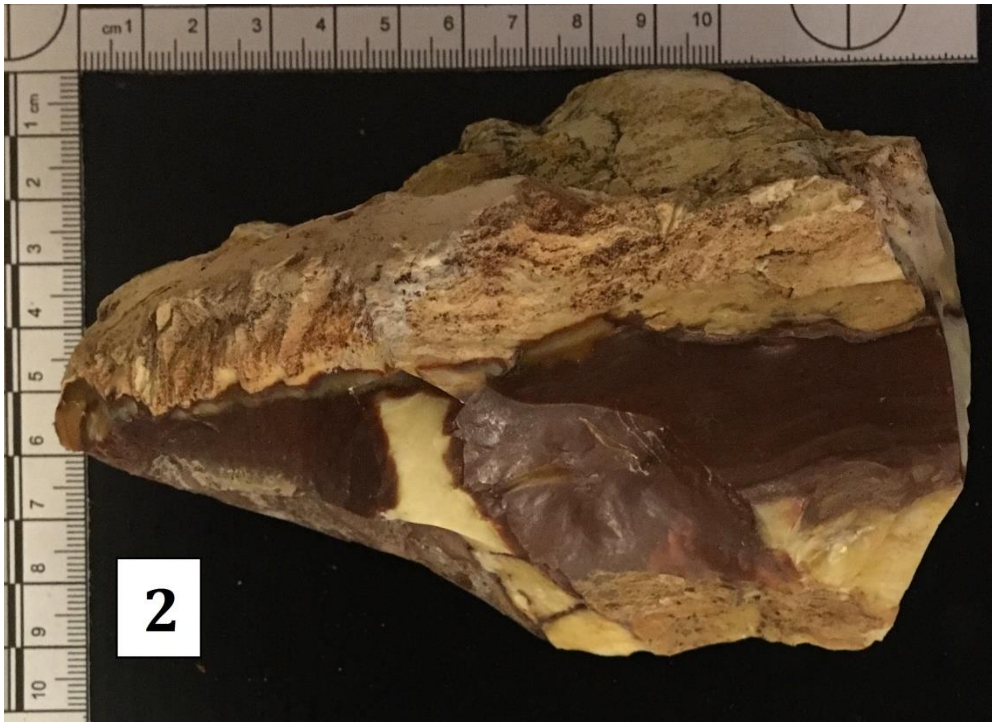


Figure 4.5 #2 Potlatch Creek (Lawrence Clark, personal communication 2015).

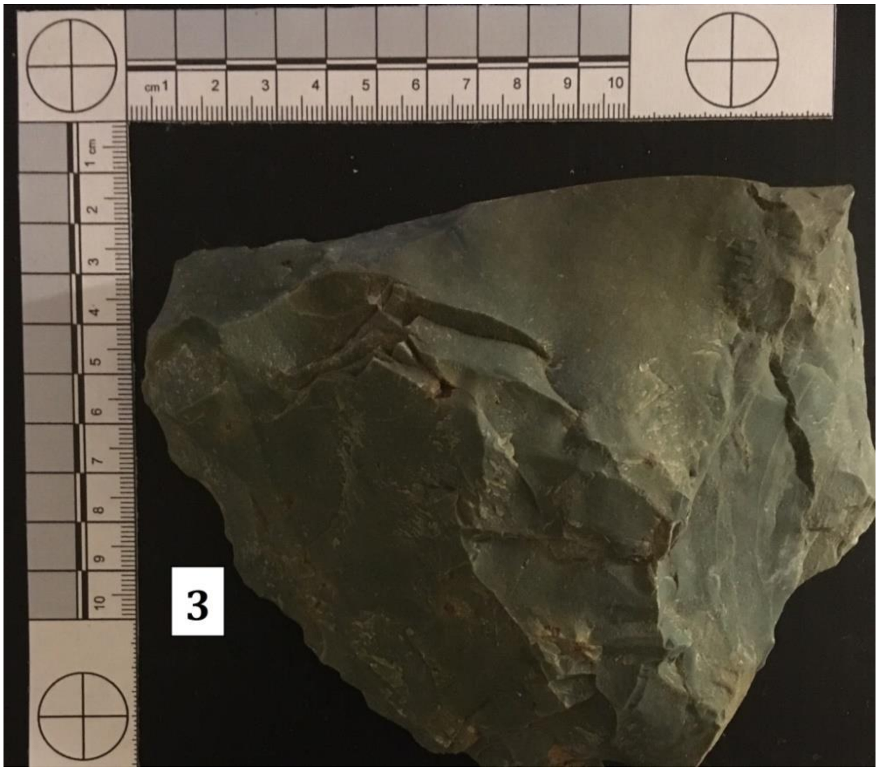


Figure 4.6 #3 Salmon River (Lawrence Clark, personal communication2015).

Figure 4.7 #4 Lower George Creek Road (Lawrence Clark, personal communication 2015).

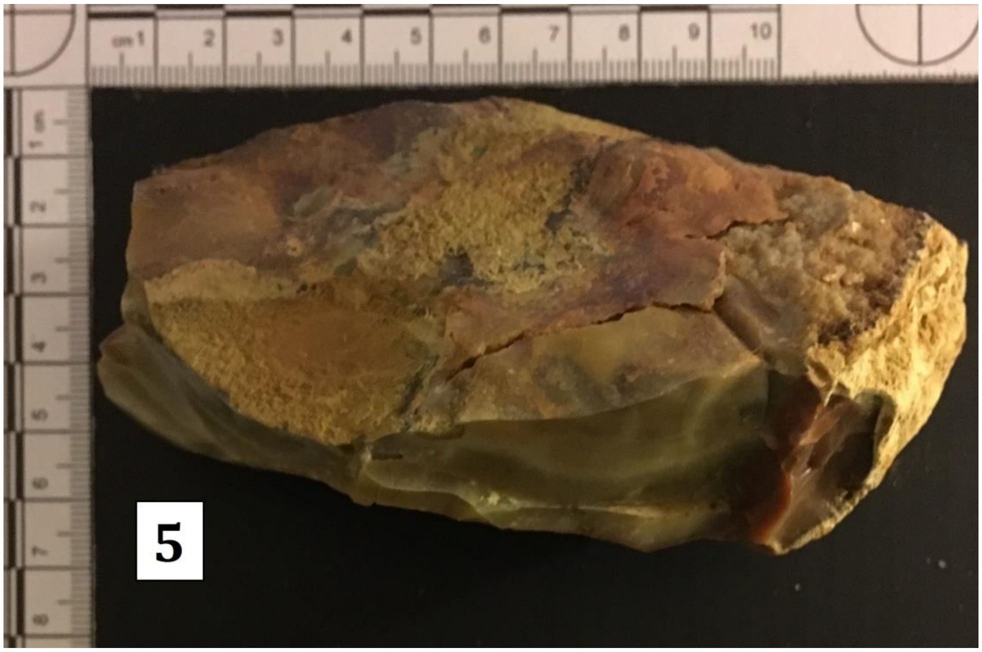


Figure 4.8 #5 Cottonwood Creek (Lawrence Clark, personal communication 2015).

