Archaeological Investigations in the Pleasant Hill Valley, Oregon

by
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INTRODUCTION

Oregon archaeologists have long been interested in the chronology, settlement patterns, and obsidian procurement strategies of prehistoric populations in the Willamette Valley. Although several studies in the Upper Willamette Valley have made significant contributions to these lines of inquiry (Skinner and Winkler 1991, Cheatham 1988, Toepel 1985, Toepel and Sappington 1982, White 1975), very little research has been done in the Pleasant Hill valley. Prior to the present study, the only formal archaeological report on the Pleasant Hill valley was based on preliminary phase II investigations of sites along the Willamette Highway (OR 58) by Infotec Research, Inc. (Silvermoon 1991).

The purpose of this study was, first, to investigate and document two significant archaeological sites in the Pleasant Hill valley; and second, to explore patterns of obsidian procurement through geochemical analysis of obsidian found at these sites, in order to learn the geologic sources of the material. X-ray fluorescence, the technique used to characterize obsidian artifacts as belonging to a particular geologic source, involves matching percentages of trace elements (i.e., strontium and zicronium) in artifacts with percentages of these elements in obsidian at potential quarry sites.

This paper is divided into three parts. The first section provides a brief review of the cultural succession within the Upper Willamette Valley. The second section describes the Sprague and Enterprise sites in the Pleasant Hill valley. The Sprague and Enterprise sites are compared to the Flanagan site in the southern Willamette Valley with regard to point typology, ground stone, and cultural chronology. The third section of this paper focuses on obsidian characterization and its application to understanding obsidian procurement strategies employed by indigenous people.

The paper concludes with a discussion of the significance of the Sprague site as a large village settlement representing continuous occupation from the Middle Archaic through the Late Archaic Periods. Patterns of obsidian procurement by its occupants are discussed in relation to evidence for long-distance and local exploitation of obsidian sources as revealed through XRF characterization of tested artifacts.

Ethnographic Background

At the time of Euro-American contact, the Willamette Valley was occupied by the Kalapuya Indians, whose language belongs to the Penutian language phylum. The Kalapuyan family consisted of a number of mutually unintelligible dialects that belonged to three main languages: Tualatin-Yamhill, Santiam, and Yoncalla (Frachtenberg 1918, Jacobs 1945, Mackey 1974, Zenk 1990). Ethnographic accounts of the Kalapuya are limited because prehistoric populations were decimated by disease in the epidemic of 1830-33 (Cook 1955, Mackey 1974). Pre-epidemic native populations of the Willamette Valley have been estimated at 12,000, while post-epidemic populations may have been as low as 600 individuals (Cheatham 1988). The Winnefelly band of Kalapuya was geographically associated with the Pleasant Hill valley (Beckham 1976, Loy 1976, Beckham et. al. 1981).

Archaeological investigations in the Willamette Valley indicate that indigenous people employed a basic economic strategy of digging camas, gathering wild nuts and berries, and hunting big and small game for at least 8000 years (Aikens 1993). The Kalapuya Indians lived primarily in small autonomous bands. Each group moved through its respective territory, exploiting a wide range of resources. Movement and activities were dictated by the seasonal availability of these resources. Fishing took place in the spring, fall, and winter; root harvest occurred in the summer; the gathering of berries and seeds took place in the summer and fall; and hunting intensified in the fall (Aikens 1993).

These cyclical movements, determined by environmental factors, were reflected in the settlement patterns of the native populations in the Willamette Valley. Large, multi-family camps were established along streams and rivers during the winter, when the weather was wet and cold and the availability of resources was low. During the spring and summer months, groups dispersed into single-family units to forage on the valley floor (Zenk 1990, Havercroft 1985).

Cultural Periods in the Willamette Valley

The four main prehistoric cultural periods in the Willamette Valley, as reviewed by Toepel (1985) and Aikens (1993) include the Paleo-Indian Period (11,000 B.P.- 8000 B.P.), the Early Archaic Period (8000 B.P. - 6000 B.P.), the Middle Archaic Period (6000 B.P. - 2000 B.P.), and the Late Archaic Period (2000 B.P. - 200 B.P.).

Paleo-Indian

The Paleo-Indian Period in North America is represented by large, fluted and lanceolate chipped stone artifacts often associated with the bones of now-extinct megafauna, such as elephants and giant bison. The Willamette Valley exhibits very little evidence for human occupation during this period. The isolated finds of two Clovis points, one found along the Mohawk River near Springfield in 1959 and the other discovered near Cottage Grove in 1935, combine to provide the only evidence for Paleo-Indian occupation in the Upper Willamette Valley. Two large lanceolate points that may have associated with nearby mammoth bones were reported near the Calapooyia River, but their provenience is still uncertain (Toepel 1985, Aikens 1993).

Early Archaic

The Early Archaic Period in the Willamette Valley provides the first extemsive evidence for human occupation on the valley floor (Toepel 1985, Cheatham 1988). The Early Archaic occurs during the Hypsithermal, defined as a climatic period exhibiting warmer, drier conditions than at present (Hansen 1947, Heusser 1960) Although camas remained an important vegetal resource throughout the prehistory in the Willamette Valley, acorns also were probably exploited during the Early Archaic, when oak groves were at their maximum as a result of the warm, dry Hypsithermal climatic phase (Johannessen 1971, Franklin and Dyrness 1973, Towle 1982). The Early Archaic Period is well-represented by the Cascadia Phase, named after Cascadia Cave in the foothills of the Cascade Range. This phase is characterized by leaf-shaped points known as Cascade points. Sites such as Hannavan Creek on the Long Tom river, radiocarbon dated at 7800 B.P. (Cheatham 1988), and Cascadia Cave and Baby Rock Shelter in the Cascade foothills, provide evidence for a seasonal round in which small groups of native peoples exploited resources in both the Casacde foothills and on the floor of the Willamette Valley. The artifact assemblage at the Hannavan Creek site includes ground stone, projectile points, scrapers, knives, hammerstones, anvils, cores, choppers, drills, spokeshaves, gravers. These tools represent activities such as hunting and vegetal food processing.

Middle Archaic

The Middle Archaic Period (6000 B.P. - 2000 B.P.) provides evidence for a well- developed adaptation to the resources available on the valley floor (Toepel 1985). The artifact assemblage includes heavy and moderately broad-necked stemmed points, and heavy stemless points, both kinds probably used in the atlatl/spear technology. There was also an abundance of ground stone (mortars, etc.) indicating a heavy reliance on vegetal foods such as acorns and camas bulbs. Cultural phases defined for the Middle Archaic include the Baby Rock Phase, the Flanagan Phase, and the Lingo phase. In the Cascade foothills, the Baby Rock Phase follows the previously discussed Cascadia Phase, and is represented at sites in the Fall Creek Reservoir, in the upper levels of Cascadia Cave, and, in Rigdon's Horse Pasture Cave.

On the Willamette Valley floor, the Flanagan and the Lingo Phases represent both early and late Middle Archaic occupation. The Flanagan Phase is defined by the early component at the Flanagan site and is characterized by heavy broad-necked and heavy stemless projectile points and ground stone artifacts such as mortar and pestle fragments. The Lingo Phase (Cordell 1967, 1975), named after the Lingo site on the Long Tom river, is represented at a number of sites in the Upper and Middle Willamette Valley: the Hurd site, the Kirk Park sites, the middle component of the Flanagan site, the Benjamin sites, the Davidson site, and the Hager's Grove site (White 1975, Toepel 1985, Cheatham 1988). The Lingo phase shows a predominance of moderately broad-necked projectile points, along with knives, drills, scrapers, hammers, choppers, anvils, mortars, and pestles. There is sufficient evidence to suggest reliance on both camas and acorn resources at this time. For instance, the Kirk Park sites, the Upper Long Tom Sites, and the Benjamin sites all include earth ovens with charred remains of camas bulbs, hazelnuts, and acorns (Aikens 1993). Based on artifact assemblage and projectile point types, the Sprague site, reported in the present study, shows evidence for Middle Archaic occupation in the Pleasant Hill valley.

Late Archaic

The Late Archaic Period (2000 B.P. - 200 B.P.) exhibits evidence for an increased population in the Willamette Valley (Toepel 1985, Cheatham 1988). This period is characterized by small stemless and narrow-necked projectile points associated with the bow and arrow technology. The cultural phases of the Late Archaic are separated into three geographic regions: the Rigdon Phase in the Cascade foothills, the Fuller Phase in the Middle Willamette Valley, and the Hurd Phase in the Upper Willamette Valley. The Late Archaic is most richly represented at the Fuller and Fanning Mounds, located on the Yamhill River. The diverse range of artifacts found at these sites includes hundreds of small arrowpoints, knives, scrapers, drills, bone points, hammerstones, bone and shell bead necklaces, ceremonial "fish clubs," and a large ceremonial obsidian knife (Aikens 1993). The Hurd phase is represented at several sites, including the upper levels at the Flanagan, Benjamin, and Lingo sites, and, in all levels of the Beebe and the Halverson sites (Toepel 1985). The present study shows that the Sprague site and the Enterprise site of the Pleasant Hill Valley should be added to this list of Late Archaic occupations.

Previous Research in the Pleasant Hill Valley

The only formal archaeological report on the Pleasant Hill valley came as result of preliminary investigations by Infotec Research, Inc. conducted for the Oregon Department of Transportation (Silvermoon 1991).

The investigation consisted of a pedestrian survey and subsequent Phase II test excavations of twelve localities along a stretch of Hwy. 58 between Goshen and Immigrant Road in Pleasant Hill. Three sites were identified as significant to the archaeology of the Pleasant Hill valley. Two of them, the Stutz site (35LA64) and the Flory site (35LA57), produced narrow-necked points which suggest Late Archaic occupations. The Parkway Junction site (35LA970) is a large lithic scatter which produced 42 tools, including 12 projectile points of broad-necked and narrow-necked styles, dating the site to the Middle and Late Archaic periods.

Results of these preliminary investigations indicated that there are a number of significant archaeological sites in the Pleasant Hill valley (Silvermoon 1991). Silvermoon also reported the presence of what appeared to be naturally occurring obsidian deposits on the Pleasant Hill Ridge near the Parkway Junction site. No obsidian characterization studies were conducted, however, to determine the primary geologic source of the obsidian.

ARCHAEOLOGICAL INVESTIGATIONS AT THE SPRAGUE AND ENTERPRISE SITES IN THE PLEASANT HILL VALLEY

Sprague Site

The Sprague site is located 1 km south of the small rural community of Jasper off Parkway Road in the Pleasant Hill Valley(Figure 1). It lies 4 km east of Mt. Pisgah and 1 km west of the Middle Fork of the Willamette River on the W. H. Shelly donation land claim property (T. 18 S., R. 2 W., Sec. 22, D.L.C. 71).

The approximate size of the Sprague site is 100 meters x 150 meters. It is situated on a rise slightly higher in elevation than the adjacent low-lying flood plain. The site is located on private property which has been farmed for about 100 years. Much of the site occurs in plowed fields, and plowing disturbs the top 18 inches of soil. No cultural features are visible on the site surface, and no archaeological excavations have been conducted there. Other than a small grove of mature big leaf maple trees and over-grown blackberry thickets approximately 150 meters to the west, no permanent vegetation now exists at the site. Present farm structures, such as the original barn (built about 1907), probably cover some parts of the archaeological site.

Artifacts from the Sprague site were recovered during surface surveys conducted in the summers of 1992, 1993, and 1994. A total of 188 artifacts were recovered from the site, including flaked stone tools and ground stone specimens. Table 1 lists the number of flaked stone tools by category and raw material. There are 134 projectile points, 12 bifaces, 4 scrapers, 5 awls/drills, and 5 utilized flakes. Ground stone tools were also recovered from the site; they include 4 complete bowls, 5 bowl fragments, 9 complete pestles, and 10 pestle fragments (Table 2). Figures 2 and 3 show examples of ground stone mortars and pestles found

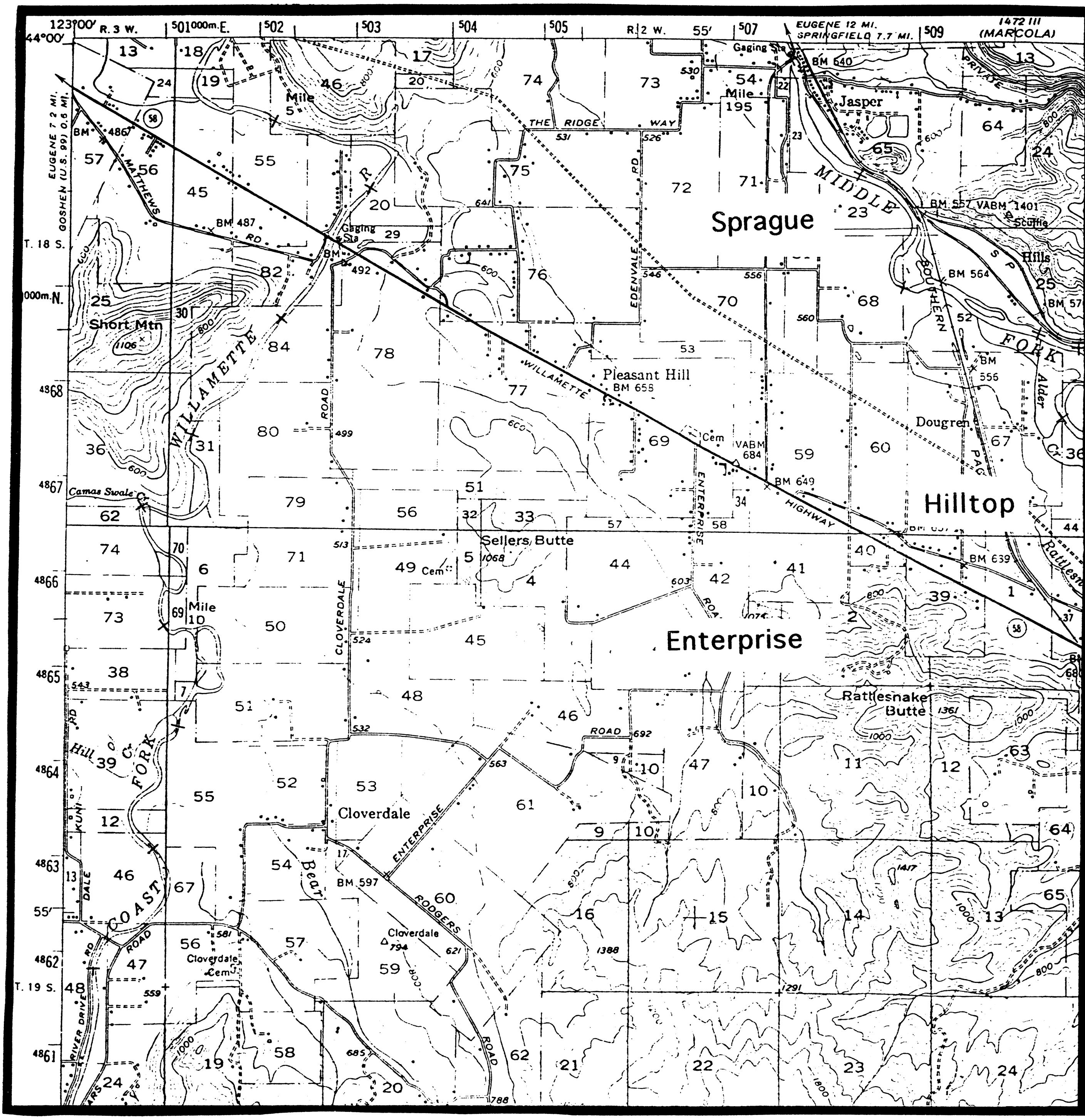


Figure 1. Locations of the Sprague, Enterprise, and Hilltop sites in the Pleasant Hill Valley.

at the Sprague site. The small bowl shown in Figure 3, 6 cm in diameter, is the smallest bowl recovered at the Sprague site. The larger bowl shown in Figure 3 is more typical of what has been recovered at the Sprague site.

