AN ABSTRACT OF THE THESIS OF

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Title: Obsidian: Archaeological Implications for the Central Oregon Cascades

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Richard E. Ross

Archaeological sites located on the western flanks of the central Oregon Cascades are often characterized by the lack of temporally diagnostic artifacts and materials suitable for radiocarbon dating. Consequently, the temporal context of these sites remains largely unknown. Various researchers also have suggested that these open-air lithic sites have been adversely affected by various pedoturbative processes active in the densely forested environment, effectively negating the value of the depositional context of the sites.

The research reported herein represents an attempt to empirically test the stratigraphic integrity of selected lithic sites through application of obsidian hydration data, and complimentary X-Ray Flouresence (XRF) chemical characterization. Concurrently, the data are applied to the evaluation of the temporal context of the sites, especially in terms of identifying single vs. multiple components.

Results of these analyses have provided new information regarding obsidian source utilization in this area, the stratigraphic value of open lithic sites, and the potential for developing a temporal framework for sites in this area. Obsidian Cliffs has been identified as the dominant source of artifactual obsidian in these sites. Hydration data indicate that the stratigraphy of most of the study sites have been mixed as a result of natural processes occurring in the forest environment. Tentative interpretation of each site's occupational history is also offered. Success in application of obsidian hydration data as a tool for relative dating has been demonstrated, and the development of a local hydration data base has been initiated. Recommendations for the advancement of obsidian studies in this area are also proposed.

Obsidian: Archaeological Implications for the Central Oregon Cascades

by

Catherine Lindberg-Muir

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CHAPTER 1

INTRODUCTION

Research Objectives

Progress in archaeological research in the Western Cascades of Oregon has been hampered by a lack of temporal control. The rarity of reliable dating materials, combined with the obscurity of definable cultural strata, has further complicated this issue. However, given the abundance of obsidian in this region, obsidian hydration analysis is one dating tool which provides a way to assess the age and stratigraphic value of archaeological deposits, as well as to identify cultural components. The research described herein represents a test of the application of hydration analysis in this region of the Western Cascades, in order to better understand the stratigraphic integrity and constituent components of lithic dominated sites.

Two assumptions commonly expressed by archaeologists working in the Western Cascades are: 1) open lithic sites have been significantly affected by pedoturbative processes to the degree that their stratigraphic value is negligible; and 2) most of these sites are single-component manifestations of prehistoric behavior. These viewpoints are interrelated, in that at sites with limited data sets archaeologists attempt to identify cultural or temporal components through detailed lithic analysis. This process generally assumes reliable stratigraphic integrity as excavation levels are used as units of comparison. However, site components inferred through such analyses are of questionable validity if the site's stratigraphic integrity has not been empirically assessed. It will be demonstrated through this research project that obsidian hydration provides one means of evaluating the stratigraphic integrity of these sites, and, in the absence of reliable stratigraphy, a tool for isolating temporal units within an assemblage.

The primary objective of this research is to demonstrate the applicability of obsidian hydration analysis in the Cascades by addressing the archaeological problems discussed above. Secondarily, this study develops a framework whereby temporal control in archaeological and hydration research in this region may be substantially advanced. This does not represent the advancement of a new technology, since obsidian hydration analysis as a geochronological method was first proposed in 1960 by Friedman and Smith. It has been the subject of continued research and application in many areas throughout the world. Although obsidian is a common toolstone in many archaeological sites, the method has not been aggressively applied locally. Thus, the value of the method's relative dating potential in this region has yet to be fully realized. Through application of the obsidian hydration method for purposes of relative dating, substantial progress can be made toward absolute dating as well.

The Element of Temporal Control

> The archaeological study of "process" - processes of technological and sociocultural stability, change and evolution, processes of adaption to changing environmental conditions, and so on - is predicated on the accurate measurement of change through time. Similarly, attempts to deal with prehistoric social units and their interactions depend on temporal controls refined enough to establish the absolute contemporaneity... of the inferred social units.
>
> (Dean 1982:373)

Few archaeologists would contest the proposition that temporal control is among the fundamental elements of archaeological research. One of the primary objectives of archaeology has been to reconstruct cultural chronologies (Thomas 1979), while another is to study cultural processes. In the absence of temporal control, neither is possible. Any development which facilitates more precise dating of the archaeological record expands the potential for analyzing the processes of change in extinct cultures (Rowe 1959), as well as for constructing cultural chronologies.

The research presented herein examines and evaluates the applicability of the obsidian hydration geochronological method for analyzing open lithic sites in the central Cascades of western Oregon. Archaeological research in this area has been generated primarily through cultural resource management (CRM) activities on National Forest lands. Over the past decade, the lack of reliable temporal control has impeded progress toward even the most basic research goals. Given that obsidian is the most ubiquitous of archaeological material remains in this area, while other cultural remains and potentially datable substances are rare or absent, the hydration method appears to be a viable approach to define temporal sequences and contemporaneity of sites and their components.

This thesis addresses several fundamental issues which are requisite to the productive application of the obsidian hydration method. Foremost in importance is the comprehension of the physical processes of obsidian hydration and its application as a dating method. The role of hydration rim measurements is assessed as <u>independent dates</u>. As opposed to those which are inherently archaeological (and subjective) in origin (e.g., stratigraphic and stylistic analyses), independent dates are derived from the analysis of nonarchaeological processes (e.g., dendrochronology, radiometry, archaeomagnetic dating) made possible by contributions of the physical, chemical, and biological sciences (Michels 1973; Dean 1982).

The hydration of obsidian is a complex process, as yet not completely understood. This necessitates extreme care in application, especially in terms of identifying the controlling variables, which affect rim development.

Furthermore, a better understanding of the archaeological deposits in this area is essential to the advancement of temporal control. Specifically, questions of stratigraphic integrity and isolation of cultural components must be resolved, in that such components must be identified before they can be effectively dated and placed in chronological order (Fredrickson 1984).

Obsidian hydration rim measurements can provide the data necessary to address these questions (Michels 1969; Fredrickson 1984), based on the fact that artifacts of similar age (of manufacture or modification) will exhibit comparable hydration rim measurements given analogous thermal histories and uniform chemical composition. The geological principle of superposition is applied to archaeological deposits to indicate that under most conditions older cultural components will be overlain by more recent manifestations (Hester et al. 1975). Therefore, it is reasonable to assume that hydration rim measurements will increase with depth of provenience in the site deposit. Again, control for chemical composition is pertinent.

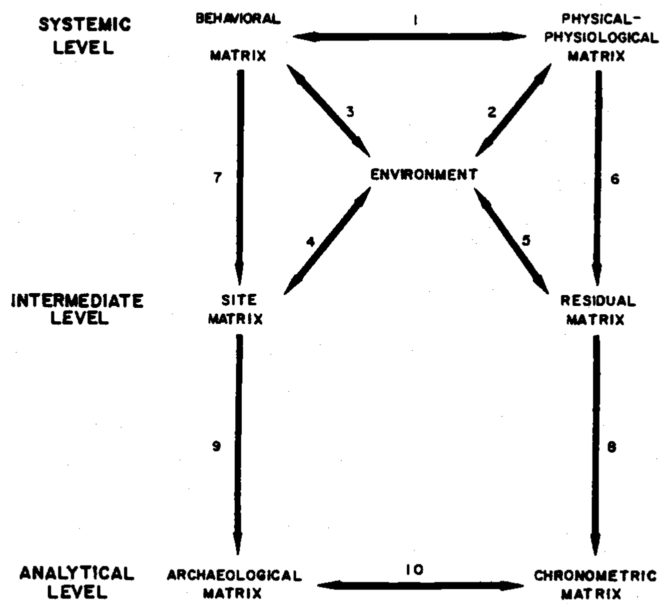
Theoretical Framework

The role of independent dates in archaeological analysis is to provide a temporal context for behavioral phenomena associated with the datable objects. It is important to distinguish between the target event, the event of archaeological interest, and the dated event, that which is actually dated. Correlations between the two events must be carefully drawn (Dean 1982).

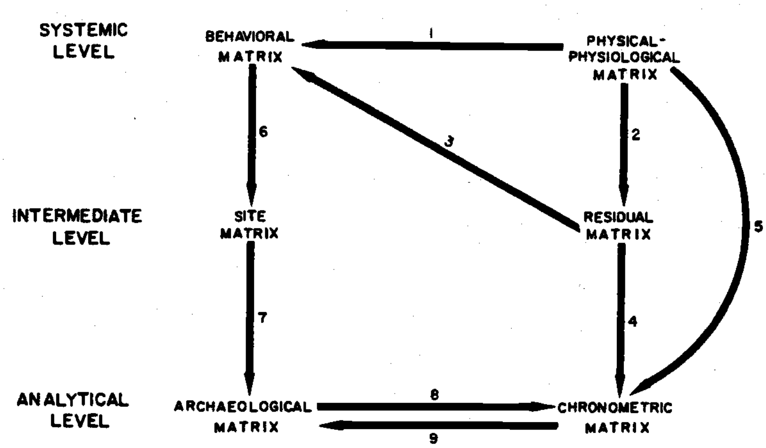
Four aspects of archaeological theory which are directly applicable to independent dating in archaeology must be taken into consideration in any dating endeavor (Dean 1982:387). The first concerns the transfer of behavioral information onto the material objects through manufacture, use, or other behavioral processes which alter the objects. In the case of obsidian artifacts, manufacture, retouch or modification, and breakage can effectuate the initiation of the hydration process on a freshly exposed surface. The second relates to changes which occur in the material elements as they pass from the behavioral association into the site matrix. For the obsidian tool, this occurs through discard or loss, or in the case of debitage, the actual manufacture or modification of tools. A third aspect of archaeological theory deals with the processes which affect the site matrix (stratigraphic integrity) and the materials contained therein prior to excavation (cf. Wood and Johnson 1982; Schiffer 1987). A fourth aspect, dependent on those outlined above, involves the analytical processes that translate archaeological data into behavioral information about the people who produced the site.

The obsidian hydration method represents the analytical process whereby behavioral process may be more fully explored at sites in the Oregon Cascades. Implementation of a model of archaeological dating, such as that proposed by Dean (Figure 1), facilitates the understanding of the complex systems of conditions, events, and interrelationships, including the effects of numerous variables in the dating systems which lead to more reliable applications of independent dating in archaeological research.

The selection of an appropriate chronometric technique ideally is directed toward obtaining the level of temporal control necessary to resolve a specific chronological problem. However, the intrinsic limitations of the particular site and/or dating methods, as well as geographic constraints, will be significant factors in the selection of the dating technique to be applied. In situations where dating options are severely limited, such as at many sites in the Western Cascades, the nature of the specific technique may in fact dictate the particular "target event" which the dating problem will



Conceptual and interactional relationships among the components of the general archaeological dating model.



Material and information flow among the components of the general archaeological dating model.

Figure 1. Provisional model of the archaeological dating process representing two aspects of a single system of relationships (Dean 1982:381-382).

address (Dean 1982:398). The selected chronometric technique, then, will direct collection procedures adapted to the sample and data requirements of the particular discipline.

The obsidian hydration method has been selected to explore the temporal context of open lithic sites in the central Cascades of Oregon. The dating potential of these sites by other, more traditional means, such as radiocarbon or projectile point typology, is extremely restricted. Hydration analysis of lithic debitage will in effect date the event(s) of flaking obsidian at these sites, providing behavioral information regarding when the site (or sites) was used. The interpretive value of open lithic sites will be enhanced through the application of the appropriate dating method to their component assemblages.

CHAPTER 2

ENVIRONMENTAL OVERVIEW

Physical Description

The archaeological sites included in this study are all located within the Sweet Home Ranger District of the Willamette National Forest in the central Western Cascades of Oregon (see Figures 2 and 3). The District (study area) encompasses an area of approximately 300 square miles (191,848 acres) and falls roughly within the following legally defined bounds:

North-South: Townships 10-15 South
East-West: Ranges 3-7 East
Willamette Meridian

The Ranger District is interspersed with private lands.

Topography

The study area is but a small part of the Cascade Range, a chain of mountains extending from British Columbia to northern California. The Cascades cover the entire length of the state of Oregon some 250 miles from north to south, varying in width from 30 to 70 miles. They create a formidable barrier between eastern and western Oregon with elevations averaging over 5,000 feet

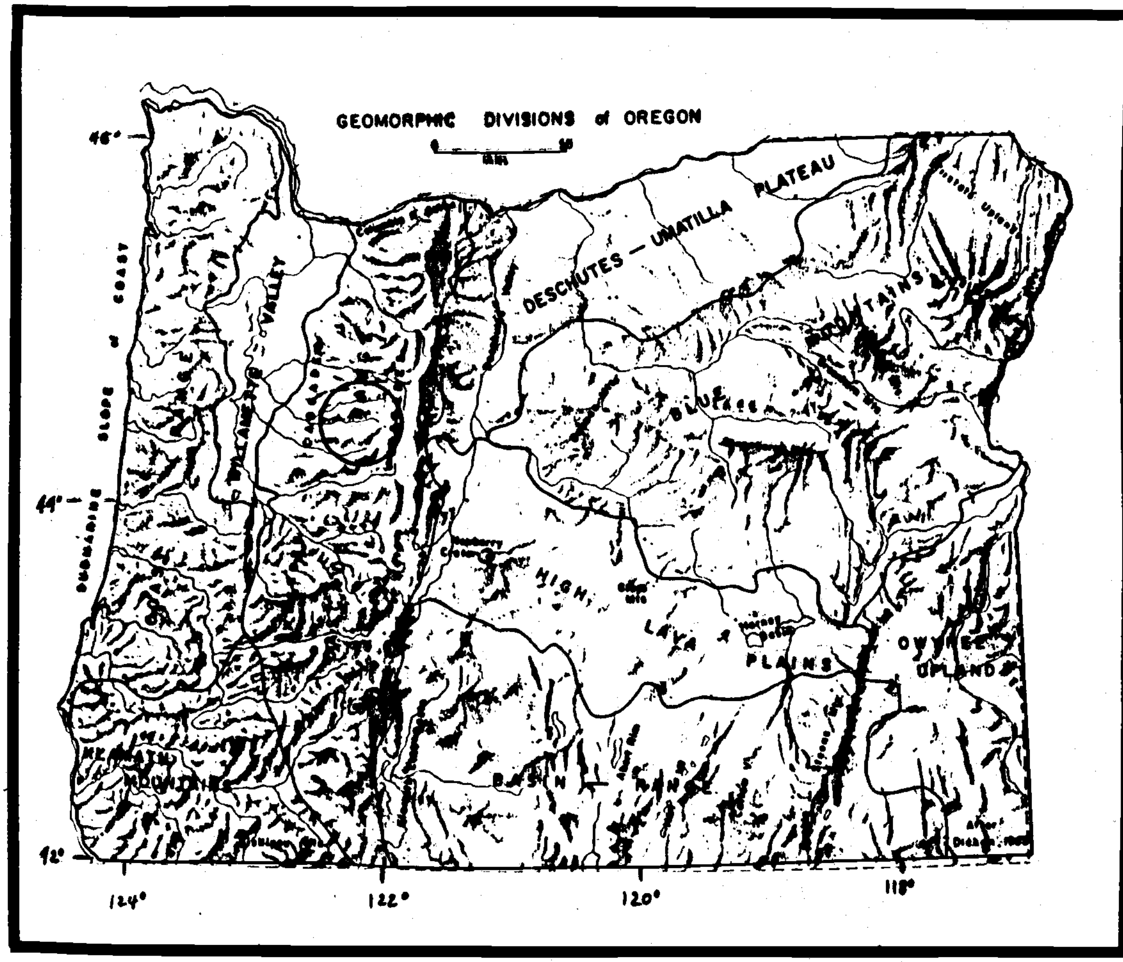


Figure 2. Physiographic setting of the study area which is enclosed with a circle. Map adapted from Leverenz (1963) and Baldwin (1981).

