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Organization of Technology at the Sanders Site (45KT315): Analysis of Formed Tools from the Yakima Uplands, WA

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ORGANIZATION OF TECHNOLOGY AT THE SANDERS SITE (45KT315) : ANALYSIS OF FORMED TOOLS FROM THE YAKIMA UPLANDS, WA

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by

Patrick Garrison

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ABSTRACT

ORGANIZATION OF TECHNOLOGY AT THE SANDERS SITE (45KT315) :

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Analysis of the stone tools from the Sanders Site reveals trends in the development of stone tool technology and settlement patterns within the Yakima Uplands west of the Middle Columbia River. The Sanders Site collection provides exceptional opportunity for the study of stratified components that date between 9000 and 1000 years ago. Three components include evidence of stone tool manufacture using local bog stone along with refuse from seasonal hunting and plant gathering. Identification of projectile point morphologies support temporal assignments for each component, and reflect shifts from dart to bow hunting. Analysis of all the bifacial formed tools (raw material, use wear, and breakage patterns) demonstrate changes in technological organization related to transitions from foraging to collecting strategies by 3000 years ago. This change in technological organization is often explained as a shift from curated to expedient tool use. This change includes collecting and storing resources, residential base stations, increased artifact frequencies and percentages of manufacturing breaks, and use of local stone tool sources. These changes also resulted in a diminished utilization of exotic stone tool sources. Diagnostic projectile points correlate with established regional cultural chronologies. Small sample sizes from the early component and incomplete dating are limitations in this investigation.

ACKNOWLEDGEMENTS

This work would not be possible without the assistance and patience of my committee chair Dr. Steven Hackenberger, as well as committee members Dr. Patrick McCutcheon and Shane Scott, MS. Additionally, I would like to thank Dr. William Smith for his original work on the Sanders Site and invaluable help in understanding the site and the assemblage for this paper. I am grateful to Dr. McCutcheon for providing analytical funds for the obsidian sourcing, as well invaluable assistance with the lithic analysis. Countless thanks go to my family and friends. This work is dedicated to my parents, Phillip and Julie Garrison.

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CHAPTER I

INTRODUCTION

Archaeologists have yet to produce a full synthesis of the cultural materials present in the tributaries and uplands of the Middle Columbia River. Pilot studies, survey and inventory projects, and limited testing programs have produced a large body of work that will serve anthropological interpretations. The lack of in depth studies of stratified archaeological sites from the uplands is one of the main factors inhibiting new consolidation and meaningful interpretation.

Subsistence activities and stone tool acquisition in the Yakima Uplands were critical to the adaptations of Middle Columbia River peoples. The ridges, saddles, and terraces of this area were vital to early mobile bands. Later these locations were heavily used by families and task groups from communities focused on the main stem of the Columbia River and lower Yakima River.

The Sanders Site, 45KT315, is one of the few excavated upland sites in the region with evidence of occupation from 9000 years to 250 years ago. In addition to early and late occupations with stone tool workshop activities, large volumes of excavated strata contain a significant sample of formed stone tools. The site is located along the Johnson Creek drainage within the current boundaries of the Yakima Training Center (YTC). The site was originally excavated on what was the private Sanders Ranch, by Dr. William Smith of Central Washington University (CWU). Dr. Smith directed two summer field schools at this location in the early 1970's. The Sanders Site was brought to the attention of Dr. Smith because digging and collecting activities that had been taking place. As a new faculty member at CWU, fresh from studies with Lewis Binford, Dr. Smith planned and executed a series of survey and testing projects aimed at explaining the upland subsistence and settlement patterns on the eastern slope of the Cascades. Although the surface of the Sanders Site was heavily disturbed, the excavation of deep trenches and block excavation of activity areas was key to Dr. Smith's research design.

Looking back it is now obvious that the overall size of the assemblage collected during the field schools, combined with new advances in analytical methods, quickly exhausted the limited resources of a small college. Also, soon after the field schools took place, all new archaeological work would be conducted as cultural resources projects through the new CWU archaeological firm Central Washington Archaeological Survey (CWAS). Dr. Smith formed CWAS and built a staff that would continue to follow and update the overall outline of his research program albeit under the constraints of multiple, separate federal compliance projects. The Sanders Site collection was bagged, boxed, and left dormant for over two decades until a new generation of faculty and students realized the value of the collection for recently developed analytical studies and the importance of more durable curation materials.

The Sanders Site was systematically excavated using arbitrary ten centimeter levels, combined with careful stratigraphic profiling and control. The few features that were encountered were mapped in field notebooks. All of the matrix was water screened and all classes of artifacts were kept and sorted. Curated and stored, the assemblage of both lithic and faunal remains from the Sanders Site has been subject of several student research projects at CWU. This thesis focuses on the formed tools from Trench 1502, the only trench at the site to be excavated outside of the margins of the looters pits (1501 and 1504). This trench provides a significant stratigraphic record and the best corresponding artifact samples for analysis. The analysis of the formed tools from 26 ten centimeter levels (including seven distinct strata) reveals changes in the technological organization of biface manufacture and use. These changes in technological organization reflect transitions from mobile bands to larger, more sedentary communities and associated task groups.

Problem

This study will determine how archaeological assemblages of formed lithic tools can be classified and quantitatively analyzed in order to document changes in subsistence and settlement adaptations in the Yakima Uplands. The Sanders Site formed tools were used to test for differences in technological organization and strategies between the Vantage to the Frenchman Springs Phases (10,000 B.P. to 2000 B.P.).

The technological organizations of lithic components from distinct strata were compared. Focused comparisons were used to test for changes in tool frequency, morphology, raw material, breakage patterns, and use-wear that illuminate possible patterns of sedentism (Andrefsky 2005). Lithic technologies found in assemblages from the Columbia Plateau provide evidence of types of subsistence activities and settlement strategies that are represented at a site. These technologies can also be used to draw conclusions about the relative mobility of foragers and collectors and its effect on the organization of technology (Andrefsky 2005, Chatters 1987).

Chronological outlines of cultural evolution in the Columbia Plateau, using phase designations that match the periods represented in the Sanders Site, include a mid-Holocene shift from the forager (curated tool dominant with residential mobility) to collector strategies (expedient tool dominant with logistical mobility) (Chatters 1987, Chatters and Prentiss 2008). This shift in subsistence and settlement pattern is used to explain changes in technological organization between the Vantage and Frenchman Springs Phases (Galm 1981, Nelson 1969, D. Rice 1968, Campbell 1985) on the mid-Columbia (Chatters 1987, Chatters and Prentiss 2004), and within the Yakima Uplands (Hackenberger 2010 and Orvald 2009).

The movement from a forager to a collector subsistence model has been most thoroughly documented within major river corridors where sedentary patterns developed between 6000 and 4000 years ago (Chatters and Pokotylo 1998). Focus on lower riverine settlement on the Columbia Plateau has created a data gap in the understanding of upland base station subsistence patterns (Lyman 2000). Upland sites were used extensively throughout the Vantage Phase on the Mid-Columbia (Chatters et al. 2009), and show more or less continuous use throughout the transition to sedentism and collector subsistence strategies.

Data obtained through lithic analysis are used to infer changes in the organization of lithic technologies expected for base localities of foragers versus collectors through intra-site comparison (Andrefsky 2005, Nelson 1991). The Sanders Site artifacts appear to compare with attributes predicted to correlate with assemblages produced by more sedentary communities of collectors (Houser 1996, Schalk et al. 1996) arising from consistent use over time. Collector assemblages are characterized by: increased artifact diversity, decrease in use wear, more limited retouch, and an increased use of low quality locally acquired stone.

Researchers have hypothesized about how ratios of curated to expedient tools can serve as indicators of mobility patterns (Andrefsky 2005, Nelson 1991, Chatters 1987, Kelly 1992). Hayden et al. (1996) use a system that neatly divides tools into different reduction strategies classed as either expedient or curated tools which relates to activity occurring at or away from base stations. The presence of curated tools suggest higher mobility and thus a sites use as a hunting or temporary location. Expedient tool frequency points toward a site was used as a more multi-use base station. Theoretically, artifact diversity should increase with sedentism (Andrefsky 2000).

In the Yakima Uplands, assemblage structure at sites can be indicative of whether sites may have been used during different periods occupation as temporary locations for resource extraction, or as fuller residential base stations. Short term extractive sites should have a redundant assemblage based on the exploitation of a few resources. Residential bases should include evidence of multiple resources, specialized tools, and higher artifact diversity (Andrefsky 2005). The overall expectation is that the Sanders Site assemblage will show a shift from a temporary workshop and hunting locale to an established seasonal residential base. Changes in assemblage attributes will reflect a shift from curated to expedient stone tool technology.

Purpose

The purpose of this thesis is to inventory, analyze, and then compile Sanders Site data into a database capable of answering questions about the composition of the bifacial stone tool technology at this Yakima Uplands location. Site records and notes and previous databases were compiled into a working database of stone tools.

The first objective (1) is to inventory the entire collection of stone tools in the current tool assemblage from the Sanders Site excavation Trench 1502.

The second objective (2) is to analyze all relevant attributes and dimensions of the bifaces, recording basic dimensions such as weight and raw material as well as through use of a projectile point typological key, a paradigmatic classification, and breakage pattern analysis.

The final objective (3) is to assemble this information into a database that can be used to provide tables that are able to illuminate patterns and answer questions about changes in tool manufacture and usage among the bifaces of the assemblage.

Significance

The significance of this research on 45KT315 is that it adds to the understanding of upland sites, while also making use of an existing and neglected legacy assemblage housed at Central Washington University. The Sanders Site is a multicomponent site, representing many of the cultural sequences from the early to late Holocene on the Columbia plateau. Understanding the composition and evolution of stone tool technology present at this site will assist further research on of upland sites and other locations peripheral to village sites. This research adds to the existing database of sites using the same paradigmatic classification system, expanding a diverse list of sites in which the lithic technologies can be easily compared through future research. The use of legacy collections like the Sanders Site lithic assemblage, that have documented provenance, will expand current understanding of patterns of technology and our overall understanding of Middle Columbia River cultural traditions.

CHAPTER II

STUDY AREA

Geology

The Columbia plateau is located between the Cascade Range Mountains to the west, and the Columbia basin to the east. The plateau was formed through a series of Miocene volcanic basalt flows erupting from vents. This formation is referred to as the Columbia River Basalt Group (CRBG). Individual CRBG layer thicknesses vary widely, from inches to hundreds of feet (Reidel et al. 1989). Between some of these flow layers are sedimentary interbeds of heated and petrified organic matter, comprised largely of forest and bog sources. These materials were agatized between the lava flows, forming the interbeds. Eroding outcrops of this raw material for tool stone acquisition were exploited by prehistoric populations.

The Sanders Site is located in the Yakima Fold Belt in Southeast Kittitas County, Central Washington State. It is a geologic formation comprised of a series of east-west anticlines and synclines formed from the compression of the Columbia River Basalt Group (Reidel et al. 1989). The anticlines and synclines of the Yakima Fold Belt are produced by regional tectonic compression moving generally to the Northeast (Reidel et al. 1989). Early to middle Holocene sedimentation in Johnson creek canyon has been marked by long periods of stability interspersed with periods of runoff and erosion. (Cochran 1978, Galm et al. 2000).

Johnson Canyon is located west of the Columbia River, north of the western half of the Saddle Mountains. Upstream locations have some intact late Pleistocene deposits, "as the river removed many downstream deposits through cutting and filling of fluvial sediments" (Galm, Gough, and Nials 2000; 7.17). In the early Holocene, Missoula floods reached to an elevation of 360 meters (1200 ft.). These events removed vast amounts of sediments, and deposited sands and gravels. The drainage above 360m is unaffected by the Missoula Flood events, leaving a landscape of fluvial deposits in valley bottoms, and aeolian, lithosol, and some loess on the hill sides (Galm 2000). In some areas on the hillsides, bedrock is either at or very close to the surface.

Flora and Fauna

The majority of the area of Johnson canyon and the surrounding ridgelines is a shrub-steppe landscape, with some areas of bunched trees. The vegetation in the area consists of shrubs like big sagebrush (*Artemisia tridentata)* and blue bunch wheatgrass (*Agropyron spicatum)*. Smaller vegetation consists of shrub-steppe species such as bitterroot, wild onions, serviceberries, currants, and chokecherry. All of these were utilized by early to late Holocene peoples (Franklin and Dryness, 1988). Animal species that would have been present and available to Holocene inhabitants include salmon, freshwater mussel, elk, pronghorn, deer, bird, and rodent species. A study of a sample of faunal remains in 2010 (Endacott and Hackenberger) show the variety of ungulate and rabbit species at the Sanders Site.

Cultural Chronology

Chronologies of the sequences of culture change over the middle Columbia region have remained mostly constant in the past 30 years. Most changes have involved subdividing preexisting sequences as new radiocarbon dates from excavations expand and illuminate occupation trends. Most chronologies deal with some permutation of an early, middle and late period (Chatters and Pokotylo 1998, Ames et al. 1998).

The overarching view of plateau cultural evolution is one that starts from small populations of highly mobile groups with a curated or preformed tools with predetermined use trajectories transitioning to more sedentary, larger populations who employ a more expedient tool technology as they need to move less and are more often near raw material and supply sources. Within this chronology are movements towards large pit house villages and an extensive trade network throughout the Pacific Northwest and beyond. Table 1 on the next page provides a succinct review of the distinct cultural phases of the Columbia Plateau.

Schalk identified three major periods of subsistence evolution (Schalk 1980). The first period was from 3500 to 11000 BP, and is characterized by a lack of permanent housing and a focus upon big game hunting. The second cultural time period was from 285 to 3500 BP, identified by increasing dependence on aquatic resources and establishment of permanent to semi-permanent village sites. The third period, from 1730 to the present, is marked by the introduction of the domesticated horse to the area and modern farming.

Table 1. Chronology of Galm et al. 1981, Summary from (King and Putnam 1994:15-17).

Clovis (11500-10500 BP): In eastern Washington, the Clovis Phase is characterized by small, mobile bands of hunter/gatherers that exploited a wide range of subsistence resources, including bison and elk (Rice and Stilson 1987). Sites are usually small, exhibit low artifact densities, and are associated with early landforms, especially upland plateaus. Clovis artifact assemblage consists of lithic debitage, large scraping tools, cobble tools, and large Plano-type projectile points (Clovis points). Bone and antler artifacts are rare, perhaps due to differential preservation.

Windust Phase (10500-8000 BP): The Windust Phase is characterized by small, mobile bands of foragers/collectors that exploited plant and animal resources during a seasonal round (Chatters 1986). The few cultural deposits known from this phase are generally small and exhibit low artifact densities. Large shouldered and large basal-notched lanceolate projectile points are diagnostic of this phase.

Cascade/Vantage Phase (8000-4500 BP): Vantage Phase peoples were highly mobile, opportunistic foragers adapted primarily to riverine environments (Chatters 1986, Galm et al. 1985). Archaeological data from this phase suggests that fish had become an important subsistence resource. Archaeological sites of the Vantage Phase are generally discovered along river and stream margins. Projectile points diagnostic of this phase include large, shouldered lancoelates and unstemmed lanceolate forms.

Tucannon/Frenchman Springs Phase (4500-2500 BP): The Frenchman Springs Phase is characterized by the introduction of semi-subterranean houses and the presence of specialized station’s for hunting, root collecting, and plant processing. Archeologists have suggested that the ethnographic Plateau pattern emerged by the end of this phase (e.g., Nelson 1969). Several styles of smaller, contracting stemmed projectile points are diagnostic of this period.

Harder/Cayuse Phase (2500-200 BP): During the Cayuse Phase, inhabitants of the Columbia Plateau wintered in large, nucleated villages of 50 pit houses or more (Chatters 1986). In the spring, people dispersed to gather roots, and in the fall and winter small parties established hunting stations in the uplands. This seasonal round became increasingly diverse and better organized over time, and trade with coastal groups was common. By about 200 years ago, the introduction of diseases reduced Native American populations and led to significant changes in the settlement and subsistence patterns of native Columbia Plateau groups

These phases are currently understood as a transition from a forager to a collector material culture (Binford 1980). Foragers do not store food for long intervals, making it necessary for them to move more frequently to acquire resources throughout the year.