FLAKED TOOLS	#of OBSIDIAN	# of CCS*	Total
projectile points	110	24	134
bifaces	5	7	12
scrapers	1	3	4
awls/drills	2	3	5
utilized flakes	5	0	4
		total	159

Table 1. Flaked stone tools by raw material from the Sprague site.
* cryptocrystalline silicate

Complete Bowls	Bowl Fragments	Complete Pestles	Pestle Fragments
4	5	9	10
		Total	28

Table 2. Ground stone bowls and pestles recovered from the Sprague site.

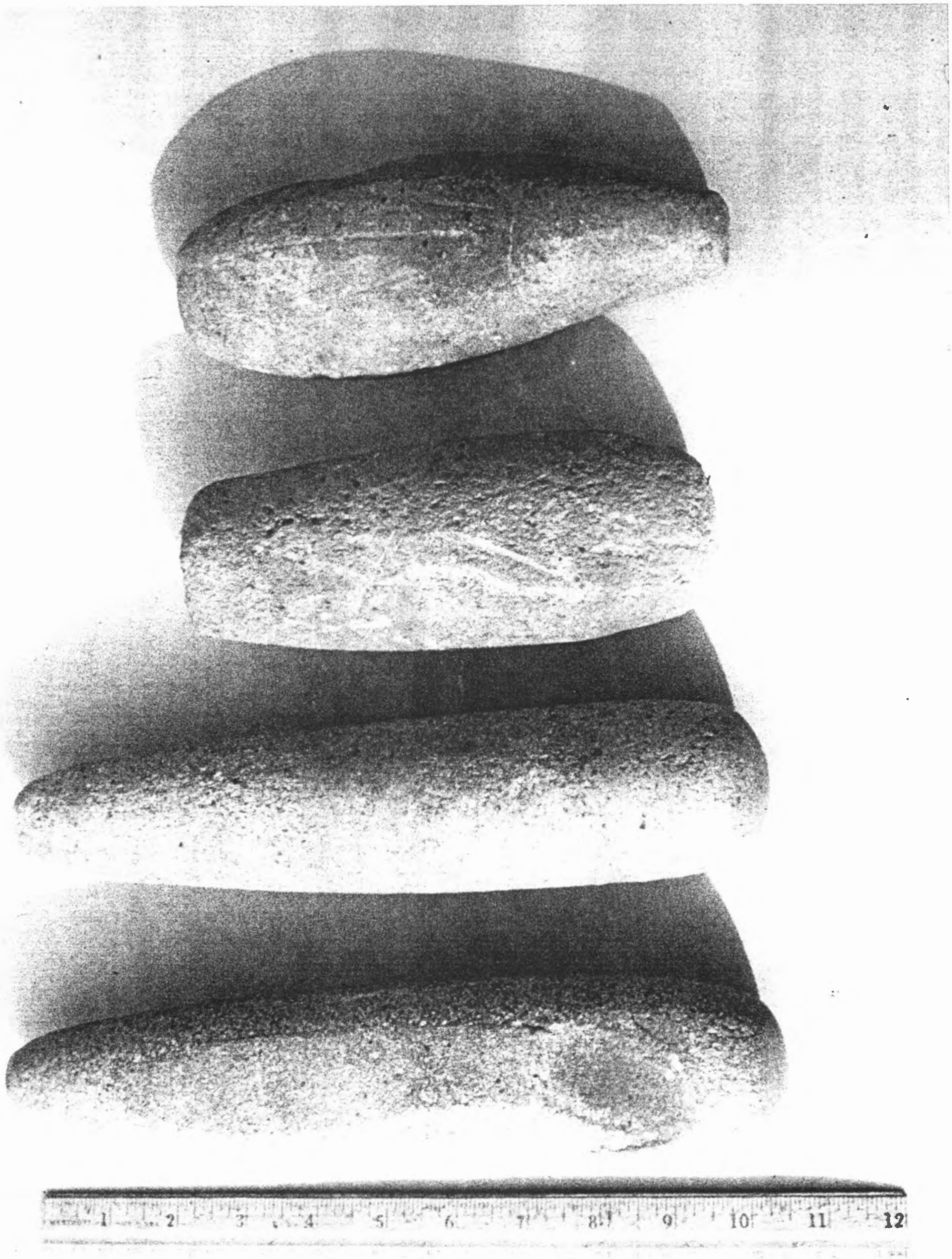


Figure 2. Ground stone pestles from the Sprague site.

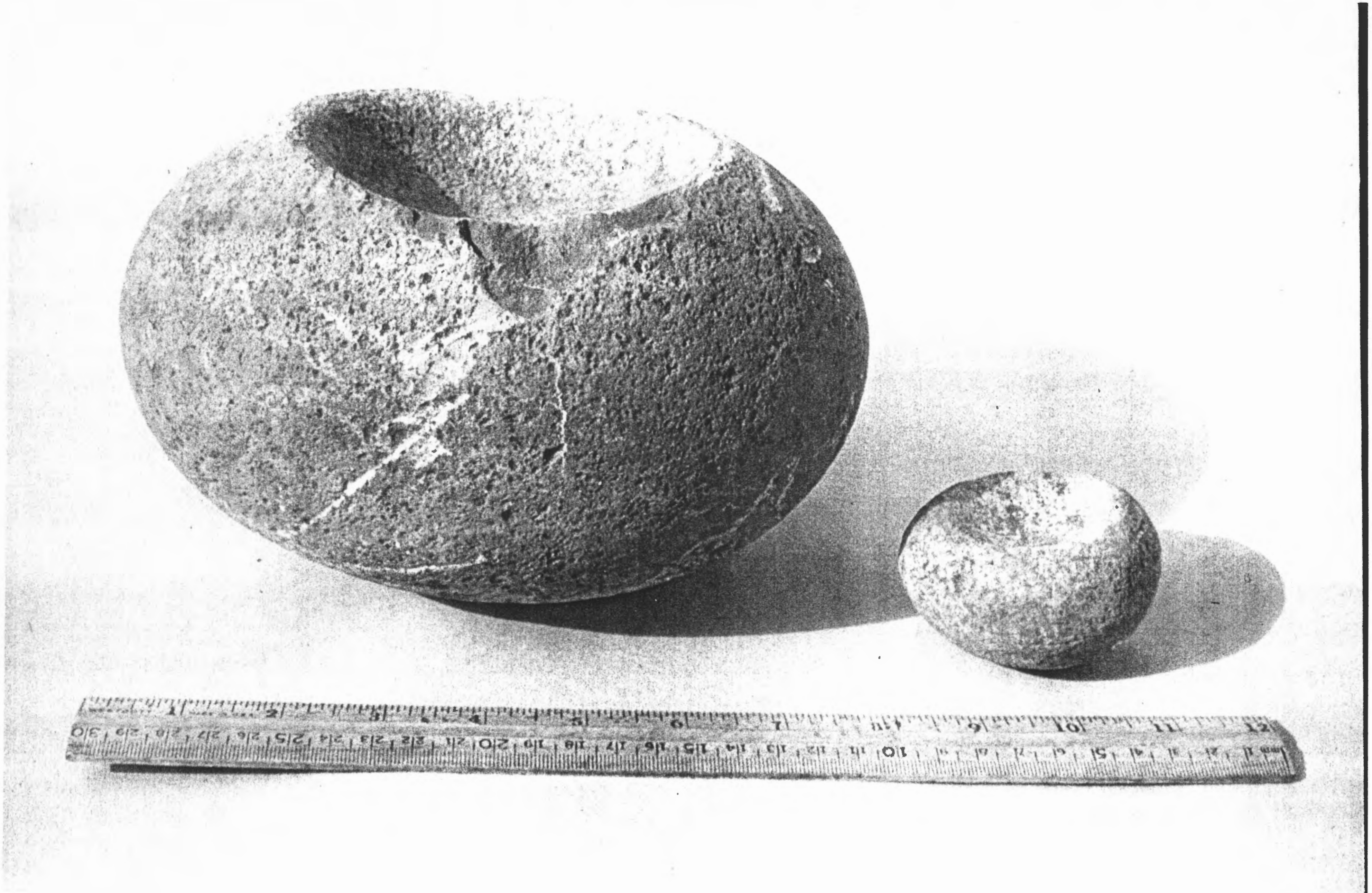


Figure 3. Ground stone bowls from the Sprague site.

The projectile points from the Sprague site were measured, analyzed, and classified according to Toepel's (1985) projectile point typology established for the Flanagan site, located 8 km west of Eugene. Toepel's typology includes three major classes of projectile points: stemless, narrow-necked, and broad-necked. These major classes are divided into five series which include fourteen point types. The key to Toepel's typology is provided in Figure 4 , which shows how the types are determined.

A total of 134 projectile points were recovered from the Sprague site; 121 of these were classified, while 13 were unclassifiable fragments. Table 3 shows the breakdown of the classified points at the Sprague site. There are 17 small stemless, 5 heavy stemless, 68 narrow-necked, 21 moderately broad-necked, and 11 heavy broad-necked points.

Heavy broad-necked points are stemmed points with a maximum width greater than 9 mm. At the Sprague site, heavy broad-necked points range in thickness between 5.3 mm - 10.8 mm and are represented by three styles: side-notched (n=1), corner-notched expanding stem (n=7), and corner-notched contracting stem (n=3). Heavy stemless points are also represented at the Sprague site. They consist of three types, differentiated by means of overall shape rather than stem configurations: heavy triangular (n=1), heavy leaf-shaped (n=1), and heavy lanceolate (n=3). Both the heavy broad-necked and the heavy stemless point series were probably associated with the atlatl and dart technology used during the early Middle Archaic Period in the Willamette Valley (6000 B.P. - 4000 B.P.). Heavy stemless and heavy broad-necked points from the Sprague site are pictured in Figure 5.

Moderately broad-necked points are stemmed points which have neck widths between 7 mm and 9 mm. Moderately broad-necked points were

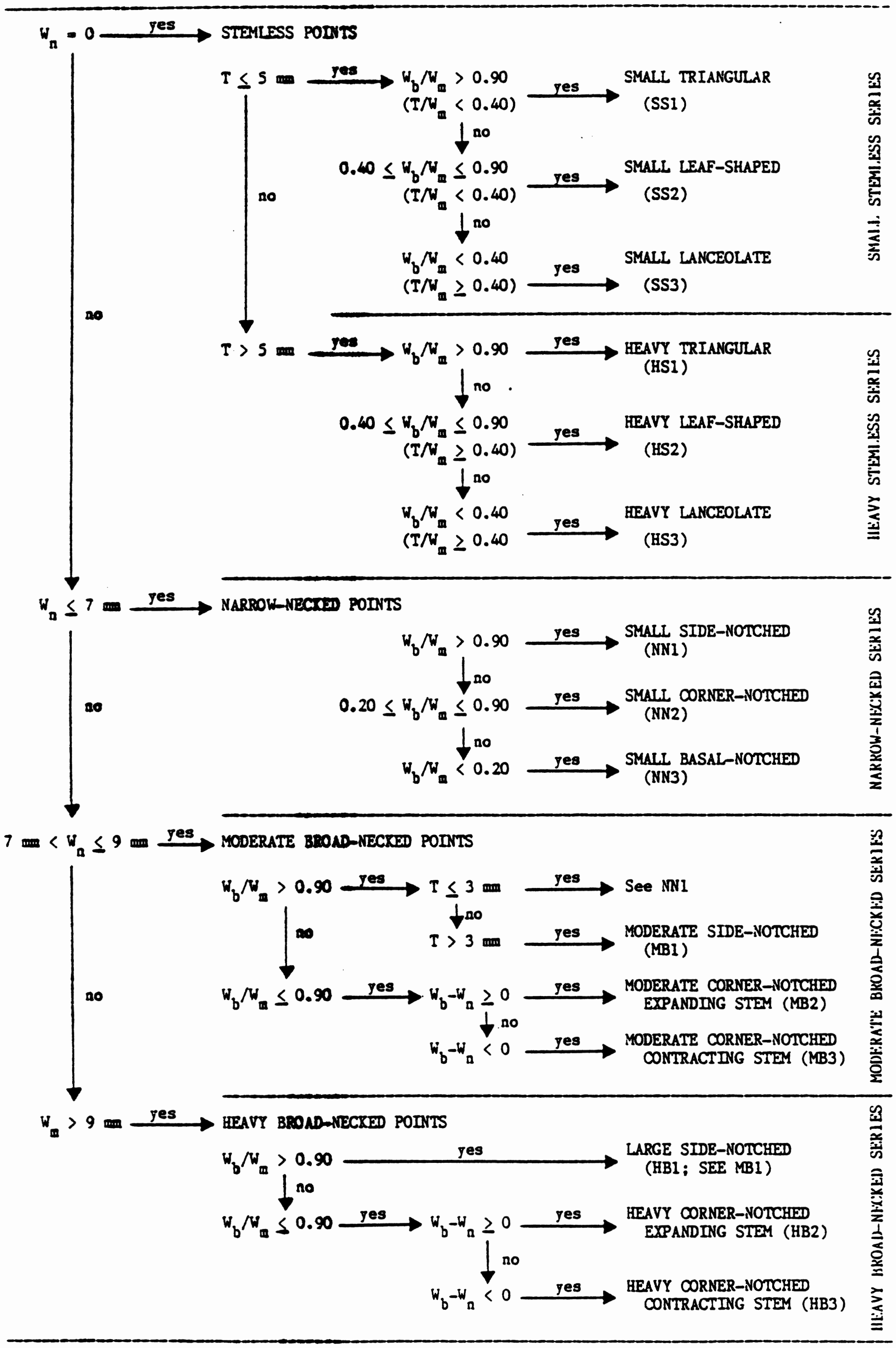


Figure 4. Key to the Flanagan Site projectile point typology used in this paper. From Toepel (1985).

also used with the atlatl, but are associated with the late Middle Archaic Period (4000 B.P. - 2000 B.P.)- a transitional phase between the Middle Archaic and the Late Archaic Periods. The Sprague site produced 21 moderate broad-necked points consisting of three types: side-notched (n=1), corner-notched expanding stem (n=12), and corner-notched contracting stem (n=7). A sample of the moderately broad-necked points from the Sprague site is pictured in Figure 6.

Major Class	Type (abv)	Type	Number	
Stemless (n=22)	SS1	Small triangular	11	
	SS2	Small leaf-shaped	4	
	SS3	Small lanceolate	2	
		sub-total	17	
	HS1	Heavy triangular	1	
	HS2	Heavy leaf-shaped	1	
	HS3	Heavy lanceolate	3	
		sub-total	5	
Narrow-necked (n=68)	NN1	Small side-notched	1	
	NN2	Small corner-notched	66	
	NN3	Small basal-notched	1	
		sub-total	68	
Broad-necked (n=33)	MB1	Moderate side-notched	1	
	MB2	Moderate corner-notched		
		expanding stem	12	
	MB3	Moderate corner-notched		
		contracting stem	7	
		sub-total	21	
	HB1	Large side-notched	1	
	HB2	Heavy corner-notched		
		expanding stem	7	
	HB3	Heavy corner-notched		
		contracting stem	3	
		sub-total	12	
		Total	121	

Table 3. Classified projectile points from the Sprague site, using the Toepel (1985) typology.