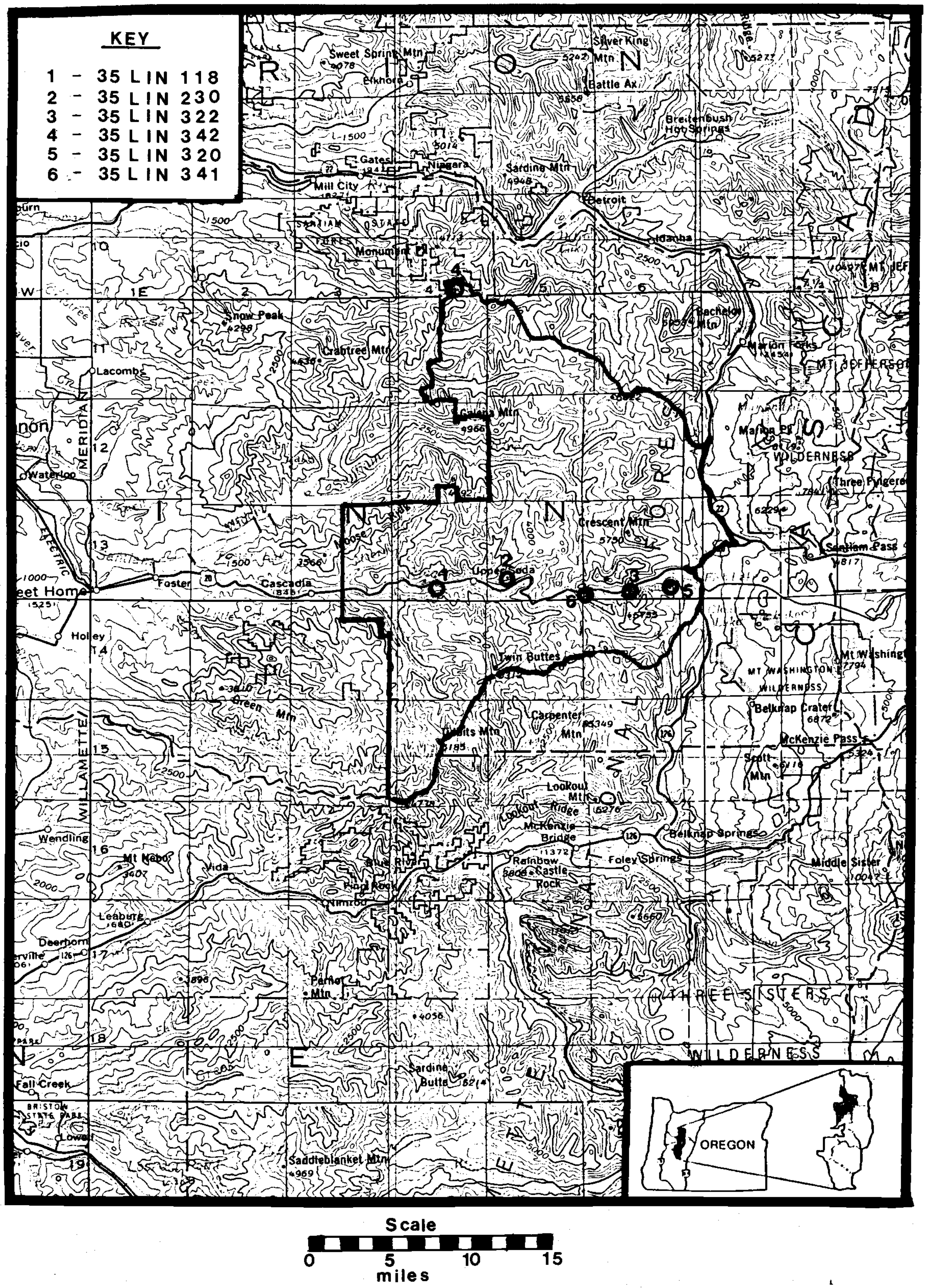


Figure 3. Study area defined on USGS topographic base map (reduced) with locations of six study sites (O).

along the crest and several spectacular peaks rising over 10,000 feet (Baldwin 1981).

The Cascade Range is divided into two topographically distinct physiographic provinces. The geologically older Western Cascades is characterized by an intricate pattern of rugged, discontinuous ridgelines and small, steep intermontane valleys. In contrast, the High Cascades area is a product of more recent volcanic activity which resulted in the formation of the major peaks and lava flows in the range, as well as the high plateau terrain scattered with numerous lakes and prairies.

The archaeological sites considered in this study are located in a variety of microenvironmental and topographic settings. Generally, they occur in ridgeline saddles, midslope benches, and river or streamside settings in the upper reaches of the Santiam and McKenzie River drainages. Specific elevations of the study sites range from 365 to 1295 meters (1200 to 4240 feet). They are discussed in greater detail in Chapter 5.

Hydrology

The study area is principally contained within the South and Middle Santiam River drainages, although the Hackleman Creek/Smith River drainage in the southeast portion of the study area flows into the McKenzie River to the south, and the headwaters of the Calapooia River are formed in the southwest portion of the District. All of these drainages eventually converge with the Willamette River flowing north to the Columbia River.

Numerous smaller tributaries and the major drainage systems have influenced the development of the highly dissected terrain of the Western Cascades. Many of the tributaries form in broad headwaters basins containing multiple cold springs. Cold springs also occur in more isolated settings, again initiating small streams which contribute to the overall drainage pattern. Precipitation, which falls mainly as rain with greater amounts of snow at higher elevations, is also a major factor of the hydrological features of the area.

In the High Cascades plateau, underground drainages are common due to the highly permeable nature of the lava beds, ash, and pumice soils. The Park Creek drainage, which flows south carrying a substantial volume of water from the easternmost portion of the study area, drains into Lava Lake (a semi-dry lake or swamp), then seemingly disappears. Evidently, the water becomes part of an underground drainage system and eventually flows out into the McKenzie River (Baldwin 1981:63).

Geology

Detailed geological information on the Cascade Range is available from a number of sources (cf. Peck et al. 1964; Beaulieu 1971; Baldwin 1981). Good summaries of aspects of the local geology are also found in Franklin and Dyrness (1973) and Legard and Meyer (1973), which primarily focus on the vegetation and soils of the area, respectively. The following geological description is derived primarily from these sources.

The Western Cascades form most of the western slope of the range, and are geologically older and more deeply dissected than the High Cascades. The Middle and South Santiam river valleys of the Western Cascades are carved largely in Oligocene and Miocene flows and tuffs of the Little Butte Volcanic Series and the Sardine Formation (Legard and Meyer 1973; Baldwin 1981). In the High Cascades province, Late Miocene, Pliocene, and Pleistocene flows and tuffs overlay volcanics equivalent to those of the Western Cascades (Baldwin 1981). The Cascan Formation makes up the crest of the Cascade Range, composed of porous and porphyritic andesite and basalt lava flows modified by glaciation. The rocks and surficial deposits of the Recent Volcanics constitute the youngest materials in this area and consist of post-glacial lava flows, ash, sand, cinders, and pumice deposits.

Glaciation has had a major modifying effect on the geomorphology of the High Cascades, as well as the upper reaches of the Western Cascades provinces. Mt. Jefferson, Mt. Washington, and the Three Sisters continue to be sculptured by glaciers. Many other lesser glacial features are still evident today. According to Legard and Meyer:

> after the initial outpourings of lava and formation of mountains such as Mt. Jefferson, Mt. Washington, and Three Sisters, the area was repeatedly glaciated. Following the retreat of glacial activity, a second period of volcanic activity ensued. Pumice from Mt. Mazama (Crater Lake), and deposits of ash, sands, and cinders from local cinder cones buried pre-existing soils developed in glacial materials. Recent lava outpourings occurred in the McKenzie Pass area.
>
> (1973:73)

Volcanic activity has great significance archaeologically, particularly with respect to the formation of obsidian and deposits of ash. Both can be useful dating tools. Strata of ash or tephra within an archaeological deposit can provide a reference date when correlated with a specific volcanic event. Thus, if the geological event can be accurately identified (e.g., the eruption of Mt. Mazama), that event can provide a reference date to which the cultural deposits can be compared. The value of obsidian as a dating tool is derived from the measurement of its hydration rim, which will be discussed in detail in Chapter 4, and is a basic element of this research.

Soils

Soils are largely a function of the geological history of an area, and are influenced by weathering processes and climate, especially moisture and temperature regimes (Mitchel 1979). Soils in this area typically develop at a slow rate, about 1 inch every thousand years in residual soils formed by rock weathering in place. Soils developing from glacial outwash and till, alluvium, loess, and colluvium tend to accumulate at a somewhat faster rate (Legard and Meyer 1973). Geological soil profile zones are generally defined as follows:

> "A" Horizon: Humus rich. Elluvial zone where leaching and other processes remove certain soil components by washing them through the profile.
>
> "B" Horizon: Illuvial zone where the materials removed from zone "A" become deposited.
>
> "C" Horizon: Chemically unaltered but weathered bedrock.
>
> (Schackley 1975:3)

The excavation of archaeological sites in the Western Cascades rarely yields well-defined stratigraphic units beyond the gross geological soil profile zones defined above. Cultural strata are notably lacking and several archaeologists have suggested that natural post-depositional disturbance, especially successive generations of tree growth (e.g., Lebow 1985), have effectively negated the stratigraphic integrity of these open sites in the forested environment. While there is little doubt that pedoturbation has affected the soil matrices in the forests of the Cascades, documentation of the degree of mixing relative to the archaeological deposits is needed for accurate interpretation of the cultural remains (e.g., Baxter 1986b). Descriptions of site-specific soils are provided in Chapter 5 with the discussion of the individual study sites.

Vegetation

The study area lies within the Douglas-Fir Region of the Pacific Northwest, one of the most densely forested areas of the world. Representing maximal development of the temperate coniferous forest, the region is characterized by its extensive areas dominated by Douglas-fir with inland climax forests of western hemlock and western redcedar, and coastal rainforests of coast redwood and Sitka spruce (Franklin 1979). The forests of this region are distinguished from other temperate forests of the world by the dominance of evergreen conifers over hardwoods, as well as "massive organic matter accumulations, and productivity and growth patterns" (Franklin 1979:93). Several large and long-lived coniferous species dominate the area, including true fir (Abies), hemlock (Tsuga), redcedar (Thuja), pine (Pinus), spruce (Picea), and Douglas-fir (Pseudotsuga).

The Douglas-fir Region is further subdivided into generally defined forest zones, reflecting biological variability resultant from diverse environmental conditions and patterns. Relevant to this study area are the Western Hemlock Zone (the most extensive in the Douglas-fir Region), and the Pacific Silver Fir Zone. These, in turn, can be broken down into numerous more specific vegetative communities (Franklin 1979; Hemstrom et al. 1985). These plant communities are useful indicators of more specific precipitation, temperature, and soil (nutrient) conditions (see Appendix A).

Within the broadly defined forest zones are many non-forested vegetation communities as well. Although they constitute only 5 percent of the total land area in the Oregon Cascades, they contain 85 percent of the floral species and are distributed throughout the elevational range of the west slope and in the High Cascades (Hickman, in Snyder 1987:49). These ecosystems are considered to be relatively stable and enduring in terms of thousands of years.

> Although many aboriginally important plant species are tolerant of a wide range of edaphic and climatic conditions and grow under forest canopies as well as in open spaces, most thrive in non-forested settings. Not only are more plants present here, but their fruit is more plentiful and of higher quality. This is particularly true of berries, a seasonally-available resource often mentioned in ethnographic accounts of aboriginal groups exploiting uplands....rich plant growth also attracted game animals.
>
> (Snyder 1987:52)

A diverse array of edible and potentially useful floral species were available to prehistoric groups utilizing the uplands. Although specific ethnographic information is limited for peoples utilizing this area, it is possible to tentatively identify valuable species through correlation of plant uses of neighboring people.

Fauna

The diversity and abundance of wildlife in the Cascades is basically a reflection of its lush and varied vegetation. The study area supports populations of Roosevelt elk, Columbia black-tailed deer, Oregon white-tailed deer, and mule deer. Rarer big game animals include black bear and cougar. The grizzly bear also once inhabited the area, but it is now extinct in Oregon. Smaller game species which are found here include bobcat, coyote, marten, hare, and squirrels. Breeding populations of grouse, quail, and pheasant are common, as are numerous passerine, raptorial, and waterfowl species. Lakes and rivers support trout (cutthroat and rainbow), whitefish and kokanee. Runs of salmon and steelhead also occur in the lower courses of several larger streams. The damming of major rivers in the Cascades may have disrupted anadromous populations which were probably more significant prehistorically. Current hatchery production, however, makes more salmon available in the Willamette River now, than in historic times.

<u>Climate</u>

Climatic conditions of the study area, past and present, have important implications in this type of research. As discussed in Chapter 4, environmental temperature is one of the key factors influencing the hydration rate of obsidian. Temperature varies primarily according to latitude and elevation, but is also affected by local and microenvironmental conditions (Figure 4). Generally speaking, however, the climate within a confined geographical area can be considered as a more or less homogeneous unit.

The contemporary climate of the central Oregon Cascades reflects a strong maritime influence due to its proximity to the Pacific Ocean, located roughly 100 miles away. The weather is temperate with mild wet winters and warm dry summers. Annual precipitation ranges from 60 to 100 inches within the study area (U.S. Weather Bureau 1974). Precipitation occurs primarily in the form of rain between November and March with snow at the higher elevations, although summer thunderstorms are common. The Coast Range reduces the impact of Pacific weather systems as they move onshore, resulting in significantly less precipitation in the Cascades (Legard and Meyer 1973).

Local temperature regimes are dictated largely by the Pacific weather patterns, as well as latitude and elevation. Seasonal variation is represented by January

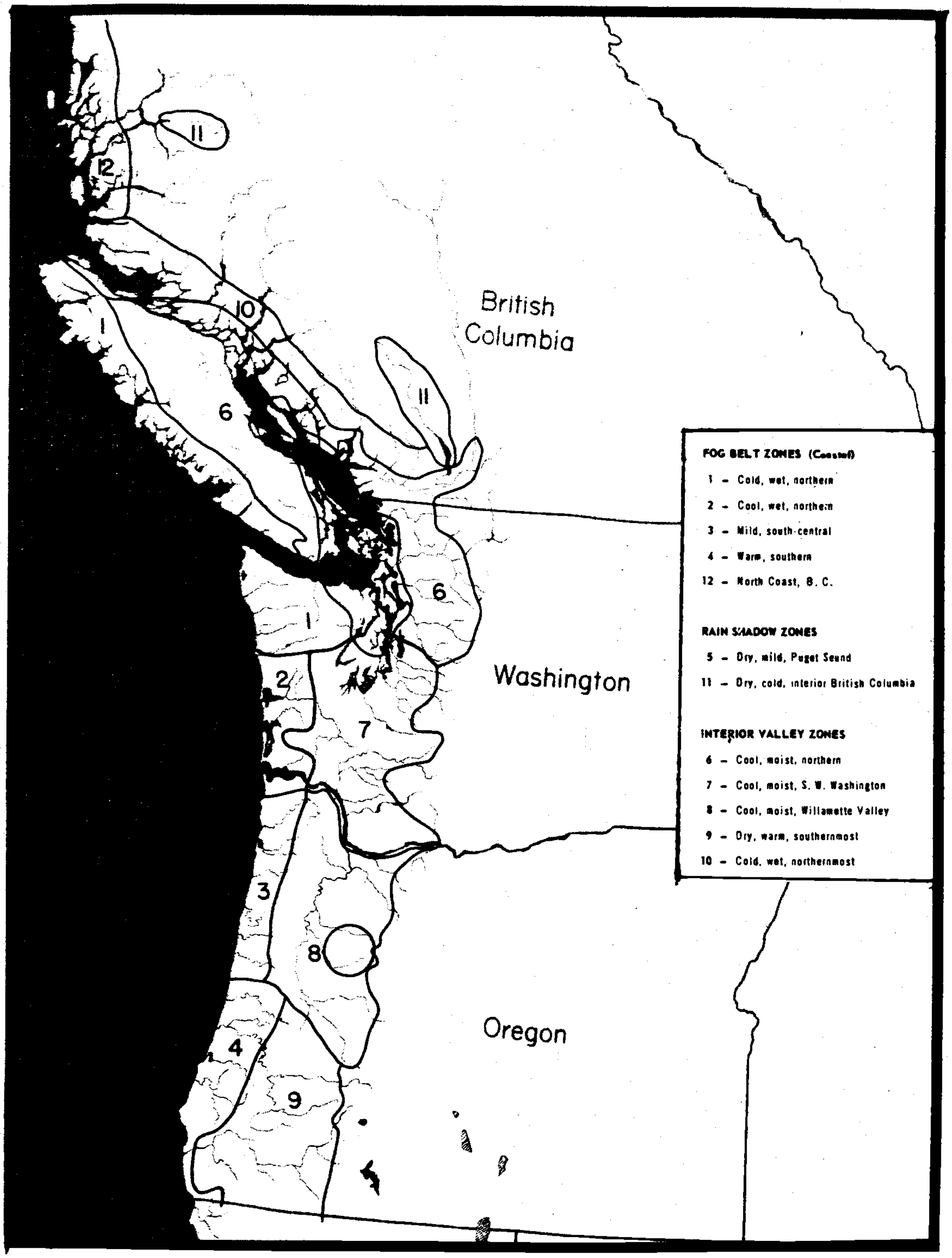


Figure 4. Generalized climatic zones of the Pacific Northwest region (from Franklin 1979:92). The study area is located in the east-central portion of Zone 8.

average temperatures of 0 to 3 degrees C (25 to 30 degrees Fahrenheit), relatively high humidity, local fogs, and regular cloud cover which tend to restrict the diurnal extremes to a range of 6 to 10 degrees Celsius (Franklin and Dyrness 1973). The warmest months of the year, July and August, exhibit monthly means of 16 to 20 degrees Celsius (60 to 70 degrees F), low humidity, and a higher range of diurnal variation (9 to 16 degrees Celsius). While precipitation is typically lower in the valley bottoms and increases with elevation, the reverse is true of temperature averages, as temperature decreases with rising elevation. Temperature lapse rates (TLR, the amount of decrease in temperature associated with increase in elevation) have been calculated for areas environmentally and climatically similar to the study area (cf. Bamberg and Major 1968; Emmingham and Lundberg 1977; Greene and Klopsch 1985). These studies indicate a greater TLR in the winter than in the summer for both soil and air temperatures, with soil TLRs generally less overall. This may be due to the insulation effect of the soil, which also exhibits less diurnal variation than does the air temperature.