Food storage and reliance on acquired resources during the winter months is the hallmark of a collector's society. The current record suggests a shift from more mobile foraging groups to more sedentary collector groups in the mid Holocene Columbia Plateau around 5000 to 3000 BP (Chatters 1994, 2005).

Diagnostic lithics at the Sanders Site indicates the presence of several distinct prehistoric cultural sequences for Washington. These were the Windust Phase (10800 – 8500 BP), Cascade/Vantage (8500 - 5000 BP), and Frenchman Springs component (4000-2500 BP) assemblages. The majority of artifacts are associated with a Frenchman Springs component (Hackenberger 2009).

Native Culture

The Yakima Uplands on the Middle Columbian Plateau are in the traditional lands of the Sahaptin language group, of which the Yakama, Kittitas, and Wanapum are the modern descendants. These groups populated the Mid-Columbia Plateau during the ethnographic period (Schuster 1998). The Yakama Training Center is within the ceded lands of the Confederated Tribes and Bands of the Yakama Nation, outlined in their treaty of 1855. The Yakama Nation is a confederation of the fourteen Tribes and Bands who were signatory to the 1855 Walla Walla Treaty, of which the Yakama Tribe and Kittitas Band are both members. The Yakama, Kittitas, and Wanapum have all maintained traditional cultural properties and sacred sites within the training center through cooperation with the army as outlined in the treaty of 1855 with the United States Federal Government.

The populations ancestral to these groups subsisted through "hunting, plant and root gathering, and exploitation of riverine resources" (Uebelacker 1984). They settled in lowland villages during winter months to optimize the use of gathered resources. Families dispersed to destinations upland, river, montane, and elsewhere from spring through fall (Hunn 1990). Small groups used some of these upland settings, whereas some downriver locations were occupied by hundreds of families. The area around 45KT315 would have offered edible roots, small game, as well as some aquatic resources like small fish and fresh water mussels (Hackenberger 2009, Gough 2000). Available toolstone would have made the location a focal point of tool manufacture in the area through procurement of toolstone from locations within the valley. There are many of these possible deep depositional upland base stations used as resource acquisition areas within the YTC (Miss 2003). Site 45KT315 probably represents Vantage Phase hunting locations and a Frenchman Springs Phase base station that could have been used throughout the year, but most heavily in spring and fall. These smaller sites then connected with the lowland winter villages for large spring gatherings in other areas in the upland meadows (Hackenberger 2009).

Site Location

The Sanders Site is situated within the boundaries of the Yakima Training Center (YTC) managed by United States Army. Johnson Canyon was a ranching area in the late nineteenth and early twentieth centuries. The establishment of the training center began in 1942 with the lease of an artillery range followed by several stages of land acquisition.

The U.S. Army owns this property for the purposes of training by the Army, Air Force, and National Guard. Johnson Creek which runs through the Sanders Site has experienced "relatively little disturbance from this civilian and military activity" (Galm, Gough, and Nials 2000). Archaeologists have extensively studied the YTC through survey as part of the Army's' responsibilities under the National Historic Preservation Act (NHPA Section 106). The Yakima Training Center and the surrounding areas are shown in Figure 1. Johnson Creek can be seen in the center of the top half of the illustration.

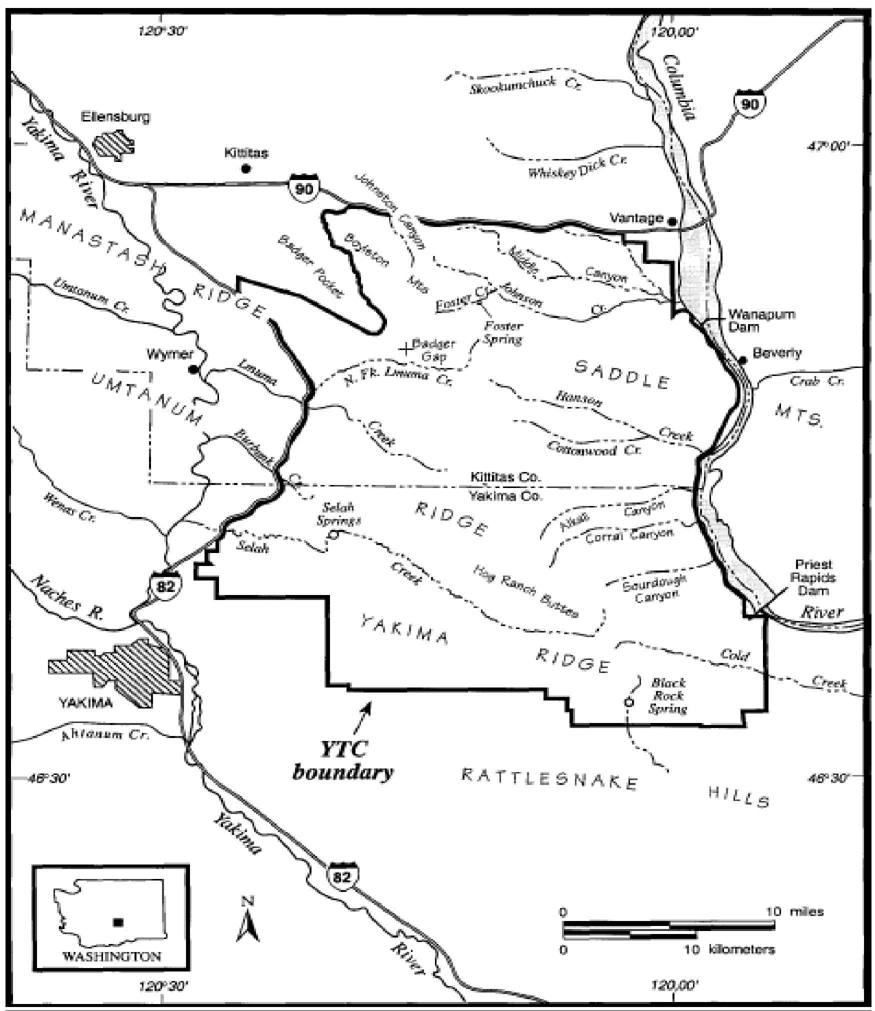

Figure 1. Yakima Training Center and surrounding area, from Galm 2000; 1.3.

The YTC represents one of the few areas of a relatively intact shrub-steppe left in Washington State. Man-made factors affecting the ecosystems of the YTC are historical ranching and over-grazing, fire suppression activities, and ground disturbance from military vehicle traffic. Modern influences aside, this area closely approximates the appearance it would have had in late prehistoric times (2000 BP-150 BP). The YTC currently encompasses 327,232 acres of ridge and basin shrub-steppe environment. It is situated along the Columbia River, east of cities of Ellensburg and Yakima. It is border by Interstate 90 on the north and WA 24 on the south. It has The Yakima River to the west, and is bordered by the Columbia River on the East. This area is rich in historic and prehistoric archaeological sites, with hundreds identified so far.

The Sanders Site is situated on a rise north of Johnson creek, which drains to the east into the Columbia River about four miles due east in the northern portion of the YTC. The historic Sanders Ranch Site is located just upstream from the site.

The Sanders Site

The Sanders Site (45KT315) is named for the historic ranch that is located near the location up river. It has also been called the Johnson Creek Site. 45KT315 is on the north side of the valley on a rise above the creek bed. Isolated finds surrounding the site as well as the possibly intact sediments on the southern side of the river indicate land use of some antiquity. The deposit most likely encompasses 45KT315 and 45KT726. It is unclear how much erosion as well as the cutting and filling of the creek has re-deposited some material from both sites.

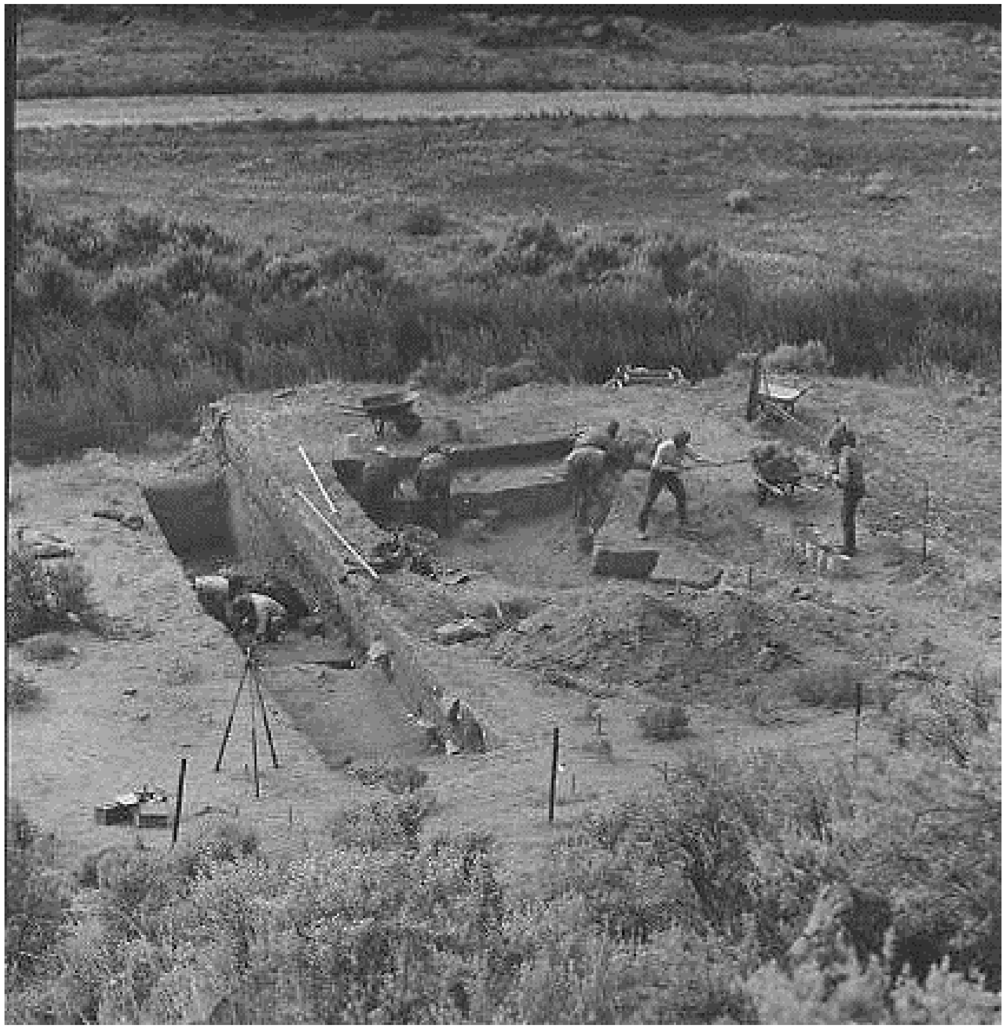

Figure 2. View of excavation, facing south. Undated photo from the collection.

Dr. Smith directed excavation of the site as part of two CWU field schools in 1971 and 1972. Excavation consisted of three areas. Trenches 1501 and 1504 were created around the previously disturbed looters pit. These trenches were eventually combined into a block excavation. Figure 2 shows the excavation in its second year with all trenches open; Trench 1502 is on the left, and Trench 1504 is on the right. Trench 1502 is directly 1-meter east of the 1502/1504 block, and runs north/south in two rows of

1x1 meter units. CWU has possession of excavation notes, original profiles, photographs, and maps pertaining to the field schools. Figure 3 details the stratums within the excavation block.

Diagnostic and non-diagnostic tools and some debitage were labelled with white out laid down first and then inked catalog numbers were written on the white out. Then both ink and white out covered with a clear acrylic nail polish. Identifiable artifacts were drawn on artifact index cards and original excavation profiles on butcher paper. Sediment bulk samples were taken from representative levels. The collection was assigned original artifact numbers in a catalog of all artifacts and samples.

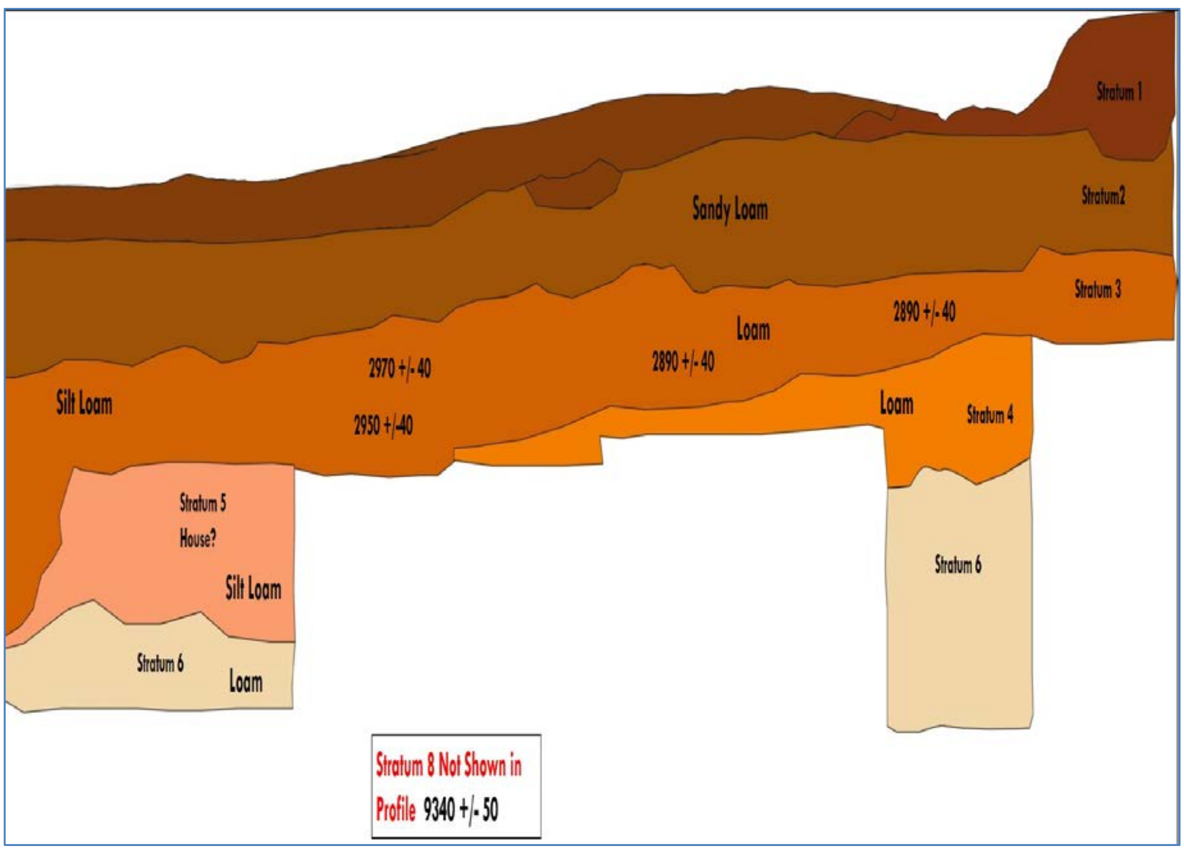

Figure 3. Composite 1502 stratigraphy (Ainsley 2010).

The Sanders Collection

The assemblage was stored after excavation in the CWU Anthropology Department from the 1970s until the early 1990s. At that time it was re-boxed with curation-quality archive boxes. The site artifacts were preliminarily sorted by trench, units, and artifact type. It was summarily updated and further curated in 1998, 1999, and 2000. The artifact assemblage contains formed tools, ground stone, large amounts of debitage, bone, and shell. Several analyses have been completed with the collection using lithics, debitage, bone, and shell artifacts (Vantine 2009, Endacott and Hackenberger 2010). Since 2005 the artifacts have been the subject of undergraduate papers, Farrell Scholarship and McNair fellowship papers, and graduate master's theses.

Dating

The first dating of Sanders Site material was done in 1998/99 under direction of the YTC Cultural Resource Manager Brantley Jackson. Douglas Frink produced a report for a pilot study of the Oxidized Carbon Ratio Dating (OCR) technique. This method uses the ratio of oxidized carbon to organic carbon and an equation taking into account for soil formation processes to arrive at a date. CWU graduate student David Woody compiled six sediment samples from Trench 1502 Unit 18. Table 2 shows the dates retrieved by Frink.

Radiocarbon dates taken from bone in 2009 as part of a Farrell Scholarship project undertaken by Vantine and Dice give dates for the upper and lower components (Tables 3 and 4.) Both Vantine (2009) and Dice obtained radiocarbon samples for dating from Trench 1502; units 4, 12, 18 and 28. Upper component dates have all ranged around 3000 BP, while the Lower component was dated to 9000 BP.