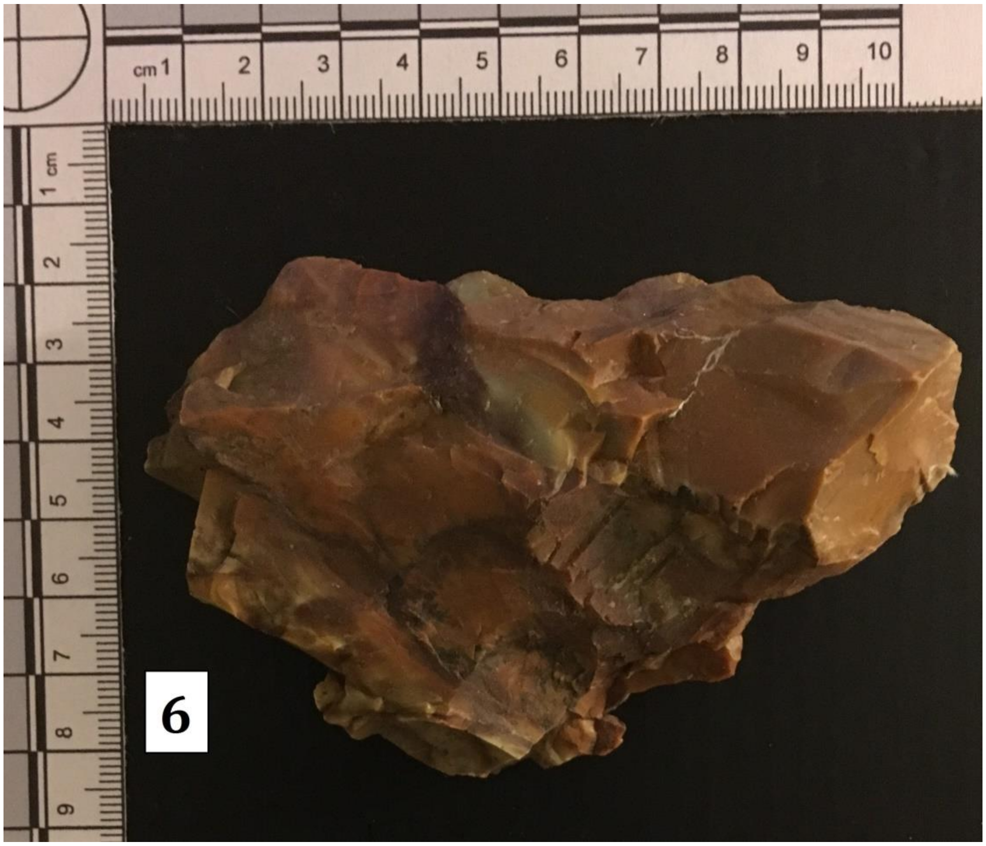


Figure 4.9 #6 East of Stevensville, MT (Lawrence Clark, personal communication 2015).

The chert samples illustrated above are not from archaeological contexts and have been gathered by professional and avocational archaeologists in the Clearwater, Salmon, and Snake river drainages as well as a source near 10CW34 in Montana. The purpose of displaying these is to provide examples of the variety of chert colors and textures available to the prehistoric peoples of the region and likely those who frequented 10CW34. Additional chert resources that have been identified in an archaeological context have been recorded by Sappington and Carley (1987) in the Kamiah area and also by Sappington (1991) around Ahsahka and the North Fork of the Clearwater River. These resource areas are included on the chert sourcing map above (Figure 69**).**

There is also a site designated on the map above (10 IH1771) by a blue triangle. This site is a 75 acre argillite quarry site. This site represents a multi-component, multi-cultural prehistoric quarry site of significant size. The site resides on US Forest Service land in the Nez Perce-Clearwater National Forest. The site has been designated the “Tahoe Ridge Ranger Station and Native American Camp/Quarry.” Numerous argillite lithic scatters as well as a broken argillite Windust point, a broken chert Cascade point, and a vitrophyre late prehistoric side-notched point have been recovered or noted on this site (Sappington 1994). Argillite represents 0.3% of the lithic assemblage recovered at 10CW34 (Longstaff 2013). An XRF analysis of the argillite contained at 10IH1771 could establish a known profile for this type of raw material in the Clearwater River drainage for comparison to the argillite in the 10CW34 assemblage. It is the author’s intent to facilitate the establishment of this unique lithic signature for future research and comparison.

The debitage assemblage from the Kelly Forks Work Center Site infers the mobile nature of the prehistoric hunter-gatherers who utilized this hunting camp. The many varieties of cherts present indicate that there are numerous resource locations on the trails used during the seasonal rounds. The small percentage of argillite recovered on the site as compared to other sites further up the Clearwater, Lochsa, and Selway rivers suggests that those who seasonally migrated to this site did so along the North Fork of the Clearwater River. The journey to the hunting camp at the confluence of Kelly Creek and the North Fork of the Clearwater River is an arduous trek on foot. Therefore, minimum supplies would be carried and those raw material that could be found and at the site and fashioned into informal, expedient tools would be so utilized. The metamorphic cobble that was found to have been worked at the site implies this.

The availability and location of lithic raw materials to prehistoric hunter-gatherers had a significant impact on the land use, mobility, and subsistence strategies. The procurement of these raw materials is the foundational building blocks upon which the stone tool technological organization stands. Knowing where these sources reside gives us insights as to how the land and resources were viewed and utilized by the prehistoric inhabitants (Andrefsky 2008:9-10).

Chapter 5:

Trade and Mobility

Lithic tool technological organization starts with the acquisition of the raw materials. There are many ways that prehistoric peoples acquired the raw materials needed for stone tool manufacture. Some of these would include dedicated trips to local or semi local quarries, gathering from known sources along seasonal routes, and trade within regional and distant trade networks. The nature of the acquisition of these raw materials will often influence the reduction strategies of the finished tool and thus the debitage. If a quarry source is used, there will likely be reduction at the quarry to make blanks or preforms to reduce the weight to be carried. Those flakes associated with the early stages of reduction will remain at the quarry and progressively smaller flakes will be detached from the blank, preform, or tool as it travels. Those tools acquired by trade are often finished or preforms and the debitage from these will be from curation or late stage reduction (Sievert and Wise 2001:88). Raw material availability has an effect on the debitage produced and subsequently recovered.

The prehistoric peoples of the Columbia Plateau were known to be Complex Hunter-Gatherers who exploited the various resources in the region. The peoples who frequented the Kelly Forks Work Center Site were known to be the ancestors of the Nez Perce people. Figure 5.1 shows the traditional areas inhabited (center in grey) and the surrounding areas where the prehistoric Nez Perce gathered resources (Longstaff 2013:47-51). The Clearwater River drainage and 10CW34 are located within the pre-contact habitation area and seasonal rounds.