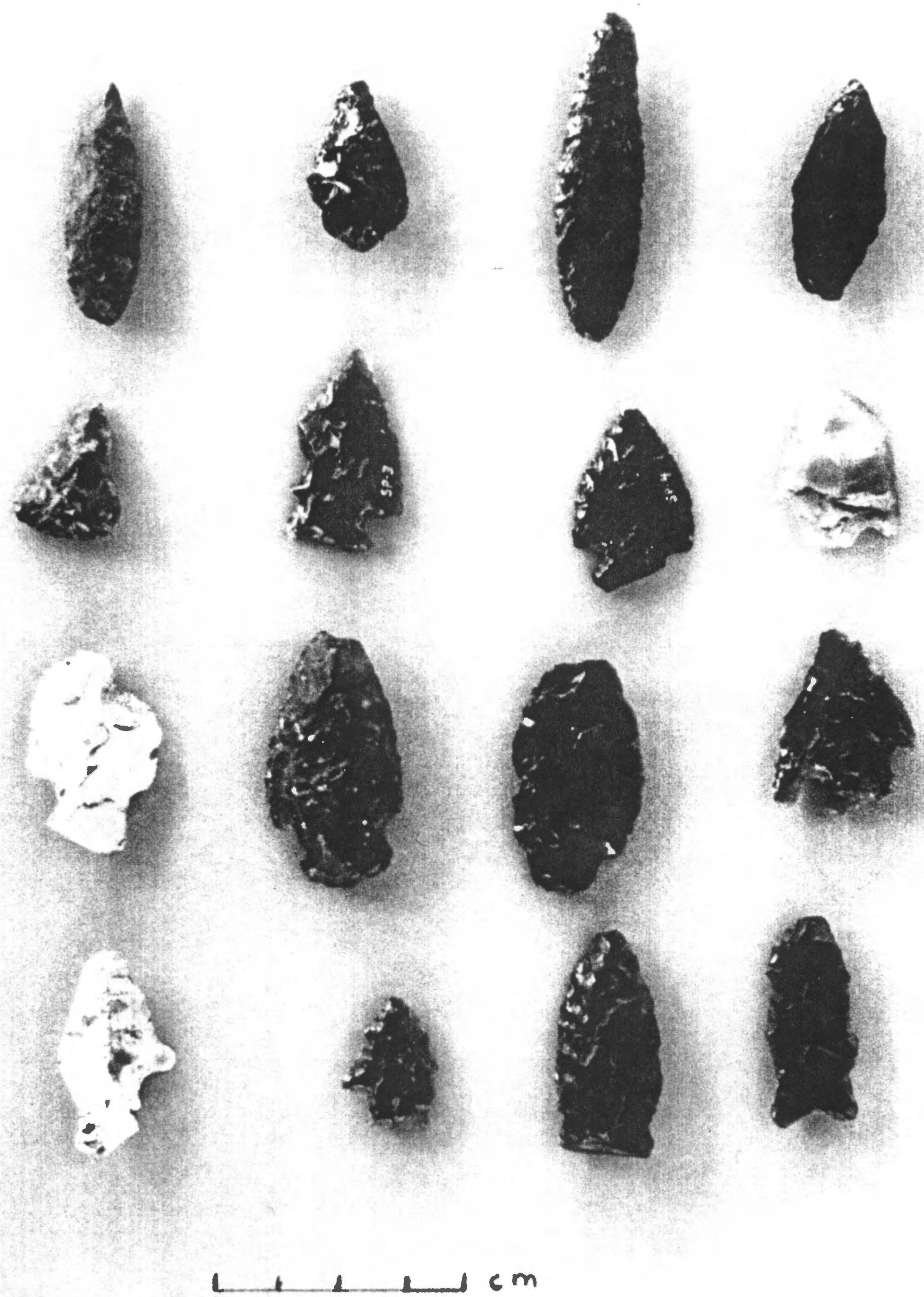


Figure 5. Sprague site: heavy stemless and heavy broad-necked points.

Figure 6. Sprague site: moderate broad-necked points.

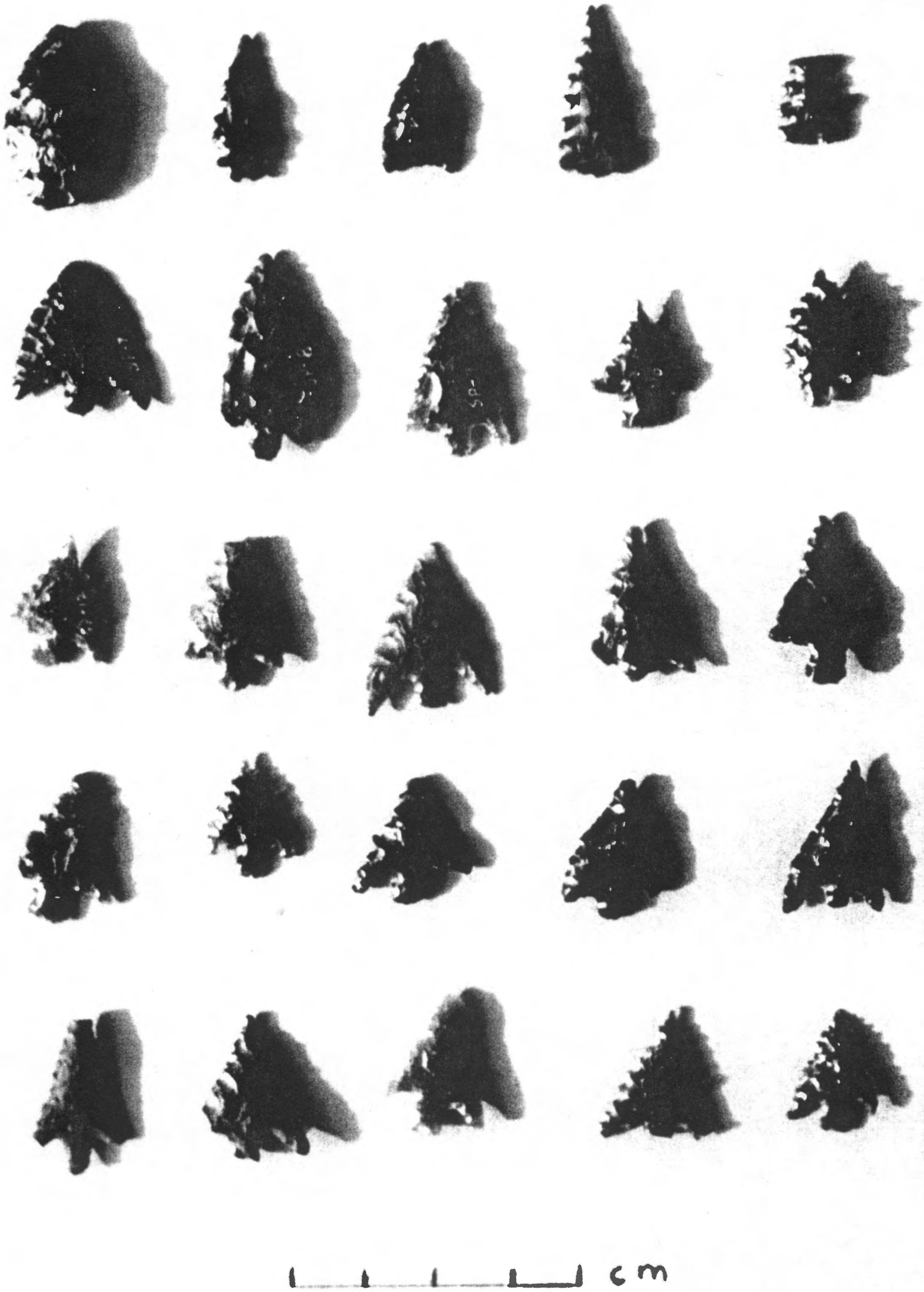


Figure 7. Sprague site: narrow-necked points.

Narrow-necked and small stemless points were both a part of the bow and arrow technology which came into use about 2000 years ago, and therefore, are associated with the Late Archaic Period. Narrow-necked points contain stems with neck widths equal to or less than 7 mm. They are often small and thin, some only 2 mm thick. The Sprague site produced a total of 68 narrow-necked points, representing three types: side-notched (n=1), corner-notched (n=66), and basal notched (n=1) (Figure 7). Small stemless points have a neck width equal to 0 and, like the heavy stemless, are defined on the basis of overall shape. A total of 17 small stemless points were recovered from the Sprague site: small triangular (n=11), small leaf-shaped (n=4), and small lanceolate (n=2).

Enterprise Site

The Enterprise site is located on the northwest-facing slope of Rattlesnake Butte, approximately 5 kilometers south of the Sprague site (T. 19 S., R. 2 W., Sec. 3). It is 4 km from the Middle Fork of the Willamette River. Rattlesnake Butte is heavily forested, predominately with Douglas Fir trees. The Enterprise site is located on a christmas tree farm on the lower slopes of the hillside, and artifacts are found bare ground exposed between the planted trees.

The site is characterized by a lithic scatter of obsidian and CCS debitage within a circular area 50 meters in diameter. Surface surveys were conducted on the site in the summers of 1993 and 1994. A total of 10 flaked stone tools were recovered from the Enterprise site, including 6 projectile points, 1 scraper, 1 graver, and 2 utilized flakes (Table 4, Figure 8). No ground stone was found. No cultural features were observed on the surface of the site, and no archaeological excavations have been conducted.

Figure 8. Artifacts from the Enterprise site.

FLAKED TOOLS	#of OBSIDIAN	# of CCS	Total
projectile points	6	0	6
scrapers	0	1	1
gravers	0	1	1
utilized flakes	0	2	2

Table 4. Flaked stone tools from the Enterprise site.

Analysis of the projectile points at the Enterprise site suggests a Late Archaic occupation there. Four points were classified in the narrow-necked series, and one was classified as a moderate broad-necked point. One fragment could not be placed within Toepel's classification (Figure 8). The nature of the site, its size, the limited number of tools recovered there, and the lack of ground stone indicate that the Enterprise site was a small, limited activity occupation dating to the Late Archaic Period.

Comparison of the Sprague and Enterprise Sites

The Sprague site produced 188 artifacts, including both flaked stone tools and ground stone. Projectile points recovered at the Sprague site include broad-necked, moderately broad-necked, and narrow-necked types, indicating the existence of several cultural components over a long period of time. The Enterprise site produced 10 flaked stone tools and no ground stone. The projectile points recovered from the Enterprise site were all narrow-necked, with the exception of one moderately broad-necked point. This suggests that the Enterprise site was a single occupation - or single component - site.

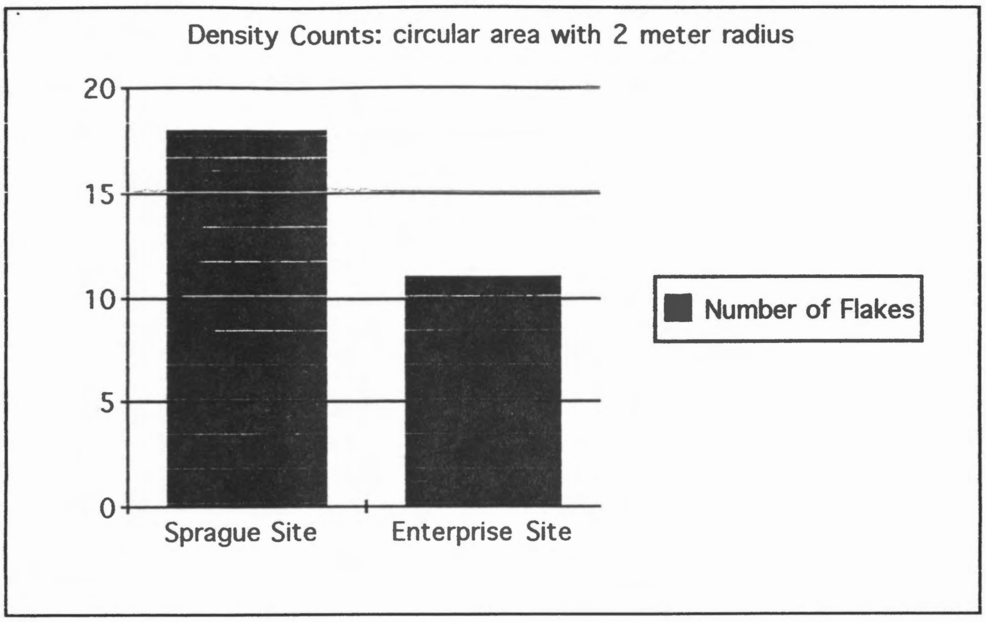


Figure 9. Artifact density counts at the Sprague and Enterprise sites.

The two sites also differ substantially in size and location. The Sprague site covers 15,000 square meters and is located in close proximity to the Middle Fork of the Willamette River. The Enterprise site, located in the hills above the valley and further away from the river, covers approximately 2,500 square meters. Density counts of lithic debitage collected within a two-meter radius at each site also show differences (Figure 9). The Sprague site produced a higher density count (18 flakes within the two-meter radius) than at the Enterprise site (11 flakes).

These differences in size, location, number and kinds of tools, and artifact density indicate that the Sprague and Enterprise sites represent quite different functions. The Sprague site, with its large size and diverse artifact assemblage (i.e., flaked stone tools, ground stone artifacts, and both early and late projectile points), represents a major and long-occupied settlement and food processing site. In contrast, the

Enterprise site exhibits the characteristics of a short-term encampment occupied by few people over a brief interval of time.

The occupants of the Enterprise site and the Sprague sites exhibited a preference for certain kinds of raw material in regard to specific tool categories. The projectile points from both sites were made overwhelmingly from obsidian; 116 were of this material, whereas only 24 were made from CCS. Contrastively, other tools, such as scrapers, bifaces, and awls were made more frequently from CCS than obsidian (15 CCS, and 8 obsidian). Also, raw material represented in lithic scatter density counts at both sites show a higher percentage of CCS and a lower percentage of obsidian (Figure 10). These patterns suggest that scrapers, drills, and other tools of CCS were being manufactured on site, while tools made of obsidian were made elsewhere and transported to the site in completed form. This evidence will be discussed more fully in subsequent pages.

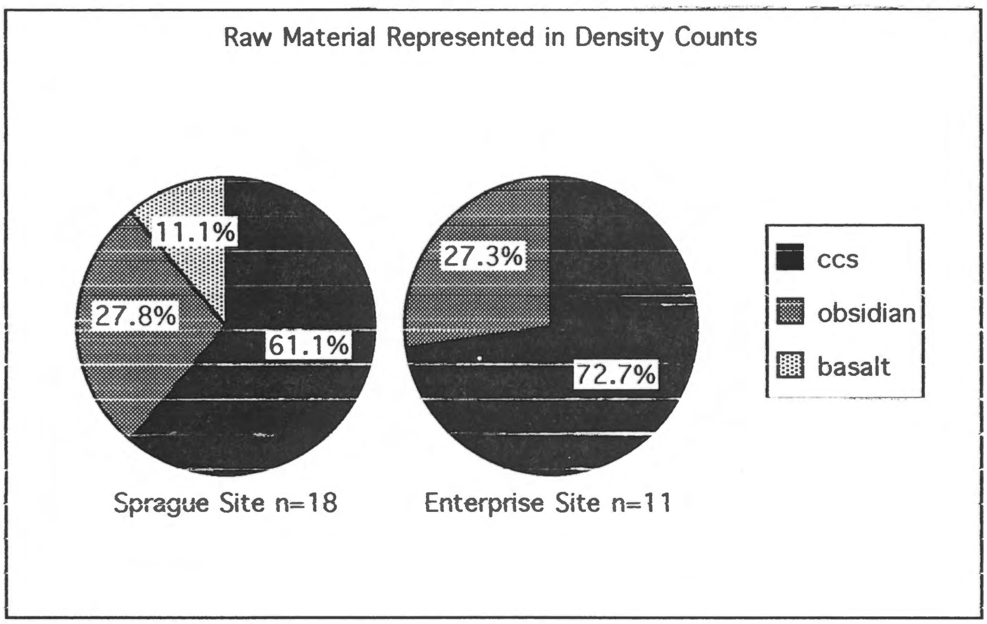


Figure 10. Raw material density counts at the Sprague and Enterprise Sites show a predominance of CCS at both sites.

COMPARATIVE DATING OF THE SPRAGUE AND ENTERPRISE SITES

The Flanagan site is used here as a basis for comparison because it is a major site in the Upper Willamette Valley which exhibits a well-developed adaptation to resources on the valley floor and spans 6000 years of occupation. Futhermore, the projectile point typology developed by Toepel at the Flanagan site has wide application to Willamette Valley archaeology.