Table 2. Oxidized Carbon Rationing (OCR) Dates.

Level	Stratum	Estimated OCR Date
12	2	1259 BP
16	3	1889 BP
20	4	3404 BP
25	6	5404 BP
29	6	5586 BP
31	6	7468 BP

Table 3. Faunal Bone Radiocarbon Dates from Bone, Dice (2009).

Sample*	Measured Radiocarbon Age	13C/12C Ratio	Calibrated Radiocarbon Age
15021825 Bone	2890+/- 40 BP	-21.4 ‰	3250 – 2980 BP
15022833 Bone	9340 +/- 50 BP	-19.7 ‰	10760 - 10560 BP

*1502 Trench, Unit, 10cm Level

Table 4. Radiocarbon Dates from bone, Vantine (2009).

Sample*	Measured Radiocarbon Age	13C/12C Ratio	Calibrated Radiocarbon Age
15020411 Bone	2970 +/- 40 BP	-20.7 ‰	3360 – 3150 BP
15020415 Bone	2950 +/- 40 BP	-19.5 ‰	3360 – 3150 BP
15021213 Bone	2980 +/- 40 BP	-21.6 ‰	3360 – 3150 BP

*1502 Trench, Unit, 10cm Level

Missing dates from between these ranges may be due to sediment erosion or lack of deposition from 9000 to 4000 years ago. Dates have been combined and compared to known YTC dates in Figure 4.

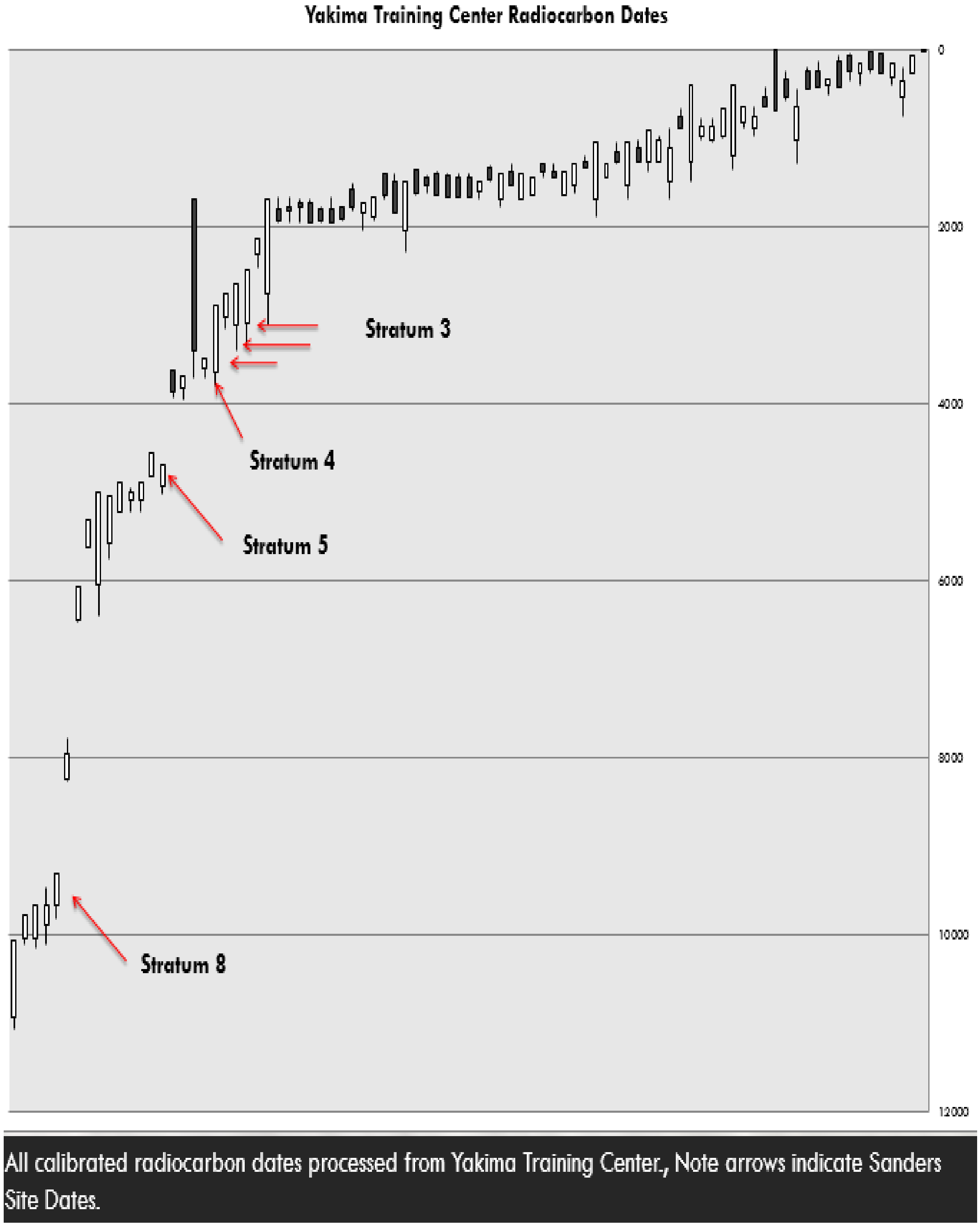

Figure 4. Yakima Training Center Radiocarbon Dates (Ainsley 2010).

45KT726

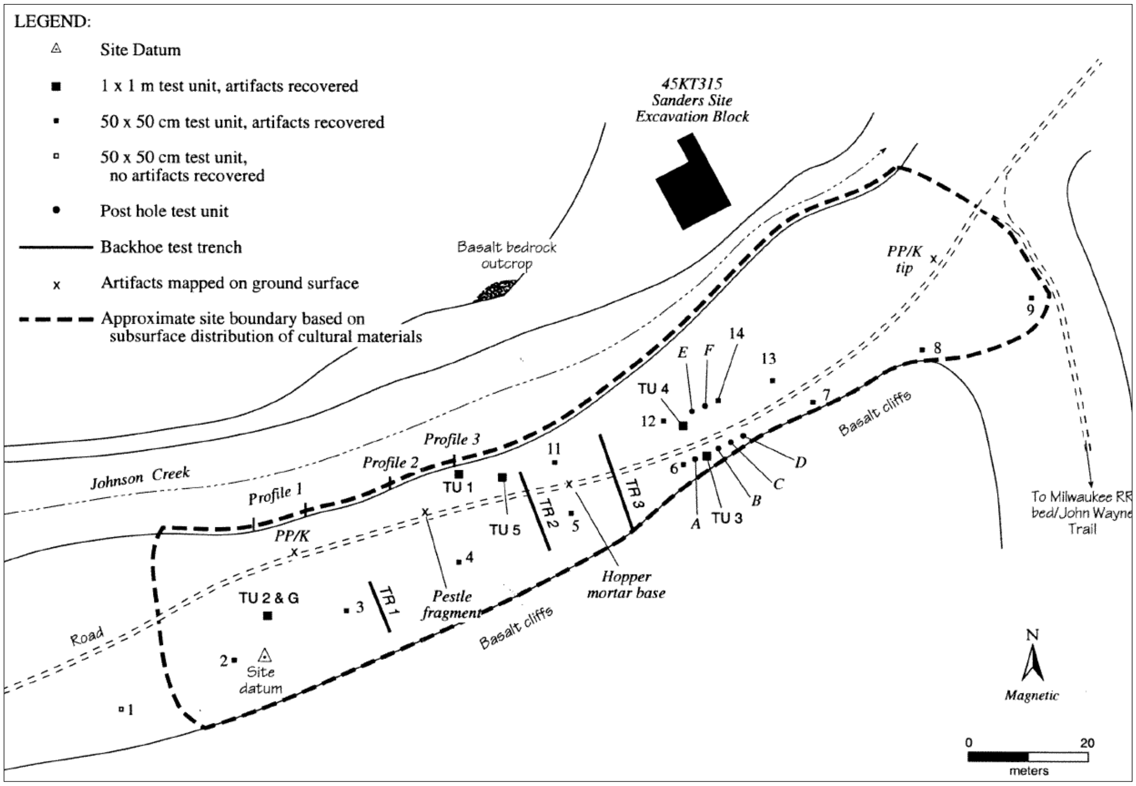

Figure 5. Locations of Site 45KT315 and 45KT726 (Gough 2002).

Archaeological and Historic Services (AHS) from Eastern Washington University test excavated site 45KT726 (Figure 5 above) in 1998 (Gough 1999) with a test unit and cut bank profiles. They found stratified alluvial deposits containing cultural material including lithics, bone, and shell. Radiocarbon dates taken from charcoal in the test unit and in the cut banks give a range of around 5840 BP for the bottom of cultural deposits, with the possibility of deeper cultural stratum. Two bifaces larger than 6cm long were found in cut bank profiles. One is identified as a Windust style point, indicating early

Holocene occupation presence of the area. Radiocarbon testing at the site of a carbon sample from a lower stratum in a cut bank dated to 5840 BP (Gough 1999).

It is likely that the sediments from 45KT315 and 45KT726 incorporate the same continuum of occupation. However, the stream has periodically eroded and re-deposited artifacts and cultural material mostly on the southern portion in the last 3000 years. AHS recommended the site for listing on the NHRP Register under Criterion D, due to the presence of intact sediments dating to the mid to early Holocene.

CHAPTER III

LITERATURE REVIEW

Columbia Plateau archaeological deposits represent land use activity after retreating glaciers opened up new areas.(Cressman, 1960, Browman,1969).This geographic area has been occupied for at least 12000 years according to current archaeological data. The Sanders Site has evidence of human activity for 9000 years through deposit and artifact analysis. This encompasses many of the cultural sequences, material cultures defined by time and space, which are thought to be representative of prehistoric life in the middle Columbia.

Foragers and Collectors

Binford proposed a structure of thinking about these two strategies that emphasizes the difference between these two patterns as a difference in mobility (Binford 1980). Mobility is divided into residential and logistical patterns or "the difference between moving the entire group to a new area and moving smaller more specialized groups to temporary sites" (Binford 1980). Others have described the strategies differently but with similar production of site types (Chatters 1995, Schalk and Cleveland 1983). While sedentism may have taken time to be fully adopted, on the southern plateau it was under way around 4000 BP and was more or less fully adopted by 2000 BP (Chatters 1995, Galm et al. 1981, Daughtery 1969). Forager populations exhibiting residential mobility locate to resource rich or advantageous bases circling around a central hub. These residential stations, usually in riverine settings, then act as a base for smaller more specialized hunting and acquisition areas with the presumptive tactic of being in the right place for the acquisition of needed subsistence resources such as raw material, plants, and animals (Binford 1980). As seasons and conditions changed operations could be moved entirely to a new location. These groups often had a diverse diet, as they might need to change locations and subsistence patterns relatively quickly (Bamforth 1997, Chatters 1987, 1995).

Collectors are more sedentary and rely on logistical mobility for resource acquisition. Logistical Mobility is the movement to areas with specific resource extraction in mind, often with the intention of brining those material back to larger residential sites for storage and use by a wider population. Hunting locales, stone tool raw material procurement, and root grounds are examples of sites utilized in a logistically mobile strategy.

Foragers and collectors use the same site types of residential/base stations and hunt/field localities (Chatters 1987, 2009). The main difference is in the application of storage in a collector strategy. Population pressures may have been a key factor in the move to a collector strategy (Schalk 1981, Croes and Hackenberger 1988, Cohen 1981).

Cascade/Vantage forager collections are understood to have a more curated focused lithic technology. This is represented in the record by large cryptocrystalline silicate (CCS) bifaces, shouldered stemmed and unstemmed lanceolates, flakes with prepared cores, and burins (Ames and Maschner 1999, Carlson 1998). Biface tools are of limited variety and used for multiple tasks. The move to a more collector like strategy described as Frenchman's Spring technology is represented by stemmed/corner/side notched varieties of projectile points, and more opportunistic reduction techniques focusing more on utilized flakes from available sources

While larger sites located on or near the main branch of the Columbian River are better understood (Nelson 1969, Campbell 1985, Rice 1981), smaller resource acquisition upland sites located closer to stone tool sources are often over looked and misunderstood. Of particular interest is how the nature of the stone tool assemblage structure of these sites changed over time as the methods of settlement and land use evolved. In village sites, it is expected that assemblages should show certain changes as sedentism increases (Schalk 1996, Houser 1996). As activities become more specialized and there is less need for mobility, tool forms show less evidence of multiple uses as well as less investment, with hafted tools decreasing in favor of expedient flake tools (Chatters 1986, Andrefsky 2000). Biface technology becomes more varied and less multi-tool. Table 5 outlines Schalk and Houser's combined predicted outcomes for assemblage characteristics changing due to in increases in sedentism.

According to this technological/cultural framework, the Sanders Site should show technological shifts during this transition that should be identifiable through assemblage characteristics from the lower to upper stratum. This thesis will examine whether the Sanders Site fits the predicted shift occurring in the Cascade to Frenchman Springs transition from a highly mobile-low density simple assemblage to a more sedentary focused assemblage with varied single purpose tools.

Table 5. Expected Site Assemblages Adapted from Schalk and Houser.

Land Use Strategy and Mobility	Expected Assemblage
Reduced residential mobility (associated with increase in task specific toolkits)	Higher frequency of cortical flakes. Less abundant bifacial flaking debris. Lower ratio of utilized biface thinning flakes to debitage. Reduced frequency of bifacial cores. Increased frequency of unprepared cores. Lower ratio of biface fragments of debitage. Less frequent bifacial tools in general. Larger and heavier lithic tools. Lower edge to mass ratio. Less common tool retouch. Reduced number of tool maintenance techniques. Less tool resharpening. Less frequent tool recycling.
Reduced residential mobility (accompanied by decrease in territory and access to raw materials)	Exchange for raw lithic materials becomes more common. Raw material types should become more diverse. Raw material quality should decline; Intersite variability in raw material should decline. A former disparity in distance-from-source between tools and debitage should disappear.
Reduced residential mobility (increase distance from source increases conservation)	Tertiary reduction to become more common and primary reduction less common. Percussion flakes to decline in frequency. Shatter to become less frequent. Flake weight and size to decline. Cortex to become less frequent on flakes. Cores to become less common in ratio to debitage. Cores to become lighter. Retouched tools to increase in relative frequency. Tool recycling to become more common. Retouch of broken tools increase.

Table 5. Expected Site Assemblages Adapted from Schalk and Houser, Continued.

Land Use Strategy and Mobility	Expected Assemblage
Reduced residential mobility (tool assemblage restructuring)	Assemblage diversity should increase. Multifunctional tools should become less frequent. Single purpose tools should proliferate. The ratio of hafted to expedient tools should decline. Intersite variability in tool assemblage content should increase.
Residential sites should exhibit	A lower ratio of utilized to unutilized biface fragments. Greater biface thickness and weight. A higher ratio of proximal to distal projectile point fragments. A higher ratio of burins and gravers to projectile points. A higher ratio of bifacial debitage to bifacial tools. A higher ratio of retouch or notching flakes to total debitage. A lower ratio to resharpening flakes to total debitage. A higher ratio of unprepared to bifacial cores. More often stockpiled raw material for tool replacement.

Previous Research

Most previous studies have focused on highly populated winter village sites, leaving smaller sites marginalized and less well understood (Dancey 1973). There could also be sites or whole cultures that were eliminated by flooding or increased sedimentation (Hammett 1976). Secondary and tertiary stations like the Sanders Site are usually placed in the context of relation to these larger population centers occupied most heavily in the winter. Use of these uplands has been found to be very selective, and possibly played a vital role in the seasonal patterns of residency and resource procurement (Senn 2007). The Sanders Site is located near subsistence resources indicating it may have been what could be classified as a semi-permanent station (Binford 1980). The Yakama Fold Uplands are a dynamic region offering not just abundant tool stone but also access to nearby springs, fish, freshwater mussels, and root grounds (Orvald 2009).

While we have little evidence of the types of shelter used at these types of sites, it is reasonable to assume that there was some sort of structure at a site that was occupied for a longer period of time than some of the winter pit-house villages (Schalk, 1983). The archaeological record does not currently have an accurate picture of how many people occupied these upland sites (Dancey 1973).