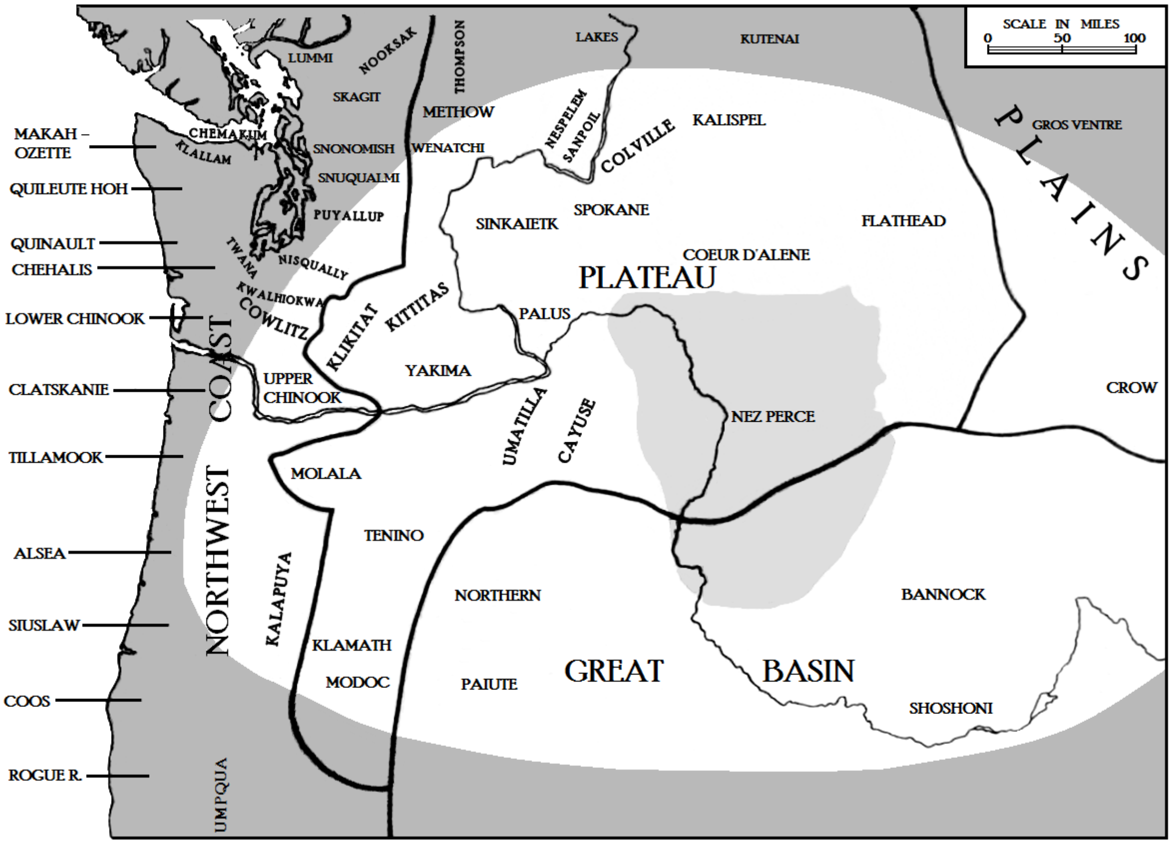


Figure 5.1 Map of Northwest ethnic groups and culture areas with Nez Perce territory (shaded grey in center) and effective resource area exploited by the Nez Perce (non-shaded area). (adapted from Longstaff 2013:51, Figure 35)

Seasonal rounds throughout the region provided the Nez Perce with an abundance of foods and the lithic raw materials needed for tool production. The area where 10CW34 is located is considered mountainous and difficult to traverse on foot and with pack animal (Robbin Johnston, personal communication 2017). Therefore, the prehistoric peoples who travelled to the confluence of the North Fork of the Clearwater River and Kelly Creek would be carrying all the tools and equipment needed over this difficult terrain. An economical and efficient tool kit and only those supplies necessary to harvest the resources and survive would have been carried on this journey. Because of this mobility and areas of difficult passage, hunter-gatherers tend to travel with formal tools and preserve these through means of curation and maintenance (Bamforth 1986; Binford 1973; Sievert and Wise 2001:88).

The variety of raw materials found in the debitage assemblage from 10CW34 indicates opportunistic raw material gathering at known sources along the seasonal rounds and the inter-regional trade of obsidian and vitrophyre. The variety of cherts in the assemblage indicates that there were multiple sources for these materials. This is also evident in the contemporarily gathered cherts and their many locations shown in the sourcing section of this thesis. This local sample of gathered chert confirms that numerous sources of chert were available to the prehistoric peoples on their seasonal rounds in the Clearwater River drainage. The size grading analysis of the chert debitage would indicate that the tools from which they were detached were formal and in a finished state when they arrived to the site.

The obsidian in the assemblage has been sourced to southern Idaho and eastern/central Oregon. Some of the obsidian may have been gathered by the occupants of the site themselves, but it is more likely that it was acquired from trade within the regional network of exchange (Figure 5.2) in which the inhabitants of 10CW34 participated (Longstaff 2013:393). The size-grading analysis of the obsidian debitage would also indicate that the tools from which they were detached were formal and in a finished state when they arrived at the site.