Relevant climatic information is presented in Tables 1 and 2 which provide specific air and soil temperature data local weather stations. Figures 5 and 6 display the physical locations of pertinent stations relative to the study area. These data provide insight

Table 1. Temperature data from selected weather stations near the study area. Numbers in parenthesis refer to locations on map, Figure 5. All temperature figures are given in degrees Celsius. MAT is the mean annual air temperature. NET is the "natural effective temperature" (Lee 1969). EHT represents an estimate of "effective hydration temperature" (Friedman and Trembour 1983) employing air rather than ground temperatures.

Weather Station	Record Period	Reference*	Elevation (meters)	Range of Monthly Means	MAT	NET	EHT
(1) Albany	1931 - 55	3	65	15.5	11.7	14.5	13.2
(2) Belknap Springs	1981	1	655	17.4	9.5	12.7	11.5
(3) Cascadia	1931 - 52	2	245	16.0	10.8	13.7	12.5
(3) Cascadia	1981	1	245	14.1	10.8	13.4	12.1
(4) Detroit R.S.	1931 - 52	2	475	16.9	9.2	12.3	11.1
(5) Detroit Dam	1981	1	370	15.5	10.7	13.5	12.7
(6) Foster Dam	1981	1	170	14.2	11.7	14.3	13.0
(7) Lacomb	1981	1	160	14.9	11.2	13.9	12.7
(8) Marion Forks	1981	1	755	17.0	8.4	11.6	10.4
(9) McKenzie Bridge	1931 - 52	2	390	17.9	10.3	13.5	12.4
(10) Montgomery Rch.	1931 - 49	2	580	18.8	9.3	12.7	11.7
(11) Oakridge R.S.	1931 - 52	2	395	16.6	11.8	14.7	13.6
(11) Oakridge F.H.	1981	1	390	15.8	11.4	14.2	13.2
(12) Santian Pass	1981	1	1450	16.9	5.3	8.7	7.2
(13) Three Lynx	1981	1	340	19.7	9.9	13.4	12.4
(14) Warm Springs	1902 - 29	2	460	21.2	10.2	13.9	13.1
Northern Cascade Division	1931 - 55	3		16.6	8.7	11.8	10.6
Willamette Valley Division	1931 - 55	3		16.6	10.9	13.9	12.7

*1 = U.S. Weather Bureau (1981)
2 = Johnsgard, G.A. (1963)
3 = U.S. Weather Bureau (1974)

Table 2. Temperature data from selected reference stands at the H.J. Andrews Experimental Forest (Emmingham and Lundburg 1977). These sites occur in forested locations (except 86), on gentle slopes with southerly aspects, generally comparable to archaeological site settings. EHTs have been calculated with air and soil temperatures for comparative purposes. See Table 1 for abbreviation definitions.

Reference Stand	Record Period	Elevation (meters)	Range of (Air) Monthly Means	MAT	NET (air)	Range of (Soil) Monthly Means	MST	EHT (air)	EHT (soil)
1	1973 - 76	490	16.0	9.7	12.7	12.3	9.6	11.4	10.6
6	1973 - 75	610	17.4	9.2	12.4	13.4	8.3	11.0	9.5
86*	1975 - 76	610	15.6	10.3	13.2	14.3	10.6	12.5	11.9
10	1973 - 76	610	15.9	9.2	12.2	12.6	8.3	10.9	9.3
11	1973 - 76	1010	16.4	7.9	11.0	14.3	7.6	9.7	9.0
16	1973 - 76	640	17.2	9.4	12.6	15.5	8.5	11.3	10.6
18	1973 - 74	1100	17.1	7.6	10.9	11.4	7.0	9.6	8.0
19	1973	380	17.0	10.1	13.2	12.4	8.5	12.1	9.6

*Reference stand 86 is the same location as reference stand 6, but represents post-timber harvest conditions.

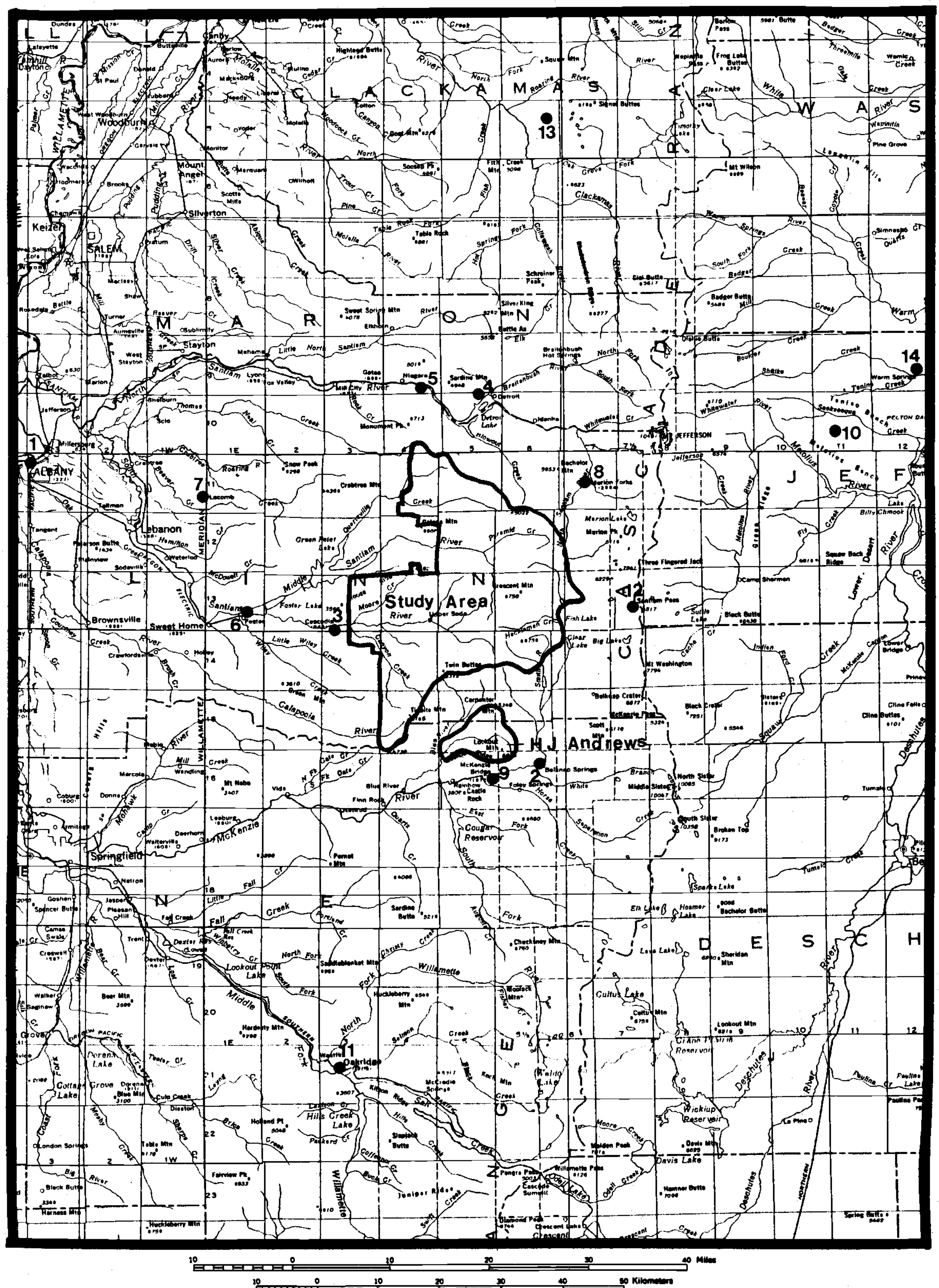


Figure 5. Locations of weather stations and H. J. Andrews Experimental Forest with respect to study area. (See Table 1 for key to numbered locations.)

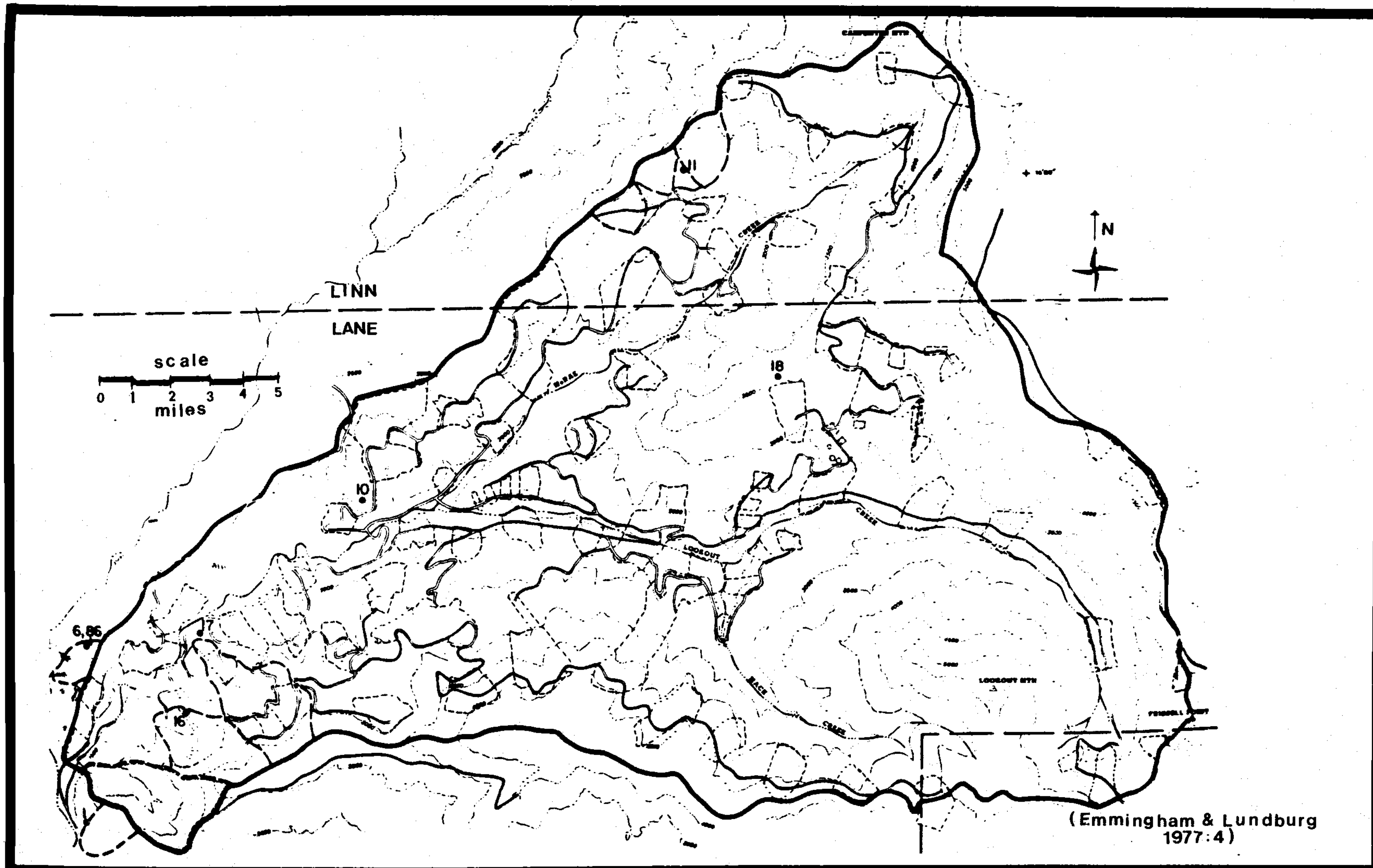


Figure 6. H.J. Andrews Experimental Forest reference stands from which temperature data was obtained.

into local variation in climatic conditions within a relatively small geographic area. In light of the fact that no site-specific temperature data are currently available, "effective hydration temperature" (EHT) and "natural effective temperature" (NET) have been calculated for various nearby weather stations and reference stands in the H.J. Andrews Experimental Forest. These are provided for comparative purposes as a basis for estimation of environmental temperature of the study area.

Palynological and geomorphic evidence have been employed to reconstruct Quaternary environments. It has been suggested that:

> accumulation-season precipitation during the Pleistocene may have been more than 30 percent higher than at present with mean temperature 4.2 ±1.0 degrees C lower in order to generate Cascade glacial systems.
>
> (Snyder 1987:45)

The Pleistocene was a time of active glaciers in the mountains, formation of volcanoes along the crest of the Cascades, and pluvial lakes in south-central Oregon (Baldwin 1981). Pollen evidence from the Western Cascades indicates subalpine type forests occurring in a cold valley bottom with more xeric forest communities on adjacent hillslopes (Gottesfeld et al. 1981).

The end of the Pleistocene about 10000 BP (years before present) was marked by warming temperatures and decreasing precipitation. Mountain glaciers receded.

Post-glacial (or Neothermal) climatic fluctuation of the Holocene are divided into three phases. Following Antevs' terminology, the Anathermal (9000-7000 BP) is characterized by generally cool and moist conditions; the Altithermal (7000-4500 BP) was significantly warmer and drier; and the final Medithermal phase marked the return of a cooler, moister regime with climatic conditions approaching those of modern times during the past 4500 years (Antevs 1955). These phases reflect broad climatic trends which are expected to have a more or less equal effect on more localized environments. That is, for the purposes of this study, specific sites are assumed to have experienced similar thermal histories within the range of variation indicated by elevational and topographic differences. Increases and decreases in environmental temperature probably occurred on the same scale for the various locales within the bounds of this geographic area.

The Human Factor

Human activities have undoubtedly been manipulating the environment in this area for hundreds, if not thousands of years (e.g., Towle 1979). In the Willamette Valley controlled aboriginal burning served to maintain the Valley and surrounding lower elevations of the mountain slopes as open prairie and savanna. Vegetative patterns distinctly different than those of today were documented by early explorers and land surveyors (e.g., Wilkes 1945, cited in Towle 1979). Winkler (1984:12 et seq.) provides a detailed discussion of aboriginal use of fire as a tool in Oregon and other North American regions. Such intentional burning was a means of encouraging the productivity of both plant and animal resources, as well as facilitating travel and the hunting of game in densely forested environments. The nature and extent of aboriginal burning practices in the central Cascades however remains speculative.

Lightening-caused fire has also affected the environment for thousands of years; though it may not always be possible to differentiate between natural and culturally-induced fires. Huberland (1987:19) suggests that in areas of Northern California controlled burns may have served to reduce "fuel loads, and hence fire hazards", an incentive that has been noted among southern Oregon Indian groups as well. Archaeological deposits often yield charred roots and other evidence of fire but with no direct cultural association they are generally assumed to be the result of "natural" occurrences.

Over the past century, substantial impacts have occurred to the environment, especially in response to growing human populations in the Northwest and elsewhere. Effects of the timber industry are perhaps the most evident. Logging of extensive timberlands has resulted in considerable changes in vegetative composition patterns.