Nearby sites include those along the Columbia River to the east, and other inland uplands sites identified through numerous surveys on the YTC (Beery 2002, Chatters 1986,1987, Chidley 2007, Deboer 2003, Flenniken, Hartman, and Lindermann 1979, Gough 1996, 1998, 1999, Gough and Hartman 1976; Kavanaugh 1977, 1978, 1979, King 1994, Lewarch, Dugas and Larson 1999, Miss 1999, Miss and Campbell 1998).

Yakima Upland Archeology

The Yakima Training Center includes over 1,350 recorded archaeological sites (Orvald 2005). Many of these sites are expressed as surface lithic scatters. Hundreds of buried multicomponent sites are located within tributary courses. Test excavations on sites dating from the Vantage through Cayuse Phases were conducted for a number of these sites during the late 1970’s through 2010.

Rice and Hartman (1979) investigated six upland sites. Test excavation recovered Cascades Phase point types. Most of the recovered assemblages indicate repeated, but brief occupations during the Frenchman Springs and Cayuse Phases. Components 45KT239 are assigned Frenchman Springs to Cayuse through projectile point types. Site

45KT242 is a deep but poorly stratified site with dense accumulations of artifacts. Point types suggest the presence of Vantage, Frenchman Springs and Cayuse occupations. Faunal remains and bone tools indicate a hunting base locale. Site 45KT240 contained an earth oven and a diversity of artifacts including formed lithics and flake tools, projectile points, and ground stone. Point types indicate brief occupations during the late Frenchman Springs and Cayuse Phases.

Chatters (1986) investigated a series of sites on the YTC within the multi-purpose range complex. Chatter's investigations document spring and fall occupations for procurement of tool stone, roots, and ungulate species, along with incidental use of freshwater mussel and sucker fish. Within 45KT252 the lowest Frenchman Springs component includes evidence for hunting, lithic procurement and tool making (Chatters 1986). Site 45KT285 is assigned to the Frenchman Springs and Cayuse Phases. Here hearths and a multitude of animal remains, representing numerous species, suggest a residential use in spring and again in fall (Chatters 1986). Site 45KT291 contains late Vantage to early Frenchman Springs Phase occupations as well as a Cayuse Phase component. Shorter occupations are suggested by sparse faunal remains, combined with bifaces, cores, and retouched and utilized flakes (Chatters 1986). Inventoried ground stone at the site reflect that spring plant processing also took place during these brief Frenchman Springs occupations.

In 1990, Archaeological and Historical Services (AHS) conducted a survey through Johnson Canyon as part of a larger project, identifying a number of low to high density lithic scatter and quarry sites, with estimated age ranges only from surface finds of diagnostic points (DePuydt 1990). Most notable of these was 45KT821, near the headwaters of the creek. This site had a Windust point and an obsidian stemmed point.

In 1998 AHS investigated Johnson Canyon (Gough 1998). Site 45KT979 dated from late Frenchman Springs to the Cayuse Phase through six radiocarbon dates from hearths and an artifact cluster. Lithic technologies present included cores, bifaces, and modified flakes. Diagnostic lithic artifacts consist of point types including Rabbit Island, Nespelem Bar, and Columbia Stemmed points. Site 45KT1003 had a low density Vantage assemblage including a Cascade point, as well as representative projectile point types indicating a Frenchman Springs through Cayuse occupation. Radiocarbon dates from cultural material give dates of 5020 BP, 3550 BP, and 1730 BP. These correspond to the Late Vantage, Frenchman Springs, and Cayuse.

HRA conducted excavations of 11 sites in 2002 (Beery 2002). Most of these were undated lithic procurement sites. Site 45YA627 has a date range from the Vantage through Cayuse Phases based on projectile point typology. Site 45KT629 has a date range from the Frenchman Springs Phase to Cayuse Phase. Site chronology was established through diagnostic point types including Rabbit Island, Quilomene Bar Basal Notched, Plateau Side Notched. Site 45YA641 had a diverse assemblage that included numerous Vantage, Frenchman Springs and Cayuse Phase bifaces.

CWAS investigated upland sites on the YTC as part of a National Registry determination (Orvald 2009), some of which were able to be dated to the mid-Holocene through projectile point typology. The Wasatos Site, 45KT253, had a surface assemblage including a Windust style point, a broken Cascade point, a Cold Springs Side Notched point, cores, and biface fragments. Subsurface excavations produced debitage to 150cmbs. Porcupine Spring and associated site 45KT680 had a surface assemblage including a diagnostic Rabbit Island B point, assigning a date range of 3000 to 1500 BP.

CHAPTER IV

METHOD

This section outlines the methods used to inventory and analyze the Sanders stone tool assemblage through macroscopic lithic analysis. The objective of this thesis is to document whether a shift from a forager/curated-dominant technology to a collector/expedient-dominant technology can be seen in this upland site. This was accomplished by coding the artifacts under a paradigmatic classification system and projectile point key, and then analyzing the resulting attribute patterns to see if the assemblage reflects theoretical patterns about prehistoric settlement models on the middle Columbian plateau.

Schalk and Houser developed an index for site assemblage expectations based on their work with the INFOTEC research group conducting the PGT-PG&E Pipeline Oregon Projects (Schalk et al. 1995). Table 6 outlines expected assemblages for varying degrees of increased sedentism, or reduced residential mobility. Predicated outcomes have been adjusted to reflect workshop expected assemblages.

Results from these analyses will be compared to the expected assemblages from this table to see how the Sanders Site assemblage fits these anticipations. The transition to higher sedentism occurred differently across different areas of the plateau, and upland workshop sites may have unique lithic aspects.

Table 6. Adjusted Expected Site Assemblages Adapted from Schalk/Houser, from Hackenberger 2010.

Land Use Strategy and Mobility	**Village Expected Assemblage**	**Work shop expected assemblage for bifaces**
Reduced residential mobility (associated with increase in task specific toolkits)	Higher frequency of cortical flakes Less abundant bifacial flaking debris Reduced frequency of bifacial cores Increased frequency of unprepared cores Lower ratio of biface fragments of debitage Less frequent bifacial tools in general Larger and heavier lithic tools Lower bifacial edge to mass ratio Less common tool retouch Reduced number of tool maintenance techniques Less tool resharpening	Fewer cortical flakes Smaller formalized tools Higher frequency of finished tool fragments Less common tool retouch Less frequent tool recycling Tool finalization and use
Reduced residential mobility (accompanied by decrease in territory and access to raw materials)	Exchange for raw lithic materials should become more common Raw material types should become more diverse Raw material quality should decline Intersite variability in raw material types should decline, a former disparity in distance-from-source between tools and debitage should disappear	Raw material types should become more diverse on completed tools Raw material quality should decline
Reduced residential mobility (increase distance from sourc increases conservation)	Tertiary reduction to become more common and primary reduction less common Percussion flakes to decline in frequency Shatter to become less frequent Flake weight and size to decline Cortex to become less frequent on flakes Cores to become less common in ratio to debitage Cores to become lighter Retouched tools to increase in relative frequency Tool recycling becomes more common Retouch of broken tools increase.	Retouched tools to increase in relative frequency Amount of use areas increase

Table 6. Adjusted Expected Site Assemblages Adapted from Schalk/Houser, from Hackenberger 2010, Continued.

Land Use Strategy and Mobility	**Village Expected Assemblage**	**Work shop expected assemblage for bifaces**
Reduced residential mobility (tool assemblage restructuring)	Assemblage diversity should increase. Multifunctional tools should become less frequent. Single purpose tools should proliferate. The ratio of hafted to expedient tools should decline. Intersite variability in tool assemblage content should increase.	Assemblage diversity should decrease.
Residential sites should exhibit	A lower ratio of utilized to unutilized biface fragments. Greater biface thickness and weight. A higher ratio of proximal to distal projectile point fragments. A higher ratio of bifacial debitage to bifacial tools. A higher ratio of retouch or notching flakes to total debitage. A higher ratio of unprepared to bifacial cores.	Higher amount of preforms and broken bifaces. Higher incidence of projectile points. Lower ratio of bifacial tools to debitage.

The first task of this thesis was to inventory the stone tool assemblage from excavation Trench 1502 from the Sanders Site. An incomplete inventory of tools was done by an Anthropology class at Central Washington University in 2009. All available boxes from the excavation were sorted, separating the various excavation blocks and units into separate bags. Damaged bags were replaced and kept with the collection. Artifact dimensions were recorded. These included weight (grams), maximum dimension (mm), length (mm), width (mm), and thickness (mm).

Paradigmatic Classification System

The artifacts were analyzed and coded using a modified version of the Saddle Mountains paradigmatic classification developed by McCutcheon (1997, McCutcheon et al. 2008: 126). A paradigmatic classification system uses a list of mutually exclusive traits to code the attribute and reduction sequence data of stone tools and their resulting debris (Dunnell and Campbell 1977, McCutcheon 1997). Because of its similarity in geology and archaeology, the system used in CWAS's 2005 Saddle Mountain Survey (McCutcheon 2005) was ideal for this analysis. A modified version of that classification was used in this thesis and is listed in Table 7, 8, and 9.

The use of a paradigmatic classification system allows the researcher to organize each artifacts attributes into classes reflecting the manufacturing process (Dancey 1973, Campbell 1981). In this analysis, a three tiered system was used to classify each artifact- technological, rock physical properties, and wear attributes.

Technological Paradigmatic Classification

The formed tools in this study are all of chipped stone and all represent to some degree a stage of lithic reduction. Stone tools begin as parent pieces of cobbles that are reduced through conchoidal fracture to cores, which are then reduced to flakes, which through further modification may become flake tools, modified flake tools, or bifaces.

Dimension I of the technological classification denotes the type of object and the degree to which is has or has not been reduced by intentional conchoidal fracture (McCutcheon 1997). Mode 1, “biface”, is the term for the final result of multiple stages of reduction sequences of conchoidal fracture flaking on two sides of a flake. Modes 2, 3, and 4 are flakes in descending order of completeness. Mode 5, “debris”, denotes artifacts that are broken, but to not exhibit conchoidal fracture. Modes 6 and 9; “cobble” and “broken cobble”, were not used in this study since the sample of Trench 1502 tools was already sorted for formed artifacts. Mode 7, “core”, classifies an artifact with only negative flake scars, indicating it was used primarily as a source of flakes.

Dimension 2,"amount of cortex", further describes the level of reduction by noting the amount of cortical or original surface of the parent cobble is left on the object. The amount of cortex present on an object is a valuable dimension in regards to "variability across reduction sequences" (McCutcheon 1997).

Dimensions 3 and 4 deal with the level and trajectory of bifacial reduction of the artifact. These dimensions are only applicable to flakes and flake tools. Bifaces, cobbles, cores, and the other object types are classed "not applicable". Dimension 3, "platform type", describes the type of object the flake is being detached from by classifying the striking platform of the flake (McCutcheon 1997) from cortical platforms to finished bifaces with wear present. Dimension 4, "reduction class", describes the dorsal surface of the flake. The dorsal surface is the outside surface of the flake, as opposed to the ventral, lower surface that is separated from the parent rock in the act of striking. Dorsal surfaces are set forth in the first three modes described as increasing levels of reduction- initial reduction flakes with cortical surfaces present on them, secondary flakes with a simple or single reduction sequence dorsal surface with arrises of all the same size, and terminal reduction with multiple layers of flake scars.

Dimension 5 notes the presence or absence of any type of wear. A more detailed examination of wear is outlined later in the wear attributes classification.

Dimension 6 notes the presence of further modification beyond that of the reduction sequence "that may be related to other technology trajectories" (McCutcheon 1997). This can be flaking the edges of flake tools to create bifacial and unofficial retouched flake tools, grinding, pecking, incising, or any other artificial process used to change the surface of the rock.

Dimension 7, thermal alteration, describes the level to which the parent nodule or the artifact itself was subjected to control heating by prehistoric techniques. The first mode, "no heating", indicates that the rock "exhibits no attributes of thermal alteration". (McCutcheon 1997; 183). Color is not used in this determination, only the presence/absence of lustrous flake scars, pot lidding, crazing, or crenulation.

Table 7. Technological Paradigmatic Classification.

I. Object Type
   1. Biface/Biface Fragment: rock exhibiting negative flake scars only which were initiated from the edge of the rock on both sides.
   2. Whole Flake: discernible interior surface and point of force is apparent; all margins are intact.
   3. Broken Flake: discernible interior surface and point of force is apparent; margins of flake exhibit step fractures (> 60^o).
   4. Flake Fragment: interior surface discernible, but point of force is not apparent.
   5. Chunk: rock exhibits non-cortical surfaces, but does not exhibit attributes of conchoidal fracture.
   6. Cobble: rock that exhibits unbroken cortical surfaces.
   7. Core: rock exhibiting non-cortical surfaces with attributes of conchoidal fracture displaying only negative flake scars.
   8. Spall: "flake" shaped chunk that exhibits evidence of thermal shock (e.g., potlidding, crazing, crenulation, etc.).
   9. Broken Cobble: Rock exhibits both cortical and non-cortical surfaces.
   10. Not Applicable: Object does not fit into any of the above categories.

II. Amount of Cortex: Cortex is the part of the rock that is the outer layer that forms as a transition zone between the chert body and its bedrock matrix (Luedke 1992: 150).
   1. Primary: cortex covers external surface (or dorsal side in the case of flakes/broken flakes/flake fragments) of rock (with the exception of point of impact, in the case of a flake).
   2. Secondary: external surface has mixed cortical and non-cortical surfaces.
   3. Tertiary: no cortex present on any surface with the exception of the area of impact.
   4. None: no cortex present on any surface.

III. Heat Treatment
   1. Cortex: refers to cortical platforms.
   2. Simple: platform with only one flake scar.
   3. Faceted: platform with more than one flake scar.
   4. Bifacial Unfinished
   5. Bifacial Unfinished-Wear Present: platform is bifacially flaked, exhibiting wear superimposed over a single stratum of flake scars.

Table 7. Technological Paradigmatic Classification, Continued.

6. Bifacial Finished: platform is bifacially flaked, exhibiting several strata of flake scars.
7. Bifacial, Unfinished, wear present: Platform is bifacially flaked, exhibiting wear superimposed over several strata of flake scars.
8. Potlids: Typically small, round flakes with the point of force located at apex of convex side.
9. Fragmentary: Platform is absent; 'missing data'
10. Not Applicable: Bifaces, cores, chunks, etc.
11. Pressure Flakes: Platform is very thin, bulb of percussion is intact, but very diffuse; this platform occurs on small flakes.
12. Technologically Absent: Results from indirect percussion where a precursor focuses the force such that as the flake is detached, another flake from the ventral side removes the bulb of percussion.

IV. Reduction Class
1. Initial Reduction: Cortex present on dorsal surface.
2. Intermediate Reduction: Simple/non-complex dorsal surface: exhibits few arrises from prior flaking and all are of the same scale.
3. Terminal Reduction: Complex dorsal surface: Exhibits two or more arrises and displays two or more scales of prior flaking.
4. Bifacial Reduction/Thinning: Complex dorsal surface, lipped striking platform: Striking platform is sub-parallel with long axis of the flake (rather than being more or less perpendicular to the long axis) and carries away a bit of a bifacial edge with it.
5. Bifacial Resharpening: Worn platform: bifacial edge is palpably smooth from chipping/abrasion/polish (compared by feel with other edges on same piece).
6. Not Applicable: Debris, flake fragments, cobbles, cores, bifaces, or spalls.

V. Presence of Wear: Wear is defined as a set of attributes that result from artificial motion of an object, here a rock (Dunnell 1978: 52).
1. Absent: No evidence of wear present on any surface of the rock.
2. Present: Wear is present on at least one surface.

VI. Other Modification
1. None: No attrition other than that explained by wear.
2. Flaking: Fragment removed by conchoidal fracture.
3. Grinding: Surfaces smoothed by abrasion
4. Pecking: Irregular or regular patterns of attrition due to dynamic non-conchoidal fracture.
5. Incising: Linear grinding.
6. Other: Types of modification not described above.

VII. Platform Type (flakes only)
1. No Heating: No attributes of thermal alteration exhibited.
2. Lustrous/Non-Lustrous flake scars: Object exhibits flake scars either intersecting or juxtaposed to non-lustrous flake scars.
3. Lustrous Flake Scars: Lustrous flake scars only, where luster is equivalent to that exhibited on objects exhibiting mode 1 above.
4. High-Temperature Alteration: Object exhibits potlidding, crazing, and/or crenulated surfaces.