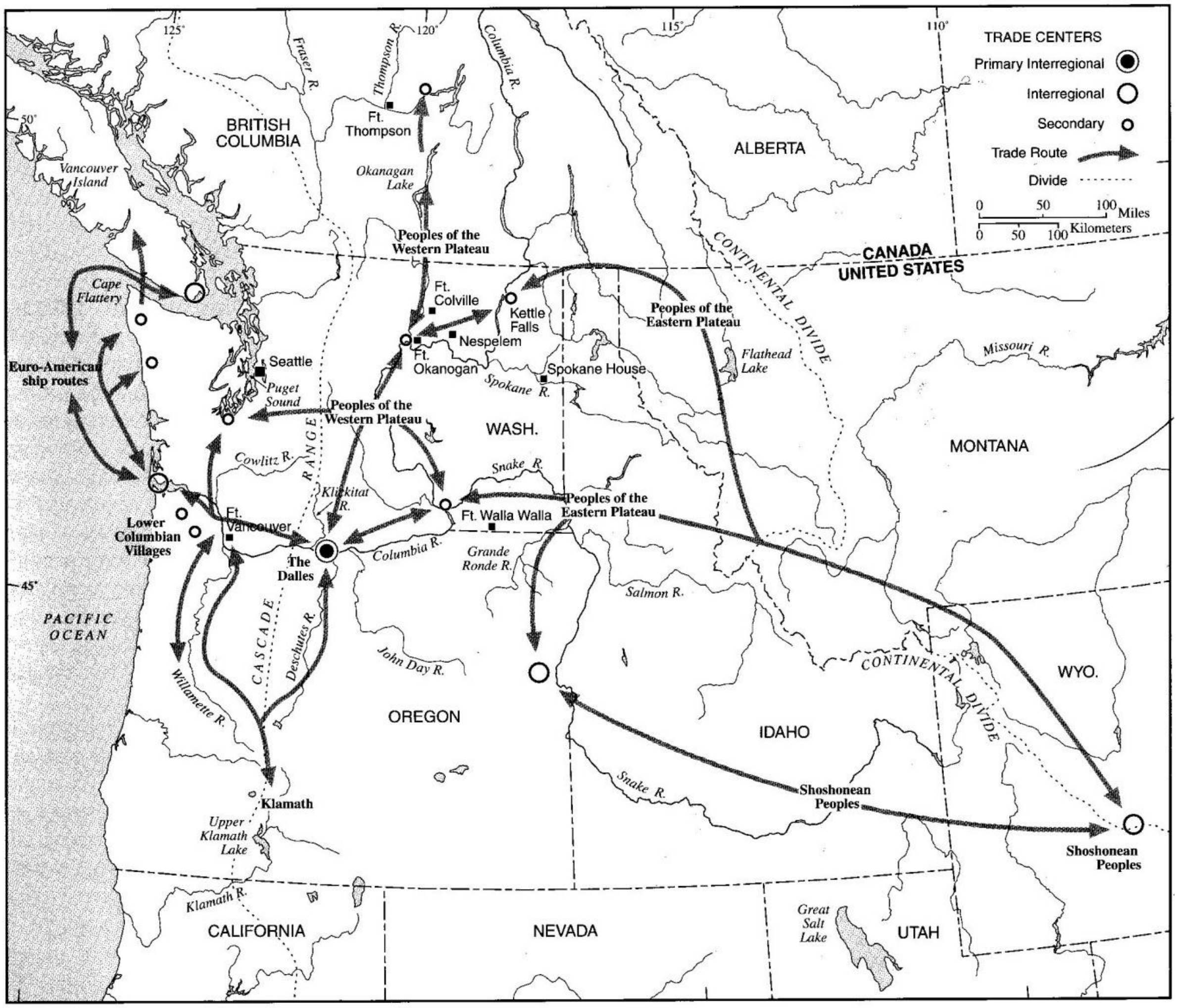


Figure 5.2 Columbia Plateau Trade Networks (adapted from Stern 1998:642).

The debitage assemblage from 10CW34 aligns with those hypothesis and academic discourses on the types of tools that highly mobile groups such as those who frequented 10CW34 would use. Formal tools in completed form would be transported to the site and the curation and maintenance of these tools would result in smaller debitage. This is confirmed by the fact that the vast majority of the assemblage was collected by the #5 size graded sieve. Use of local raw materials to manufacture expedient and informal tools for the processing of game is evidenced by the larger cobble flakes and the weights associated with the early stages of reduction.

Chapter 6:

Site Comparisons

The lithic debitage assemblages from continuous seasonal occupation prehistoric sites in the Clearwater River drainage represent the most numerous artifact class to be recovered (Keeler1973; Longstaff 2013; Sappington 1991). This is not an anomaly that is distinct to the Clearwater River basin, but it is seen throughout the Plateau cultural area as a whole and on many prehistoric sites in North America. The lack of a ceramic industry and poor soil preservation conditions in the Plateau area make lithic debitage as the most numerous artifact class (Sappington 2017). An examination of three continuous-use sites in the Clearwater River drainage supports the statement that the lithic debitage assemblages represent greater than 90% of the material remains recovered (Table 6.1 and Figure 6.1). The three sites to be compared are the Kelly Forks Work Center Site (10CW34), the Weitas Creek Site (10CW30), and the Clearwater Fish Hatchery Site (10CW4). The debitage assemblage associated with 10CW34 has been examined throughout this thesis; therefore there will be no contextual references for this site. A cursory examination of the Weitas Creek and Clearwater Fish Hatchery site's placement in the Clearwater River basin and seasonal rounds will be reviewed to provide context for the comparison.

Site	Debitage	Artifacts	Percentage
10CW34	15763	17210	91.6%
10CW30	7092	7606	93.2%
10CW4	36514	37596	97.1%

Table 6.1 Overall debitage percentages from10CW34 and the comparison sites.

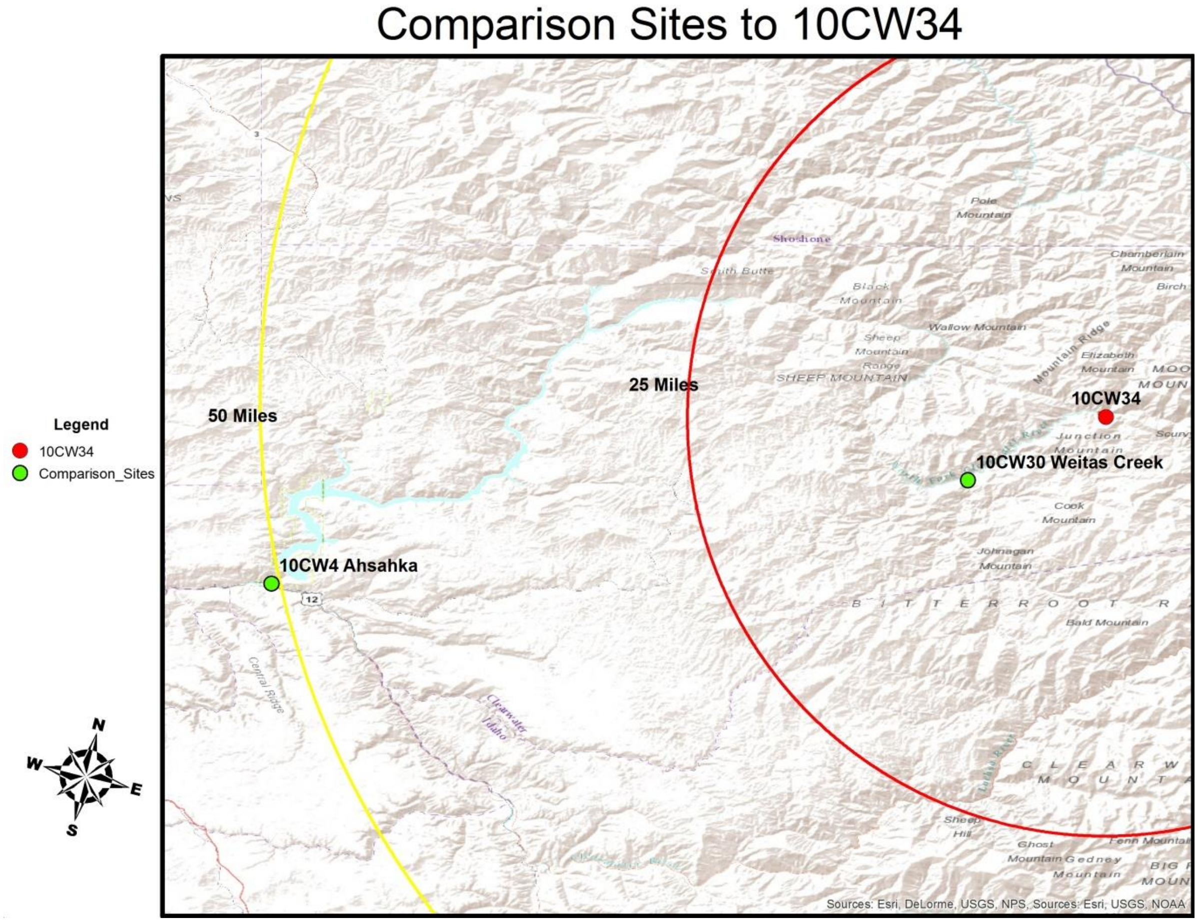


Figure 6.1 Map of distances to the comparison sites from 10CW34.