Resultant erosion affects the local watersheds, as well as the capacity for the soil to regenerate. Similarly, road construction and the damming of rivers have further altered the environment. Archaeologically, these activities resulted in the disturbance and destruction of numerous sites, though logging has facilitated the discovery of many others as a result of cultural resource management activities on public lands. Studies are being conducted which strive to document the nature of the direct impacts of logging and other forest management practices on archaeological sites (e.g., Philipek 1985; Silvermoon n.d.). Other experiments represent attempts at stabilizing archaeological sites in this changing environment (Bennett-Rogers and Francis 1988; Farque' 1988b).

CHAPTER 3

LOCAL PREHISTORY

Cultural Setting

The study area is located on the west face of the central Cascades of Oregon. The Cascades form a substantial barrier between the western and eastern portions of the state, a fact which creates considerable implications for understanding the prehistory. The Cascade Range lies at the interface of several major cultural and natural areas of western North America (Aikens 1984), including the Great Basin, Plateau, Northwest Coast, and California culture areas (Figure 7). Additionally, the Willamette Valley (or Inland Valleys) subarea is of cultural significance in discussions of the prehistory of the central Western Cascades (Davis 1988). As a contact zone of several distinct culture areas, the archaeology of the Cascades becomes complex.

The concept of culture areas is basically a heuristic device of Euro-American design, based primarily on geographical and environmental features, and not necessarily recognized by the native inhabitants of these lands. Although the Indian cultures of Oregon had no distinct territorial borders, this is not to say that they had no concept of territories. Certainly, the tribes possessed lands that they considered to be tribal

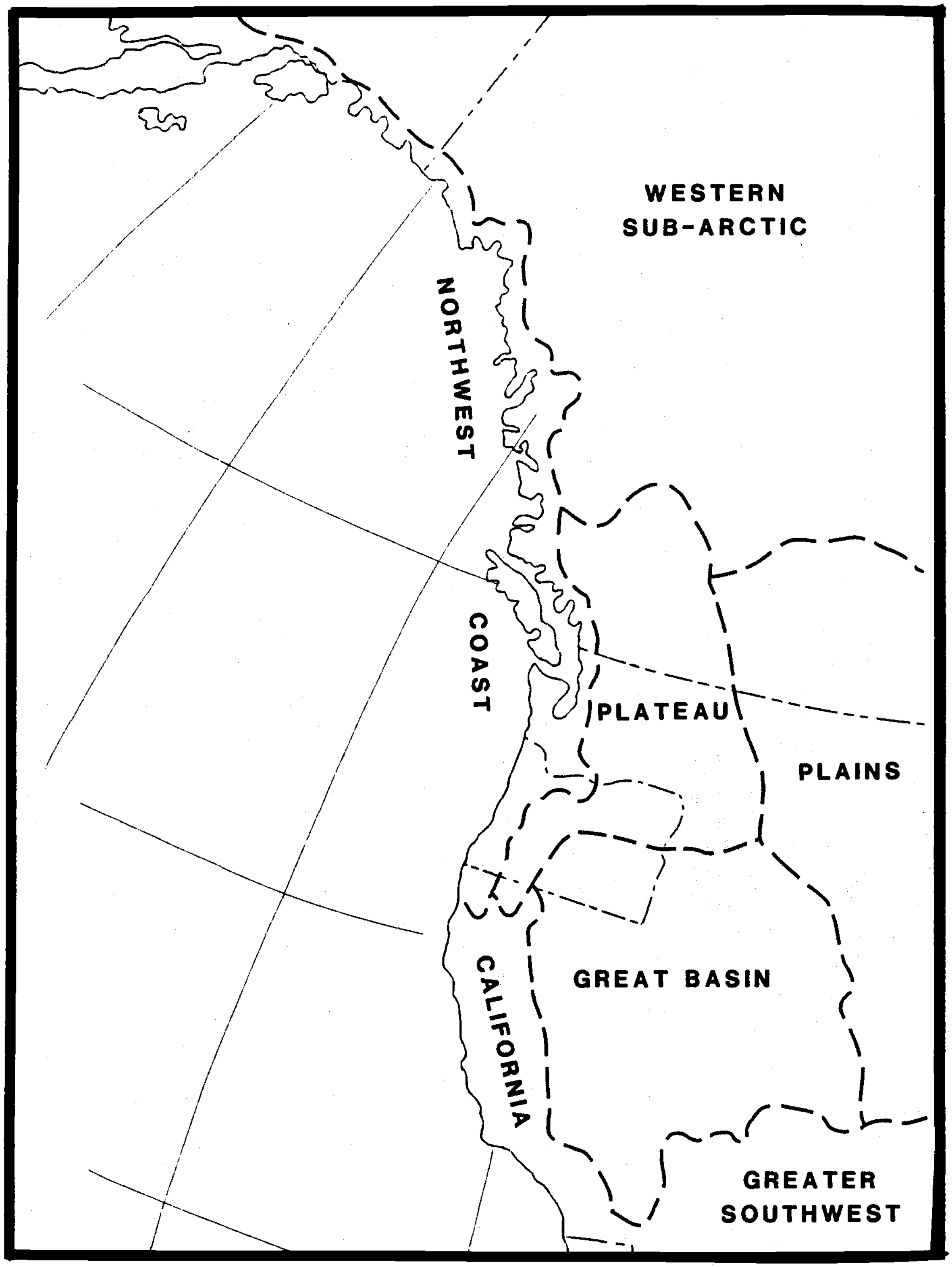


Figure 7. Major culture areas of Western North America, representing the Cascade range as a boundary between the Plateau and Northwest Coast areas (Aikens 1984:3). Others suggest subareas of the Inland Valleys area (cf. Beckham 1977:40; Zucker et al. 1983:2).

territories, in the sense that they maintained the rights for the use of certain areas for hunting, berry picking, fishing, villages, and so forth.

In that American Indian tribes were closely adapted to the environment, the concept of culture areas which coincide with the natural landscape is useful for describing the general aspects of native lifeways as we perceive them. Thus, the boundaries are not considered absolute; Indian people moved around and shared cultural traits and traditions across natural and artificial confines, as their individual or tribal customs dictated (Zucker et al. 1983).

Ethnographic Summary

Despite the fact that the Oregon Cascades represent a distinct environmental zone, it has not received the same level of archaeological attention as neighboring regions (cf. Beckham 1981; Zucker et al. 1983; Aikens 1984). The area has been generally treated as a boundary of other culture areas, or is often ignored. Toepel has termed the Western Cascades a "cultural no man's land" (Minor et al. 1987:7) due to the paucity of ethnographic information available on the Molalla, the aboriginal inhabitants of this portion of the Cascades at the time of historic contact.

Archaeologically, this area of the Oregon Cascades remains incompletely understood in terms of the ages, origins, and cultural affiliations of the prehistoric sites. At least four distinct explanations have been proposed for the archaeological sites found in the western Cascades of Oregon:

1. Archaeological sites in the western Cascades are seasonal high altitude manifestations of Columbia Plateau or Great Basin prehistoric cultures (e.g., Newman 1966; Henn 1975; Olsen 1975).

2. The archaeological sites are high altitude manifestations of prehistoric Willamette Valley cultures (e.g., Miller 197; Davis et al. 1973).

3. They reflect a combination of eastside and westside peoples seasonally inhabiting the eastern and western flanks, or interior mountain valleys (e.g., Minor et al. 1987).

4. Archaeological sites in the western Cascades are not indicative of any of the above, but rather reflect indigenous cultures (e.g., Molalla, Yonkalla) distinctive from either the Columbia Plateau, Great Basin, Willamette Valley, or southwestern Oregon

prehistoric groups (e.g., Cole 1968; Grayson 1975; Baxter 1986a).

Furthermore, it is equally possible that cultural affiliations have changed through time. In that serveral sites reflect great antiquity (e.g., Newman 1966; Olsen 1975), while others represent obvious proto-historic occupation (e.g., Olsen 1975; Baxter et al. 1983; Baxter and Connolly 1985), it is not unreasonable to speculate that various groups of peoples have inhabited the area at different times prehistorically.

As the area has become better known archaeologically, the question of cultural affiliations has remained unanswered. From a regional perspective, the long cultural chronologies of adjacent regions will remain incomplete until the upland components are better understood. It is essential then to consider such data with as broad a context as possible (cf. Tainter 1979; Glassow 1985).

Molalla

The lack of ethnographic documentation of Molallan lifeways is a reflection of isolation of their homeland. The Cascades were not easily accessed by early white explorers and settlers. The surrounding "flatlands" were more inviting to the newcomers interested in establishing residency and travel routes. In this light, it is not surprising that the natives of the Cascades had little contact with early Euro-American arrivals.

Most references consider the Molalla to be the primary occupants of the western Cascades of Oregon, as documented in historic times (Baxter 1986a; Snyder 1987; Minor et al. 1987). Their territory included the western slopes of the Cascades from the Clackamas to the Rogue River, but they ranged as far east as the Deschutes River drainage in their seasonal rounds. Maintaining relatively small populations, the Molalla were divided into smaller bands, the precise locations and names of which are unconfirmed, as indicated by Zucker's comments:

> Early authors such as Melville Jacobs (1845) separated the Molalla geographically, into northern and southern groups divided by an area occupied by Kalapuyan bands. More recent authors (Rigsby 1966, 1969; Benson; and others) depict the Molalla bands as continuously inhabiting the upper tributaries of the Cascades.
>
> (Zucker et al. 1983:10)

On the basis of linguistic evidence, researchers have proposed various theories regarding tribal origins.

> Murdock hypothesizes that the Molalla were driven westward, and eventually pushed over the Cascades, by the Tenino, while Garth suggests that the Molalla were driven westward and the Cayuse eastward by Paiutes. Other anthropologists such as Bruce J. Rigsby (who recently demonstrated that the two languages are not closely related) support the theory that the Molalla and Cayuse lived in the areas ...(where they were

> historically recorded)...for a long time previous to non-Indian contact.
>
> (Ibid:11)

Recently the question of the tenure of Molalla occupation of the Cascades has been addressed by Baxter (1986a:13), who suggests that "a glottochronological assessment of the Molalla dialect variation" with supporting archaeological evidence is necessary to resolve this issue. His study of four archaeological sites in the upper Willamette Basin indicates that a relatively recent "Molalla movement into the Cascades corresponds to the sudden and overwhelming appearance in AD 1400 of a distinct projectile point style" which is found in the Umpqua basin to the south, but is poorly represented to the north in the McKenzie and Santiam drainages (Baxter 1986a:187-188). Nonetheless, it remains difficult to assess the ethnicity of upland archaeological sites.

The subsistence of the Molalla focused on wild game, fish, roots, and berries, pursued through seasonal rounds which led them into the uplands during the warmer months. In the winter they resided along streams at lower elevations. Their winter homes are thought to have resembled the semi-subterranean earth lodges of Columbia Plateau peoples (Zucker et al. 1983:36). The basic social unit consisted of small family groups; the Molalla apparently lacked complex village or tribal organization. Leadership, derived from personal reputation and family status, was flexible among the Molalla (Rigsby n.d.). Kinship ties were bilateral; exogamy was the norm; and levirate (whereby a widow marries her deceased husband's brother) was practiced. Their dead were usually cremated.

The traditional lifeways of the Molalla, as well as other Oregon tribes, were basically ended with the arrival of the Euro-Americans during the middle of the 19th century. The Molalla, together with their Kalapuyan neighbors, ceded their lands through the Dayton Treaty of 1855 and were subsequently removed to the Grande Ronde Reservation. Apparently, a few members of the group ended up at the Klamath Reservation, and some at the Warm Springs.

Neighboring Indian Groups

The Kalapuya, Klamath, Northern Paiute, and Tenino are among the Indian groups who resided near the Cascades (Figure 8), and probably made some use of its vast resources. The Kalapuya were primarily occupants of the Willamette Valley located to the west of the central Cascades. The Tenino and Northern Paiute resided to the east of the range. The Klamath inhabited the southern portion of the Cascades and the lakes country to the east thereof. In contrast to the Molalla, these groups have more extensive ethnographic accounts describing their native traditions. Each of these groups spoke a distinct language belonging to either Penutian (Kalapuya, Molalla,

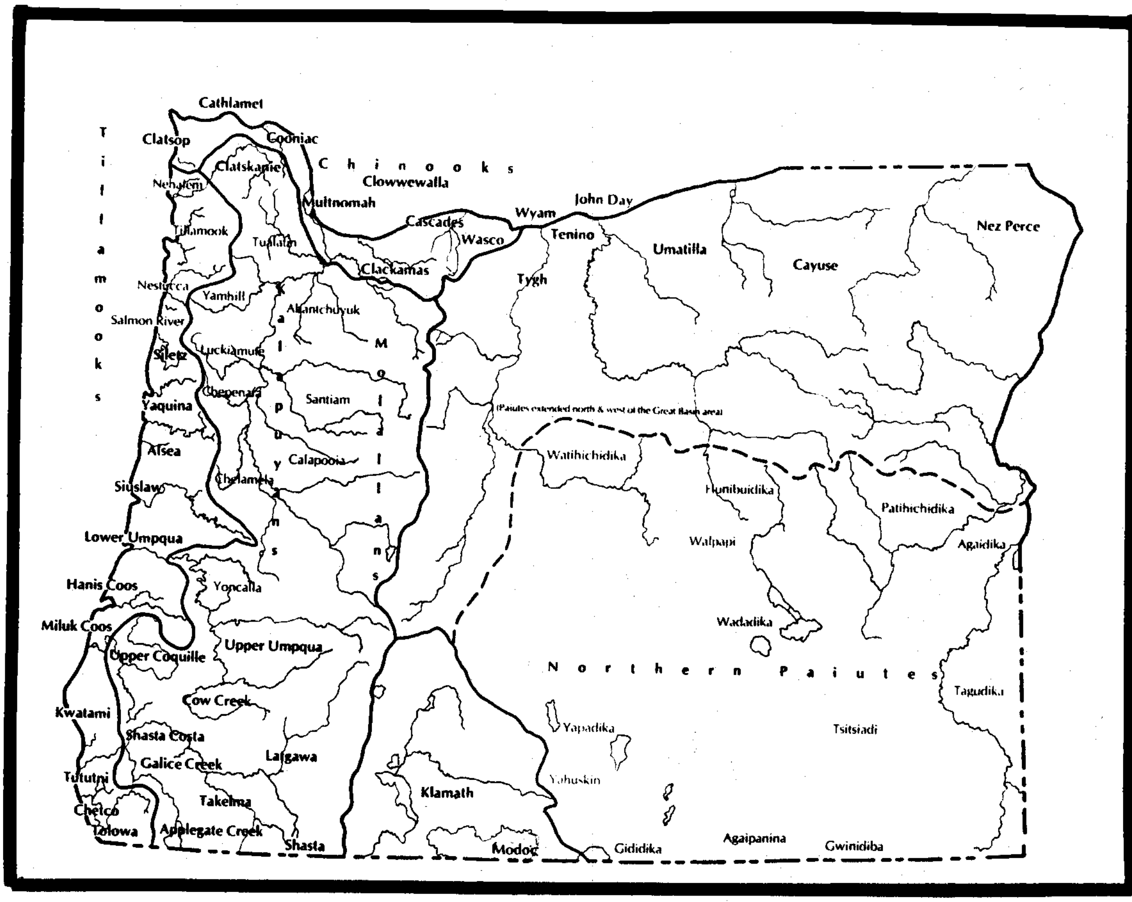


Figure 8. Tribes and bands of traditional Oregon, 1750-1850 (from Zucker et al. 1983: 9).

Tenino) or Uto-Aztecan (Northern Paiute) phyla. Each practiced some variation of the seasonal subsistence round, depending on the local resources.

Ethnographic evidence documents the use of the eastern slopes of the Cascades by Tenino and Northern Paiute. More recent historic accounts describe continued use of the Cascades by people from the Warm Springs Reservation, where many Tenino and Paiute reside. Spier (1930) and Gatschet (1890) comment on associations of Molalla with Kalapuya and Klamath people. The Klamath ranged into the Cascades to hunt, collect berries, and obtain obsidian (Spier 1930). It is generally assumed that the Kalapuya participated in similar forays into the mountains to obtain resources unavailable in their home territory (Minor et al. 1987).

Local Archaeological Research

The earliest documented archaeological investigations undertaken in this area of the Oregon Cascades were surveys conducted prior to the construction of many of the dams and reservoirs along the major rivers in the Western Cascades (e.g., Newman 1966; Cole 1968; Davis 1973). Generally, these occurred at the lower elevations in the broad river valleys of the mountain range, just the sort of places where Molalla winter camps might be expected based on ethnographic information.