Sprague Site

The rich and varied artifactual assemblage recovered from the Sprague site indicates that this site is comparable to Flanagan in both scope and age. While 282 projectile points were recovered from 69 excavated 1 x 1 meter units at the Flanagan site, the Sprague site produced 134 projectile points from the surface alone and excavations would surely increase this number.

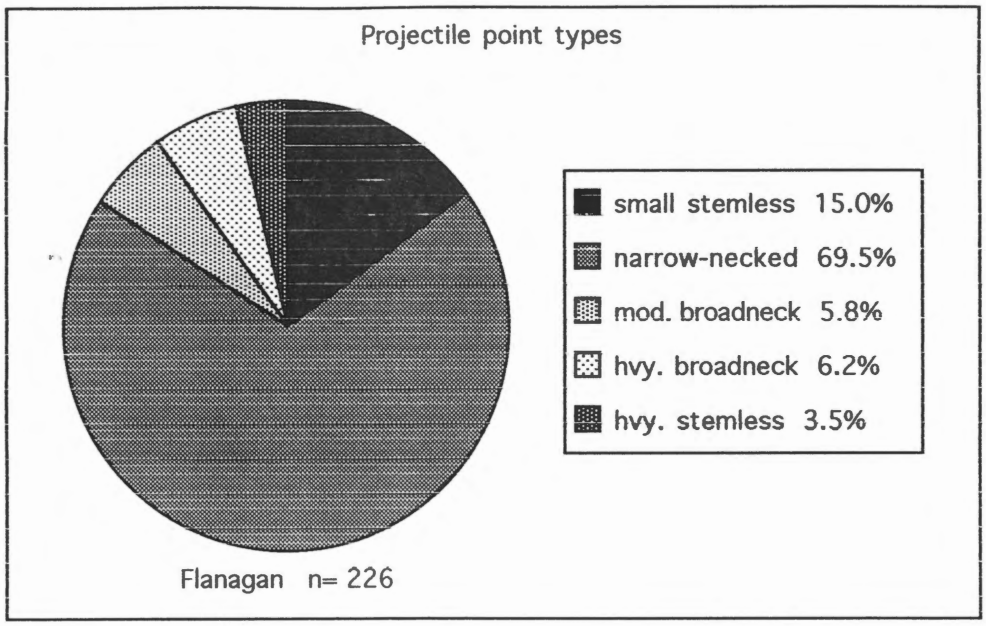
Comparisons between projectile point types represented at Sprague and Flanagan show highly similar assemblage compositions for the two sites, which indicates that occupation of the Sprague site occurred over the same span of time as that at the C-14 dated Flanagan site, i.e., from about 6,000 B.P. to 200 B.P. (Figs. 11 and 12).

Although the point type assemblage at the Sprague and Flanagan sites are strikingly similar, the percentage of pre-bow and arrow points is noticeably higher at the Sprague site (Figure12). At the Sprague site 4.1% of the classified points are heavy stemless, while at the Flanagan site 3.5% are heavy stemless. Heavy broad-necked points were represented by 9% of the points at the Sprague site and 6.2% at the

WILLAMETTE BASIN PERIODS	FLANAGAN SITE COMPONENTS (TOEPEL 1985)	FLANAGAN SITE PROJECTILE POINT TYPES	SPRAGUE SITE PROJECTILE POINT TYPES
Historic (A.D. 1750 - 1855)			
Late Archaic (A.D. 0 - 1750)	Late Component (2000 - 200 B.P.)	narrow-necked n=157 small stemless n=34	narrow-necked n=68 small stemless n=17
Middle Archaic (4000 B.C. - A.D. 0)	Middle Component (4000 - 2000 B.P.)	moderate broad-necked n=13	moderate broad-necked n=21
	Early Component (6000 - 4000 B.P.)	heavy broad-necked n=14 heavy stemless n=8	heavy broad-necked n=12 heavy stemless n=5
Early Archaic (6000 B.C. - 4000 B.C)			
PaleoIndian			

Figure 11. Comparison of Flanagan and Sprague Projectile Point Chronologies

Projectile point types	small stemless	narrow-necked	mod. broadneck	hvy. broadneck	hvy. stemless
Flanagan n= 226	34	157	13	14	8



Projectile point types	small stemless	narrow-necked	mod. broadneck	hvy. broadneck	hvy. stemless
Sprague n=121	17	68	21	11	5

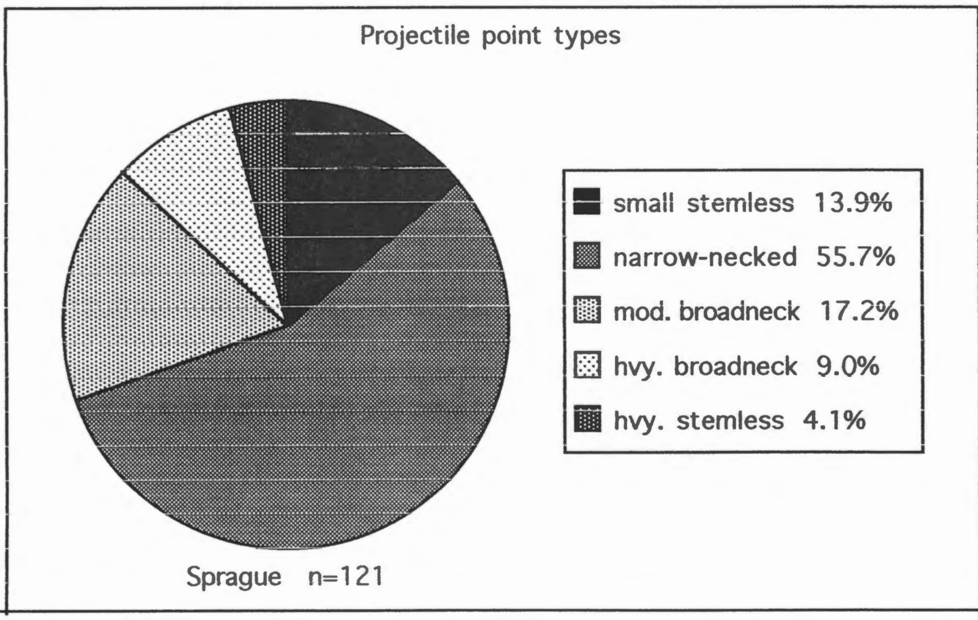


Figure 12. Comparison of Projectile Point Type Frequencies: Flanagan and Sprague Sites

Flanagan site. Moderately broad-necked points, however, were represented by 17.2% of the points at the Sprague site as compared to only 5.8% at the Flanagan site. This distribution suggests a somewhat more intense - or longer duration - occupation during the Middle Archaic at the Sprague site than at the Flanagan site.

The Sprague site, in sum, is an important archaeological site not only in the context of studies in the Pleasant Hill valley, but for the entire Upper Willamette Valley . The high degree of diversification within the artifact assemblage indicates that the Sprague site was a major occupation center, representing repeated, if not continuous, occupation from 6,000 B.P. to 200 B.P. It compares closely with the Flanagan site, and, like Flanagan, shows evidence for a well-developed adaptation to the valley's resources.

Enterprise Site

The Enterprise site, representing a smaller and less dense lithic scatter when compared to the Sprague site, produced only ten artifacts from surface collections. Point type analysis places five points in the narrow-necked series and one point in the moderate broad-necked series (Figure 13). No ground stone was recovered. The site's location above the floodplain, its small size, the lack of ground stone, and the predominance of narrow-necked points indicate that Enterprise is a Late Archaic temporary occupation site.

WILLAMETTE BASIN PERIODS	FLANAGAN SITE COMPONENTS (TOEPEL 1985)	FLANAGAN SITE PROJECTILE POINT TYPES	ENTERPRISE CLASSIFIED POINTS
Historic (A.D. 1750 - 1855)			
Late Archaic (A.D. 0 - 1750)	Late Component (2000 - 200 B.P.)	narrow-necked n=157 small stemless n=34	narrow-necked n=5
Middle Archaic (4000 B.C. - A.D. 0)	Middle Component (4000 - 2000 B.P.)	moderate broad-necked n=13 heavy stemless	moderate broad-necked n=1
	Early Component (6000 - 4000 B.P.)	heavy broad-necked n=14 heavy stemless n=5	
Early Archaic (6000 B.C. - 4000 B.C)			
PaleoIndian			

Figure 13. Comparison of Flanagan point types with Enterprise site.

GEOCHEMICAL CHARACTERIZATION OF OBSIDIAN TOOLSTONE FROM THE PLEASANT HILL VALLEY

Introduction to Pleasant Hill Obsidian Studies

After initial investigations and analysis at the Sprague site, the decision was made to explore obsidian characterization in order to further our understanding of trade and/or procurement strategies of prehistoric populations in the Pleasant Hill valley. The first line of inquiry became an option during survey work at the Sprague site in 1991. Observed discrepancies in expected ratios of tools to debitage aroused suspicions that recovered debitage and tools were not fully related through the process of on-site tool manufacture. First, while tool manufacture produces far more debitage than tools, the Sprague site produced almost equal quantities of tools and debitage. Secondly, 90% of the recovered debitage pieces were broken nodules with cortex, indicating that very small stones were the main raw material source. It was difficult to attribute this debitage - much of which was small (2-4 cm) and of poor quality - to the abundance of finely crafted tools at the Sprague site. X-ray fluourescence (XRF) analysis of these two categories of artifacts, tools and debitage, seemed the most expedient way of resolving this issue because it would indicate whether or not the tools and the debitage came from the same geological source. It would then be possible to ascertain if the tools were being manufactured at the Sprague site, or elsewhere, such as at a quarry site. The opportunity to extend this characterization study into an inter-site comparison arose in 1994 with the discovery of a small lithic scatter off Enterprise Road near Pleasant Hill High School. The Enterprise site, which shows characterisitcs of a temporary camp, provided an opportunity to test whether inter-site differences in toolstone procurement were related to site function.

The geochemical properties of obsidian, a naturally-occurring volcanic glass, provide the opportunity to characterize, or fingerprint, specific geological sources of obsidian. Each obsidian-forming event produces geo-chemically distinct characteristics which can be measured. Through X-ray fluouresence (XRF), an energy dispersive technique involving an electron microscope, trace element patterns of obsidian can be analyzed and linked to the parent source (Stevenson 1971, Haering 1975, Nelson 1975, Skinner 1983a). In this way, obsidian artifacts from archaeological sites can be tested to determine the origin of the raw material from which they were made. Thus, obsidian characterization enables archaeologists to investigate and reconstruct patterns of prehistoric trade and procurement.

<u>Naturally Occurring Obsidian in the Willamette Valley</u>

There are over 150 geochemically distinct obsidian sources in Oregon (Skinner p.c. 1994,1983a). Many of these are located in the Casacade Range and in eastern Oregon. Prior to 1983, the only known source of naturally-occurring obsidian in the Willamette Valley was the gravel beds of the McKenzie River. Obsidian nodules originating from Obsidian Cliffs (located near the North Sister just west of the Cascade Ridge) were being washed down the river and deposited on the valley floor. Archaeologists have speculated that these nodules were exploited by native populations and manufactured into tools. Although this may have occurred with small projectile points and tools, however, large points and knives could not have been made from the small water-worn nodules of obsidian found in the gravel bars of the Mckenzie River. Skinner found only small obsidian nodules, up to no more than 4 cm in length, during extensive foot surveys in the river (Skinner, p.c. 1994).

With the recent discovery of the extensive Inman Creek obsidian gravel deposits near Fern Ridge Reservoir (Skinner 1983b), archaeologists had to reconsider patterns of obsidian procurement in the Willamette Valley. Inman Creek is a small, intermittent tributary to the Fern Ridge Reservoir near Eugene which contains secondary deposits of two kinds of obsidian (Inman A and Inman B). Water-worn nodules up to 17 cm in diameter have been found in the gravels of Inman Creek and are also eroding from an exposed layer of well-cemented gravels on the banks of the creek (Skinner 1983b). Inman Creek cuts through two meters of alluvial deposits (sand, mudstone, and gravels) that characterize the Ingram geomorphic unit laid down during the Pleistocene and Holocene.

The obsidian deposits at Inman Creek have been geochemically linked with parent sources located near Salt Creek Falls up the Middle Fork of the Willamette River near the town of Oakridge. The large size of some of the nodules and the nature of the outcrops suggest that the Inman Creek obsidian was transported down the Middle Fork by a geologic event, or a series of geologic events, more catastrophic in nature than the more common fluvial transport of materials such as those associated with the Obsidain Cliffs nodules in the McKenzie River. Skinner (p.c. 1994) suspects that large mud-flows during the Pleistocene were responsible for the movement and deposition of Inman A and Inman B obsidian on the valley floor. A recent discovery of naturally-occurring, water-worn nodules (one as large as 25 cm in length) in the Pleasant Hill valley further establishes the wide distribution of Inman Creek obsidian.

<u>Review of Obsidian Characerization Studies Western Oregon</u>

Many of the early XRF studies were hampered by the restricted universe of then-known potential sources and by limited information on trace element patterning for known sources. The Halverson site, near the Mohawk River, produced evidence of trans-Cascade exchange of obsidian, but the study was conducted before the discovery of Inman Creek obsidian. Therefore, it did not establish that indigenous peoples were exploiting this potential resource for manufacturing tools (Toepel and Sappington 1982). Skinner's initial studies of the Inman Creek deposits dealt with the primary problem of geologic characterization and he did not apply x-ray fluouresence to obsidian tools recovered from the Willamette Valley. Toepel (1985) later characterized artifacts from the Flanagan site and found the expected reliance on Inman Creek and Obsidian Cliffs sources. The results also indicated the establishment of trans-Cascade procurement of obsidian, as evidenced by the presence at Flanagan of South Sister obsidian not naturally occurring in the Willamette Valley. No interpretations of this data were attempted. Cheatam (1988) tested 11 artifacts from the Long Tom sites, but test results showed difficulty in distinguishing between the Tucker Hill source in south central Oregon and local deposits at Inman Creek.

The most extensive study to date utilizing XRF analysis of obsidian artifacts is Skinner and Winkler's 1991 paper on "Prehistoric Trans-Cascade Procurement of Obsidian in Western Oregon." This study focused on the spacial distribution of characterized obsidian artifacts. They employed trace element analysis of 1,941 obsidian samples from 192 archaeological sites in the western Cascade drainages. These included the Clackamas, Santiam, McKenzie, Middle Fork Willamette, Umpqua, and Rogue River sub-basins. General trends showed a marked north/south differentiation of eastern Oregon obsidian recovered from western Oregon archaeological sites (see Figure 14b). For instance, sites south of the

Middle Fork Willamette River show a much greater reliance on obsidian sources east of the Cascade Ridge, while those to the north are characterized by obsidian from more local sources in western Oregon. Seventeen sites from the Upper Middle Fork Willamette River drainage showed a reliance on an increasing number of obsidian sources from central Oregon. These included Newberry Volcano, McKay Butte, Cougar Mountain, Silver Lake, Scyan Marsh, and Spodue Mountain. Inman Creek and Obsidian Cliffs together represented 62% of the tested artifacts from these sites. No sites in the Lower Middle Fork Willamette drainage, which includes the Pleasant Hill valley, were tested.

Skinner and Winkler also undertook a preliminary study into the question of whether raw material preferences exist for different types of obsidian tools. They compared three artifact categories (debitage, projectile points, and other tools) from specimens obtained from seventeen sites in the Upper Middle Fork Willamette drainage. They found no difference in the relative percentages of debitage to projectile points. These relative frequencies were tested for specimens made of stone from both eastern and western Oregon sources. They did find a difference, however, between projectile points and "other tools" (bifaces, preforms, and utilized flakes) relative to east/west procurement. Obsidian sources west of the Cascade Ridge are represented twice as often as eastern sources for both debitage and projectile points, while the category of "other tools" shows equal representation of eastern and western sources (Figure 15). Thus, the percentage of "other tools" from eastern sources is greater than the percentage of projectile points from eastern sources. Although the sample of "other tools" is small, these data suggest that prehistoric peoples did exhibit a preference for obsidian in the manufacture of certain types of tools. Skinner and Winkler add that "this is a trend worth watching in future western Oregon obsidian characterization studies (1991:7)."