The Weitas Creek Site was identified in 1969, recorded in 1970, excavated in 1970 and again in 1972. Keeler identifies the site as an “aboriginal hunting camp” as part of the seasonal rounds (1973:2-3). Based on recovered point typologies, Keeler cites Leonhardy and Rice‘s (1970) cultural chronology to identify the cultural associations of the site with the Windust and Cascade Phases (Keeler 1973:3). No radiocarbon dates are associated with the excavations at 10CW30.

The site was excavated using 2 x 2 meter units with arbitrary depth levels of 10 and 20 centimeters (10 cm in artifact heavy concentrations and 20 cm in light artifact concentrations). The excavated soils were screened through a ¼ inch hard wire mesh (Keeler 1973:17-18). The use of ¼ inch screen at 10CW30 likely allowed smaller debitage flakes to pass through and it must be assumed that many of the small flakes, such as those that were recovered at 10CW34 using 1/8 inch screen, were not recovered at 10CW30. The non-recovery of these smaller flakes at 10CW30 will have skewed the data when considering percentage of debitage to the entirety of the recovered assemblage.

Keeler identifies the larger flakes in the debitage assemblage at 10CW30 as the result of expedient cobble reduction. The smallest debitage flakes are identified as cryptocrystalline with some larger basalt debitage (1973:61). There was no size grading analysis performed on this assemblage. Of the 7,606 artifacts recovered from 10CW30, 7,092 were identified as debitage. Debitage represents 93.2% of the overall recovered material culture from 10CW30.

Table 6.2 compares the debitage raw materials from 10CW30 and 10CW34. Keeler recorded basalt and chert in different columns as "heat treated" and "non-heat treated" (Keeler 1973). For the purposes of this comparison, the heat treated and non-heat treated raw materials have been combined. Additionally, Keeler did not include argillite, cobble, or

Material	10CW30	Percentage	10CW34	Percentage
Argillite	0	0%	49	0.3%
Basalt	4893	69.0%	830	5.3%
Chert	1447	20.4%	12443	78.9%
Cobble	0	0.0%	1355	8.6%
Obsidian	13	0.2%	56	0.4%
Quartz Crystal	739	10.4%	541	3.4%
Vitrophyre	0	0.0%	489	3.1%

Table 6.2 Debitage raw material comparison between 10CW30 and 10CW34.

vitrophyre debitage. Quartz crystal and quartzite was differentiated by Keeler and these also have been combined.

While there appears to be some glaring discrepancies between the debitage assemblages of the two sites, some of these can be explained by the excavation methodology and also the lack of knowledge of the available raw materials in 1973. The first issue that will be addressed is the ¼ inch screen used during the 1970 and 1972 excavations at 10CW30. The use of this size screen would allow for any debitage smaller than ¼ inch to pass through and not be collected. At the Kelly Forks Work Center Site excavations, 1/8 inch screen was used and this infers that many more smaller debitage flakes were recovered during these excavations than at the Weitas Creek Site excavations. This statement is supported by the data generated by the size-graded sieve sorting performed as part of the aggregate analysis. The majority of the debitage recovered from10CW34 was size sorted into sieves #5 (>1/8”) and #6 (>1/16”) during the analysis (n=11,703). This number represents 74% of the debitage assemblage from 10CW34. Of the 11,703 flakes collected in sieves #5 and #6, 9,861 of these 84% were chert. When a numerical comparison is made of the chert collected (n=2377) in the #4 size grade sieve (>1/4”) from 10CW34 and the overall chert collected from the ¼” screens at 10CW30 (n=1447) is made, there appears to be a statistical correlation. Weitas Creek chert is 20% of the assemblage whereas the Kelly Forks chert (>1/4”) represents 15% of the assemblage. Had 1/8 inch screens been used during the 1970 and 1972 excavations at 10CW30, it is likely that the overall number of debitage flakes would have been increased as well as the number of chert flakes recovered.

The Weitas Creek debitage assemblage indicates a heavy concentration of basalt flakes (n=4893) but shows no record of argillite, cobble, or vitrophyre flakes. Given the color, texture, and overall characteristics of basalt, it is a possibility that some of the “basalt” flakes recovered at 10CW30 were actually the aforementioned absent raw materials (argillite, cobble, and vitrophyre). Additionally, argillite and vitrophyre are rarely mentioned as lithic raw materials in association with the region prior to the mid-1980s. Leonhardy and Rice make no mention of these raw materials in their overview of the cultural typology of the region (Leonhardy and Rice 1970).

It is the opinion of this author that had the same excavation methods used at 10CW34 also been used during the 1970 and 1972 excavations at Weitas Creek, the debitage assemblages would be more similar in their raw material numbers and distributions.

The Clearwater Fish Hatchery Site (10CW4) is a multicomponent site located at the confluence of the North Fork of the Clearwater River and the Clearwater River proper. The site resides upon a modern ca. 250 meter wide flood plain on the north bank of the Clearwater River (Sappington 1991:1). This site is approximately fifty-two miles from 10CW34. The geologic, climatic, and natural setting contexts differ considerably from the upper reaches of the North Fork of the Clearwater due to the differences in elevation and geologic processes. The climate in this area is considerably warmer and dryer than at the Kelly Forks Work Center Site. The vegetation and fauna associated with 10CW4 differs from 10CW34 as well. The ponderosa pine series dominates the area and large game animals can still be found in the area and are known to migrate seasonally (Sappington 1991:6-7).

The Clearwater Fish Hatchery Site was first recorded in 1961. In the late 1960s, the site was covered with 4-7 meters of fill produced by the construction of the nearby

Dworshak Dam. The site remained buried until 1987 when plans to build the Clearwater Fish Hatchery on the site prompted the need for further archaeological testing to determine the site’s cultural significance to the area. Testing revealed mitigation of the site was necessary to offset the adverse effects from this construction. Exploratory test units were excavated in 1988 and late 1989 to determine the site boundaries and feature concentrations. An extensive data recovery was conducted between January and April of 1990 (Sappington 1991:21). Fifteen radiocarbon dates from “Area A” of the site indicate a continued occupation from approximately 3000 years BP into the historic period which represents the Ahsahka phase in this region. The ethnographic history of the area designates the site as having been utilized by the “river mouth people” whose fishing and hunting territory was known to be the North Fork. This site is considered a “wintering village” where the maintenance and curation of fishing and hunting tools was conducted. Other site activities such as the harvesting of the anadromous fish and processing of game occurred on the site as well (Sappington 1991:11-13).

The site was excavated using 1 x 1, 1 x 2, and 2 x 2 meter units as well as test trenches. All excavated soils were passed through 1/8 inch hard mesh screen. Arbitrary levels of 10 cm and natural stratigraphic levels were excavated to sterile soils ranging from 130 cmbs to 220 cmbs (Sappington 1991:21). Because 1/8 inch screen was used, those smaller flakes not recovered at the Weitas Creek Site were recovered at the Clearwater Fish Hatchery Site.