Since that time, archaeological investigations have been more aggressively pursued, primarily on public lands under the auspices of Cultural Resource Management (CRM), although isolated investigations have been sponsored by local universities (cf. Aikens 1975). These efforts have resulted in the location of hundreds of archaeological sites, many of which have been the focus of evaluative testing and more extensive excavations (Minor et al. 1987). Among the prehistoric sites along the western flanks of the Cascades, those which have been studied fall into two main categories: the caves/rockshelters, and the open lithic-dominated sites. A few attempts have been made to summarize and compare the wealth of information contained within these diverse sites (e.g., Winkler 1984; Baxter 1986a, 1986b; Snyder 1987), each emphasizing different aspects of these archaeological manifestations. Figure 9 provides the locations of sites discussed in the following sections.

Rockshelter Sites

Among the sites in this area, the rockshelters provide the most complete record of prehistoric material culture available. Conditions are conducive to the preservation of organic remains, hence providing valuable evidence regarding diet, as well as good potential for obtaining reliable radiocarbon samples. Sites of this type, however, are rare in and around the study area, but

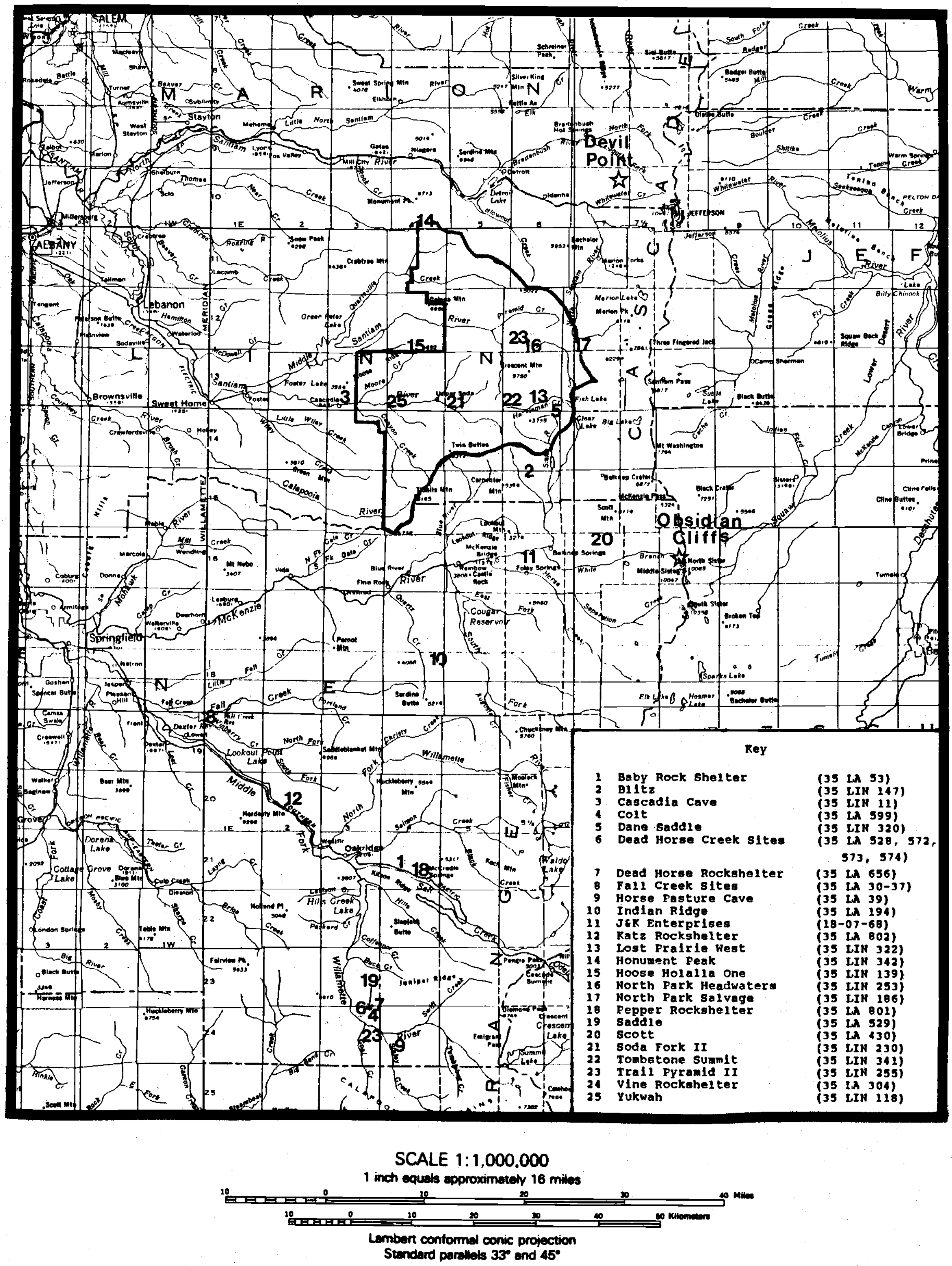


Figure 9. Locations of the archaeological sites discussed in the text.

more common in the upper Willamette River drainage to the south.

Cascadia Cave (35 LIN 11), located on the South Santiam River at an elevation of 275 meters (900 feet), was rediscovered in conjunction with an early reservoir survey (Newman 1966). It had previously been documented in Cressman's Petroglyphs of Oregon (1937), and was well-known to local individuals as "Indian Cave". This site, though seriously disturbed by looters, yielded an impressive assemblage of stone tools, faunal and floral remains, and a radiocarbon date of 7910 ±280 (WSU-228) from the lowest level of the deposit (Newman 1966:23). Archaeological evidence at Cascadia Cave suggests

> "a single generalized cultural pattern with apparent cultural relationships shifting from the [Columbia] Plateau to include part of the Great Basin in addition to the Plateau, over a span of several millenia"
>
> (ibid:31)

This site is probably the most important major site investigation undertaken in close proximity to the study area, in terms of the span of occupation and diversity of cultural remains.

Baby Rock Shelter (35 LA 53), located along the Middle Fork of the Willamette River at an elevation of 760 meters (2,500 feet), was also heavily disturbed by looters prior to its excavation (Olsen 1975). Nonetheless, a substantial collection of flaked and ground stone

Table 3. Excavated Rockshelters

Site Name/Number	Elevation	Major Drainage	Cultural Affiliations	Chronometric Data	Report Reference
Cascadia Cave/ 35 LIN 11	275m	South Santiam	Columbia Plateau Great Basin	7910+/- 280 BP C14: lowest level	Newman 1966
Baby Rock Shelter/ 35 LA 53	760m	Middle Fork Willamette	Willamette Valley Great Basin	6845 BP Mazama Ash near bottom	Olsen 1975
Horse Pasture Cave/ 35 LA 39	975m	Middle Fork Willamette	Indigenous	Four C14: 2450 +/- 60 BP (Stratum 4); 130 BP (Stratum 1)	Baxter et al. 1983
Vine Rockshelter/ 35 LA 304	760m	Middle Fork Willamette	Indigenous	530 +/- 70 BP 390 +/- 90 BP (C14)	Baxter and Connolly 1985
Dead Horse Rockshelter/ 35 LA 656	1000m	Middle Fork Willamette	Unknown	1560 +/- 70 BP	Swift 1986
Katz Rockshelter/ 35 LA 802	745m	Middle Fork Willamette	Unknown	Historic Artifacts	Winkler, personal communication 1987
Pepper Rockshelter/ 35 LA 801	560m	Middle Fork Willamette	Unknown	Volcanic Tephra	Clayessens, personal communication 1987

tools was recovered, from below and above a layer of pumice believed to have been deposited during the eruption of Mt. Mazama. Faunal remains reflect an emphasis on deer processing, although a sample of other local game animals was represented. Pictographs depicting horses and riders, and an Olivella shell bead were perhaps the most outstanding findings. Olsen suggests that the shelter had been occupied by Willamette Valley peoples who had contact or affiliations with eastside peoples, based on similarities he saw between projectile points style of Baby Rock and those associated with Great Basin cultures. An extensive span of occupation is indicated by the pre-Mazama cultural deposit and characterization of horses on the shelter walls.

In contrast, Horse Pasture Cave, Vine Rockshelter, and Dead Horse Rockshelter (35 LA 39, 35 LA 304, 35 LA 656), all located along the Middle Fork of the Willamette River, represent relatively recent occupations with an obvious post-contact components present at Horse Pasture and Dead Horse. Otherwise, the site assemblages reflect similar subsistence activities, including hunting and processing of vegetal resources, evidenced by faunal and floral remains, flaked and ground stone tools (Baxter et al. 1983; Baxter and Connolly 1985; Swift 1986b).

Two more rockshelters have undergone preliminary evaluative test excavations during the 1987 field season along the upper Willamette River drainage. Katz

Rockshelter, located in the Cloverpatch Bluffs 370 meters (1,200 feet) above the Middle Fork of the Willamette River is apparently a late Archaic/Historic period, single-component occupation. A shallow deposit (0 to 15 cm) yielded several very small obsidian projectile points, unifaces, possible bone tools, and a rolled copper bead, but relatively little debitage and no ground stone (Carol Winkler, personal communication, 1987).

The Pepper Rockshelter, located on nearby Salt Creek, not far from Baby Rockshelter, revealed a deposit rich in cultural materials to a depth of over 150 cm. A lens of pumice and ash separated two components, each containing stylistically and typologically distinct assemblages, largely of obsidian manufacture. Faunal remains were also present, predominantly ungulate (Paul Claeyssens, personal communication, 1987). No dates have yet been offered for this site, but analysis of the pumice and ash may indicate a very early occupation, if the ash is from the eruption of Mt. Mazama.

Open Air Lithic Sites

The open lithic sites investigated to date have provided comparatively limited archaeological data which is perhaps in part a reflection of less favorable conditions for preservation of organic remains. Lithic scatters are by far the most common type of archaeological manifestation found in the Oregon Cascades. These lithic sites are found throughout the uplands at most elevations. They vary in size, depth, and artifact density. These sites generally exhibit a limited range and number of formed flaked stone artifacts, and extensive lithic debitage. In the study area, obsidian is the prevalent lithic raw material, although cryptocrystalline silicates (CCS) and basalt are often present in smaller proportions. When combined, these attributes of the upland lithic sites appear to reflect short-term occupations by small prehistoric groups engaged in subsistence activities in the Western Cascades.

Numerous investigations of upland lithic sites have been conducted in this and adjacent areas of the Cascades, primarily under the auspices of CRM (e.g., Baxter 1983, 1986b; Lindberg-Muir 1983a, 1983b, 1984, 1987; Lebow 1985; Silvermoon 1985; Jenkins and Churchill 1987). The earliest investigations occurred in conjunction with the river basin surveys associated with reservoir development (e.g., Cole 1968; Davis 1973). One of the more successful river basin surveys identified nine lithic sites at elevations of 215-245 meters (700-800 feet) to the south of the study area along Fall Creek, a tributary to the Middle Fork of the Willamette River (Cole 1968). These sites were determined through test excavations to have primarily surface or shallow deposits. One exception was 35 LA 33, which exhibited some depth (60 cm) and provided an impressive array of stone artifacts made of locally available CCS and basalt, and a minor (2 percent) amount of obsidian. Cole surmised the existence of a long-standing indigenous cultural tradition, based on similarities he recognized between artifact types represented at Fall Creek, Cascadia Cave, and the Upper Umpqua area (1968:27).

A few sites in the Western Cascades were investigated in the early 1970s by the University of Oregon in conjunction with research designed to expand the understanding of Willamette Valley prehistory (cf. Aikens 1975). One such site, the Indian Ridge (35 LA 194) is located at an elevation of 1465 meters (4800 feet) near the headwaters of a tributary to the McKenzie River drainage. The artifact assemblage included biface and uniface tools, modified flakes, and a high percentage of obsidian debitage. A few cores and manos were also recovered. No evidence by which the site could be dated was obtained (Henn 1975). Henn noted several traits which distinguished Indian Ridge from sites located in the Willamette Valley, including the prevalence of obsidian and the presence of at least two projectile point types not represented in the Valley. He tentatively proposed that the site had been used by peoples from east of the Cascades, with people from the Warm Springs Reservation continuing the tradition until as recently as the 1920s (1975:467-468).

In 1982 a University of Oregon field school, under the direction of Paul Baxter, test-excavated a series of six lithic sites along Dead Horse Creek, a tributary to the Middle Fork of the Willamette River (Baxter 1983). The sites, situated between 640 and 795 meters (2,100 to 2,600 feet), display remarkable variability in their archaeological deposits. One of the sites (35 LA 528) is associated with four cambium-peeled Ponderosa pine trees, but yielded a very sparse collection of cultural material. Site 35 LA 573 is also small, but exhibits a deep and moderately dense lithic deposit. Site 35 LA 572, a small concentration of lithics (primarily debitage), was interpreted as a manifestation of "a single chipping event" (Baxter 1983:62). Site 35 LA 574 revealed a modest lithic deposit, and a hearth which apparently was not dated.

Two other sites, however, did yield radiocarbon dates through subsequent, more intensive excavation (Baxter 1986b). Two were obtained from the Colt site (35 LA 599) in a fairly dense, deep deposit: a "modern" date for charcoal extracted from Stratum 1 (Beta 12467), and a date of A.D. 1880 ±50 marked Stratum 3 (Beta 12468), possibly resultant from the same fire episode (Baxter 1986b:17). The Saddle site (35 LA 529) also provided a recent C-14 date of A.D. 1830 ±60 from stratum II (Beta 12469) (ibid). Statistically, the three dates are equivalent, and may not be directly associated with the cultural deposit but may be the result of a wild fire (Baxter 1986a:97). Both Colt and Saddle sites yielded projectile points, or fragments, attributable to the Middle Archaic period between 4000 B.C. and A.D. 200 (Baxter 1983:19-22).

In closer proximity to the study area, many sites have been studied on the McKenzie River drainage. These sites are considerably closer to Obsidian Cliffs, a major source of prehistoric toolstone, and thus display a very high proportion of obsidian relative to CCS and other lithic materials. Typically, these lithic sites are large in areal extent, and often yield more debitage representative of earlier stages of the reduction. For example, the Blitz site (35 LIN 147), located at an elevation of 1130 meters (3,710 feet), occupies about 40,000 m^2 in a ridgeline saddle. The site was interpreted to be an "early Middle Archaic campsite" on the basis of the projectile point styles (Minor and Toepel 1984). Formed tools include bifaces and preforms, projectile points, and utilized flake tools. Blitz has yielded the greatest number of points of any site excavated to date on the McKenzie Ranger District (Minor et al. 1987).

In contrast, preliminary excavations at the J&K Enterprises site provided a higher proportion of tools, but most are utilized flakes and unifaces (Silvermoon 1985). Five grinding slabs were also recorded during the course of the investigation. This is the only site in the McKenzie River drainage where these slabs have been found, though they are more common at sites to the south along the upper Middle Fork of the Willamette River (cf. Baxter 1983; Baxter et al. 1983). As is the case with most open lithic sites in the area, faunal and other organic remains are notably absent.

The Scott site (35 LA 430), also located in the McKenzie River drainage, is unusual in that it has provided a radiocarbon date (1810 ±90 B.P.) assayed from a charred wood sample, that may have been a digging stick (Jon Silvermoon, personal communication, 1988). The small lithic assemblage composed primarily obsidian includes bifaces, unifaces, worked flakes, and cores.

Within the South and Middle Santiam drainages (the present study area), about 50 sites have been investigated through evaluative or other preliminary test excavations (Farque' 1988a). A few of these have been more extensively studied through mitigative data recovery excavations (e.g., Lebow 1985; Winthrop and Gray 1985; Jenkins and Churchill 1987; Flenniken and Ozbun 1988). Most of the known archaeological sites in the study area are open lithic sites; prehistorically occupied rockshelters have yet to be discovered within this area, though Cascadia Cave is located just west of the District/study area boundary. The lack of rockshelters in this area and the nature of remains represented at open lithic sites render archaeological interpretations more difficult, due to the lack of organic remains and a diversity of cultural materials besides lithics.

For example, at the Yukwah site (35 LIN 118) test excavations had indicated that the peripheral area of the site contained very low density deposits (Lindberg-Muir 1984). Data recovery excavations were limited to two 1- by 2-meter units, and a 2- by 2-meter unit in the areas of anticipated disturbance. These excavations confirmed what had been established through the preliminary investigation, but added little to the overall understanding of the site. The site was interpreted as a dual component, seasonally occupied site where activities appear to have centered around hunting (Spencer 1987). Few complete, formed tools were recovered, suggesting these were intentionally conserved by the prehistoric inhabitants of the site. Lithic debitage is the primary component of the recovered assemblage. A few small bone fragments were recovered but were unidentifiable, and may have been intrusive (Lindberg-Muir 1984). Cultural affiliations and temporal context of the site remain unknown.