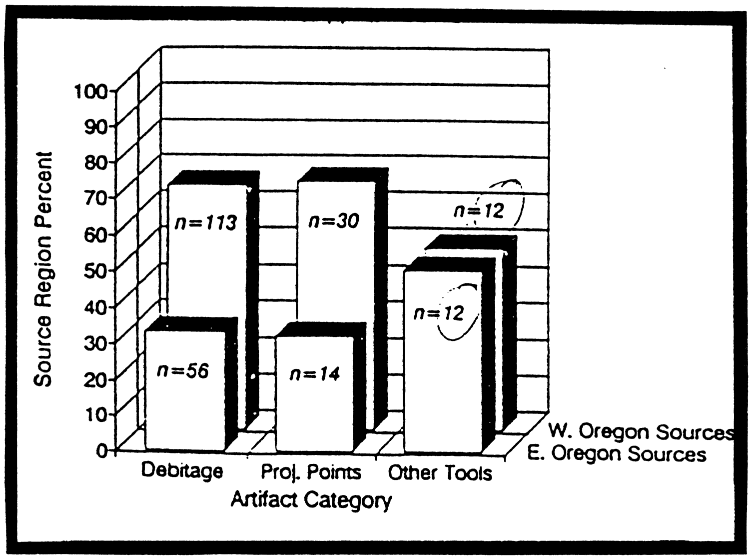


Figure 19. Artifact Category and Source Region Use Data from 17 Upper Middle Fork Sites From Skinner and Winkler (1991)

Results of XRF Characterization of Obsidian Specimens for the Sprague and Enterprise sites

A total of 45 obsidian specimens from the Pleasant Hill valley were characterized by Biosystems Analysis, Inc. of Santa Cruz, California. A Spectrace 5000 energy dispersive X-ray fluorescence system was employed to measure the following trace elements: zinc (Zn), lead (Pb), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobidium (Nb) (see Appendix B for complete Biosystems report). Twenty-three obsidian artifacts from the Sprague site and 16 from the Enterprise site were characterized. Six specimens of non-cultural obsidian from the Hilltop location were also tested (Table 5).

Site	# of Tools	# of Debitage	Total
Sprague	12	11	23
Enterprise	6	10	16
Hilltop	-	6 (non-cultural)	6
		Total	45

Table 5. Characterized obsidian from Pleasant Hill.

The choice was made to test obsidian from two archaeological sites in the Pleasant Hill valley in order to investigate inter-site comparisons. The Sprague and Enterprise sites provided the opportunity to compare a large, long-occupatied village site with a small, briefly occupied temporary site. Intra-site comparisons were established by characterizing both tools and debitage to determine whether the raw material of which they were made came from the same obsidian source. Twelve tools and 11 pieces of debitage were tested from the Sprague site. Six tools and 10 pieces of debitage were tested from the Enterprise site.

The obsidian specimens characterized in this study are traced to 5 sources: Inman Creek A, Inman Creek B, Obsidian Cliffs, Newberry Volcano, and Unknown. Figure 16 represents a scatter plot of two important trace elements, strontium and zirconium, used in determining the sources of obsidian from the Pleasant Hill sites. Although Inman A and Inman B are often lumped together and referred to as Inman Creek obsidian, Figures 16 and 17 represent them separately to illustrate how they fit within the pattern established in the Willamette Valley - that Inman A and Inman B consistenly occur together in both natural deposits and archaeological sites

The 39 obsidian artifacts characterized from the Sprague and Enterprise sites produced 27 specimens (69.2%) from Inman Creek, 10 specimens (25.6%) from Obsidian Cliffs, 1 flake (2.6%) from Newberry Volcano, and 1 broad-necked projectile point (2.6%) from an unknown source (Figure 18). A much different representation emerges, however, when the two sites are examined separately (Figure 19).

Comparison of the two sites shows a marked differentiation in source material represented. At the Sprague site 52.2% of the characterized obsidian originated from Inman Creek, while 43.5% originated from Obsidian Cliffs. In contrast, at the Enterprise site, 93.8% of the characterized obsidian came from Inman Creek, while Obsidian Cliffs was not represented at all(Figure17). The greater diversity of obsidian sources represented at the Sprague site is attributed to elements such as site size, function, complexity, and length of occupation, rather than geographic factors. Sprague is a more complex archaeological site, showing evidence for more intense occupation over longer periods of time, and exhibiting characteristics of more diverse site activities than are evident at the Enterprise site. It follows, then, that the Sprague site would produce a more complex obsidian procurement pattern.

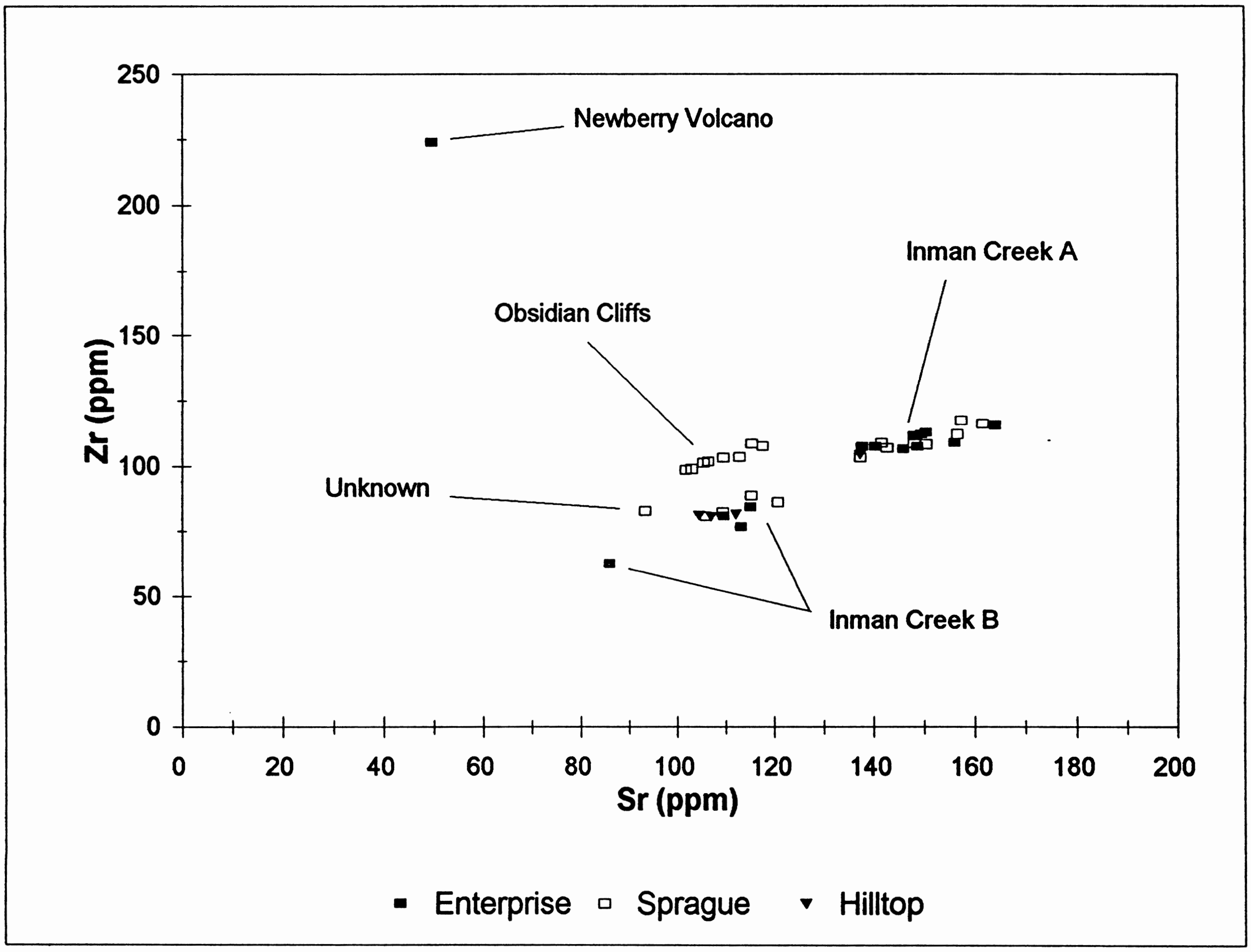


Figure 16. Scatterplot of trace elements from characterized obsidian in the Pleasant Hill Valley.

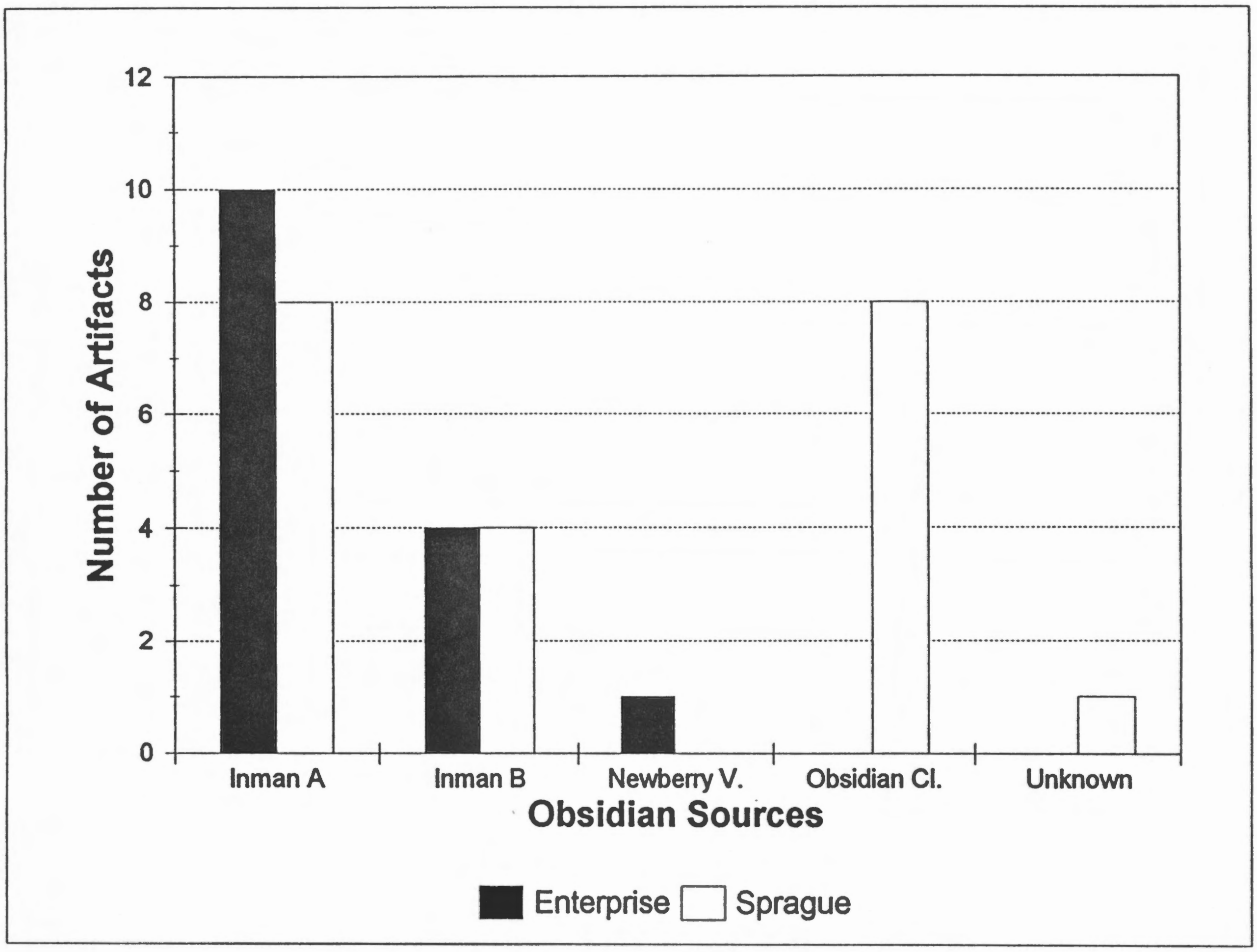


Figure 17. Bar graph showing obsidian sources represented at the Sprague and Enterprise sites.

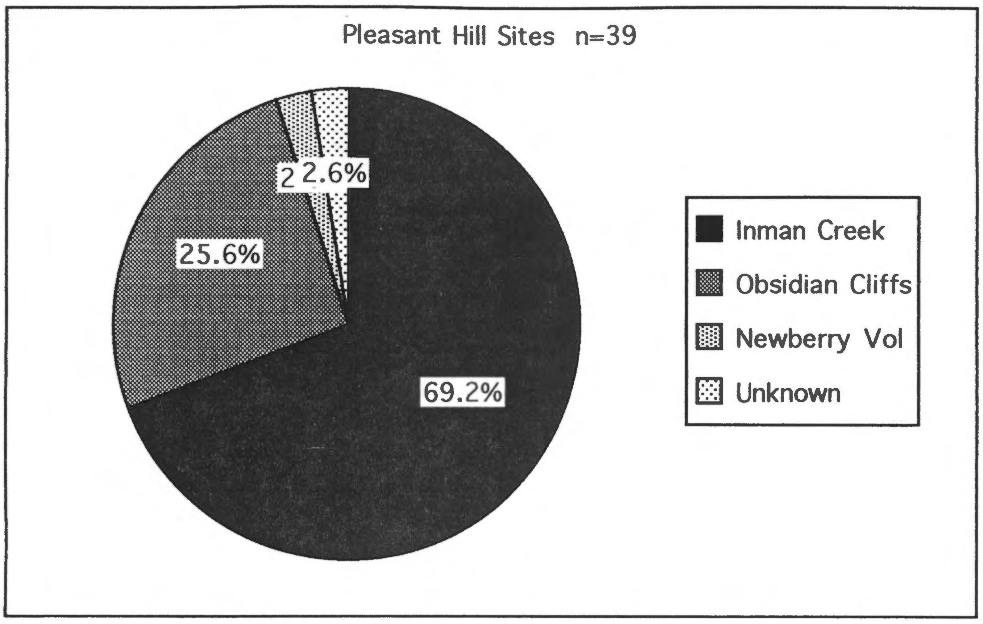


Figure 18. Obsidian sources represented at the Sprague and Enterprise sites.

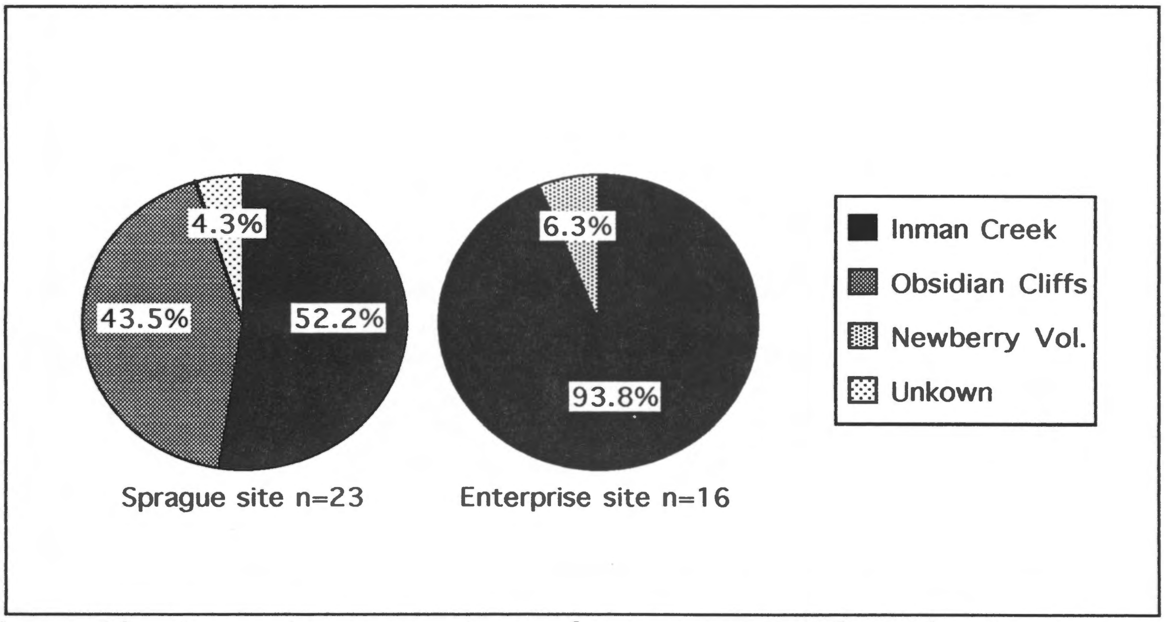


Figure 19. Inter-site comparison of source material at the Sprague and the Enterprise sites shows greater diversity at the Sprague site.