Of the lithic artifacts recovered from 10CW4 (n=37,596), not including fire-cracked rock, debitage makes up 97% of the assemblage (n=36,154). Sappington identifies nine types of lithic raw materials recovered from 10CW4 and does not identify any cobble debitage. In order to make a numerical comparison between 10CW34 and 10CW4, the sample numbers (n=3414) submitted by Sappington for debitage analysis will be used. Those flakes designated as “granitic” in this sample were entered under the “cobble” heading in Table 6.3.

Material	10CW4	Percentage	10CW34	Percentage
Argillite	8	0.2%	49	0.3%
Basalt	32	0.9%	830	5.3%
Chert	3329	97.5%	12443	78.9%
Cobble	18	0.5%	1355	8.6%
Obsidian	5	0.1%	56	0.4%
Quartz Crystal	9	0.3%	541	3.4%
Vitrophyre	13	0.4%	489	3.1%

Table 6.3 Debitage raw material comparison between 10CW4 and 10CW34.

The comparison in the table above matches more closely than the Weitas Creek comparison. Chert dominates the 10CW4 sample assemblage as it does the 10CW34 assemblage. The biggest inconsistencies fall in the percentages of basalt, cobble, and quartz crystal. This is likely due to the local availability of these materials (quartz) and the need for expedient tools (cobble). The Clearwater Fish Hatchery Site has been identified ethnographically and archaeologically as a winter village site utilized during the Tucannon Cultural Phase until historic times (3 kya BP). Leonhardy and Rice cite the heavy use of basalt during the Cascade Cultural Phase of the region (1970:9). The low percentage of basalt recovered at 10CW4 could be the result of the site not being utilized during the Cascade Cultural Phase.

The comparison of these two sites to 10CW34 show similarities and dissimilarities. In the case of the Weitas Creek Site, it is likely the methods of excavation and classification of raw materials that result in the discrepancies noted above. The fact that the two sites are so close in proximity and were utilized for the same purpose (seasonal hunting camp) and temporal span (estimated based on point typologies) would suggest that the assemblages would be similar. Additionally, the availability of lithic raw materials both locally and along the routes used during the seasonal rounds would suggest similar raw material assemblages. The Clearwater Fish Hatchery Site was utilized for a different purpose and temporal span than was 10CW34. The availability of local raw materials would also effect the composition of the assemblage. Regardless of the distribution of lithic raw materials, it is clear that debitage is the most numerous artifact class recovered on all three sites.

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Chapter 7:

Conclusion

The research goals associated with this study were realized, however, not always to the extent that was initially sought. Based on the spatial distribution of the debitage at 10CW34, no inferences could be made about specific behavioral foci on the site. Debitage identified as the result of both soft hammer percussion and pressure flaking were equally distributed throughout the excavated units in Area E. However, it must be noted that the areas that were excavated comprised <1% of the terrace on which the site is located. Also, the areas that were excavated were focused on the prior geophysical data that indicated sub-surface anomalies thought to be features.

Based on the site location and difficulty of access by foot, the highly mobile groups that frequented the site would have brought only formal tools of high quality materials with them to the site. The curation and maintenance of these tools generally produce smaller flakes that would be the result of pressure or soft hammer indenters. Expedient tools were made from local river cobble and would produce the larger flakes associated with the early stages of reduction. The debitage assemblage from 10CW34 supports this statement and the assemblage is representative of highly mobile groups or bands. The trade networks of the Columbia Plateau region and beyond are evidenced at 10CW34 as well. Obsidian that was recovered and sourced at 10CW34 has been recovered from sites along the known local, regional, and inter-regional trade routes (Sappington 2017).

The investigation of the local sources of cherts, argillite, and vitrophyre shed light on the seasonal rounds and native use of the land. The assemblage shows many different varieties of cherts that were likely gathered from numerous sources. The continued documentation of these raw material sources would be beneficial in determining preferred materials, determining the different qualities, and the building of a regional data base.

The application of “multiple lines of evidence” by using the combined methodologies of mass analysis and individual flake analysis proved to be complimentary. One was found to correlate with the other and there was very little in the way of outlying data. However, a sample of the assemblage could probably be used in the individual flake analysis of the application load typology. This would save considerable time in future investigations. The statistical analyses that were used to evaluate methodologies indicate that the efficacy of the combined use of aggregate and individual flake analysis in this capacity can predict the reduction stage or activities from an archaeological assemblage.

The peripheral goal of compiling a comprehensive data base of these analyses to be included with the overall data from the Kelly Forks Work Center Site has been realized. This is an important site locally and regionally because of its temporal span and use as a seasonal hunting camp. There is still much research that can be done with the assemblages gathered from 2010 to 2012 and it is my hope that the research I have done here will assist in any future study of the site. The plotting of the debitage assemblage in three-dimensions may have been a bit of self-indulgence. However, spatial display in three dimensions allows one to more easily identify clusters and patterns that may not be evident on spreadsheet pages. Archaeology is all about spatial relations and being able to visualize these can bring us closer to those whom we study.

The undertaking of this research has vastly improved my knowledge of the region and those peoples who have inhabited it since their creation traditions. Additionally, the research skills that were needed for this study have expanded my knowledge of the lithic technological organizational theoretical framework and particularly the importance of the role that debitage holds within it. Lastly, I feel that the combined methodologies used for this analysis can be effectively replicated, and that is a good thing in science.

Works Cited

Ahler, Stanley A.
1989 Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Tree. In *Alternative Approaches to Lithic Technology,* edited by Donald O. Henry and George H. Odell. Archaeological Papers of the American Anthropological Association No. 1. Washington, D.C.

Amick, Daniel S., and Raymond P. Mauldin
1989 "Comments on Sullivan and Rozen's "Debitage Analysis and Archaeological Interpretation" *American Antiquity* 54(1):166-68.

Andrefsky, William Jr.
1998 *Lithics: Macroscopic Approaches to Analyses.* Cambridge University Press, New York, NY.

2001 *Lithic Debitage: Context, Form, Meaning.* University of Utah Press, Salt Lake City.

2006 The Application and Misapplication of Mass Analysis in Lithic Debitage Studies. *Journal of Archaeological Science* 34(3):392–402.

2008 *Lithic Technology: Measures of Production, Use, and Curation.* Cambridge University Press, New York, NY.

2009 The Analysis of Stone Tool Procurement, Production, and Maintenance. *Journal of Archaeological Research* 17(1):65-103.

Bamforth, Douglas B.
1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.

Bamforth, Douglas, and B. Finlay
2008 Introduction: Archaeological Approaches to Lithic Production Skill and Craft Learning. *Journal of Archaeological Method and Theory* 15(1):1-27.

Beardsell, Robert J.
2013. "Mass and Attribute Analysis of the Quartz Lithic Assemblage from the Grandfather Quarry (HbMd-4), Near Granville Lake, Northern Manitoba." Order No. NS28028, University of Manitoba (Canada).

Bettinger, Robert L.
1982 Aboriginal Exchange and Territoriality in Owens Valley, California. In *Context for Prehistoric Exchange.* edited by Jonathon E. Ericson, and Timothy K. Earle. Studies in Archaeology. New York: Academic Press.

Binford, Lewis R.
1973 Interassemblage Variability in the Mousterian and the "Functional" Argument. In *The Explanation of Culture Change: Models in Prehistory*, edited by Colin Renfrow pp. 227- 254. London: Duckworth.