Investigation of the Trail Pyramid II site (35 LIN 255) yielded similar results (Lebow 1985). This small lithic scatter site provided an assemblage dominated by debitage, only a few of the artifacts were classified as tools, primarily utilized flakes with use wear indicative of scraping tasks (Lebow 1985:15). Other tools included two biface fragments, several retouched flakes, and three core fragments. Notably, CCS was the main lithic material represented at the site. Butchery was suggested as a primary function of the site. Cultural affiliations and temporal context again were not determined.

This lack of specific cultural associations and temporal data is repeated through most investigation of lithic sites in the study area. Excavation and analysis of the Moose Molalla One (35 LIN 139) led the investigators to pose some interesting propositions. Noting the meagerness of local sites' tool assemblages, and association with historic (possible aboriginal) trail routes, they suggest that

> "if the Molalla indeed formed a cultural group inhabiting the Western Cascades for some time, they were well placed to act as traders between the various culture areas to the west and north, and east. Perhaps these upland sites relate to prehistoric trade routes"
>
> (Winthrop and Gray 1985:21)

They also suggest that the prevalence of broad-necked projectile points, commonly attributed to the Middle Archaic period (4000 B.C.-A.D. 200), at open upland sites in the north-central Cascades may actually reflect a specialized tool kit for hunting large game, or extensive use of the uplands during this period (ibid:20).

In the easternmost portion of the study area two sites, North Park Headwaters (35 LIN 253) and North Park Salvage (35 LIN 186), were the focus of recent research efforts (Jenkins and Churchill 1987). Fairly extensive evaluative test excavations were conducted at these open lithic sites. Both sites are located in the High Cascades plateau area, less than 6.5 kilometers (4 miles) apart in the Park Creek drainage. The investigators noted several distinctions between the two site assemblages:

> The functional aspects of each site appear to differ. At North Park Headwaters is a single component site. The primary raw material used was CCS. Tool production and maintenance was the major activity taking place at the site. The North Park Salvage site by comparison has two components, a multi-task oriented upper component and a more problematic lower component. A variety of scraping and shredding activities are inferred to have taken place at this site. Tool production and maintenance was also carried out.
>
> (Jenkins and Churchill 1987:51)

Thus, the North Park Salvage site may represent an upland base camp from which excursions to local task-specific sites were made. Its sheltered location, in conjunction with the quantity and variety of materials recovered from the site, lends support to this functional interpretation. The Headwaters site, in contrast, appears to have been used less intensively, perhaps as a temporary stop-

Table 4. Open Lithic Sites

Site Name/Number	Elevation	Major Drainage	Cultural Affiliations	Chronometric Data	Report Reference
Fall Creek/35 LA 33	230m	Middle Fork Willamette	Indigenous Yonkolla	None	Cole 1968
Indian Ridge/ 35 LA 195	1465m	McKenzie River	Eastside Peoples	None	Olsen 1975
Colt/35 LA 599	670m	Middle Fork Willamette	Indigenous	C14: Modern, 70 +/- 50 BP	Baxter 1983; 1986a; 1986b
Saddle/35 LA 529	795m	Middle Fork Willamette	Indigenous	C14: 120 +/- 60 BP	Baxter 1983; 1986a; 1986b
Scott/35 LA 430	1170m	McKenzie River	Unknown	C14: 1810 +/- 90 BP[a]	Churchill and Jenkins 1984
Trail Pyramid II/ 35 LIN 255	1220m	Middle Santiam	Unknown	None	Lebow 1985
Yukwah/35 LIN 118	365m	South Santiam	Unknown	None	Lindberg-Muir 1984; Spencer 1987
Moose Molala One/ 35 LIN 139	1205m	South Santiam	Indigenous	None	Winthrop and Gray 1985
North Park Head-waters 35 LIN 253	1190m	Middle Santiam-McKenzie Rivers	Unknown	Projectile Points "Middle Archaic"	Jenkins and Churchill 1987
North Park Sal-vage 35 LIN 186	1130m	McKenzie River	Unknown	Projectile Points "Middle Archaic"	Jenkins and Churchill 1987

[a]Personal communication (Silvermoon 1987).

over point or travel camp (Jenkins and Churchill 1987:47). The investigators also note similarities between North Park Headwaters site and Trail Pyramid II (previously discussed), in terms of the predominance of CCS in the assemblage, especially debitage, while obsidian seems to be the preferred material represented in the tool assemblage (ibid:42).

The authors hesitate to provide more than a "general direction" for dating the sites, citing the limited usefulness of current projectile point typologies for cross-dating, as well as the low frequency of this artifact class. The few points and point fragments recovered from these two Park Creek sites resemble Elko and Northern Side-Notched types of the Great Basin, Cold Springs Phase Side-notched specimens of the Plateau, and Cascade type points; but they "appear to most closely resemble other side- notched points from the Cascades area" (Jenkins and Churchill 1987:44).

Challenged by the lack of temporal control obtained through traditional archaeological methods at these sites, the researchers pursued temporal refinement through obsidian hydration analysis, complemented by X-ray flourescence (XRF) analysis of chemical composition, for specimens obtained from excavations at the North Park Salvage site (Jenkins 1987). The XRF analysis indicated that all of the samples submitted exhibit chemical compositions consistent with that of the Obsidian

Cliffs source. Obsidian gravels found in the McKenzie and Willamette Rivers also exhibit the same proportions of diagnostic trace elements as Obsidian Cliffs, so it cannot be assumed that the obsidian found at North Park Salvage was obtained directly from the Obsidian Cliffs source area. Specific results of the hydration analysis were not provided beyond noting that the general pattern exhibited was that rim thickness increased with depth below the surface. This might suggest that the site retains some degree of stratigraphic integrity.

Current Research Direction

The preceding discussion of selected archaeological sites serves to demonstrate the level of understanding of local prehistory that has been attained. A review of the literature related to lithic-dominated sites in the western Cascades, and other areas (e.g., Tainter 1979; Fredrickson 1984; Glassow 1985), clearly indicates that lithic scatters, whether surface or buried manifestations, are difficult to study and interpret due to the nature of scientific information contained within them. The Cascades of Oregon remain an enigma to archaeologists endeavoring to formulate holistic prehistoric settlement models and explanatory frameworks. Surrounded by major culture areas and subareas, the long cultural chronologies of these adjacent regions will remain incomplete until the upland components are better understood.

Therefore, it is essential to consider such data in as broad a context as possible (Talmage et al. 1977; Tainter 1979; Glassow 1985).

Although both field surveys and site excavations have provided evidence of widespread prehistoric seasonal use of the forested upland environment, as well as significant time-depth for that use, the data generated through these efforts have proven difficult to place within existing cultural historical frameworks. The problem lies, in part, with the inherent limitations of the lithic-dominated sites in a montane forest environment, compounded by the lack of a systematic, problem-oriented research strategy (Davis 1987b).

Although a number of research questions and approaches pertaining to this area have been identified, including the definition of cultural chronologies, the reconstruction of prehistoric lifeways, and explication of culture processes (Minor et al. 1982), only the question of cultural chronologies is currently germane. Until such time as questions of "<u>who</u> has inhabited the Cascades in the prehistoric past?" and "<u>when</u> did this habitation, or forest-use, occur?" can be confidently answered, and variations through time identified, other research concerns must remain secondary. Because temporal control is deemed to be basic to more complex research issues, it is the primary focus of this study.

CHAPTER 4

OBSIDIAN STUDIES

Obsidian is a naturally occurring volcanic glass formed through the solidification of molten lavas. It is one of the most widely known and commonly recognized lithic materials, and for some time has been the focus of great interest to geologists and archaeologists alike. As a "window" to geologic processes, obsidian is thought to accurately reflect the pristine chemical composition of silicic magmas. The name, obsidian, may be one of the most ancient of rock names still in use today, derived from the name of its discoverer, Opsius, by Pliny the Elder some two thousand year ago (Iddings 1988:261).

Obsidian is distributed throughout the world (Figure 10). As a product of volcanic activity, it is commonly associated with tectonic features such as spreading axes and plate boundaries, but also occurs in continental interior locations (e.g., Yellowstone) that are geologically active for other reasons (Skinner 1983). The state of Oregon may, in fact, be one of the most obsidian-rich geographic area in the world, with over 100 discrete sources reported to date (Skinner 1986).

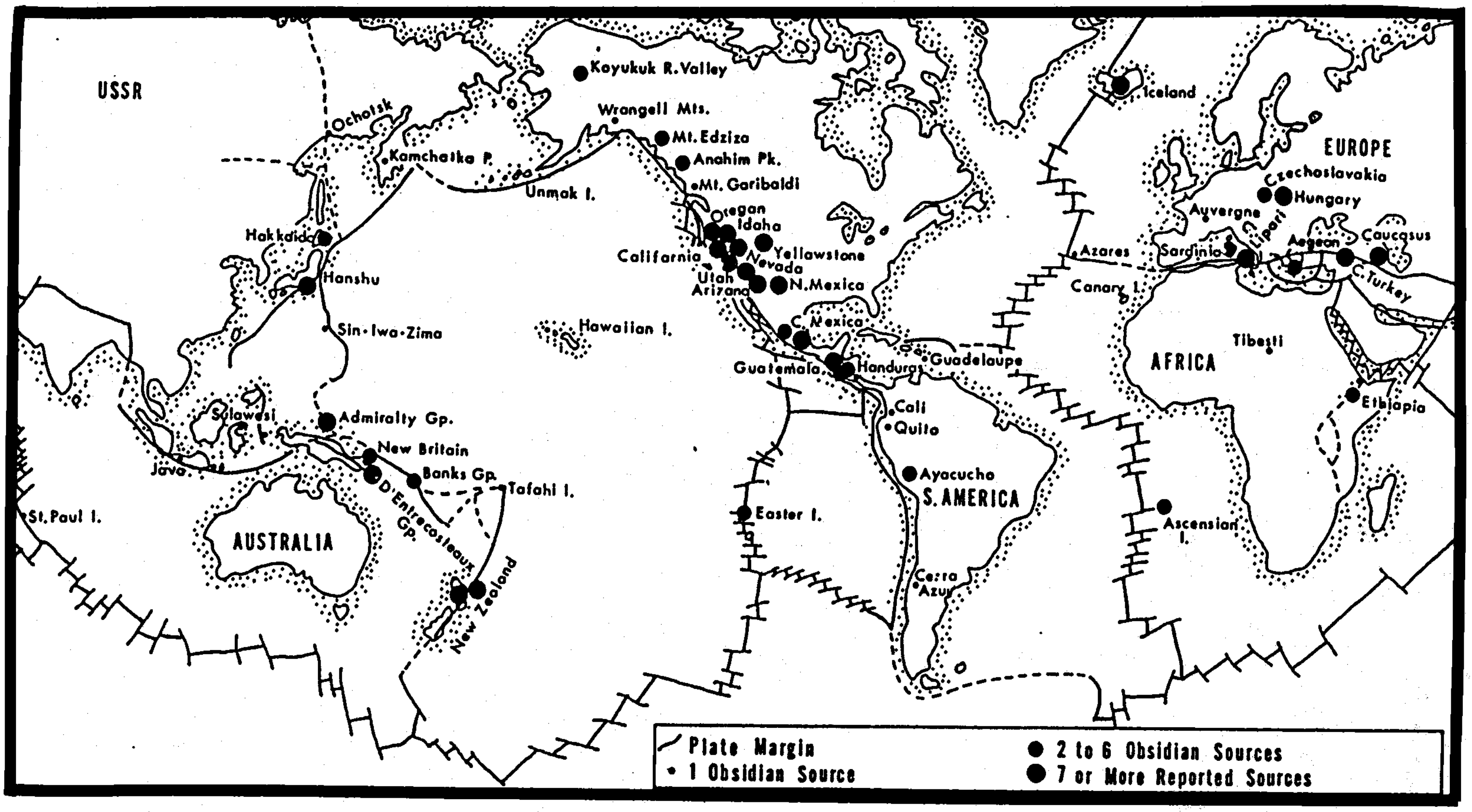


Figure 10. Worldwide distribution of primary geologic sources of rhyolitic and dacitic obsidian (Skinner 1983:11). Note the abundance of sources in western North America.

Petrographic Properties of Obsidian

Obsidian is not a specific chemical compound, but rather is a variable mixture of many substances drawn from the parent magma from which it is derived. Therefore, the term obsidian is a textural one, and the chemical composition of the glass varies among sources (Table 5). Petrographically, obsidians are most often classified by their silica (SiO_2) content, and may be basaltic, andesitic, dacitic, or rhyolitic in composition (Skinner 1983). Rhyolitic obsidian is most widespread geographically, and most commonly encountered in archaeological sites (Michels 1971).

Table 5. Major element constituents of rhyolitic obsidian (Michels 1971).

Chemical Compound	Percentage
SiO_2	68 - 77
Al_2O_3	10 - 15
Na_2O	3 - 5
K_2O	1 - 7
Fe_2O_3	0.5 - 2.6
FeO	1.0 - 1.8
CaO	0 - 1.2
TiO_2	0 - 0.5
MnO	0 - 0.1
MgO	0 - 0.4
H_2O	0.2 - 0.9
P_2O_5	0 - 0.1

Numerous trace elements (ranging in abundance of less than one to about a thousand parts per million) also exist in obsidian (Skinner 1983). While major elements are found in fairly homogeneous concentrations within individual obsidian sources, a certain amount of variation is found among distinct sources. Certain trace element concentrations are highly variable among sources and are considered to be useful "diagnostic" elements for chemical characterization analyses, such as X-ray flourescence spectrometry and neutron activation analysis (Skinner 1983; Hughes 1986a).

Archaeological Significance

The high cultural value of obsidian has been evidenced in the material culture of prehistoric societies worldwide. Obsidian has been used throughout the millenia as a raw material for the production of tools and ornamental objects. Qualities which contribute to its desirability for tool manufacture include its glassy consistency, its reliable fracturing behavior, and its tendency to provide and maintain a incomparably keen edge. A highly valued commodity in prehistoric (pre-metal) societies, obsidian was transported and traded over great distances. When locally available, it was invariably a major component of the lithic assemblage of Stone Age peoples.

Aside from its functional importance in prehistoric tool kits, obsidian was commonly employed in the manufacture of other nonutilitarian objects. For example, among Mesoamerican cultures, obsidian was fashioned into various ceremonial and ornamental objects such as beads, pendants, earspools, and figurines. In Egyptian tombs and Ethiopian chambers, it was also laid in the form of mirrors. Not only was obsidian prized for its excellent flaking qualities, but it could also be ground or turned to produce fine bowls and other useful objects (Gowlett 1984).

Obsidian exploitation extends back at least a million years to the earliest episodes of the Paleolithic. Sites in East Africa, notably Melka Kunture' in Ethiopia and Kariandusa in Kenya, have yielded fine obsidian Acheulean bifaces left by early hominids (Muir and Hivernel 1976; Gowlett 1984). As early as 30,000 years ago, obsidian was being transported (or traded) over great distances, some 300 km to Shanidar Cave from the Lake Van area of Turkey. By 7000 to 5000 BC, the obsidian trade was extensive throughout the Middle East and Mediterranean areas (Gowlett 1984). These few examples serve to demonstrate the archaeological evidence for the high cultural value associated with obsidian throughout the millenia. Certainly many other examples could be cited from areas of North and Mesomerica as well.

The study of artifactual obsidian can reveal a great deal about the chronologies and behaviors of past cultures. Archaeologists have long realized the significance of such artifacts in terms understanding and reconstructing cultural histories through the development of typologies and component assemblages. More recently, however, technological advances have enabled the archaeologist to apply more sophisticated and discriminating analyses to obsidian artifacts and assemblages (Figure 11).

In western North America, significant advances have been made toward reconstruction of prehistoric obsidian exchange and procurement patterns through the application of obsidian analyses (e.g., Hughes 1978, 1982, 1986a; Findlow and Bolognese 1980, 1982; Ericson 1982; Fredrickson 1987). Many archaeologists are now applying similar research strategies in which obsidian studies represent an integral facet (cf. Fredrickson 1984).