The Sprague site provided an opportunity to test whether recovered debitage is the by-product of on-site tool manufacture. A comparison of the characterized tools with the debitage showed a marked difference in the percentage of sources present in the two kinds of specimens (Figure 20). Stone for seven (58.3%) of the tools originated from Obsidian Cliffs, stone for four (33.3%) came from Inman Creek, and stone for one point (8.3%) was characterized to an unknown source. Characterized debitage showed different percentages. Only three (27.3%) of the pieces of debitage came from Obsidian Cliffs, while eight (72.7%) originated from Inman Creek. This suggests that suggests that while tool manufacture was carried out at the Sprague site, much was also conducted at locations other than Sprague. In other words, many of the tools found at the Sprague site were ready-made of exotic obsidian, and were brought to the site as

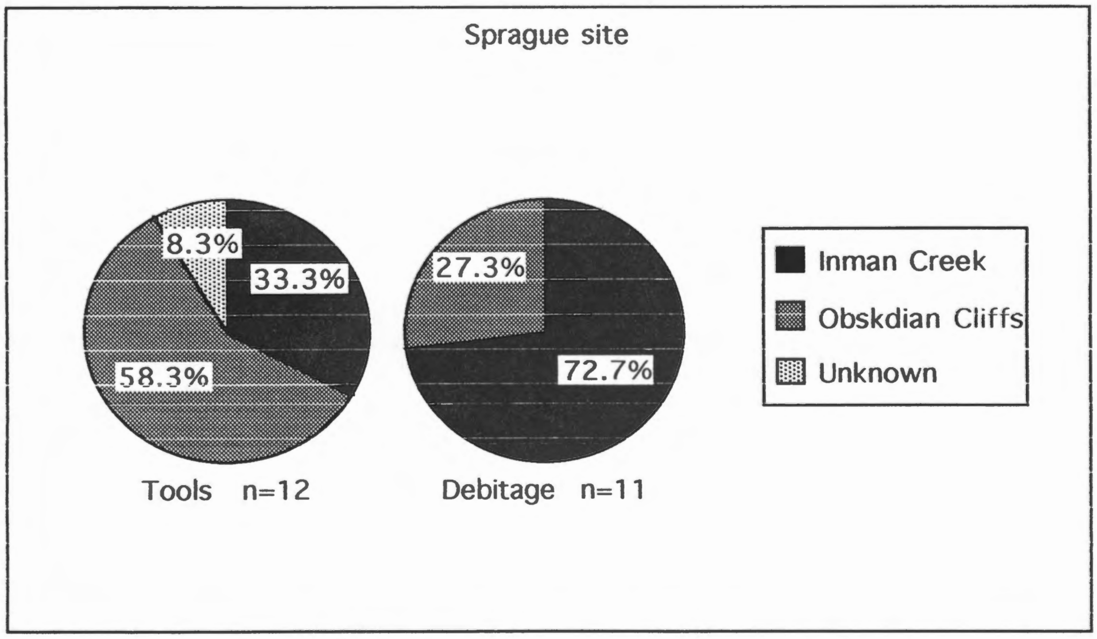


Figure 20. Representation of obsidian sources for artifacts at the Sprague site shows the majority of tools made from Obsidian Cliffs, while the majority of debitage came from local Inman Creek obsidian.

or nearly complete, tools. The evidence also suggests that the tools that *were* manufactured at the site were made of local Inman Creek obsidian.

The question still exists, however, whether the raw material from Obsidian Cliffs was obtained from the primary source or from the gravel bars in the McKenzie River. Although it is logical that obsidian in the local river bed would be exploited, it is unlikely that large tools were manufactured from these water-worn nodules as they simply were not big enough to fashion tools over 3 - 4 cm in length. Instead, it is more likely that indigenous peoples either traded or directly obtained Obsidian Cliffs obsidian from its primary source near the North Sister in the Cascade Range.

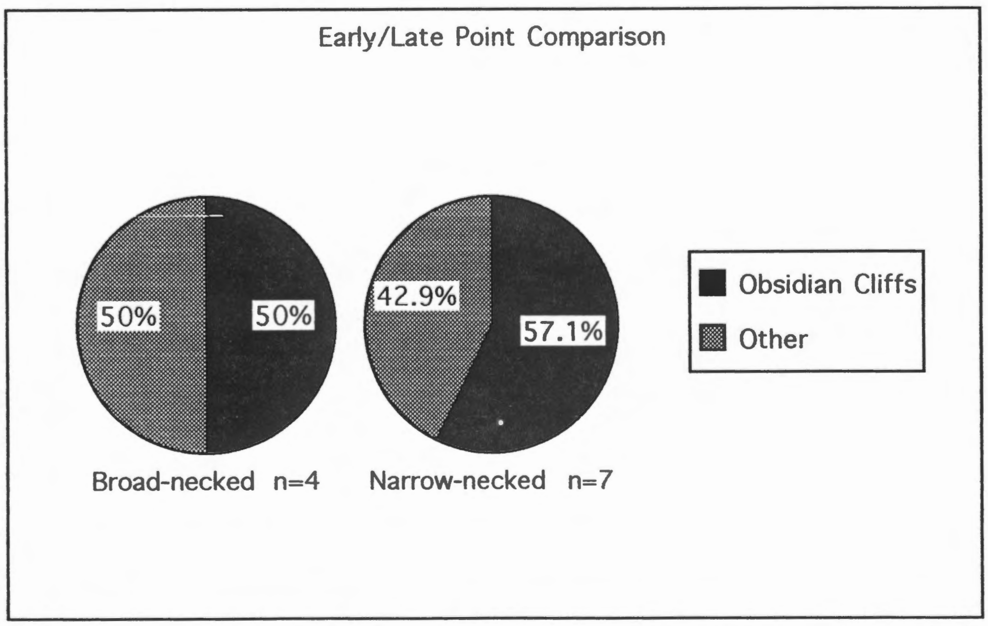


Figure 21. Comparison of broad-necked (Early Archaic) and narrow-necked (Late Archaic) points from the Sprague site indicates that the exploitation of Obsidian Cliffs obsidian remained stable over time.

Four broad-necked points of Middle Archaic type and 7 narrow-necked points of Late Archaic type from the Sprague site were characterized to see if any difference could be found between points from early and late occupation periods. No significant differences were found. The Obsidian Cliffs source was represented by very similar percentages for broad-necked and narrow-necked points (Figure 21). This suggests that expoitation of obsidian sources remained stable over time at the Sprague site.

One broad-necked point from the Sprague site could not be assigned to a known local source of obsidian, but initial tests show trace elements similar to the Tuscan source near Red Bluff in northern California. This suggests the possibility of long-distance procurement or trade during early periods of Willamette Valley settlement. The presence of Newberry Volcano obsidian at the Enterprise site provides further evidence for long-distance obsidian procurement/trade strategies of prehistoric peoples in the valley.

Local Secondary Obsidian Source

A local Pleasant Hill obsidian deposit consists of abundant chunks of obsidian eroding from a northeast facing knoll discovered near Hilltop Drive and Immigrant Road, approximately four kilometers northeast of the Enterprise site. Lithic analysis has shown these chunks to be non-cultural material. Six samples of this material were characterized as Inman Creek. Four of these tested Inman B, and two tested Inman A. This secondary deposit of Inman Creek A and B obsidian occurring in the same site is consistent with recent findings of Skinner (p.c. 1994). One of these specimens tested to Inman B measured 22 cm x 19 cm x 15 cm and weighed 7.3 kilometers (Figure 22). This is the largest cobble from a secondary deposit of Inman Creek obsidian discovered to date.

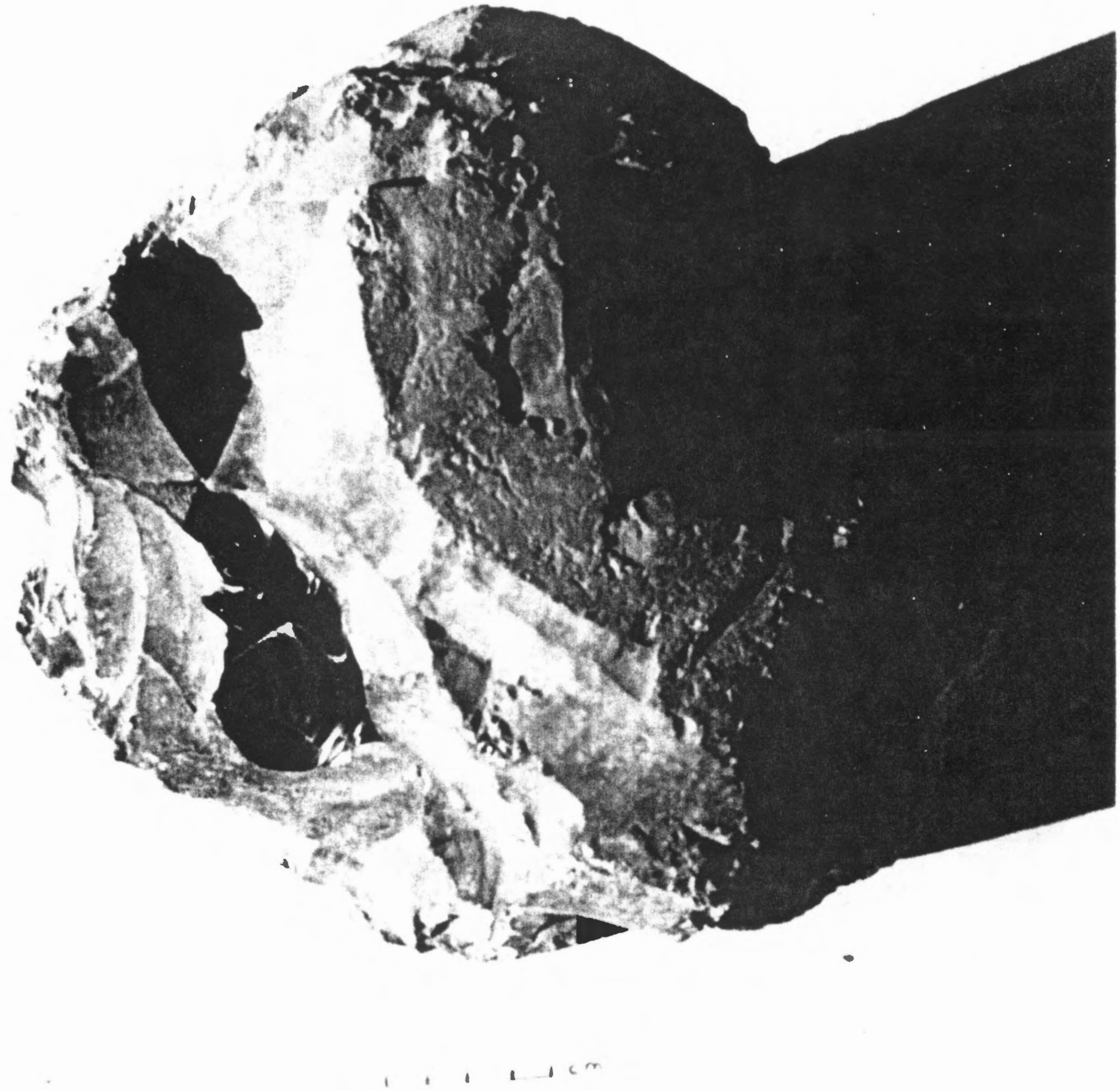


Figure 22. Inman Creek obsidian cobble recovered from the Hilltop deposit in Pleasant Hill.

CONCLUSION

The Sprague site, located near Jasper Park in Pleasant Hill, is thought, on the basis of its surface assemblage of numerous projectile points and ground stone artifacts, to be a major occupation center repeatedly used over the period from 6000 B.P. to 200 B.P. The Sprague site produced 187 tools, including 134 projectile points, 12 bifaces, 4 scrapers, 5 awls, 4 utilized flakes, and 28 mortars and pestles.

There were 11 heavy broad-necked and 5 heavy stemless points, which date to the early Middle Archaic (6000 - 4000 B.P.), recovered at the Sprague site. It also produced 21 moderate broad -necked points, dating to a transitional phase during the late Middle Archaic (4000 - 2000 B.P.), and narrow-necked and small stemless points of the Late Archaic (2000 B.P. - 200 B.P.). The progression from broad-necked through moderate broad-necked to narrow-necked points along with the abundance of ground stone, indicate significant and repeated if not continuous occupation of a single site for as long as 6000 years.

Obsidian characterization studies indicate that some tools recovered at the Sprague site were not manufactured there. A marked differentiation of lithic source material was found between tools and debitage; the majority of tools were made from Obsidian Cliffs obsidian, while the majority of debitage tested to local Inman Creek obsidian sources. A similar pattern was detected by Jenkins and Connolly (1990) in archaeological sites in Harney County, eastern Oregon. It is reasoned that if quarry sites are located significant distances from permanent settlements, the need to reduce the weight of transported material would dictate tool manufacture at or near the quarry site. This would increase the ratio of tools to debitage recovered from the permanent settlement.

Comparisons between narrow-necked and broad-necked points show a stability in procurement strategies over time. The percentages of narrow-necked and broad-necked points at the Sprague site that were made from Obsidian Cliffs obsidian were very similar (57% and 50%). This suggests that obsidian from Obsidian Cliffs was used by occupants of the Sprague site throughout the Middle and Late Archaic Periods and that no significant changes in obsidian procurement practices were evident over time.

Obsidian characterization studies also indicated that substantial settlements occupied for long periods of time will produce more complex obsidian procurement patterns than small, seasonal or single occupation sites. The Sprague site, occupied over a period of 6000 years, showed a greater diversity of characterized obsidian than the smaller Enterprise site, which was occupied briefly as a temporary camp within the last 2000 years. This diversity is attributed to a number of variables including duration of the site occupation, population density, site function, social complexity, and procurement strategies.

This study produced evidence of raw material preference with regard to tool categories. Differences between obsidian and CCS tools at both the Sprague site and the Enterprise site indicate an overwhelming preference for obsidian in projectile point manufacture (116 points of obsidian, 24 of CCS), while other tools, such as bifaces, scrapers, and awls are made more often of CCS (15 CCS, 8 obsidian).

This study indicates that obsidian for tool manufacture was obtained through both long-distance procurement and the exploitation of local sources. Evidence for long-distance procurement consists of three findings. First, debitage of obsidian from Newberry Volcano was recovered from the Enterprise site, and one broad-necked point falling within the trace element parameters of the Tuscan obsidian source in northern California was recovered from the Sprague site. Second, there was an observed discrepancy between the largeness of the artifacts tested to the Obsidian Cliffs source and the smallness of the naturally occurring nodules of Obsidian Cliffs material within the local McKenzie River gravels. It is, therefore, asserted that although Obsidian Cliffs obsidian was available locally in the McKenzie River, prehistoric people of the Sprague site were obtaining the material from its primary source near the North Sister in the Cascade Range. Third, whereas tool manufacture produces far more debitage than tools, the ratios of tools to debitage recovered from the Sprague site was equal. This suggests that many tools were carried to the site in completed, or nearly completed, form.