Rock Physical Properties Paradigmatic Classification

This system allows the researcher to classify the matrices and characteristics of the raw material used in lithic artifacts. This allows analyses of what types of rocks were used for types of artifacts and how raw material selection changes over time.

Dimension 1, "Groundmass" classifies the types of matrix making up the majority of the rock. Mode 1, "uniform" groundmasses, are unvarying and even throughout. These are typically high quality raw material highly valued for its predictability in fracture. Mode 2, "bedding planes", describe matrices where distinguishable planes, or stia, are positioned parallel to one another. This is a form petrified wood often takes in the lithics of the interbeds of the Yakima fold belt. Mode 3, "Concentric banding", is concentric layers which can be of different colors or textures. Mode 4, "Mottled" matrices, are swirled clouded or splotched with varying colors and textures, and is a mode common for bogstone and other formerly organic silicates.

Dimensions 2, 3, 4, and 5 deal with the identification of the presence or absence of solid and void inclusions, and their distribution within the body of the rock. Solid inclusions are phenocrysts or other solid objects embedded within the matrix of the rock. Void inclusions are "cavities of empty space within the rock, and impede the fracturing by increasing surface area" (McCutcheon 1997; 214). Types of void inclusions can be vugs- cavities formed from a variety of volcanic, sedimentary, and erosional processes. Void inclusions can also be fossil and mineral casts or unfilled cracks from the sedimentary process. Distributions can be random, uniform, or structured.

Dimension 6, translucency, refers to whether light can easily pass through the rock, depending upon the level of quartz or other translucent minerals within the composition. Translucent rocks will diffuse light, illuminating the body of the stone. Opaque stones will not let light pass through them, even if they are thin.

The 7Th and final dimension, material type places the rock into one of four modes of general rock categories. Chert refers to cryptocrystalline, microcrystalline, and micro fibrous silicates that can often contain fossils. Sub varieties of chert that have been recorded on the Yakima Training Center include opal and chalcedony (Orvald 2009).

Table 8. Rock Physical Properties Paradigmatic Classification.

I. Groundmass
1. Uniform: A consistent and unvarying structure, where the distribution of color, texture, or luster is even.
2. Bedding Planes: Linear striae superimposed upon and parallel to one another. Individual stria can be distinct in color and/or texture.
3. Concentric Banding: Concentric layers of different color and/or texture.
4. Mottled: Abrupt and uneven variations (e.g., swirled or clouded) in color or texture.
5. Granular: A consistent structure composed of many individual grains.
6. Oolitic: The matrix is composed of small round or ovoid shaped grains.

II. Solid Inclusions
1. Present: Particles present that are distinct from the rock body (e.g., oolites, sand grains, filled cracks, grains, fossils, minerals).
2. Absent: Particles are absent from the rock body at 40X magnification or lower.

III. Void Inclusions
1. Present: Areas devoid of any material are present in the rock body (e.g., vugs, fossil and mineral casts, unfilled cracks).
2. Absent: Areas devoid of any material are absent from the rock body at 40X magnification or lower.

IV. Distribution of Solid Inclusions
1. Random: The distribution of inclusions is irregular and not patterned in any fashion.
2. Uniform: The distribution of inclusions is unvarying and even throughout the rock body.
3. Structured: The distribution of inclusions is patterned or isolated within the rock body.
4. None: Inclusions are absent from the rock body at 40X or lower magnification.

V. Distribution of Void Inclusions
1. Random: The distribution of inclusions is irregular and not patterned in any fashion.
2. Uniform: The distribution of inclusions is unvarying and even throughout the rock body.
3. Structured: The distribution of inclusions is patterned or isolated within the rock body.
4. None: Inclusions are absent from the rock body at 40X or lower magnification.

VI. Translucency
1. Opaque
2. Translucent

VII. Material Type
1. Chert
2. Petrified Wood
3. Petrified Bog
4. Other

Petrified wood is a raw material that can be identified as Miocene permineralized wood and woody structures. Bogstone refers to silicified forest floor organic material. Bogstone may contain bits of remnant wood within it, but is primarily a mix of elements. The final mode, other, refers to all other materials used in the manufacture of lithic materials in the Yakima uplands. In this study the only expected raw materials that fall into this category are volcanic, fine grained basalts and obsidian.

Wear Attributes Paradigmatic Classification

This portion of the classification system deals with the macroscopically visible artificial wear attributable to human activity. The following are the dimensions used in the paradigmatic classification.

Dimension 1, Use wear results from damage to the edge or surface of an artifact. Mode 1, chipping, is "defined here as a series of 5 or more regular flakes removed from the edge" (McCutcheon 1997; 244). Mode 2, abrasion is formed from linear striations visible on a point edge or planar surface. Mode 3, crushing, is edge-on damage leaving irregular pitting on the surface of the rock. Mode 4, polishing, is the reduction and polishing down of arrises of the rock.

Dimensions 2, 3, and 4 describe the placement, shape, and orientation of the wear on the rock body. Dimension 2, Location of wear describes the position of the damage, whether it is an angular point, edge, or plane; or a curvilinear point, edge, or plane; or non-localized. Dimension 3, shape or plan or worn area describes the shape the damage follows on the rock body. Convex would be damage on an outward curving line, as on a curved blades outside edge. The other shapes are "concave, straight, point, and oblique and acute notches" (McCutcheon 1997; 246).

The final Dimension 4, orientation of wear, describes the direction the wear focused in on the object. This is determined by taking the Y-plane to be the plane perpendicular to the plane connecting the wear to the body of the artifact. This can be explained by placing a flake on a piece of paper. The body of the tool is the X plane, and the paper is parallel to the Y plane for edge damage such as chipping and crushing. Perpendicular to the Y plane is pitting and edge crushing. Oblique orientations are unidirectional damage patterns such as unifacial chipping, such as that in a beveled scraper used primarily for one repetitive activity. Variable orientations are those that take multiple angles towards the rocks edge, as in bifacial chipping or crushing (McCutcheon 1997). As a study of bifaces, this dimension was expected as the most common.

Table 9. Wear Attributes Paradigmatic Classification.

I. Kind of Wear
1. Chipping: Small conchoidal fragments broken from edge; a series of flake scars.
2. Abrasion: Striations and/or gloss or polish on edge or point or surface.
3. Crushing: Irregular fragments removed from object leaving pitted surface.
4. Polishing (As in Witthoft 1967).
5. None - No wear is visible.

II. Location of Wear
1. Angular Point: Intersection of three or more planes at a point, including the point.
2. Angular Edge: Intersections of two planes including the line of intersection.
3. Angular Plane: A single planar surface.
4. Curvilinear Point: A three-dimensional parabola or hyperbola.
5. Curvilinear Edge: A curved plane bent significantly in only one axis (two-dimensional parabola or hyperbola).
6. Curvilinear Plane: A curved plane with spherical or elliptical distortion of large radius.
7. Non-localized: a closed curve.
8. None: wear absent.

III. Shape or Plan of Worn Area
1. Convex: an arc with a curve away from a flat surface.
2. Concave: an arc with a curve toward a flat surface.
3. Straight: a straight or flat surface.
4. Point: a point.
5. Oblique notch: two lines whose intersection forms an oblique angle.
6. Acute notch: two lines whose intersection forms an acute angle.
7. None: wear absent.

IV. Orientation of Wear: this dimension describes the linear orientation of the wear itself relative to the Y-plane of the object. The Y-plane will be taken to be a plane that is perpendicular to a line or plane connecting the wear to the body of the tool (X-axis or -plane). For example, if the object is a flake and is placed on a horizontal surface, ventral side down, the Y-plane is parallel to the horizontal surface for all edge damage (e.g., chipping, crushing, etc.).
1. Perpendicular to Y-plane: mainly pitting, edge-on crushing, etc.
2. Oblique to the Y-plane: a single direction is noted (e.g., unifacial chipping).
3. Variable to the Y-plane: a number of different orientations, all linear, turning from a left oblique through perpendicular to right oblique (e.g., bifacial chipping, crushing, pounding, etc.).
4. Parallel to the Y-plane: precludes most percussive wear.
5. No orientation: non-linear wear (e.g., heating).
6. None: wear absent.

Projectile Point Identification

Projectile point morphology in the Central Columbian Basin are well documented and can be directly related to cultural sequences when this information is coupled with depositional levels(Lohse 1985, 1995). Projectile point typology remains one of the best methods for determining the age of sites. For diagnostic identification, this thesis used a typological key for the central Columbia Basin developed by James Carter. (Carter 2010) The key is outlined in Tables 10 and 11, and Figure 6. Table 10 and Figure 6 illustrate the coding and measurement locations for the application of the key. Table 11 is the text of the dichotomous key, without the full descriptions of the point types listed.

Table 10. Measurements Used for Projectile Points.

Code	Description
HL	Haft length, measured parallel to ML and from proximal end (at base) to the position of the MW
ML	Maximum length, measured proximal (base, at hafted end) to distal (tip, at piercing end)
MBW	Maximum basal width, measured parallel to MW
MSL	Shoulder length, measured as the maximum length of the distal edge of the notch or removed shoulder
MW	Maximum width, perpendicular to ML
NW	Neck width, measured at the distal end of the stem, parallel to MW
TH	Maximum thickness, measured perpendicular to length and width

(Carter 2010: Table 1). All measurements are in mm.

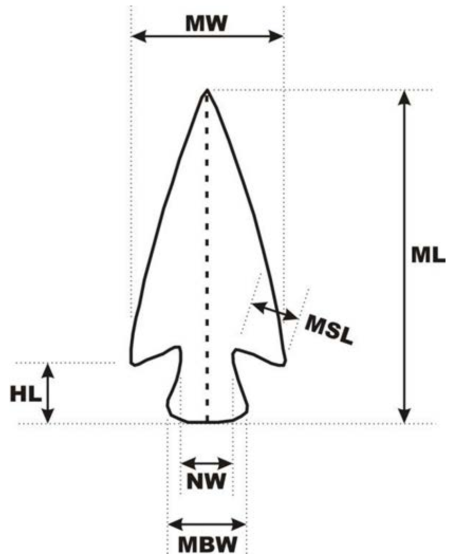

Figure 6. Measurements used for describing projectile points (Lubinski et al. 2007: Figure 1).

Table 11. The Central Columbia Basin Projectile Point Key.

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1) Shouldered or Notched? (*non-metric attribute*: proximal corners removed or lateral or basal margins notched [or both])

Yes = go to 3: No = go to 2

2) *Leaf-Shaped/Lanceolate Projectile Points*

0.3 ≤ MBW/MW ratio ≤ 0.6; *and* meets other Cascade criteria (below)?

Yes = **Cascade**

No = **other unshouldered**

Cascade criteria: fine pressure flaking; retouched basal margin; widest at 20-40% from proximal end (0.2 ≤ HL/ML ≤ 0.4); *and* meets length and width limits (25.0 ≤ ML ≤ 67.0 mm; 9.0 ≤ MW ≤ 22.0 mm; 2.1 ≤ ML/MW ≤ 4.4).

---

3) Side-Notched? (MBW/MW ratio ≥ 1.0; *non-metric attribute*: notching limited to the lateral margins only)

Yes = go to 4; No = go to 5

4) *Side-Notched Projectile Points*

MBW ≥ 16.0 mm *or* TH ≥ 4.0 mm ?

Yes = **Cold Springs Side-Notched**

No = **Plateau Side-Notched**

---

5) Corner-Notched? (MSL ≥ 1.0 mm; *non-metric attribute*: notching extends into both the lateral and the basal margins)

Yes = go to 6; No = go to 9

6) Wide neck (NW > 6.5 mm *and* MBW ≥ 9.0 mm), thick (TH ≥ 4.0 mm), *and* divergent stem (MBW/NW ≥ 1.1)?

Yes = go to 7; No = go to 8

7) *Wide Neck Corner-Notched Projectile Points*

Very wide neck (NW ≥ 14.5 mm) *or non-metric attribute*: otherwise massive stems, may include a basal notch?

Yes = **Quilomene Bar Corner-Notched**

No = **Columbia Corner-Notched A**

8) *Narrow Neck Corner-Notched Projectile Points*

Table 11. The Central Columbia Basin Projectile Point Key, Continued.

Narrow (NW ≤ 6.5 mm *or* MBW < 9.0 mm) *and* divergent stem (MBW/NW ≥ 1.1).
Yes = **Columbia Corner-Notched B**
No = go to 13

---

9) Basal Notched? (MSL ≥ 1.0 mm; HL/ML < 0.1; *non-metric attribute*: notching limited to the basal margin, not extending into the lateral margins)
Yes = go to 10; No = go to 11

10) Wide stem (NW > 6.5 mm *and* MBW ≥ 9.0 mm) *and* thick (TH > 4.0 mm) *or non-metric attribute*: otherwise massive?
Yes = **Quilomene Bar Basal-Notched**
No = go to 13

---

1) Shouldered or Stemmed? (straight or converging stem [MBW/NW < 1.1]; *non-metric attribute*: corners removed, resulting in a stem at proximal end, rather than distinctive notches)
Yes = go to 12; No = ***out of key***

2) ***Stemmed Projectile Points***

MBW ≥ 11.5 mm; HL/ML > 0.1; *and* MSL < 1.0 mm ?
Yes = go to 13; No = go to 14

3) Relatively short blade (HL/ML > 0.25); stem and base edges abraded; collateral flaking**?**
Yes = **Windust**
No = **Mahkin Shouldered**

4) MBW < 9.0 mm; long stem (HL/ML ≥ 0.2); straight stem (0.9 < MBW/NW < 1.1); *and non-metric attribute*: straight to very slightly convex basal margin?
Yes = **Wallula Rectangular Stemmed**
No = go to 15

5) MBW < 11.5 mm; NW > 6.5 mm; TH > 3.5 mm; MSL < 1.5 mm; *and* slightly to strongly converging stem (MBW/NW ≤ 0.95)?
Yes = **Rabbit Island Stemmed**
No = go to 16

6) MBW < 9.0; NW ≤ 6.5 *or* TH ≤ 3.5; *and* short stem (HL/ML < 0.2); may be basal notched?
Yes = **Columbia Stemmed**
No = other; ***out of key***

Note: From Carter (2010).

Carter's Key designations draw heavily from Nelson's work at the Sunset Creek Site, and Lohses' work on point types at the Chief Joseph Dam Project (Nelson 1969; Lohse 1985). The key follows a descending series of questions about dimensions of each particular artifact. As each question is answered with artifact measurement data, the key either assigns a type, prompts the researcher to move forward, or classifies the artifact as out of the key.

Artifacts that fell out of key but in other respects resembled the morphology of known point types were further compared using additional lithic typologies for the region. In these cases the analysis used the Protocols for Inventory and Analysis of Ground Stone and Chipped-Stone Artifacts (Root and Ferguson 2003) and Lohse (1985) were used to narrow the selections and assign a point type.

Breakage Patterns

Breakage data can provide information on possible trends or patterns in tool production and re-manufacture. Different excavation levels and associated time periods have more or less tool breakage caused during tool manufacturing versus tool utilization.

The basic breakage patterns in lithic analysis are step, overshot, axial, hinge and feather fractures. A fracture that continues past the desired area and results in a clear break is a step fracture. An overshot curves away from the expected area of detachment and curves to terminate on the opposite side. A fracture which bisects the artifact in half perpendicularly "is an axial also called a perverse fracture" (Miller, 2006), or a bending fracture (Fischer et al. 1984). Bending fractures; including snap, feather, and hinge terminating, are understood to result from knapping error, trampling, and accidental dropping. (Fisher et al. 1984, Whittaker 1994, Frison and Bradley 1980).

These breaks can result from errors in the placement of the platform or in striking force resulting in the force travelling through the body of the object (Crabtree 1972). The break then reorients itself perpendicular to the body of the biface, splitting it in two.

(Miller 2006). Bending Fractures occur when force is directed through the biface, resulting in a snap with a distinct lip. The types of bending fractures used in this analysis for manufacturing breakage are hinge terminating (BFHT) and feather terminating (BFFT) bending fractures (Pargeter 2013). These two types are interpreted as manufacturing error or accidental/environmental damage.