1980 Willow Smoke and Dog Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

Binford, Lewis R., and George I. Quimby
1963 Indian Sites and Chipped Stone Materials: In the Northern Lake Michigan Area. *Fieldiana Anthropology* 36(12):277-307.

Bradbury, Andrew P., and Philip J. Carr
1995 Flake Typologies and Alternative Approaches: An Experimental Assessment. *Lithic Technology* 20(2):100-15.

2009 Hits and Misses when Throwing Stones at Mass Analysis. *Journal of Archaeological Science* 36(12):2788–2796.

Carlson, Garry and Steven D. Sheriff
2009 *Total Field Magnetometry and Ground Penetrating Radar Investigations at Kelly Forks Work Center, Clearwater National Forest, Idaho*. Submitted to USDA Forest Service. Adapted from Longstaff, 2013.

Carr, Phillip J. and Andrew P. Bradbury
1999 Flake Debris Analysis, Levels of Production, and the Organization of Technology. In *Lithic Debitage: Context, Form, Meaning*, edited by William Andrefsky. University of Utah Press, Salt Lake City.

2004 Exploring Mass Analysis, Screens, and Attributes. In *Aggregate Studies in Chipped Stone Analysis*, edited by Christopher T. Hall and Mary Lou Larson. University of Utah Press, Salt Lake City.

Chapman, Henry
2009 *Landscape Archaeology and GIS.* The History Press, Gloucestershire, UK.

Connolly, James and Mark Lake
2006 *Geographical Information Systems in Archaeology*. Cambridge University Press, New York, NY.

Cotterell, Brian, and Johan Kamminga
1987 “The Formation of Flakes” *American Antiquity* 52(4):675-708.

Cowan, Frank L.
1999 Making Sense of Flake Scatters: Lithic Technological Strategies and Mobility. *American Antiquity* 64(4):593-607.

Crabtree, D.E.
1972 An Introduction to Flintworking. *Occasional Papers of the Idaho Museum of Natural History* Number 28.

Danner, Bryce
2017 *An Overview of the Pre-Contact Archaeology of the Lochsa River, North Central Idaho.* Master’s Thesis, Department of Sociology and Anthropology, University of Idaho, Moscow.

Daugherty, Richard D., Jeffrey J. Flenniken, Jeanne M. Welch
1987 *A Data Recovery Study of Judd Peak Rockshelters (45-LE-222) in Lewis County, Washington*. Studies in Cultural Resource Management ; No. 8. Portland, Or.: USDA-Forest Service, Pacific Northwest Region.

Dibble, Harold L.
1997 Platform Variability and Flake Morphology: A Comparison of Experimental and Archaeological Data And Implications for Interpreting Prehistoric Lithic Technological Strategies. *Lithic Technology* 22(2):150-170.

Dibble, Harold L.,Utsav A. Schurmans, Radu P. Iovita and Michael V. McLaughlin
2005 The Measurement and Interpretation of Cortex in Lithic Assemblages. *American Antiquity* 70(3):545-560.

Drennen, Robert D.
2010 *Statistics for Archaeologists: A common Sense Approach.* Springer Science and Business, New York.

Ensor, H. Blaine, and Erwin Roemer
1989 Comments on Sullivan and Rozen's Debitage Analysis and Archaeological Interpretation. *American Antiquity* 54(1):175-78.

Ericson, Jonathon E.
1982 Production for Obsidian Exchange in California. In *Contexts for Prehistoric Exchange, e*dited by Jonathon E. Ericson and Timothy K. Earle. Academic Press Inc. New York, NY.

Faulkner, Alaric
1972 *Mechanical Principles of Flintworking*, PhD. Dissertation, Department of Anthropology, Washington State University, Pullman.

Flenniken, J. Jeffrey

1981 *Replicative Systems Analysis: A Model Applied to the Vein Quartz Artifacts from the Hoko River Site.* Washington State University, Laboratory of Anthropology.

Flenniken, J. Jeffrey, and Philip J. Wilke

1989 Typology, Technology, and Chronology of Great Basin Dart Points. *American Anthropologist*, New Series, 91(1):149-58.

Flenniken, J. Jeffrey, and C. J. Haggarty

1979 Trampling as an Agency in the Formation of Edge Damage: An Experiment in Lithic Technology. *Northwest Anthropological Research Notes* 13:208-214.

Franklin, J., and J. Simek

2008 Core Refitting and the Accuracy of Aggregate Lithic Analysis Techniques: The Case of 3rd Unnamed Cave, Tennessee. *Southeastern Archaeology* 27(1):108-121.

Grisham, Abram

2015 Prehistoric Use of Quartz Crystal Lithic Material in the Clearwater River Basin, North Central Idaho : A Replicative Study in Manufacture and Use-wear Analysis. Master’s Thesis, Department of Sociology and Anthropology, University of Idaho, Moscow.

Henry, Don O., C. Vance Haynes, and Bruce Bradley

1976 Quantitative Variations in Flaked Stone Debitage. *Plains Anthropologist* 21(71):57-61.

Huntley, Jim, Dave Schaepe, Ali Abusaid, Cindy Schacher, Steve Armstrong

2010 *Tahoe Ridge Ranger Station and Native American Camp/Quarry Site Update (10IH1771).* Report No. 11-NZ-02, USFS.

Hogentogler Geologic Sieves

2017 Electronic document, https://www.hogentogler.com/sieves/8-inch-sieves.asp, accessed April 24, 2017.

Johnson, Jay K.

2001 Some Reflections on Debitage Analysis. In *Lithic Debitage: Context, Form, Meaning*, edited by University of Utah Press, Salt Lake City.

Keeler, R. W.

1973 An Upland Hunting Camp on the North Fork of the Clearwater River, North-Central Idaho. Occasional Papers No. 30. Idaho State University Museum, Pocatello.

Kelly, Robert L.
1983 Hunter-Gatherer Mobility Strategies. *Journal of Anthropological Research* 39(3):277-306.

1985. "Hunter-Gatherer Mobility and Sedentism: A Great Basin Study." Order No. 8600470, University of Michigan.

1988 The Three Sides of a Biface. *American Antiquity* 53(4):717-734.

1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21(1):43-66.

Kendall, Heather and Brandi Lee MacDonald
2015 Chert Artifact-Material Correlation at Keatley Creek using Geochemical Techniques. In *Toolstone Geography of the Pacific Northwest*, edited by Terry L. Ozbun and Ron L. Adams. Archaeology Press, Simon Fraser University, Burnaby, BC, Canada

Kimball, Larry R.
2013 Archaeological Theory. Lecture. Appalachian State University, Boone, NC.

Larson, Mary Lou
2004 Chipped Stone Aggregate Analysis in Archaeology. In *Aggregate Studies in Chipped Stone Analysis,* edited by Christopher T. Hall and Mary Lou Larson. University of Utah Press, Salt Lake City.

Larson, Mary Lou, and Marcel Kornfeld
1997 Chipped Stone Nodules: Theory, Method, and Examples. *Lithic Technology* 22(1):4-18.