The evidence for the exploitation of local obsidian sources consists of the XRF findings that 55% of tested artifacts from the Pleasant Hill valley were characterized as Inman Creek material. The recovery of a large cobble of Inman Creek obsidian from the Hilltop site, a natural secondary deposit 4 km from the Sprague site, testifies to the availibility of this high-quality obsidian in the Pleasant Hill valley.

Further Research

The present study represents the first major archaeological investigation in the Pleasant Hill valley. Although it was established that the Pleasant Hill area was occupied from the Middle Archaic through the Late Archaic Periods, the valley as a whole remains largely uninvestigated. Settlement patterns, chronology, and obsidian procurement and exchange are all in need of further study. Continued investigations are recommended; specifically, sites with relatively undisturbed provenience need to be studied through systematic excavation, obsidain hydration, and radiocarbon dating.

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Appendix A:
Inventory of Artifacts* and Characterized
Obsidian from the Pleasant Hill Valley, Oregon

*Artifacts have been returned to the private landowners.

Characterized Obsidian Specimens from Sprague, Enterprise, and Hilltop Sites, Pleasant Hill

Site	Spec	Description	Point type	Length	Width	Thickness	Weight (g)	Wn	Wm	Wb
SP	1	debitage	-	33.0	20.2	9.0	6.40	-	-	-
SP	2	debitage	-	23.5	18.0	5.1	1.97	-	-	-
SP	3	point	HB2	33.0	20.3*	5.0	1.62	10.8	20.3*	15.0
SP	4	point	HB2	29.3*	20.0	4.0	2.13	10.0	20.0	-
SP	5	point	MB2	36.1	18.1	6.5	2.97	9.0	18.1	9.2
SP	6	point	MB2	34.0*	14.0	5.3	2.15	8.0	14.0	11.9
SP	7	point	NN2	21.0	19.7	2.0	0.90	4.4	19.7	4.4
SP	8	point	NN2	28.3	13.8	3.0	1.04	4.7	13.8	3.5
SP	9	point	NN2	23.0	14.0	3.2	0.63	4.2	14.0	3.3
SP	10	point	NN2	18.0	12.7*	3.0	0.40	5.5	12.7*	5.3
SP	11	point	NN2	19.0	11.0*	3.8	0.62	3.9	11.0*	3.5
SP	12	point	NN2	19.2	14.2*	3.0	0.58	4.4	14.2*	4.4
SP	13	point	SS1	14.1	10.0	2.0	0.29	0.0	10.0	10.0
SP	14	debitage	-	33.2	16.5	8.0	3.68	-	-	-
SP	15	debitage	-	18.0	14.6	3.5	0.66	-	-	-
SP	16	debitage	-	21.8	11.6	6.0	1.45	-	-	-
SP	17	debitage	-	23.0	16.2	8.5	2.32	-	-	-
SP	18	debitage	-	29.0	16.7	5.0	2.14	-	-	-
SP	19	debitage	-	20.1	15.6	3.2	1.09	-	-	-
SP	20	debitage	-	18.2	14.0	4.0	1.20	-	-	-
SP	21	debitage	-	23.0	19.8	9.8	3.97	-	-	-
SP	22	scraper	-	38.2	27.0	7.4	5.96	-	-	-
Sp	23	debitage	-	23.5	21.4	14.0	6.84	-	-	-
Ent	1	debitage	-	37.4	18	9.9	3.79	-	-	-
Ent	2	point	MB2	21.0*	17.4	5.0	1.81	8.3	17.4	10.0
Ent	3	point	NN2	17.0*	11.0*	4.2	0.71	5.0	11.0	5.8
Ent	4	debitage	-	36.6	23.5	11.0	8.06	-	-	-
Ent	5	debitage	-	16.0	11.1	3.8	0.60	-	-	-
Ent	6	debitage	-	16.0	10.2	2.0	0.52	-	-	-
Ent	7	point	NN2	21.0	13.5*	2.0	0.65	4.0	13.5*	3.0
Ent	8	point	NN2	19.8	12.2*	3.6	0.55	4.0	12.2*	3.0
Ent	9	point	tip	11.0*	13.6*	3.0	0.39	-	13.6*	-
Ent	10	point	NN2	9.0*	9.1	2.0	0.20	2.0	9.1	1.9
Ent	11	debitage	-	19.9	12.0	7.0	1.99	-	-	-
Ent	12	debitage	-	15.6	8.1	2.3	1.33	-	-	-
Ent	13	debitage	-	17.8	15.0	4.0	0.93	-	-	-
Ent	14	debitage	-	11.0	11.0	5.0	0.49	-	-	-
Ent	15	debitage	-	15.2	11.6	2.4	0.48	-	-	-
Ent	16	debitage	-	27.8	19.0	12.5	4.45	-	-	-
H	1	non-cult	-	16.2	12.0	2.0		-	-	-
H	2	non-cult	-	22cm	19cm	15cm	7.3 kg	-	-	-
H	3	non-cult	-	24.0	17.1	17.9		-	-	-
H	4	non-cult	-	14.3	12.3	5.2		-	-	-
H	5	non-cult	-	15.8	14.8	3.0		-	-	-
H	6	non-cult	-	12.4	12.0	7.0		-	-	-

Flaked Stone Artifact Measurements From the Sprague Site (mm) [* = incomplete]

Site	Spec	Description	Mat.	Type	Length	Width	Thickness	Wn	Wm	Wb
SP	24	point	CCS	HS3	40.5	12.7	6.0	0.0	12.7	5.0
SP	25	point	OBS	SS2	25.0	15.0	5.0	0.0	15.0	5.6
SP	26	point	OBS	SS2	27.7	17.9	4.9	0.0	17.9	15.1
SP	27	point	OBS	HS2	18.6*	12.8	8.0	0.0	12.8	9.3
SP	28	point	OBS	SS1	12.2	9.0	1.8	0.0	9.0	9.0
SP	29	point	OBS	tip	21.1*	-	1.4*	-		
SP	30	point	OBS	MB3	24.2	4.4	4.6	7.4	4.4	3.5
SP	31	point	CCS	MB3	33.0	15.5	5.3	8.0	15.5	6.0
SP	32	point	CCS	MB2	21.0	14.9*	2.3	7.9	14.9*	14.9*
SP	33	point	CCS	HB3	26.6	20.8	5.3	10.0	20.8	8.0
SP	34	point	CCS	HB3	31.9*	21.0	5.9	11.4	21.0	12.7
SP	35	point	CCS	NN2	19.0*	7.8	2.9	4.7	7.8	5.0
SP	36	point	OBS	NN2	16.0*	14.2	3.5	4.7	14.2	-
SP	37	point	CCS	NN2	15.9	12.3	2.9	3.5	12.3	4.5
SP	38	point	OBS	NN	16.0*	13.6*	2.4	3.5	13.6*	-
SP	39	point	OBS	NN2	15.0*	11.1	3.3	4.6	11.1	5.3
SP	40	point	OBS	NN2	13.3	10.6	3.0	2.7	10.6	2.6
SP	41	point	OBS	NN3	14.4*	16.1	2.7	4.0	16.1	2.1
SP	42	point	CCS	-	25.5*	9.0	7.2	-	9.0	-
SP	43	point	CCS	tip	33.5*	23.8	7.5	-	23.8	-
SP	44	point	CCS	mid	19.0*	12.7	6.1	-	12.7	-
SP	45	point	OBS	frag	16.8*	15.0	3.6	-	15.0	-
SP	46	point	OBS	mid	19.9*	13	4	-	13.0	-
SP	47	point	OBS	tip	15.5*	12.7	2.5	-	12.7	-
SP	48	point	CCS	SS2	20.2	15.3	4.7	-	15.3	13.0
SP	49	point	OBS	SS3	20.0	8.3	2.2	-	8.3	3.0
SP	50	point	OBS	tip	10.8*	14.6*	3.5	-	14.6*	-
SP	51	point	OBS	MB2	32.4	11.8	5.2	9.0	11.8	10.0
SP	52	point	OBS	NN1	26.0	14.3	2.5	9.0	14.3	14.3
SP	53	point	CCS	MB3	25.6	12.4	4.3	7.5	12.4	6.0
SP	54	point	OBS	MB3	21.4*	11.8	3.5	7.9	11.8	5.8
SP	55	point	OBS	NN2	27.8	14.4	4.5	5.3	14.4	7.8
SP	56	point	OBS	NN2	17.7	13.0	4.0	6.0	13.0	7.4
SP	57	point	CCS	NN2	19.0	15.0*	2.6	5.5	15.0*	6.6
SP	58	point	OBS	NN2	18.8	18.1	2.4	4.6	18.1	-
SP	59	point	CCS	NN2	19.8*	14.0	2.8	4.6	14.0	4.0
SP	60	point	OBS	NN2	18.8	12.3*	3.9	4.7	12.3*	5.0
SP	61	point	OBS	NN2	17.3	16.5*	3.3	4.4	16.5*	-
SP	62	point	OBS	NN2	19.5	11.6	3.0	4.5	11.6	3.0
SP	63	point	OBS	NN2	17.0	13.8	3.9	3.8	13.8	3.5
SP	64	point	OBS	NN2	19.0	14.3*	2.7	4.6	14.3*	6.4
SP	65	point	OBS	NN2	16.0	12.5	2.7	3.0	12.5	3.0
SP	66	point	OBS	NN2	12.7*	9.9*	2.5	3.8	9.9*	4.0
SP	67	point	OBS	NN2	14.9	9.6*	2.5	3.5	9.6*	2.9
SP	68	point	OBS	NN2	12.4*	8.5	2.0	2.7	8.5	2.0
SP	69	biface	OBS	-	29.9*	29.7*	10.0	-	-	-
SP	70	biface	CCS	-	37.6	20.1	5.0	-	-	-
SP	71	biface	CCS	-	27.9	20.2	6.0	-	-	-
SP	72	biface	CCS	-	24.4	22.0	7.8	-	-	-

Flaked Stone Artifact Measurements From the Sprague Site (mm) [* = incomplete]

SP	73	biface	CCS	-	23.5	25.0	12.0	-	-	-
SP	74	biface	CCs	-	27.0	21.4	6.0	-	-	-
SP	75	biface	OBS	-	40.5	26.5	7.7	-	-	-
SP	76	ut. flake	OBS	-	30.0	28.0	4.9	-	-	-
SP	77	ut. flake	OBS	-	18.1	6.6	1.8	-	-	-
SP	78	ut. flake	OBS	-	23.0	17.4	1.9	-	-	-
SP	79	ut. flake	OBS	-	18.8	12.0	5.4	-	-	-
SP	80	scraper	CCS	-	49.4	40.5	18.9	-	-	-
SP	81	scraper	CCS	-	40.3	45.9	12.0	-	-	-
SP	82	awl	CCS	-	68.7	15.5	10.5	-	-	-
SP	83	point	CCS	SS2	36.0	23.1	4.0	0.0	23.1	10.0
SP	84	point	OBS	SS3	30.0	13.8	5.5	0.0	13.8	5.0
SP	85	point	OBS	SS1	22.0	15.0	5.0	0.0	15.0	15.0
SP	86	point	OBS	SS1	16.0	15.2	3.5	0.0	15.2	15.2
SP	87	point	OBS	SS1	17.9	10.3	2.5	0.0	10.3	10.3
SP	88	point	OBS	SS1	20.3	12.0*	2.9	0.0	12.0*	12.0*
SP	89	point	OBS	HB2	41.6	22.0	9.3	14.2	22.0	15.0
SP	90	point	OBS	HB3	37.9*	21.5	6.0	11.9	21.5	8.0
SP	91	point	OBS	HB2	29.7	24.7*	6.0	10.8	24.7*	12.3
SP	92	point	CCS	HB2	32.4	19.0*	7.6	10.4	19.0*	10.8*
SP	93	point	OBS	HB2	21.4	15.8*	4.9	10.0	15.8*	10.4
SP	94	point	OBS	SS1	22.1	15.4	5.0	0.0	15.4	15.1
SP	95	point	OBS	MB2	32.0	13.5	4.5	8.8	13.5	9.5
SP	96	point	OBS	MB2	34.0	13.0	5.8	8.6	13.0	10.1
SP	97	point	CCS	MB3	30.3	16.0*	4.5	8.0	16.0*	6.6
SP	98	point	OBS	MB	24.4*	15.0	5.3	8.8	15.0	-
SP	99	point	OBS	MB3	26.8	12.0	4.5	7.5	12.0	4.6
SP	100	point	OBS	MB3	25.2	12.9	3.5	7.4	12.9	4.0
SP	101	point	OBS	NN2	24.0	16.0*	4.0	4.0	16.0*	2.5*
SP	102	point	OBS	NN2	18.5*	18.7*	3.5	4.4	18.7*	4.4
SP	103	point	OBS	NN2	21.4	18.0	3.0	3.6	18.0	5.0
SP	104	point	OBS	NN2	12.2	14.0	2.9	3.7	14.0	4.0
SP	105	point	OBS	NN2	15.0*	15.3	3.4	3.0	15.3	-
SP	106	point	CCS	NN2	13.8*	15.4*	2.5	5.0	15.4*	6.0
SP	107	point	OBS	NN2	14.6	13.6	2.1	3.6	13.6	3.0
SP	108	point	CCS	NN2	15.5	12.0	2.4	4.4	12.0	2.9
SP	109	point	CCS	NN2	17.5	13.3	2.0	4.7	13.3	4.0
SP	110	point	OBS	NN2	12.0	10.6*	2.0	3.2	10.6*	4.1
SP	111	point	OBS	NN2	11.0	9.2	2.0	3.0	9.2	2.5
SP	112	point	OBS	NN2	11.1*	8.5	1.9	2.9	8.5	2.0
SP	113	scraper	CCS	-	44.7	24.9	8.0	-	-	-
SP	114	biface	CCS	-	52.6	33.0	14.0	-	-	-
SP	115	biface	OBS	-	34.0	22.8	8.0	-	-	-
SP	116	biface	CCS	-	27.5	27.0	13.0	-	-	-
SP	117	biface	OBS	-	15.5	15.0	4.5	-	-	-
SP	118	drill	CCS	-	42.8	14.9	6.5	-	-	-
SP	119	bif. knife	OBS	-	45.0	25.5	10.6	-	-	-
SP	120	point	OBS	HS3	54.0	15.1	7.0	0.0	15.1	3.0
SP	121	point	OBS	HS3	36.0	11.6	7.4	0.0	11.6	7.3
SP	122	point	OBS	SS1	22.1	11.6	5.0	0.0	11.6	11.6

Flaked Stone Artifact Measurements From the Sprague Site (mm) [* = incomplete]