Impact fractures result from an impact of the distal point of the propelled biface on a resistive surface. Experimental archaeology has provided insight into how different breaks occur and what mechanical processes produce them (Pargeter 2011). The types of fractures interpreted as resulting from impact are step terminating bending fractures (BFST), unifacial and bifacial spin-off fractures, and impact burinations. Spin-off fractures and impact burinations are combined for expediency in this analysis into impact fractures (IF) (Fischer et al. 1984, Lombard 2005, Pargeter 2011).

The codes used in this study to describe breakage types are outlined in Tables 12 and 13. Table 12 outlines breakage codes, while Table 13 outlines the sections of the broken bifaces that were recovered.

Table 12. Breakage Pattern Codes.

Code	Description
BFFT	Bending fracture, feather termination
BFHT	Bending Fracture, hinge termination
BFST	Bending fracture, step termination
FT	Feather termination
OT	Over-shot termination
S	Snap fracture, a 90 degree break
W	Whole, the artifact was complete

Adapted from Pargeter 2011, Andrefsky 2000

Table 13. Biface Completeness.

Code	Description
Distal (D)	Distal portion intact, with a fracture at its proximal base, margins, or both.
Medial (M)	Middle section of the biface, with fractures at proximal and distal, may have broken margins.
Proximal (P)	Proximal or base of biface, fracture at distal end, margins, or both.
Shatter (S)	Shattered, fractures on all margins.
Complete (W)	Complete, may be missing sections of margins, but otherwise intact.

CHAPTER V

RESULTS

This chapter summarizes the results of the analysis of the formed tools in the Sanders Site assemblage. The analyses were conducted with the purpose of describing the composition of the technology present at the Sanders Site. Patterns in formed tool organization may reveal how the use of this upland site may have changed, and whether a mid-Holocene shift from foragers to collectors can be seen in bifacial tool patterns. It was predicted in this study that as an upland tool stone acquisition site and base station, the Sanders Site should show a progression from a forager dominated technology in the Vantage Phase, to a collector technology of large biface and blade manufacture for smaller flake tools and dart forms of the Frenchman Springs/Cayuse Phases.

The analyses are presented as follows: (1) projectile point analysis, (2) paradigmatic classification, (3) breakage type analysis, (4) raw material analysis, and (5) obsidian sourcing.

Projectile Point Analysis

The first analysis is an application of Carter's dichotomous typological key (Carter 2010) to identify central Columbian Basin projectile point types. This sub-sample of bifaces were identified as potentially diagnostic. The 1502 Trench from the Sanders Site contains 18 projectile points, and two projectile point bases. The bases were not complete enough to be used in this analysis. Stratigraphically, the points range from Levels 1, 2, 3, 4, and 6. This represents a temporal range from the Cascade Phase (8000-4000 BP) to the ethnographic Cayuse Phase (1500 – 150 BP) at the time of European contact. The majority of the artifacts come from Levels 2 and 3, and there is only one point from Level 6. Some points could not be keyed due to breakage, mostly at the shoulders and the distal end. Table 14 gives the accepted date ranges for the identified points from the assemblage. Table 15 outlines the results from the typological analysis.

Table 14. Sanders Site Projectile Points.

Period (BP)	Point Type	Count
8000-4000	Cascade	2
4000-1500	Rabbit Island Stemmed	5
2000-150	Columbia Corner Notched Type B	1
1500-150	Columbia Stemmed	3
	Total Identified with key only	11

Table 15. Projectile Point Typological Analysis.

Measurement	211	273	274	281	282	284	286	290
HL	32.11	10.11	9.96	2.53	3.5	4.54	4.39	5.49
ML	82.26	28.66	35.11	13.58	17.81	14.69	23.97	37.49
MBW	15.14	4.98	4.97	4.88	6.23	17.54	4.54	3.14
MSL	7.21	3.58	6.84	5.17	3.42	4.46	4.71	4.18
MW	27.38	14.0	18.78	13.87	8.4	17.57	17.62	20.51
NW	20.01	9.7	14.8	4.62	4.6	17.54	4.82	7.18
TH	8.82	4.86	6.71	3.58	2.54	6.16	3.58	4.42
Type	OUS	Cascade	OUS	CS	CCNB	OOK*	CS	RI*

Table 15. Projectile Point Typological Analysis, Continued.

Measurement	292	294	295	298	299	301	302	303
HL	3.28	7.21	4.96	5.57	NA	4.21	6.01	5.23
ML	30.32	29.6	30.3	31.96	22.15	22.62	17.82	14.31
MBW	1.95	3.58	3.44	4.17	NA	3.61	2.54	3.73
MSL	4.62	1.54	5.56	6.35	7.43	3.98	3.03	2.28
MW	17.73	13.21	17.56	18.86	17.05	12.03	15.11	17.18
NW	8.39	7.21	6.1	11.49	NA	5.87	5.42	6.72
TH	5.56	5.53	6.13	4.77	2.56	2.92	2.61	7.27
Type	RI*	RI	OOK	OOK	OOK	CS	CS	RI*

Table 15. Projectile Point Typological Analysis, Continued.

Measurement	304	576
HL	5.35	3.93
ML	17.87	25.53
MBW	3.91	6.45
MSL	2.95	5.68
MW	15.58	20.06
NW	6.84	8.66
TH	4.19	7.05
Type	OOK	OOK

The points from Trench 1502 included one Cascade (273) and two willow shaped lancoelates (other unshouldered), one Rabbit Island (294) and four points that keyed as Rabbit Island except for the measurement of shoulder width length, which put them out of key, one Columbia Corner Notched B (282), and four Columbia Stemmed (281, 286, 301, 302).

One artifact is identified as a probable broken Windust stem (Figure 7). It is a small basal notched biface fragment, positioned in a level with Stratums 4 and 6.. It is made from a deep red, fine grained chert that is unlike anything else recovered from 45KT315. As only the base is present it is difficult to conclusively verify its type beyond a basally notched projectile point stem. It is the only basally notched artifact in the collection of Trench 1502.

The assemblage has three unshouldered willow shaped points that were complete enough to use with the key, Artifacts 211, 273, and 274. Artifact 273 keyed as Cascade and is a very small point, 28.66mm long. The other is a pale purple bogstone biface, 15021816-211, that is Cascade in all respects except for being too long and wide (82.26 mm long and 27.38 wide – Carter key parameters are 25.0mm≤ML≤67.0mm; 9.0≤MW≤22.0mm) Artifact 211 is pictured in Figure 8. This point was recovered from Stratum 3 which is dated less than 4000 BP, but may be the product of mixing through bioturbation or another natural process.

Figure 7. Windust Style Stem from the Lower Component.

Artifact 211 undoubtedly represent large blade manufacture and maintenance. Grinding on the proximal margins suggests it was hafted. The remaining unshouldered point, 15020114-274, presents as an unshouldered point, but could be an unfinished Rabbit Island point. Artifact 274 is of a rough white petrified wood with bedding planes visible without the aid of a microscope. Artifacts 211 and 274 are formed from finely flaked, heat treated, translucent bogstone and chert. Artifact 211 is pictured in Figure 8.

Figure 8. Artifact 211, Large Leaf Shaped Blade.

One point, Artifact 294, keyed correctly initially as a Rabbit Island point. Four points were identified as Rabbit Island through the secondary protocol (Root and Ferguson 2003). The secondary classification (Root and Ferguson 2003) identified them as Rabbit Island (shoulder width >18.8mm, rounded base, serrated blade). These points date between 4000 and 2000 BP (Nelson 1969:115). The Rabbit Island projectile points were excavated from Levels 2 and 3, except for one, which was found in Level 6. The Rabbit Island points were all dark in color, ranging from brown to red to purple chert, petrified wood, and bogstone.

Four points keyed as Columbia Stemmed. This style dates after 2000 BP for the smaller variants such as these (Nelson 1969), with a neck width (NW) < 6.5mm (Lohse 1985:354). Columbia Stemmed are described as “delicate, triangular forms, with distinctive basal notches and barbs” (Nelson 1969:129-135). For the Carter key the most important ratio is a MBW/NW being less than 1.1. These three were crafted from fine grained CCS and petrified wood.

The final identifiable point is a Columbia Corner Notched B, from Stratum 3. This style dates later than the “A” variant, and is understood to be arrow hafted (Lohse 1985) and have a date range from 2000 BP to 150 BP (Nelson 1969). This point is formed from a grey bogstone with silicified organics visible. Ten points coded as “out of key”. Four were closest to Rabbit Island. The only deciding factor that keyed them out is the MSL. Four were closest to Columbia Stemmed, and were found in Stratums 1 and 2. These were morphologically very similar to the Columbia Stemmed described in the Root and Fergusons Protocols (Root and Ferguson 2003). The last unidentified point (15020413-299) is missing its stem, but is closest in MW and morphology (triangular) to Columbia Stemmed (Root and Ferguson 2003, Lohse 1985)

Two projectile point bases were analyzed to see if the possible types could be ascertained or narrowed. No type could be given without length and width parameters.

They were excavated from Stratum’s 2 and 3. By the neck width measurements they are too large to be arrow points (17.35mm and 10.54mm).

Arrow and Dart Identification

Projectile points can be identified as either a dart or arrow point using neck and width measurements (Ames 2001, Shott 1997). Shott (1997) uses a neck width of less than 8.6mm as indicative of arrow hafting, and more than 15mm as darts. 13 of the points were classified as arrows (1 Cascade, 4 Columbia Stemmed, 1 Rabbit Island, 1 Columbia Corner Notched B, and 7 of the out of key points). Only the Cascade point (20.01mm) and the large basally notched Windust stem (17.54mm) were larger than 15mm and therefore classify as darts or blades.

Paradigmatic Classification

The second analysis is based on coding the bifaces using the paradigmatic classification system. The Sanders assemblage of formed tools includes 73 biface, biface fragments, and projectile points. This analysis used a modified form of the Saddle Mountains Paradigmatic Classification describe in the methods section of this paper in Chapter IV to code the artifacts to specific mutually exclusive characteristics.

The classification has three main categories focusing on technology, the physical attributes of the stone, and use-wear. The itemization of the attributes are presented in Tables 15, 16, and 17. Examples of the lithic artifacts used in this study are shown in Figure 9.

Table 16. Technological Paradigmatic Classification for Sanders Bifaces.

		Count
I	**Object Type**	Count
1.	Biface/Biface Fragment:	73
2.	Core:	
II	**Amount of Cortex**	
1.	Primary:	0
2.	Secondary:	0
3.	Tertiary:	0
4.	None:	73
5.	Not Applicable	0
III	**Platform Type**	
1.	Cortex:	0
2.	Simple:	1
3.	Faceted:	0
4.	Bifacial, Unfinished:	0
5.	Bifacial, Unfinished, Wear Present:	0
6.	Bifacial Finished:	0
7.	Bifacial, Finished, Wear Present:	0
8.	Potlids:	0
9.	Fragmentary:	2
10.	Not Applicable:	70
11.	Pressure Flakes:	0
12.	Technologically Absent	0
IV	**Reduction Class**	
1.	Initial Reduction:	0
2.	Intermediate Reduction:	0
3.	Terminal Reduction:	0
4.	Bifacial Reduction/Thinning:	3
5.	Bifacial Resharpening	70
6.	Not Applicable	0
V	**Presence of Wear**	
1.	Absent:	38
2.	Present:	35
VI	**Other Modification**	
1.	None:	28
2.	Flaking:	42
3.	Grinding:	3
4.	Pecking:	0
5.	Incising	0
6.	Other	0
VII	**Thermal Alteration**	
1.	No Heating:	18
2.	Lustrous/Non-Lustrous Flake Scars:	11
3.	Lustrous Flake Scars Only:	44
4.	High-Temperature:	0

Table 17. Rock Physical Properties for Sanders Bifaces.

I	**Ground Mass**	
1.	Uniform:	22
2.	Bedding Plane:	12
3.	Concentric Banding:	3
4.	Mottled:	35
5.	Granular	1
5.	Oolitic:	0
II	**Solid Inclusions**	
1.	Present:	52
2.	Absent:	21
3.	Tertiary:	0
4.	None:	73
5.	Not Applicable	0
III	**Void Inclusions**	
1.	Present:	0
2.	Absent:	1
3.	Faceted:	0
4.	Bifacial, Unfinished:	0
5.	Bifacial, Unfinished, Wear Present:	0
6.	Bifacial Finished:	0
7.	Bifacial, Finished, Wear Present:	0
8.	Potlids:	0
9.	Fragmentary:	2
10.	Not Applicable:	70
11.	Pressure Flakes:	0
12.	Technologically Absent	0
IV	**Distribution Of Solid Inclusions**	
1.	Random:	0
2.	Uniform:	0
3.	Structured:	0
4.	None:	3
V	**Distribution of Void Inclusions**	
1.	Random:	
2.	Uniform:	
3.	Structured:	38
4.	None:	35
VI	**Translucency**	
1.	Translucency:	28
VII	**Material Type**	
1.	Chert:	18
2.	Petrified Wood:	11
3.	Petrified Bog:	44
4.	Other:	0

Table 18. Wear Attributes for Sanders Bifaces.

I	**Kind of Wear**	
1.	Chipping:	
2.	Abrasion:	
3.	Crushing:	73
4.	Polishing:	
5.	None	
II	**Location of Wear**	
1.	Angular Point:	0
2.	Angular Edge:	0
3.	Angular Plane:	0
4.	Curvilinear Point:	
5.	Curvilinear Edge:	
6	Curvilinear Planet:	
7.	Non-Localized:	73
8.	None	0
III	**Shape of Plan or Worn Area**	
1.	Convex:	0
2.	Concave:	1
3.	Straight:	0
4.	Point:	0
5.	Oblique Notch:	0
6.	Acute Notch:	0
7.	None:	0
IV	**Orientation of Wear**	
1.	Perpendicular to the Y Plane:	0
2.	Oblique to the Y Plane:	0
3.	Variable to the Y Plane:	
4.	Parallel to the Y Plane:	
5.	No Orientation	0
6.	None:	3

Adapted from McCutcheon 2004

Use Wear

Biface and biface fragments found at the Sanders Site make analysis of curated and expedient bifaces difficult, as traditional definitions may not fit perfectly. We know both foragers and collectors uses bifaces. Foragers carried their tools with them for longer distances, and should show higher rates of use-wear and additional modification. Collector use of bifaces should exhibit lower levels of retouch and use wear as they are used when needed and discarded relatively quickly (Binford 1977:34).

Figure 9. Formed Tool Artifacts from the Sanders Site.

Wear presence and absence in bifaces stays evenly divided for all levels (Table 19). Presence and absence of use wear in the upper stratums is comparable with 33 to 35 percent, respectively. In the lower stratum it is similar, 3 to 5 percent. Artifacts exhibiting multiple use wear types were, 2 out of 5 in the lower component and 17 out of 67(25%). Despite a low sample size, the lower component shows more retouch and additional use wear types.

Table 19. Presence of Wear by Strata.

Strata	Wear Present	Wear Absent	Totals
1	9	9	18
2	19	18	37
3	7	6	13
L.S.	3	2	5
Totals	38	35	73

Bifacial modification and retouch after initial production is an indicator that tools were used for longer periods of times, and reused for other purposes. Stratigraphic placement of other modification is presented in Table 20. The Sanders Bifaces show a greater percentage of modification in the lower component, with 4/5 artifacts displaying modification. Strat 3 and above display a decreasing level of modification.

Table 20. Other Modification by Strata.

Strata	None	Chipping	Grinding	Total
1	9	9	0	18
2	16	21	0	37
3	2	9	2	13
LS	1	3	1	5
Total	28	42	3	73

Length/Width/Thickness.

Theoretical tool patterns for the Columbia Plateau outline a pattern of decreasing size and thickness. An analysis of 14 Artifacts deemed to be complete enough for analysis provides the data for Table 21. This shows a pattern of generally decreasing artifact dimensions, with a spike in level 11, corresponding to the observed increase in manufacture and artifacts in stratums 2 and 3.

Table 21. Length, Width, and Thickness Ratios.