Leonhardy, Frank C. and David G. Rice
1970 A Proposed Culture Typology for the Lower Snake River Region: Southeastern Washington. *Northwest Anthropological Research Notes* 4(1):1-29.

Longstaff, Laura
2013 *Archaeological Investigations at the Kelly Forks Work Center Site (10CW34): Clearwater River National Forest, North Central Idaho*. Master's Thesis, Department of Sociology & Anthropology, University of Idaho, Moscow.

Magne, Martin P.R.
1985 *Lithics and Livelihood: Stone Tool Technologies of Central and Southern Interior British Columbia*. Ottawa: Mercury series. University of British Columbia.

2001 Debitage Analysis as a Scientific Tool for Archaeological Knowledge. In *Lithic Debitage: Context, Form, Meaning,* edited by William Andrefsky Jr. University of Utah Press, Salt Lake City.

Milne, S. Brooke

2009 Debitage Sample Size and Its Implications for Understanding Lithic Assemblage Variability. *Canadian Journal of Archaeology / Journal Canadien D'Archéologie* 33(1):40-64.

Morrow, Carol A., and Richard W. Jefferies

1989 Trade or Embedded Procurement? A Test Case from Southern Illinois. In *In Time, Energy and Stone Tools,* edited by R. Torrence. pp. 27-33. Cambridge: Cambridge University Press.

Morrow, Toby A.

1997 A Chip off the Old Block: Alternative Approaches to Debitage Analysis. *Lithic Technology* 22(1):51-69.

Nelson, Margaret C.

1991 The Study of Technological Organization. *Archaeological Method and Theory* 3(1):57-100.

Newcomer, M. H.

1971 Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3(1):85-104.

Odell, George H.

2004 *Lithic Analysis.* Springer Science & Business, New York.

Ozbun, Terry L.

2015 Toolstone Geography and the Larger Lithic Landscape. In 2015 *Toolstone Geography of the Pacific Northwest,* edited by Terry L. Ozbun and Ron L. Adams.Archaeology Press, Simon Fraser University, Burnaby, BC, Canada.

Pecora, Albert M.

2001Chipped Stone Tool Production Strategies and Lithic Debitage Patterns. In *Lithic Debitage: Context, Form, Meaning* edited by William Andrefsky Jr. University of Utah Press, Salt Lake City.

Prentiss, Anna Marie and David S. Clarke

2008 Lithic Technological Organization in an Evolutionary Framework: Examples from America's Pacific Northwest Region. In *Lithic Technology: Measures of Production, Use, and Curation,* edited by William Andrefsky, Jr. Cambridge University Press, New York, NY.

Rasic, Jeffrey and William Andrefsky Jr.
2001 Alaskan Blade Cores as Specialized Components of Mobile Tool Kits: Assessing Design Parameters and Tool Kit organization through Debitage Analysis. In *Lithic Debitage: Context, Form, Meaning*, edited by William Andrefsky Jr. University of Utah Press, Salt Lake City.

Root, Matthew J.
1992 The Knife River Flint Quarries: The Organization of Stone Tool Production. Ph.D. dissertation. Department of Anthropology, Washington State University. Pullman, WA.

1997 Production for Exchange at the Knife River Flint Quarries, North Dakota. *Lithic Technology* 22(1):33-50

2004 Technological Analysis of Flake Debris and Limitations of Size-Grade techniques. In *Aggregate Studies in Chipped Stone Analysis,* edited by Christopher T. Hall and Mary Lou Larson. University of Utah Press, Salt Lake City.

Sappington, Robert L.
1994 *The Prehistory of the Clearwater River Region*. Ph.D. dissertation. Department of Anthropology, Washington State University. Pullman.

2010 *A Proposed Archaeological Testing Plan for the Kelly Forks Work Center Site (10CW34), Clearwater National Forest*. Submitted to USDA Forest Service. Adapted from Longstaff, 2013.

2015 Archaeological Theory and Methods. Lecture. University of Idaho, Moscow ID.

2016a PreHistory of North America. Lecture. University of Idaho, Moscow ID.

2016b Lithic Technology. Lecture. University of Idaho, Moscow ID.

2017 Plateau Prehistory. Lecture. University of Idaho, Moscow ID.

Sappington, Robert L. with contributions by J. A. Draper, D. L. Olsen, M. D. Pittenger, J. J. Flenniken, T. L. Ozbun, J. Markos, L. Barry-Steinman, R. Sprague, and R. Johnston
1991 *Archaeological investigations of the Clearwater Fish Hatchery (10-CW-4), North Fork of the Clearwater River, North Central Idaho.* University of Idaho Anthropological Reports No. 91. University of Idaho, Moscow.

Sappington, Robert L. and Caroline D. Carley
1987 *Archaeological Investigations at the Kooskia Bridge Site (10IH1395).* University of Idaho Anthropology Reports, No. 87.Alfred W. Bowers Laboratory of Anthropology. University of Idaho, Moscow.

Schiffer, Michael B.
1972 Archaeological Context and Systemic Context. *American Antiquity* 37(2):156-65.

Sievert, April K. and Karen Wise
2001 A Generalized Technology for a Specialized Economy. In *Lithic Debitage: Context, Form, Meaning*, edited by William Andrefsky Jr. University of Utah Press, Salt Lake City.

Shelley, Phillip H.
1990 Variation in Lithic Assemblages: An Experiment. *Journal of Field Archaeology* 17(2):187-93.

Shott, Michael J.
1986 Technological Organization and Settlement Mobility: an Ethnographic Examination. *Journal of Anthropological Research* 42(1):15-51.

1996 Stage Versus Continuum in The Debris Assemblage From Production of a Fluted Biface. *Lithic Technology* 21(1):6-22.

2007 The Role of Reduction Analysis in Lithic Studies. *Lithic Technology* 32(1):131-141.

Stahle, David W., and James E. Dunn
1982 An Analysis and Application of the Size Distribution of Waste Flakes from the Manufacture of Bifacial Stone Tools. *World Archaeology* 14(1):84-97.

Stern, Theodore
1998 Columbia River Trade Network. In Handbook of North American Indians, Plateau, Vol. 12, edited by Deward E. Walker, Jr., pp. 29-48. Smithsonian Institution, Washington, D.C.

Sullivan, Alan P. and Kenneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50(4):755-779.

VanPool, Todd L. and Robert D. Leonard
2011 *Quantitative Analysis in Archaeology*. Wiley-Blackwell. West Sussex, UK.

Wenzel, Christine E. and Phillip H. Shelley
2001 What Put the Small in the Arctic Small Tool Tradition. In *Lithic Debitage: Context, Form, Meaning*, edited by William Andrefsky Jr. University of Utah Press, Salt Lake City.

White, A.M.
1963 Analytic Description of the Chipped Stone Industry from the Snyders Site, Calhoun County, Illinois. In 1963 *Miscellaneous Studies in Typology and Classification*, edited by A.M. White, L.R. Binford, and M. L. Papworth, pp. 1-70. Anthropological Papers No. 19. Museum of Anthropology, University of Michigan, Ann Arbor.

Whittaker, John C.
1994 *Flintknapping: Making and Understanding Stone Tools.* University of Texas Press, Austin, TX.