SP	123	point	OBS	HS1	23.0	13.0	6.2	0.0	13.0	13.0
SP	124	point	OBS	SS1	23.3	10.5	3.0	0.0	10.5	10.5
SP	125	point	OBS	SS1	11.6	8.6	2.0	0.0	8.6	8.6
SP	126	point	OBS	HB2	37.0*	18.0	7.0	14.1	18.0	15.0
SP	127	point	OBS	HB1	33.0	14.4	5.0	11.4	14.4	13.6
SP	128	point	OBS	MB2	28.0	13.0	4.0	8.0	13.0	9.2
SP	129	point	OBS	MB2	27.1	14.0	4.8	8.5	14.0	7.5
SP	130	point	OBS	MB2	25.5	14.4	4.6	8.6	14.4	11.0
SP	131	point	CCS	MB2	27.3	15.7	4.8	8.6	15.7	10.2
SP	132	point	OBS	MB2	23.5	17.4	2.6	8.0	17.4	-
SP	133	point	CCS	MB2	25.5	8.6	4.0	7.7	8.6	10.4
SP	134	point	OBS	MB3	27.5	9.4	4.0	8.9	9.4	7.5
SP	135	point	OBS	MB1	23.8	13.0	3.6	8.6	13.0	12.0
SP	136	point	OBS	SS1	21.3	14.0	2.5	0.0	14.0	14.0
SP	137	point	OBS	NN2	18.4	14.0	3.0	6.6	14.0	10.0
SP	138	point	OBS	NN2	20.3*	14.7	3.0	5.0	14.7	4.5
SP	139	point	OBS	NN2	15.0	4.4	2.6	4.0	4.4	3.8
SP	140	point	CCS	NN2	22.5	17.2	2.0	4.6	17.2	4.5
SP	141	point	OBS	NN2	21.4	10.6	3.5	4.8	10.6	-
SP	142	point	OBS	NN2	22.7	14.6	3.5	4.9	14.6	5.0
SP	143	point	OBS	NN2	21.0	14.7	2.7	5.0	14.7	6.0
SP	144	point	OBS	NN2	16.6	12.0	2.4	3.0	12.0	3.4
SP	145	point	OBS	NN2	17.0	15.6	2.6	5.0	15.6	5.1
SP	146	point	OBS	NN2	19.4	15.0	3.0	4.0	15.0	3.8
SP	147	point	OBS	NN2	22.0	13.0	3.0	3.0	13.0	2.8
SP	148	point	OBS	NN2	21.6	13.0	3.0	3.6	13.0	2.7
SP	149	point	OBS	NN2	20.0	15.*	3.6	4.4	15.*	4.0
SP	150	point	OBS	NN2	19.6	9.4	3.4	4.0	9.4	4.6
SP	151	point	OBS	NN2	19.7*	11.0*	2.2	3.8	11.0*	-
SP	152	point	OBS	NN2	16.6	12.0	2.4	3.8	12.0	4.4
SP	153	point	OBS	NN2	20.5	16.0	3.8	4.0	16.0	4.4
SP	154	point	OBS	NN2	18.8	15.2	3.0	4.5	15.2	4.0
SP	155	point	OBS	NN2	17.7	14.8*	2.3	5.0	14.8*	6.0
SP	156	point	OBS	NN2	18.0	12.7*	2.0	4.9	12.7*	4.9
SP	157	point	OBS	NN2	14.0	12.0*	2.7	3.6	12.0*	4.6
SP	158	point	OBS	NN2	15.3	13.6*	2.7	4.8	13.6*	-
SP	159	point	OBS	NN2	12.7*	15.2*	3.9	4.6	15.2*	-
SP	160	point	OBS	NN2	19.2	10.2	2.7	4.0	10.2	4.7
SP	161	point	OBS	NN2	19.6	10.0	3.2	4.0	10.0	3.4
SP	162	point	OBS	NN2	15.8	13.5	2.4	4.0	13.5	-
SP	163	point	OBS	NN2	18.5	10.4*	2.6	5.3	10.4*	5.5
SP	164	point	OBS	NN2	12.7*	12.4*	2.4	4.7	12.4*	7.4
SP	165	point	OBS	NN2	15.3*	8.0*	1.6	4.4	8.0*	-
SP	166	point frag	OBS	mid	11.0*	11.0*	2.7	-	11.0*	-
SP	167	point frag	OBS	tip	11.0*	8.1*	1.6	-	8.1*	-
SP	168	drill	OBS	-	32.7	11.6	3.8	-	-	-
SP	169	drill	OBS	-	24.4	23.0	8.0	-	-	-
SP	170	drill	OBS	-	22.0	17.1	8.1	-	-	-

Appendix B:
Report of XRF Analysis of Artifact Obsidian
from the Pleasant Hill Valley, Oregon
Prepared by Biosystems Analysis, Inc.

REPORT OF X-RAY FLUORESCENCE ANALYSIS OF ARTIFACT OBSIDIAN FROM PLEASANT HILL, OREGON

Thomas L. Jackson, Jennifer M. Farquhar,
Charles H. Miksicek, and M. Kathleen Davis

October 4, 1994

Forty pieces of artifact obsidian from three localities around Pleasant Hill, Oregon were submitted for determination of the geological source of the raw material using energy dispersive X-ray fluorescence trace-element analysis.

X-RAY FLUORESCENCE METHODS

Analyses were completed using a Spectrace 5000 energy dispersive X-ray fluorescence system. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area $30mm^2$. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHz Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV.

For analysis of the elements zinc (Zn), lead (Pb), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb), the Rh X-ray tube is operated at 30 kV, 0.30 mA (pulsed), with a 0.127 mm Pd filter. Analytical lines used are: Zn (K-alpha), Pb (L-alpha), Rb (K-alpha), Sr (K-alpha), Y (K-alpha), Zr (K-alpha) and Nb (K-alpha). Samples are scanned for 200 seconds live-time in an air path. Trace-element intensities for the above elements are calculated as ratios to the Compton scatter peak of rhodium, and converted to parts-per-million (ppm) by weight using linear regressions derived from the analysis of 20 USGS and GSJ rock standards. Reported errors represent counting and fitting error uncertainty, and do not reflect the true precision of the measurement.

For analysis of the elements iron (Fe), and manganese (Mn), the X-ray tube is operated at 15 kV, 0.22 mA with a 0.127 mm aluminum filter. Samples are scanned for 200 seconds live-time in an air path. Iron and manganese values are reported as a ratio of the iron K-alpha peak to the manganese K-alpha peak.

All samples are scanned as unmodified rock specimens (not powder). Element concentration values may vary according to mass and surface configuration of the sample.

BioSystems Analysis, Inc.
XRF LABORATORY CATALOGUE

PROJECT NAME: Pleasant Hill

ACCESSION DATA lab#	catalog#		TRACE-ELEMENT CONCENTRATION VALUES (ppm) Zn	Pb	Rb	Sr	Y	Zr	Nb	Ba	Fe/Mn ratio	SOURCE
1	HE-1		58.7	14.2	88.1	116.9	20.9	83.5	7.3			Unknown D
		+/-	5.0	2.5	2.3	7.4	1.4	5.5	1.2			
2	HW-1		62.2	17.9	86.0	153.7	17.6	111.1	7.9			Inman A
		+/-	5.5	2.7	2.5	7.5	1.6	5.6	1.6			
3	RN-1		66.8	14.4	88.0	165.4	21.7	116.3	12.3			Inman A
		+/-	5.0	2.4	2.4	7.4	1.5	5.6	1.3			
4	SP-1		46.2	10.9	90.2	121.5	16.5	107.5	11.7			Obsidian Cliffs
		+/-	4.7	2.3	2.4	7.4	1.5	5.5	1.3			
5	SP-2		37.6	13.4	74.8	120.9	17.1	108.3	8.4			Obsidian Cliffs
		+/-	4.8	2.3	2.3	7.4	1.4	5.5	1.3			
			38.0	24.9	146.9	102.4	22.7	218.4	8.6			RGM-1 Reference Standard
		+/-	4.5	2.1	2.4	7.3	1.4	5.5	1.1			

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Inman
Secondary outcrop
originating
Salt creek Falls

Inman A →
Inman

Cont'd.

ACCESSION DATA lab#	catalog#		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ba	Fe/Mn ratio	SOURCE
			TRACE-ELEMENT CONCENTRATION VALUES (ppm)									
26	9		43.0	7.8	82.2	109.5	16.6	103.3	12.5		36.0	Obsidian Cliffs
		+/-	5.6	3.2	2.8	6.1	1.7	4.8	1.8			
27	10		42.9	12.5	79.0	103.1	16.6	98.9	10.0		35.1	Obsidian Cliffs
		+/-	6.2	3.2	2.9	6.2	1.8	4.9	2.0			
28	11		54.3	16.1	93.5	120.8	18.8	86.2	9.6			Inman B
		+/-	5.8	2.7	2.8	6.1	1.7	4.7	1.8			
29	12		51.8	15.4	82.7	106.4	16.6	101.9	11.3		39.5	Obsidian Cliffs
		+/-	5.6	2.8	2.8	6.1	1.7	4.8	1.8			
30	13		57.1	15.7	84.1	105.9	19.0	80.7	8.1			Inman B
		+/-	6.4	3.1	3.1	6.3	2.0	5.0	2.3			
31	14		63.9	18.7	86.8	161.5	21.2	116.5	9.5			Inman A?
		+/-	5.4	2.6	2.7	6.2	1.6	4.7	1.8			
32	15		56.3	15.1	85.1	141.6	18.5	108.8	6.2			Inman A
		+/-	6.1	2.9	2.8	6.2	1.7	4.8	1.9			
33	16		51.6	15.5	87.0	109.4	19.9	82.4	10.2			Inman B
		+/-	6.0	3.0	2.8	6.1	1.7	4.8	1.8			
34	17		52.4	12.9	94.8	115.3	20.9	88.7	6.6			Inman B
		+/-	5.1	2.5	2.7	6.1	1.5	4.7	1.7			
35	18		51.2	15.0	76.8	137.3	19.9	103.3	10.1			Inman A
		+/-	5.2	2.6	2.7	6.1	1.5	4.7	1.7			
36	19		58.4	14.6	83.7	156.6	20.3	112.3	11.9			Inman A
		+/-	5.3	2.6	2.7	6.1	1.6	4.7	1.6			
37	20		33.3	13.3	80.3	101.8	17.2	98.5	9.8		36.8	Obsidian Cliffs
		+/-	5.1	2.5	2.6	6.1	1.5	4.6	1.6			
38	21		57.1	15.6	83.5	148.1	18.3	108.6	7.7			Inman A
		+/-	5.7	2.8	2.7	6.1	1.6	4.7	1.8			
39	22		34.9	9.3	78.5	115.4	18.9	108.7	7.8		38.6	Obsidian Cliffs
		+/-	5.0	2.5	2.6	6.0	1.5	4.6	1.6			
40	23		57.5	13.7	77.1	142.7	20.5	107.0	11.8			Inman A
		+/-	5.1	2.5	2.7	6.1	1.5	4.7	1.6			

Cont'd.

ACCESSION DATA lab#	catalog#		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ba	Fe/Mn ratio	SOURCE
RN												
10	2-2		60.0	12.9	82.3	156.0	19.2	108.8	9.2		31.7	Inman A
		+/-	6.0	3.2	2.8	6.2	1.7	4.8	1.9			
11	2-3		52.5	15.6	89.8	115.2	20.1	84.4	7.8			Inman B
		+/-	5.8	2.8	2.8	6.1	1.7	4.7	1.8			
12	2-4		57.7	9.6	75.5	137.9	22.7	107.4	4.0			Inman A
		+/-	8.5	4.7	3.3	6.5	2.2	5.2	3.0			
13	2-5		45.9	12.7	64.5	86.1	16.4	62.5	3.6		28.1	Inman B*
		+/-	8.2	4.2	3.2	6.3	2.1	5.1	3.1			
14	2-6		47.3	11.1	88.6	109.7	20.2	80.7	6.7			Inman B
		+/-	5.8	3.0	2.7	6.1	1.6	4.7	1.8			
15	2-7		51.7	14.6	120.3	49.7	34.8	224.0	8.0		54.2	Newberry Volcano
		+/-	8.9	5.1	3.5	6.2	2.3	5.3	2.6			
16	2-8		58.8	11.6	81.9	149.4	19.7	112.1	9.9			Inman A
		+/-	5.6	2.9	2.7	6.1	1.6	4.7	1.7			
17	2-9		62.3	14.0	83.9	148.1	21.4	111.6	11.2			Inman A
		+/-	6.4	3.1	2.9	6.3	1.8	4.9	2.0			
18	2-10		73.6	19.4	94.6	164.0	21.4	115.7	6.8			Inman A?
		+/-	6.1	2.9	2.9	6.3	1.8	4.8	2.0			
19	2-11		48.7	16.3	81.5	150.3	18.5	112.9	9.6			Inman A
		+/-	5.4	2.6	2.7	6.1	1.6	4.7	1.7			
SP												
20	3		46.4	16.1	85.5	93.4	16.1	82.8	8.3		13.3	Unknown
		+/-	5.5	2.7	2.8	6.1	1.7	4.7	1.8			
21	4		62.8	13.1	87.4	157.3	19.0	117.6	9.2			Inman A
		+/-	5.2	2.6	2.6	6.1	1.5	4.7	1.6			
22	5		43.0	11.7	85.3	112.9	18.0	103.4	8.3		37.9	Obsidian Cliffs
		+/-	5.3	2.6	2.7	6.1	1.6	4.7	1.7			
23	6		48.4	16.7	85.3	117.7	16.2	107.7	7.5		35.4	Obsidian Cliffs
		+/-	5.3	2.6	2.7	6.1	1.6	4.7	1.8			
24	7		62.0	13.2	83.6	150.4	19.8	108.3	8.8			Inman A
		+/-	5.2	2.6	2.6	6.1	1.5	4.7	1.6			
25	8		29.9	10.6	79.5	105.4	16.9	101.3	7.6		38.4	Obsidian Cliffs
		+/-	5.3	2.6	2.7	6.1	1.5	4.7	1.7			

TRACE-ELEMENT CONCENTRATION VALUES (ppm): Zn, Pb, Rb, Sr, Y, Zr, Nb, Ba

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BioSystems Analysis, Inc.

XRF LABORATORY CATALOGUE

PROJECT NAME:

ACCESSION DATA lab#	catalog#		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ba	Fe/Mn ratio	SOURCE
			TRACE-ELEMENT CONCENTRATION VALUES (ppm)									
	Standard		34.7	19.5	147.9	101.1	25.5	220.2	11.4		66.7	RGM-1 Reference Standard
		+/-	4.9	2.5	2.8	6.0	1.5	4.7	1.5			
	Standard		39.1	22.9	150.9	97.0	24.0	219.4	9.9			RGM-1 Reference Standard
		+/-	4.8	2.4	2.8	6.0	1.5	4.7	1.5			
	Standard		34.4	24.5	152.6	103.9	25.7	222.3	7.7			RGM-1 Reference Standard
		+/-	5.1	2.5	2.8	6.0	1.5	4.7	1.6			
HW												
1	2		57.0	9.2	84.9	112.1	21.0	81.4	9.3		31.8	Inman B
		+/-	5.3	2.7	2.7	6.1	1.5	4.7	1.6			
2	3		57.9	11.8	79.2	137.3	18.7	104.2	6.4			Inman A
		+/-	5.2	2.6	2.6	6.1	1.5	4.7	1.7			
3	4		47.1	14.0	88.8	104.5	19.6	81.1	10.0			Inman B
		+/-	5.4	2.6	2.7	6.1	1.6	4.7	1.7			
4	5		51.8	17.9	84.7	107.0	18.2	80.6	8.0		38.1	Inman B
		+/-	5.7	2.8	2.7	6.1	1.6	4.7	1.7			
RN												
5	1-2		59.4	12.4	77.7	146.0	19.3	106.5	8.6			Inman A
		+/-	5.3	2.7	2.6	6.1	1.5	4.7	1.6			
6	1-3		63.4	16.1	81.4	148.7	20.8	107.5	12.8			Inman A
		+/-	6.7	3.3	2.9	6.3	1.8	4.9	1.9			
7	1-4		58.1	18.6	81.4	148.5	20.9	111.4	9.5		29.2	Inman A
		+/-	5.4	2.6	2.7	6.1	1.6	4.7	1.7			
8	1-5		55.6	15.3	76.9	140.3	19.3	107.5	9.7			Inman A
		+/-	5.7	2.8	2.8	6.2	1.7	4.8	1.8			
9	2-1		50.3	12.7	87.6	113.3	16.2	76.6	8.3			Inman B
		+/-	5.9	3.0	2.8	6.1	1.7	4.8	1.8			

X-RAY FLUORESCENCE RESULTS

Analytical results are given in the following table. Of the analyzed specimens, 19 (47.5%) have minor and trace element concentrations consistent with the Inman B chemical group. Eleven (27.5%) are Inman A, eight (20%) come from Obsidian Cliffs, one (2.5%) comes from Newberry Volcano, and the remaining specimen (2.5%) represents an unknown obsidian source.

Samples smaller than approximately 7 mm in diameter and/or thinner than 1 mm are asterisked. Element concentration values for such specimens often deviate from concentration values obtained from larger or thicker specimens, but source assignments may be made with reasonable accuracy in cases where relative proportions of the elements remain constant. Element concentrations for such specimens are considered less reliable than those obtained from larger samples. Samples than deviate only slightly from expected values for various sources are indicated by a question mark.