Strat	Ratio Length to Width	Ratio Length to Thickness
1	0.98	3.79
1	1.15	4.26
1	1.73	1.65
2	1.42	5.20
2	1.69	6.70
2	1.73	4.94
2	1.87	5.23
2	1.88	7.75
2	2.01	6.22
3	1.36	6.70
3	1.83	8.48
3	2.05	5.90
3	3.00	9.33
6	1.89	4.05

Debitage to Biface ratios

Observed rates of debitage to bifaces show a relatively higher rate of resharpening and manufacture in the lower component, with fewer tools being left behind in the record. Figure 10 shows that while there was considerable debitage recovered from the excavation, there were few artifacts from these levels. Units 23 through 28 in particular have a large component of debitage. This is also due to the stepped nature of the southern end of 1502, where units there had a large percentage of lower level cultural material.

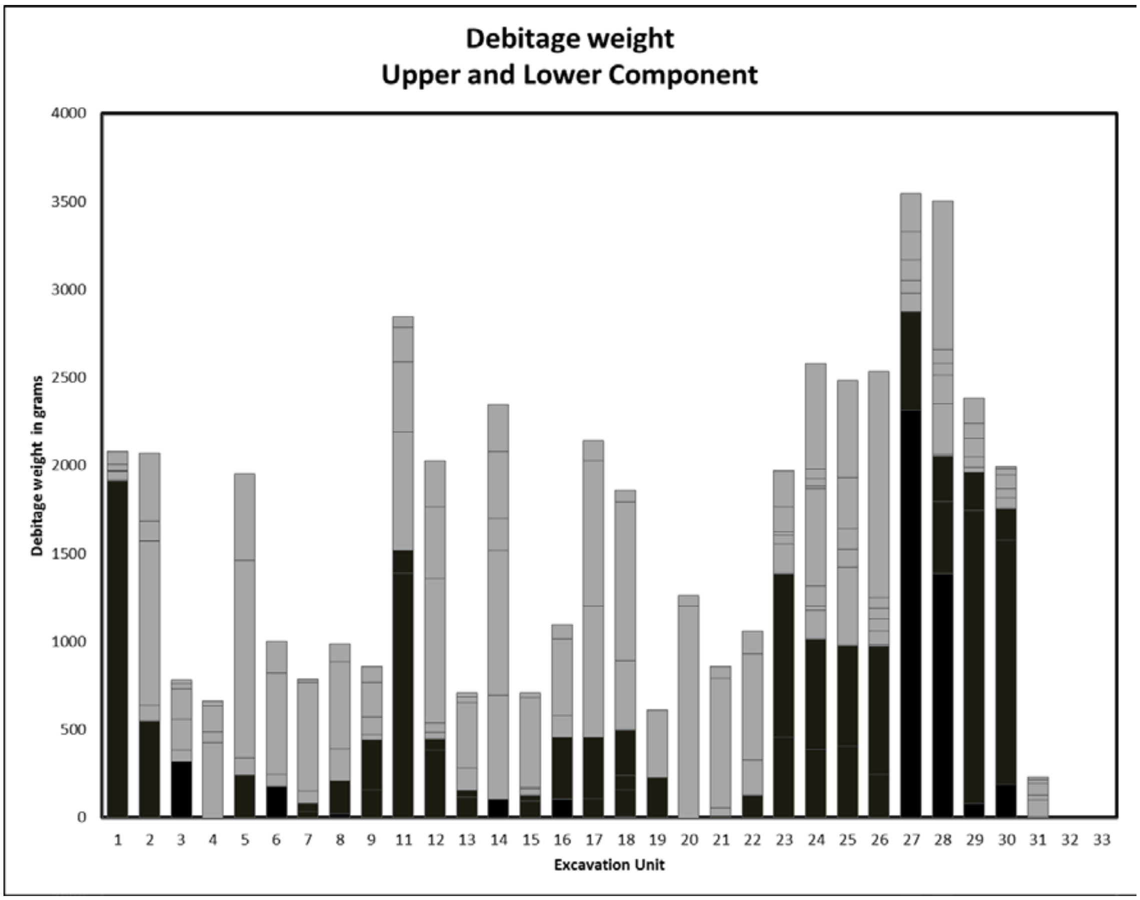

Figure 10. Debitage Weight by Unit. Grey displays the upper levels, black the lower.

Biface Breakage

The third analysis identifies biface breakage patterns. Biface fracture can indicate what types of activities were taking place at archaeological sites. Bifaces make up the majority of tools from 45KT315; of 73 bifaces, 19 %(n=14) were complete, 65 %(n=48) were manufacturing/trampling breaks, and 15 %(n=11) were impact fractures. Table 22 and Figure 11 show the data for breakage patterns.

Manufacturing, trampling, or dropping/accidental breaks were the most frequent type of breakage of tools at the Sanders Site. With its close proximity to raw tool stone, biface production, thinning, resharpening were major activities at the site. Across different raw material types the percentage of manufacturing breaks were; chert – 14/21 (66%), petrified wood 7/15 (46%), and bogstone 25/35(71%).

Table 22. Breakage Types by Stratum.

Stratum	BFFT	BFHT	BFST	IF	S	W	Total
1	2	2	1	3	6	3	17
2	4	10	1	2	14	6	37
3	1	4	1	1	2	4	13
L.S.	1	1	0	2	0	1	5
Total	8	17	3	8	23	14	73

Manufacturing, trampling, or dropping/accidental breaks were the most frequent type of breakage of tools at the Sanders Site. With its close proximity to raw tool stone, biface production, thinning, resharpening were major activities at the site. Across different raw material types the percentage of manufacturing breaks were; Chert – 14/21 (66%), Petrified wood 7/15 (46%), and Bogstone 25/35 (71%). Bogstone has many inclusions and voids, resulting in more manufacturing and other accidental breaks.

Across the different stratum manufacturing breaks were; Stratum 1- 58%, Stratum 2 – 76%, Stratum 3 – 54%, and Lower Stratums - 40%.

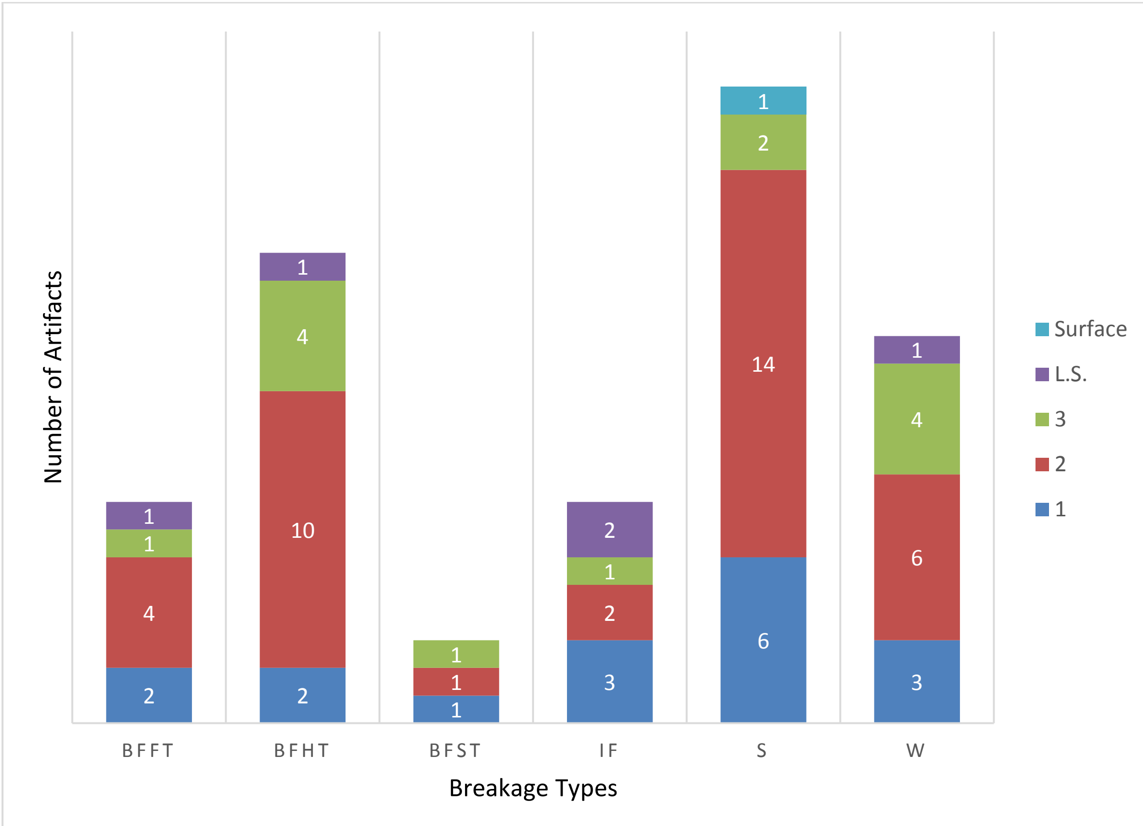

Figure 11. Biface Breakage Type by Stratum

Impact fractures of Sanders Site bifaces accounted for 15% of the assemblage. Across the different raw materials present at the site IF breaks were; 19% for chert, 13% for petrified wood, and 14% for bogstone. Impact fractures across stratums were 23% for Stratum 1, 8% for Stratum 2, 8% for Stratum 3, and 40% in the Lower Stratum.

Breakage patterns at the Sanders Site indicate that over time more bifaces were being produced or repurposed through manufacture, and that the site was being used as an acquisition and base station. In the lower stratums, impact fractures were more common, about an even split with manufacturing breaks (40% - 40%), indicative of a hunting base location where the production and maintenance of large hafted bifaces was the primary activity. In the stratum dated post 4000 BP manufacturing breaks were the majority, particularly in Stratum 2 where they account for 76%.

Raw Material

The objective of the fourth analysis is to ascertain patterns in raw material used for formed tools at 45KT315. The results of this analysis are listed in Table 23. The Sanders Site is near abundant sources of highly variable petrified wood and bogstone, located in the outcrops of interbeds of silicified material. These make up the overwhelming majority of raw material at the site. Biface (Mode 1) raw material numbers were 21 chert, 15 of petrified wood, 35 bogstone, and two of “other” (basalt and obsidian).

Table 23. Formed Tool Raw Material by Stratum.

Stratum	Raw Material Type				
	Chert	Petrified Wood	Bogstone	Other	Total
1	7	5	6	0	18
2	8	6	21	2	37
3	5	2	6	0	13
L.S.	2	2	1	1	5

Raw material and breakage

There appears to be little linkage between raw material selection and tool type. Additionally, percentages of tool stone selection between the different stratums remain close over time. The availability of petrified wood and bogstone seems to have been well understood and similarly exploited over time at the site. This outcome fit my expected outcome of relatively static use of raw material. As researchers have pointed out, proximity to raw material can have a greater effect of assemblage structure than mobility patterns. (Bamforth 1986)

Obsidian Sourcing

Two obsidian samples from 45KT315 were sent to Northwest Research Obsidian Studies Laboratory for X-Ray Florescence sourcing in the spring of 2014. From Trench 1502, Artifact 272, an obsidian biface medial fragment with a snap fracture is sourced to Obsidian cliffs, Oregon. Obsidian from these far away but well know sources indicate that the Sanders Site was part of a larger trade network well in place by the Frenchman Springs Phase (See Appendix B).

CHAPTER VI

INTERPRETATIONS AND RECOMMENDATIONS

The purpose of these investigations into the organization of technology at the Sanders Site is to document the composition of the lithic technology. Specifically the study tries to identify changes in lithic assemblages expected with organizational changes from foragers to collectors on the Columbia Plateau. This was accomplished by analyzing the biface lithic assemblage for projectile point types, breakage patterns, raw material types, and use wear.

The Sanders Site and the surrounding area were inhabited and exploited periodically from possibly the late Windust Phase (10500-8000 BP) to the Cayuse (2500-200 BP), and through to the 20th century. Results from the analyses of the assemblage show a move from a low artifact density in the lower stratum to an increasing artifact types and quantity. They also show a progression from multifunctional to increasing specialized and single purpose tools that are renewed and maintained for fewer episodes of use. It is exceptional to have representative artifacts from so many of the region's main cultural sequences. The results of the analyses by stratum are outlined in Table 24. This table helps chronologically summarize the major changes in the Sanders Site lithic assemblage. The counts of the combined results of the analyses are presented in Table 25.

Table 24. Stratigraphic Results.

Stratum	**Volume Excavated/ Debitage/ Biface Wt.**	**Carter Projectile Point Key**	**Use Wear**	**Breakage Patterns**	**Raw Material**
Stratum 1. 18 Bifaces: 3 points, 1 drill or perforator , 3 point tips, 11 un-notched bifaces,	9.4 meters³ 8615.2g debitage, 36.35g bifaces	One base fragment and 3 Columbia Stemmed (1500-150) BP	13 heat treated. Half artifacts have use wear and half have additional flaking.	High occurrence of biface distal tips. Mostly manufacturin g breaks with 3 impact fractures.	Chert and petrified wood favored for points. Bogstone for bifaces. 6 chert(3 ppt), 5 petrified wood(1ppt), 6 bogstone
Stratum 2. 37 Bifaces; 8 points, 6 points distal tips, 1 triangular biface, 22 un-notched bifaces	11.2 meters³ 11850.9 g debitage, 145.86 g bifaces	3 Columbia Stemmed(1500-150 BP), 3 rabbit island (4000-1500 BP)	Majority heat treated,48% have use wear present, 56% Have additional flaking	Majority biface distal tips, most broken in manufacture, with 3 impact fractures.	Chert favored for points, bogstone for other bifaces 8 chert (5 ppt) 6 p wood (1 ppt) 21 bogstone(2 ppt) 2 other(obsidian and basalt)
Stratum 3. 13 Bifaces; 6 points, 7 un-notched bifaces	11.1 meters³ 10621.9 g debitage, 71.97 g bifaces	2 Cascade (8000-4000 BP), 1 Columbia corned notched B(2000-150 BP), 1 Columbia Stemmed(1500-150 BP), 2 rabbit island(4000-1500 BP)	Peak in use wear and additional modification to tools. 46% have use wear present, 69% Flaking, 15% grinding. Majority heat treated	Majority distal tips. 4 complete. 2 possible impact fractures, most manufacture breaks	Bogstone and petrified wood favored for points, chert for bifaces. 5 chert, 2 petrified wood (1 ppt), 6 bogstone(4 ppt)
Lower Stratum. 5 Bifaces: 2 points, 1 pp distal tip, 2 un-notched bifaces	17.9 meters³, 21.668.3 g debitage, 22.81 g bifaces	1 rabbit island(4000-1500 BP), 1 Windust (11000-7500 BP)	Majority heat treated, higher occurrence of additional modification(60% flaking, 20% grinding)	1 distal, 1 medial, 2 proximal, 1 complete 1 whole, 2 IF, 2 Manufacture breaks	Chert is favored for points, petrified wood for bifaces.

Table 25. Combined Results from Analyses.

		Stratum 1	Stratum 2	Stratum 3	Lower Stratum	Grand Total
Biface Section	**Distal**	8	18	5	1	32
	Medial	3	7	2	1	13
	Proximal	3	4	2	2	11
	Shatter	2	1			3
Raw Material	**Whole**	2	7	4	1	14
	Chert	6	8	5	2	21
	Petrified wood	5	6	2	2	15
	Petrified Bog	7	21	6	1	35
	Other		2			2
Breakage	**Bending Fracture Feather Termination**	2	4	1	1	8
	Bending Fracture Hinge Termination	2	10	4	1	17
	Bending Fracture Step Termination	1	1	1		3
	Impact Fracture	3	2	1	2	8
	Shatter	7	14	2		23
	Whole	3	6	4	1	14
Carter Key	**Base Fragment**	1	1			2
	Cascade			1		1
	Cascade or other unshouldered			1		1
	Columbia Corner Notched B			1		1
	Columbia Stemmed	1	1			2
	Other Unshouldered		1			1
	Out of Key	2	2		1	5
	Rabbit Island		1	1		2
	Rabbit Island*		3	1		4
	Windust				1	1

Table 25. Combined Results from Analyses, Continued.