Science in Contemporary Archaeology

Since the early 1960's, a major theoretical shift has occurred in the field of archaeology. A transformation was actually initiated in the mid-forties, when Walter Taylor evaluated the aims and accomplishments of American archaeology to date and proposed an alternative theoretical approach through his monograph, A Study of Archaeology (1948). Although Taylor's approach was not

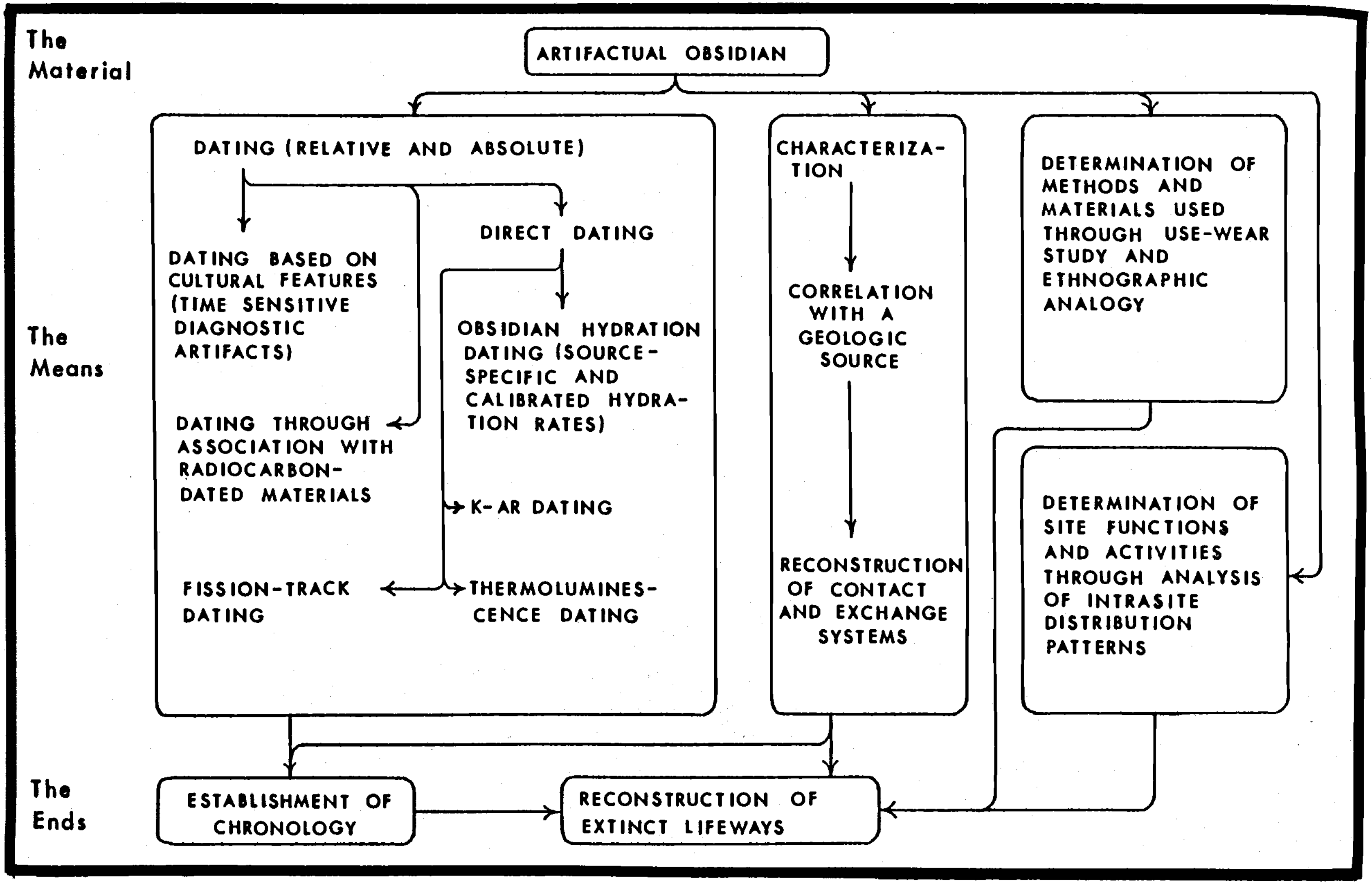


Figure 11. Preliminary model of possible research approaches employing artifactual obsidian developed by Skinner (1983:60).

widely applied, his work initiated a critical awareness in the consideration of the methods and goals in archaeology, and its relation to anthropology, history, and science (Leone 1977). In essence, Taylor's work is at the roots of the "new" archaeology, which emphasizes the explicitly scientific approach (Watson et al. 1971). The dichotomy of the so-called traditional vs. new archaeology is basically one of inductive vs. deductive research methodologies. Rather than attempting to fit

> archaeological remains into ethnographically known patterns of life... [the] archaeologist must make use of his data as documents of past conditions, proceed to formulate propositions about the past, and devise a means for testing them against archaeological remains
>
> (Binford and Binford 1968)

During the sixties, Lewis Binford, as one of the earliest and most avid proponents of "new archaeology", provided the impetus necessary to keep the transition focused toward scientific methodologies and archaeological theory building (Wilson 1976).

As a part of this movement, archaeologists have turned increasingly to the other sciences for models, developments, and theories which might be applicable to their own field. This trend has continued with archaeologists becoming chronic borrowers, as opposed to developing unique, discipline-specific models and theories. Such applications have realized various levels of success. Obviously, those which are arbitrarily or carelessly applied are among those that do not make a lasting contribution to archaeological theory building (cf. Betz 1987). Others, such as systems theory, have been incorporated into the methodologies of most archaeologists and have proven quite useful for explaining culture processes. Archaeology has benefited greatly from some of the advances made in other sciences.

Among the major technological advances developed in the past few decades, two based firmly in geological science are applicable to artifactual obsidian: the obsidian hydration geochronological method, and chemical characterization employed to identify the geological source of artifactual obsidian.

The basis of obsidian hydration band analysis as a dating tool is founded in the theory that obsidian hydrates at a predictable and determinable rate, which results in the development of a measurable band on the exposed surfaces of a sample (Friedman and Smith 1960). This band measurement can serve as a proxy measure of age. In some areas, extensive research and analysis of substantial obsidian artifacts, usually correlated with radiocarbon dates, have resulted in the determination of source-specific regional hydration rates. This in turn allows archaeologists to assign accurate calendric dates to cultural features and artifacts. Applications of the method as a tool for relative dating are also abundant.

Obsidian source characterization methods are used to identify the primary geological source of artifactual obsidian. This is usually accomplished through analysis of chemical composition (Hughes 1986a). A variety of techniques exist for characterizing volcanic glass. Archaeologists have applied this type of information to trace the movement of obsidian, and thereby attempt reconstruct prehistoric trade routes and procurement patterns (e.g., Hughes 1978, 1986a; Fredrickson 1987).

History and Development of Hydration Dating

Geochemical research during the 1950s revealed that obsidian is subject to a chemical and physical form of weathering termed "hydration" (Ross and Smith 1955). Hydration is a process whereby obsidian adsorbs water from the environment, saturating its surface with a layer of water molecules which slowly diffuse into the body of the obsidian (Michels and Tsong 1980). The outer layer increases in density which, in turn, raises the index of refraction, creates mechanical strain, and becomes visible when viewed in cross-section under appropriate microscopic conditions. The hydration process begins anew each time a freshly fractured surface of obsidian is exposed. Several excellent summaries are available which detail the hydration phenomenon itself, and describe the exact measurement procedure for determining hydration rim values (e.g., Michels and Bebrich 1971; Friedman and Long

1976; Taylor 1976; Michels and Tsong 1980; Origer 1982, 1988a, b).

In 1960, two geologists, Irving Friedman and Robert Smith proposed that hydration dating was a potentially useful tool for archaeologists. However, the researchers were cautious and explicitly identified variables which appeared to affect the rate of hydration, encouraging further research prior to its widespread application.

> Using artifacts from archaeological sites of known age, the influence of temperature, relative humidity, chemical composition of the obsidian, burning and erosion of the obsidian on the rates of hydration was determined. Temperature and chemical composition are the main factors controlling the rate of hydration... Using archaeological data from various parts of the world, several tentative hydration rates were determined from tropical, temperate, and arctic climates. The method in its present state of development is especially suited to determine relative chronologies...future work to refine the method is also suggested.
>
> (Friedman and Smith 1960:476)

Friedman and Smith proposed that hydration proceeds according to the following diffusion equation:

$$x^2 = kt, \quad \text{or} \quad x = kt^{\frac{1}{2}}, \qquad (1,2)$$

where x = depth of penetration of water in microns, k = constant for a given temperature, and t = time in years. They determined rates of hydration ranging from $0.4x^2/103$

years for the Arctic region to $11x^2/10^3$ years for the tropical Equador through analysis of artifacts measured from various parts of the world (see Figure 12).

Clifford Evans and Betty J. Meggers, archaeologists from the U.S. National Museum, worked closely with Smith and Friedman, and provided them with independently dated obsidian artifacts of known provenience, as well as valuable archaeological insights. They also published an archaeological evaluation of the hydration dating method (Evans and Meggers 1960). Emphasizing the method's early stage of development, Evans and Meggers reviewed the limitations of the method, and attempted to explain some of the incongruencies recognized in comparison of archaeologically-estimated and obsidian-estimated dates for the various specimens. They identified stratigraphic mixing and artifact reuse as the principal archaeological source of error. They did not yet recognize the role of chemical composition in affecting the hydration rate. Despite the complex nature of the dating method stemming from the number of variables which come into play in the hydration process, Evans and Meggers recognized the outstanding contribution geologists Friedman and Smith had made to the discipline anticipating that they would:

> ...join the ranks of other great benefactors of archaeology, such as A.E. Douglass, the astronomer who had pioneered the study of dendrochronology, and William F. Libby, the chemist who devised the radiocarbon dating method.
>
> (Evans and Meggers 1960:537)

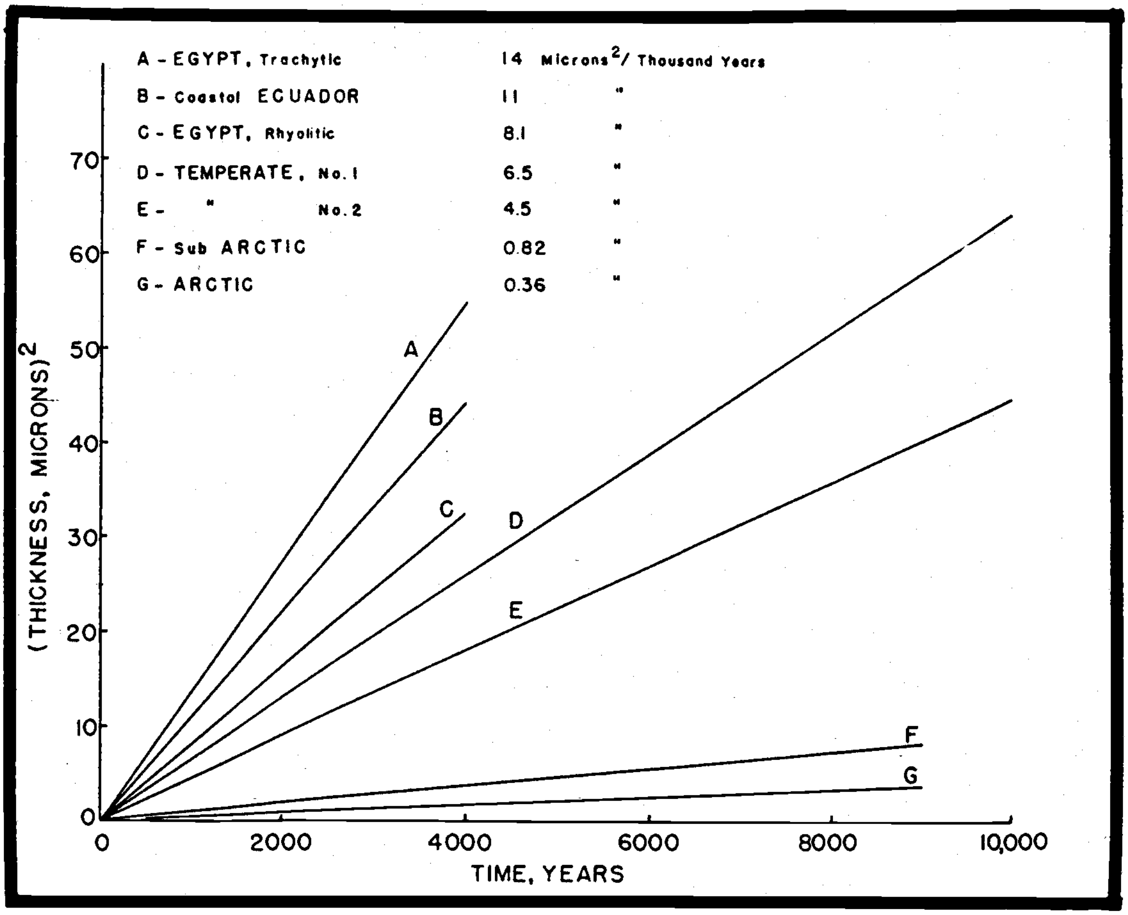


Figure 12. Tentative hydration rates for seven distinct climatic zones based on correlation of artifacts dated through other means and their hydration rim measurements. (Note: Chemical composition was not taken into consideration at this stage of development. (Friedman and Smith 1960).

This prediction is apparently being realized as Friedman, especially, has remained an active contributor in the research and development of the method. Undoubtedly, Friedman's geologic expertise, coupled with his understanding of various intricacies of archaeological research, has enhanced the refinement of obsidian hydration as a dating method for archaeology.

Perhaps the earliest direct archaeological application of the new method was reported by Donovan L. Clark in his doctoral dissertation (Clark 1961a). Clark measured specimens from a number of different sites from within the same region in order to correlate hydration measurement values with a chronometric scale provided by radiocarbon dating. In the process of discovering a rate that best fit his data, he found a slightly different version of the diffusion equation:

$$x = kt^{3/4}. \qquad (3)$$

This became the first of many variations of the equation which would be used to convert hydration values to calendric years. It set the stage for a controversy over the existence of an "universally applicable" diffusion equation that began in 1968 and persists yet today (Michels and Tsong 1980).

Another important aspect of Clark's early dissertation research concerns a discovery made working with obsidian from Hidalgo, Mexico. Two macroscopically distinct obsidians, green and grey varieties of rhyolitic obsidian, were found to hydrate at different rates under otherwise equal environmental and temporal conditions (Clark 1961a). Although Friedman and Long (1960) had originally recognized the difference in the hydration rates of ryholitic and trachytic obsidian in Egypt, it was implicitly assumed that rhyolitic obsidians exhibited sufficient homogeneity, in terms of chemical composition, to hydrate at a uniform rate. Clark's discovery confirmed the profound effect on the rate of hydration produced by variation in chemical composition of different obsidians.

It was still several years before archaeologists began to differentiate among obsidian sources when dating a group of obsidian specimens (Findlow et al. 1975; Kimberlin 1976; Friedman and Long 1976; Ericson and Berger 1976). Some archaeologists continued to assume that obsidian recovered from a single site, or group of geographically related sites would exhibit homogeneous chemical composition, or simply failed to account for this variable (e.g., Fagan 1975). Others determined the obsidian in their site(s) to be "sufficiently homogeneous" on the basis of the percentage of silica content alone, as indicated by the glass-bead method (Kittleman

1963), disregarding other chemical constituents (Johnson 1969; Minor 1977).

Through the 1960s and 1970s, researchers attempted to determine rates of hydration for specific archaeological settings often making use of independent radiometric scales. Alternative rates seemed only to create new problems, and frustration was mounting. Many researchers completely rejected the method since obsidian dates often were inconsistent with existing or expected dates. Sometimes the incongruencies were explained away by attributing them to stratigraphic mixing and artifact reuse, though Kimberlin (1976:72) claims that "stratigraphic mixing is a somewhat overworked phenomenon used because there is no other apparent explanation". On the other hand, a form of mixing common among archaeological sites is that of different sources of obsidian. Evidently, many of the difficulties encountered in the chronometric application of the obsidian dating method during the first several decades of its use were directly related to the failure to recognize or fully appreciate the significance of chemical composition in affecting the rate of hydration (Michels and Tsong 1980).