Morphology	**Rectangular Bifaces**			1		1
	Lanceolate Bifaces			1		1
	Indeterminate Biface Midsection	5	5	2		12
	Bifacial Drill Forms	1				1
	Windust				1	1
	Cascade			1		1
	Triangular, Asymmetrical Bifaces		1			1
	Rabbit Island Stemmed	1	4	2		7
	Pointed Bifaces, Fractured	3	12	3	1	19
	Bipolar Percussion		1			1
	Miscellaneous Arrow Points	2	1			3
	Stemmed Point, Not Further Specified		1		1	2
	Side-Notched Point, Not Further Specified	1	1			2
	Bifacial Edge Segments		5	1		6
	Stem Fragment, Not Further Specified		1	1		2
	Arrow Point Blade Fragment	1	1			3
	Dart Point Blade Fragment	1	1			2
	Barb, Stem Fragments, Dart-Sized Tools		1			1
	Ovate Biface Fragments	1				1
	Unidentified	2	1	1	1	5
	Grand Total	17	36	13	4	73

Projectile Points

The results of the projectile point analysis are mixed. The identifiable points do match recognized cultural phases associated with those strata. However, half the points could not be identified by the key. Using the secondary protocol, *Lithic Tools Inventory Protocols* (Root and Ferguson 2003), five of those points could be typed as what they were closest to in the Key. Rabbit island shoulder width in particular seem to cause the key to throw points out of the system. The assemblage of Sanders projectile points show a progression of decreasing size and increasing frequency. Stratums 2 and three have the most artifacts, consisting mostly of Rabbit Island and Columbia Stemmed points. The points by stratum generally reflect accepted age ranges for the point types, with a few exceptions. These are likely due to mixing from rodent activity and other bioturbation, or other natural processes.

The assemblage of projectile points displays a progression from a low tool density Vantage component through the eventual transition to increased sedentism of the Frenchman Springs and later Cayuse Phases. In the expected assemblage table (Table 6), the projectile points correspond to smaller formalized tools and decreasing raw material quality. There is increase in utilization of bogstone in points, particularly in Stratum 2, which corresponds to late Frenchman Springs/Cayuse, producing tools with far more inclusions and imperfections.

Compared to the expected results table, projectile points mostly fit the model of decreasing size as the bow was slowly selected over the dart. Raw material on projectile points became less diverse, not more. This likely occurred as the best toolstone for specific points became better known. Assemblage of projectile points did increase from the lower stratum to the upper, with the most point types in Stratums 2 and 3.

Breakage

Breakage patterns at the Sanders Site show evidence of biface manufacture over all periods represented. Impact fractures are more frequent in the lower component, with manufacturing breaks more common in the upper stratum. Stratums 2 and 3 show an intensification of the use of the CCS raw material from the interbeds, primarily for the creation of preforms and cutting bifaces.

Biface manufacturing breaks seem to reveal a pattern of more bifacial maintenance and resharpening, though at low levels, in the earliest stratum. Impact fracture occur the same as manufacturing breaks, indicating the site was used as a hunting locality where bifaces were crafted and possibly repurposed. In later strata, especially Stratum 2, manufacture of bifaces takes up 76% of biface breakage. The Sanders Site may have seen its most heavy resource exploitation and biface reduction sequences in this later period. Thus even though curated bifaces are more prevalent, the site still shows resource intensification, and the transition from a hunting area to a resource base station.

Artifact densities are predictably low in the earlier Vantage deposits, with a significant uptick in tool frequency it Stratum 3, with the largest collection coming from Strat 2. In relation to the expected outcomes in Table 5, the bifaces from Trench 1502 fit the opposite of a village site, with shatter becoming more common. This likely places the Sanders Site in the workshop category, with very few manufacturing breaks in the lower stratum, but increasing manufacturing from Stratums 2 to 3.

Raw Material

Raw material use of the site relied heavily on the locally available bogstone and petrified wood, accounting for 68% of all bifaces. Chert accounted for only 20% of overall tool raw material source. Stratigraphically though, it is 40% in the lower component, 38% in Stratum 3, 21% in Stratum 2, and 35% in Stratum 1. This signifies that imported material was an important tool stone in the early hunting deposits, and continued to be utilized for bifaces as the site transitioned to a base station.

Raw material results match workshop assemblages better than village assemblages. Raw material diversity declines over time. Bogstone becomes the leading tool stone selected in the upper components. Chert is more uniformly used for some tools. The availability of the bogstone seems to override and particular advantages of chert or petrified wood. Petrified wood is used for some ovate biface forms. Raw material quality gets better over time, with both solid inclusions and void inclusions decreasing over time.

Use Wear

Use-wear at the Sanders Site is consistent through time. Presence of wear on tools remains at about 50% from the lower stratums through Stratum 1. Artifacts with additional modification (flaking and grinding) are a majority in the Lower stratum. The peak for additional modification is in Stratum 3, with 70% of artifacts exhibiting flaking and/or grinding. Stratums 1 and 2 have around 50% percent use wear.

Comparison with expected results shows that use wear corresponds to a workshop assemblage with increased distance to source, especially in Stratum 3, with retouched tools increasing. However, in Stratums 1 and 2, retouched tools decline somewhat, and remain constant at 50%. The results from the analysis of use wear at the site seem to indicate a somewhat constant balance of manufacture and edged lithic tool use.

Recommendations

A full accounting of the lithic tools from Trench 1504 would be the first place to start to get a better picture of the evolution of technology at the Sanders Site. Additionally, the results from analysis of debitage from the deeper units from Trench 1502 could be joined together to give a picture of how biface manufacture may have changed from early blade manufacture to the later production of stemmed and shouldered points.

Radiocarbon dating faunal samples from the site offer the best hope of providing a better knowledge of local and regional chronologies. Additional dates should be obtained as funding allows.

The Sanders Site itself should be revisited and stabilized. 45KT726 has already been suggested for nomination to the National Register of Historic Places. With the new radiocarbon dates, and analyses of the lithic and faunal components of the site, there is sufficient evidence to move forward with the nomination of the Sanders Site.

Conclusion

The Sanders Site most likely served as a base station for hunting. Over time lithic workshop activities grew due to the well-known local source of bogstone. The site also became important for gathering and processing plant foods during the Frenchman Springs Phase. Biface manufacture seems to have been a primary manufacturing activity at the Sanders Site throughout its various occupations. In earlier sequences tool making focused on larger blade technology and tool maintenance. In these early periods toolstone includes a higher proportion of imported material than in later periods. Later periods of occupation show a decreasing size of points, but a greater variety of types of points. The organization of lithic technology at the Sanders Site (45KT315) represents important regional changes in the evolution of lithic technology and resource use in the Middle-Columbia uplands.

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APPENDIX A

SANDERS SITE BIFACE DATABASE

Provenience Number	Strat	Artifact Number	Weight (g)	Maximum Dimension	Length (mm)	Width (mm)	Thickness (mm)	Haft Length(HL) (mm)	Maximum Shoulder Length (MSL) (mm)	Maximum Basal Width (MBW) (mm)	Neck Width (NW) (mm)	Technology Code	Rock Physical Properties Code	Wear Code
1502 0115-	1b 2 2-	245	0.44	11.04	10.17	9.37	4.5					14(10)6122	4121 421	5876
1502 0114-	2	274	4.16	35.11	35.11	18.78	6.71	9.96	6.84	4.97	14.8	14(10)6213	2224 411	1213
1502 0112-	1a	236	1.02	23.03	20.55	11.66	5.25					14(10)6213	3224 412	1233
1502 0111-	1a	304	0.83	17.87	17.87	15.58	4.19	5.35	2.95	3.91	6.84	14(10)6221	4112 111	5876
1502 0110-	1	230	2.48	36.86	34.45	12.61	4.41					34(10)6221	2121 412	1213
15020211-302	1a	302	0.78	17.82	17.82	15.11	2.61	6.01	3.03	2.54	5.42	14(10)612 1	1224411	5876
15020316-286	3	286	1.31	23.97	23.97	17.62	3.58	4.39	4.71	4.54	4.82	14(10)612 2	4111113	5876
150203 12-225	1 2	225	11.54	40.27	36.34	34.4	11.21					14(10) 6222	411111 3	1212
15020311-269	1 1a 2	269	6.03	33	33	22.06	7.91					14(10)621 1	5121413	1143

APPENDIX A CONTINUED

15020707-239	15020608-220	15020614-535	15020511-221	15020412-294	15020413-148	15020413-295	15020413-299	15020312	15020310-229
2	1 2	LS	2	1a 2	2	2	2	1 2	1 1a 2
239	220	585	221	294	148	295	299	128	229
0.88	11.7	1.03	16.46	1.66	0.3	2.25	0.86	5.28	6.07
25.67	43.29	19.66	15.85	29.6	13.01	30.3	22.15	30.19	36.72
25.67	33.72	19.66	56.31	29.6	13.01	30.3	22.15	30.19	31.37
9.25	33.74	12.26	27.98	13.21	8.93	17.56	17.05	28.25	26.21
4.18	8.52	4.83	9.06	5.53	2.46	6.13	2.56	7.48	9.3
				3.46		4.96			
				1.54		5.56	7.43		
				3.58		3.44			
				7.21		6.1			
14(10)661 1	14(10)621 1	14(10)611 1	14(10)622 2	14(10)411 3	14(10)411 2	14(10)611 1	14(10)611 1	14(10)621 1	14(10)621 2
4111113	4112113	1224411	3111112	4214113	1224413	1111113	1112211	4111113	4113113
5876	1213	5876	1213	5876	5876	5876	5876	1332	2234

APPENDIX A CONTINUED

15021212-267	15021213-213	15021213-272	15021121	15021114-248	15021006-285	15020904-258	15020807-254	15020809-227
1a 2	1a 2	1a 2	6	2		2 2a	2	2 3
267	213	272	590	248	285	258	254	227
2.36	4.25	1.32	5.76	1.57	1.87	0.71	0.29	3.42
25.47	27.42	31.51	30.52	11.89	21.06	20.34	19.88	30.04
25.47	27.42	31.51	30.52	16.75	21.31	20.34	19.76	30.04
19.04	25.46	11.47	23.91	18.58	12.82	11.98	9.44	13.27
4.56	4.9	3.72	9.03	6.55	7.14	3.52	2.26	7.52
					13.32			
					20.55			
					17.35			
14(10)622 3	14(10)621 2	14(10)612 1	14(10)622 3	1496223	14(10)611 2	4496123	14(10)611 1	14(10)622 1
4121413	2111112	1224424	4121413	4121413	1214111	224412	2224412	4121413
1232	2314	5876	2334	2244	5876	5876	5876	3231

APPENDIX A CONTINUED

15021416-86	15021915-276	15021308	15021309-255	15021310-292	15021311-290	15021312-273	15021316-212	15021211-244
2a 3	2 2a 3	2 3	3	3	3 3a4	3 3a4	6	1a
86	276		255	292	290	273	212	244
5,41	3.76	1.28	0.55	2.71	2.59	2.13	10.65	0.13
32.24	27.54	22.73	13.29	30.32	37.49	28.66	49.74	10.24
27.22	23.09	22.73	13.29	30.32	37.49	28.66	49.74	10.24
32.24	27.54	10.46	13.41	17.73	20.51	14	26.27	7.51
8.18	5.34	6.2	3.54	5.56	4.42	4.86	12.28	2.44
			7.84	3.28	5.49	10.11		
				4.62	4.18	3.58		
			13.69	1.95	3.14	4.98		
			10.54	8.39	7.18	9.7		
14(10)6223	14(10)6113	14(10)6123	14(10)6123	14(10)6123	14(10)6121	14(10)6123	14(10)6223	14(10)6123
4121421	3121412	4121413	4121413	4121413	2111412	4121423	2113112	4224423
2314	5876	5876	5876	5876	5876	5876	3211	5876

APPENDIX A CONTINUED

15021816	15021811-303	15021816-211	15021712	15021710-110	15021713-106	15021715-92	15021613-284	15021415-270
3	1a 2	3	2	1 2	2	2	4 6	2 2a 3
	303	211		110	106	92	284	270
4.56	1.53	15.28	1.89	3.55	0.69	5.17	1.66	12.33
46.1	14.31	82.26	34.02	28.72	15.57	37.02	20.76	43.82
46.1	14.31	82.26	34.02	27.55	15.25	23.47	14.69	37.54
22.39	17.18	27.38	19.59	16.95	14.68	32.33	17.57	30.64
5.47	7.27	8.82	3.62	7.97	4.42	7.15	6.16	13.21
	5.23	32.11					4.54	
	2.28	7.21					4.46	
	3.73	15.14					17.54	
	6.72	20.01					17.54	
14(10)622 3,	14(10)612 2	14(10)622 3,	14(10)622 1	14(10)622 3	14(10)612 3	14(10)622 2	14(10)612 3	14(10)622 2
4111121	4111111	4111113	1214114	4121413	4111113	4111113	1111111	2123411
2234	5876	1233	2143	2233	5876	2234	5876	3231

APPENDIX A CONTINUED

15022010-189	15022010-298	15022010-301	15022012-177	15022013-160	15022014-588	15021910-132	15021915-576	15021809
2	2	2	2	2	2	2	6	Surface 1a
189	298	301	177	160	588	132	576	
0.38	2.24	0.71	0.87	0.35	19.28	7.71	3.71	,84
16.72	31.96	22.62	20.83	16.83	50.36	32.05	25.53	22.31
14.46	31.96	22.62	11.01	16.83	42.81	24.18	25.53	22.31
12.38	18.86	12.03	20.83	8.7	43.87	25.91	20.06	8.38
2.37	4.77	2.92	4.17	3.32	9.35	11.56	7.05	5.39
	5.57	4.21					3.93	
	6.35	3.98					5.68	
	4.17	3.61					6.45	
	8.49	5.87					8.66	
14(10)6123	14(10)6123	14(10)6123	14(10)6223	14(10)6123	14(10)6223	14(10)6213	14(10)6123	14(10)6213
4224421	1122411	1224421	4224421	1122413	4112113	4111113	2122412	4121113
5876	5876	5876	3231	5876	2234	5876	5876	3233

APPENDIX A CONTINUED

15022511-253	15022515-114	15022207-89	15022112	15022106-157	15022110-277	15022110-278	15022113-226	15022008-238
Surface 1a	2 2a	2	3 3c	1 2	3	3	3c	2 1
253	114	89		157	277	278	226	238
0.13	0.19	20.34	8.24	6.26	9.85	1.78	9.81	0.77
13.28	8.95	58.87		32.45	38.62	21.4	54.6	16.86
13.28	8.95	56.68	45.4	31.86	27.61	13.1	54.6	14.08
6.17	8.01	39.81	25.35	24.08	32.14	21.4	25.98	6.86
1.88	3.17	10.9	6.51	8.56	9.03	6.52	8.69	3.71
14(10)6113	14(10)6113	14(10)6223	14(10)6123	14(10)6123	14(10)6223	14(10)6133	14(10)6223	14(10)6213
2224412	4224413	4121412	1224411	4121413	1112113	1224411	4111113	1122413
5876	5876	1234	5876	5876	2234	5876	1333	2314

APPENDIX A CONTINUED

15020112	15023113-147	15022811-96	15022812-108	15022812-111	15022813-266	15022818-282	15022713-281	15022612-127
1a	Surface	Surface	1a	1a	1a	3	1a 2 2a	1a
	147	96	108	111	266	282	281	127
0.22	0.45	3.8	3.8	4.65	0.81	0.33	0.44	0.18
13.11	12.92	27.9	27.8	32.89	15.68	17.81	13.87	9.74
11.43	12.92	21.47	17.27	32.89	15.68	17.81	13.58	9.74
9.93	12.18	27.9	27.8	19	12.73	8.4	13.87	8.95
2.06	3.05	5.58	4.99	19.93	3.44	2.54	3.58	3.12
						3.5	2.53	
						3.42	5.17	
						6.23	4.88	
						4.6	4.62	
14(10)6213	14(10)6113	3432223	14(10)6223	1424223	14(10)6111	14(10)6111	14(10)6113	14(10)6113
1224421	1122423	4121413	1121413	4111113	2121412	1112113	2112112	1224411
1233	5876	1212	1212	1232	5876	5876	5876	5876

APPENDIX B

Obsidian XFR Results

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: 45-KT-315, Kittitas County, Washington

Site	Specimen No.	Catalog No.		Trace Element Concentrations Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Ratios Fe:Mn	Fe:Ti	Geochemical Source
45-KT-315	28	150420		88	109	62	280	11	NM	NM	1466	NM	NM	NM	Indian Creek
			±	3	3	3	4	3	NM	NM	41	NM			
45-KT-315	29	359		72	108	15	97	8	NM	NM	904	NM	NM	NM	Obsidian Cliffs
			±	3	3	3	3	3	NM	NM	43	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.