Relative Dating Applications

Aside from research directed at establishing hydration rates for specific geographic regions, a few researchers pursued other lines of hydration investigation. Many relative dating applications were recognized early (Evans and Meggers 1960; Michels 1966, 1969, 1971) and continue to be valuable in archaeological research today (e.g., Origer and Wickstrom 1982; Fredrickson 1984; White 1984; Raymond 1985; Huberland 1987). Michels and Bebrich (1971) provide a comprehensive, although not necessarily exhaustive, summary of research problems which can be addressed utilizing obsidian hydration data in a relative mode.

<u>Stratigraphic integrity</u> can be empirically evaluated by plotting the frequency distribution of hydration rim values against the depositional units of individual excavation units (Michels 1969). Assuming the validity of the geological principle of superposition, which holds that younger units of deposition overlie older ones in serial order, it follows that hydration rim values will increase in thickness as a function of increased depth within the deposition unit (Michels and Bebrich 1971). An assessment of the degree of mixing can be obtained; Michels has termed this the "net stratigraphic value" of a site or excavation unit (1969:15).

<u>Artifact reuse</u> can also be recognized. Reuse of obsidian is an ancient and widespread trait, confirmed by archaeological evidence from sites in Alaska, California, Mexico, and Equador (Clark 1961b). Although this phenomenon may be considered a hindrance to the obsidian dating method, it is through the application of hydration

analysis that artifact reuse can be documented. An artifact that has been reworked provides two (or more) distinct hydration measurements; a thinner rim appears on the more recently modified margin of an artifact, while a thicker reading indicates an older, or original, working surface. Artifacts exhibiting anomolous hydration readings can be re-examined for evidence of reuse.

Perhaps the most fundamental application of the hydration dating technique is to associate artifacts with each other for the purpose of forming artifact assemblages, or cultural components, in the absence of reliable stratigraphy or other date producing evidence (e.g., Michels 1971; Origer 1982). Segregation is accomplished by establishing arbitrary micron ranges and considering all artifacts with hydration values within a particular range as being associated. Michels (1971) operationalized this approach in a study of Colonial Period sites in the Valley of Mexico.

Obsidian hydration analysis can also be employed as a complement to ceramic seriations, or to verify proposed projectile point typologies. Similarly, obsidian artifacts (characterized with respect to form, physical dimensions, typological affiliation, site provenience, method of manufacture) provide variables which can be treated individually as time series data through hydration analysis. Thus, in terms of relative dating application, obsidian hydration has become a valuable tool for archaeologists examining a broad range of research problems.

Refinement of Hydration Rate Determinations

Hydration research has continued toward discovery of a universally applicable hydration rate through improved control of the key variables: chemical composition of obsidians and effective hydration temperature. Although the significance of chemical composition as a variable has been recognized and a concerted effort has been made to identify the chemical constituents of particular geological sources of obsidian, there is as yet no accepted framework for relating them directly to each other (Friedman and Trembour 1983). The understanding of the compositional effects is still quite limited. Apparently, increased silica (SiO_2) content is related to an acceleration of the hydration rate and increased CaO and MgO reduce the rate, while Al_2I_3, FeO, Na_2O, and K_2O ratios appear to have little effect (Friedman and Long 1976). The silica-oxygen ratio may be a suitable index to describe the influence of composition on the hydration rate (Ericson and Berger 1976), but most studies indicate that it is not substantially discriminating in areas where multiple sources of obsidian are available. More empirical studies are needed to better understand the role of chemical composition in the hydration of obsidian.

The temperature factor, on the other hand, has received more attention, and as a result, is better understood. Friedman and Smith (1960) identified environmental temperature as a key variable in their original research on the hydration phenomenon, and proposed rates for several climatic zones (see Figure 12). Since that time, controlled experiments have further defined the influence of temperature in the hydration process. Friedman and others support the use of the Arrhenius equation to relate the hydration rate (k) to temperature (T).

$$k = Ae^{-E/RT} \qquad (4)$$

where the hydration rate is expressed in microns per thousand years, A is a constant (specific to distinct obsidian sources), E is the activation energy of the hydration process (calories per mole), R is the gas constant (calories per degree per mole), and T is the absolute temperature (degrees Kelvin) (Friedman and Long 1976:347).

Continued research into the temperature factor indicated that the hydration rate increases exponentially with elevated temperature by a factor of approximately 10 percent for each 1 degree Celsius increase (Friedman and Trembour 1983). More recently, a study conducted at Sonoma State University employing data from 67 obsidian sources led to the discovery that "the percent change in hydration rate is not constant at 10 percent [as suggested above], but is source-specific and temperature dependent, decreasing with increase in temperature" (Tremaine 1987).

Although mean annual air temperatures (MAT) are commonly used, a more accurate assessment of the <u>effective hydration temperature</u> (EHT) is a higher integrated value derived through a series of corrections taking into account multiple microenvironmental variables, as well as diurnal and seasonal temperature fluctuations (Friedman and Trembour 1983:544-545). Mean annual soil temperature (MST) may in fact be the best indicator of EHT, however, in that the ground is typically the medium which contains the archaeological deposit, and thus insulates the obsidian from the diurnal extremes of air temperature, and the effects of solar radiation on the surface.

Site-specific EHT determinations can be facilitated through the use of specialized sensors, such as the thermal diffusion cell tested and described by Ambrose (1976). Trembour and Friedman (1984) also evaluated thermographs devised by Pallmann et al. (1940) and Ambrose (1976). They found the Ambrose model to be preferable, due to:

> its comparative simplicity, compactness, ruggedness and economy... advantages which make it attractive for liberal use at particular archaeological sites, and in numbers for

> more thorough exploration of extensive areas.
>
> (Trembour and Friedman 1984:82)

Conversion graphs are available to derive EHT for obsidian from both the Pallmann and Ambrose integrated means, for various temperature levels and ranges of fluctuation (Norton and Friedman 1981). Selected examples of these derived from this study are provided in Figure 13.

Origer (1982) employed the concept of <u>natural effective temperature</u> (NET), as developed by Lee (1969), in his hydration study of projectile points from archaeological sites in the North Coast Ranges of California. NET is derived from the following formula:

$$Ta = -1.2316 + 1.0645Te - 0.1607Rt, \qquad (5)$$

where:

Ta = mean annual air temperature (MAT)

Te = natural effective temperature (NET)

Rt = temperature range of annual monthly means

(Origer 1982:23)

Origer advises caution in applying NETs because greater NET values can result from a wider range of monthly means (Rt), as well as higher temperatures overall. Again, the

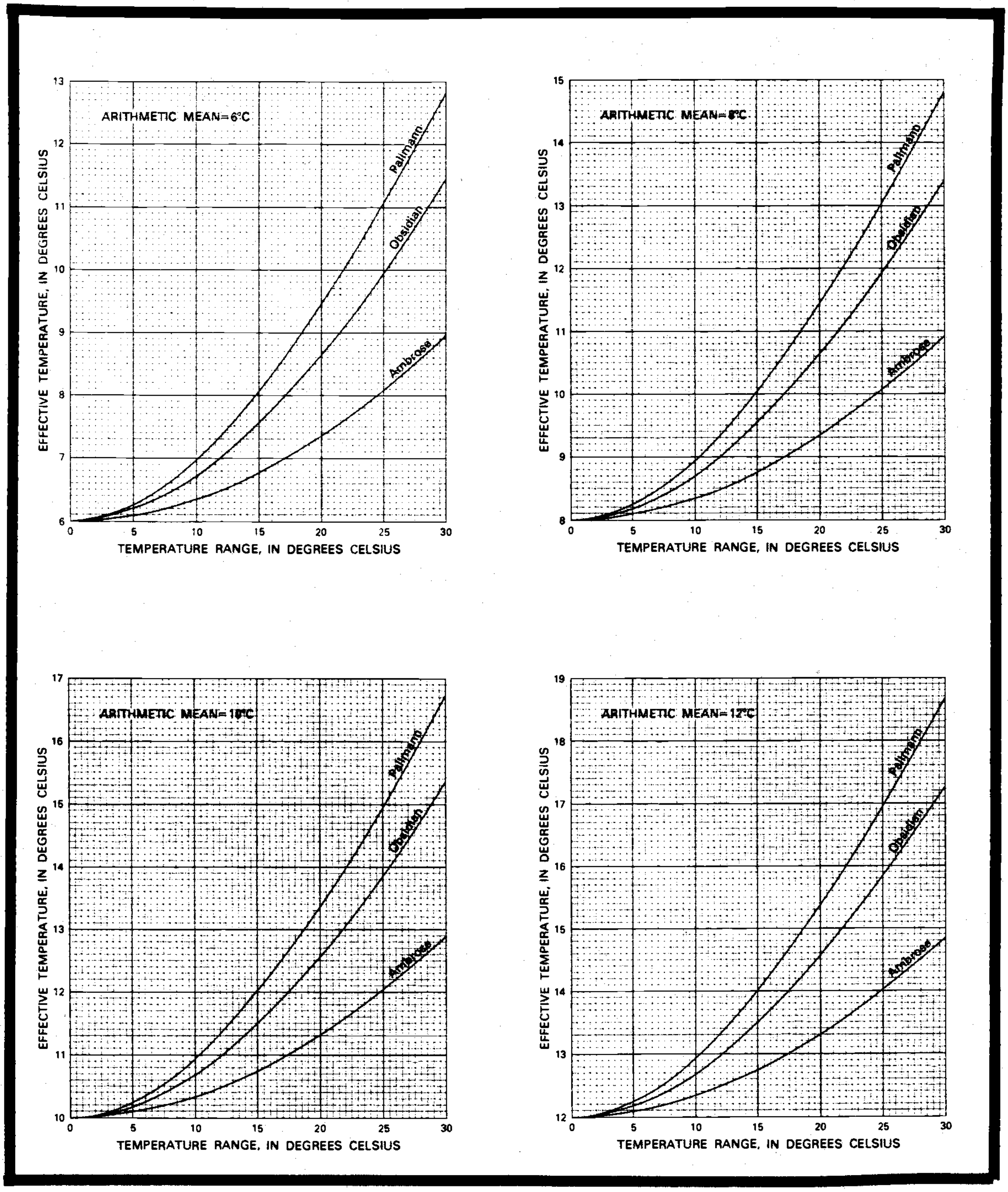


Figure 13. Selected calibration curves for deriving effective hydration temperature. Adapted from Norton and Friedman (1981: 8-11).

calculation of NETs employs air temperatures, whereas ground temperature measurements are more appropriate for hydration rate determinations (Friedman and Long 1976). Evidently the NET calculation is in need of further refinement for application in hydration.

Thus, conversion of the observed hydration depth of an obsidian sample to an "absolute" age requires a knowledge of the intrinsic hydration rate of the obsidian (based on chemical composition) and an estimation of EHT for the sample. Generally, samples found in association at a particular archaeological site are assumed to have experienced similar thermal history. Given that the hydration rim develops as a function of the square root of time (Friedman and Long 1976), two such associated artifacts which exhibit different hydration rim thickness reflect relative ages that are in direct ratio to the squares of their respective hydration rim values, provided they are of equal chemical composition.

As research continues on several fronts with the primary objective of establishing an intrinsic hydration dating method independent of other chronometric methods, it becomes increasingly clear that hydration is a complex geochemical process. Reliable dating depends upon a complete understanding and control of the key variables: chemical composition and temperature (EHT). Eventually the universal rate controversy will be resolved. To summarize the current status of the obsidian hydration dating method as Meighan did 5 years ago:

> On the one hand, investigators cannot have total confidence in the exact answer they get from obsidian chronology, but on the other hand, they can have a reasonable degree of confidence that their dating is in the ball park and that they can reliably discriminate the time periods of sites and collections. In other words, the dating results have to be used with care and discrimination and balanced against other sources of dating information. The same can be said about radiocarbon dates or any other dating method used by archaeologists.
>
> The initial phases of the study of obsidian hydration as a dating tool have been slow and costly. Figuring out the size of the hydration band is cheap and easy, but translating that observation into age determination has required a lot of ancillary studies, and hydration dating is not cheap and easy if one must first have a neutron activation or X-ray analysis and a suite of radiocarbon dates. Fortunately, once a hydration rate is determined, it is possible to use shortcut methods and derive chronological data fairly rapidly.
>
> (Meighan 1983:608)

Considerable progress has been made over the past 25 years towards advancement of the obsidian hydration method of dating, considering the complexity of the processes involved. Archaeologists now have a practical tool for defining chronologies, which in some areas has become an integral facet of archaeological research.

Current Applications in the Western United States

In the United States, two facilities have remained active in hydration research: Pennsylvania State University Lab, under the direction of Joseph Michels; and University of California, Los Angeles, Lab, under the direction of Clement Meighan. Both of these names are prominent in the research literature. Irving Friedman has remained at the forefront of geochemical research on hydration and has maintained a fundamental interest in refining archaeological application. More recently, as archaeologists in Northern California have actively pursued obsidian studies in that region, the Sonoma State University Anthropological Studies Center has maintained a laboratory specializing in obsidian characterization and hydration analysis directed by Richard Hughes and Thomas Origer. For example, Fredrickson (1984) proposed a research strategy for Northern California. One essential element of this strategy is the use of multiple, source-specific, obsidian hydration readings, as a functional equivalent to temporally-sensitive artifacts, such as projectile points, beads, or ornaments.

This approach has been quite successful, although hydration "dates" are applied largely in relative terms. As sites are recorded or excavated, a sample of obsidian is routinely submitted for hydration analysis and chemical characterization. The results are presented as raw values (in microns) segregated by geological source, and generally are discussed in terms of hydration and source data from other local sites. If other chronometric data is available (e.g., radiocarbon or projectile point type), they are correlated with the hydration rim values as well (e.g., Huberland 1984; White 1984; Hayes and Hildebrandt 1985). Hydration data have also been employed to test local projectile point typologies (Origer 1982), to test stratigraphy, and to isolate units of contemporaneity (White 1984). Trends in obsidian use, in light of numerous local sources, have also been examined by Fredrickson (1987).

In short, source-specific hydration analyses have greatly enhanced the understanding of temporal associations in the Coast Ranges of Northern California, an issue which had until recently been precluded by the scarcity of radiometric data, unreliable site stratigraphy, and vague unverified projectile point typologies. This situation closely parallels the current stage of temporal control in Cascades archaeology.

Applications of hydration studies in Oregon have been sporadic, at best. It is interesting that the earliest published application of hydration analysis in this state (aside from Friedman and Long 1960) is by an artifact collector (Heflin 1963) who submitted a few samples from Glass Buttes. The majority of hydration analyses were performed on uncharacterized obsidian samples (Layton 1972; Fagan 1974, 1975; Aikens and Minor 1978).

Others relied on the glass-bead method (Kittleman 1963) for estimating silica content from the index of refraction through correlation with glass beads of known silica content (Johnson 1969; Minor 1977; Kittleman 1977). However, the glass-bead method is not discriminating enough to determine the geologic sources of artifacts in that only the silica content is assessed. Although Johnson (1969) and Minor (1977, 1985) proposed hydration rates for the Klamath Basin, Lower Columbia River, and the upper Willamette Valley, these rates come into question given the lack of chemical characterization and the numerous potential sources of obsidian. In most of the other studies, researchers were frustrated by the erratic hydration values, resulting from the lack of control of the compositional variable, and attempted little in the way of interpretation (e.g., Fagan 1975).

In the past few years, obsidian analyses have again been implemented, notably on sites on the Willamette National Forest. Baxter (1986b) acquired source-specific hydration measurements for 36 out of 40 characterized specimens from two sites in the upper Willamette River drainage (35 LA 529, 35 LA 599). Hydration values range from 0.9 to 4.8 microns, and seven distinct geochemical types are represented (Hughes 1986b). This information is included as an appendix to the main report, and no interpretation is attempted.

Another sample of 9 obsidian artifacts from two other sites in the upper Willamette drainage (35 LA 475, 35 LA 519), and 29 from 15 sites in the North Santiam drainage was submitted by Kathryn Elsesser for source characterization and hydration analysis at the Sonoma State University Lab. The artifacts from the upper Willamette sites were correlated with the Inman Creek source, except for one specimen from Quartz Mountain (Hughes 1986c). Two specimens exhibited no hydration bands, including the one from the Quartz Mountain source. Of the remaining seven specimens, hydration values range from 1.1 to 2.9 microns and generally exhibit an increased band thickness correlating with provenience depth (Origer 1986). Apparently, the collection consisted primarily of surface finds from disturbed sites; most specimens are formed tools, such as projectile points, bifaces, and unifaces, or tool fragments (Rounds 1986). Unfortunately, the research value of these data is limited because of their surface context (in logged areas) and generally uncertain provenience. As surface finds, most of the artifacts from the North Santiam were exposed to relatively intense solar radiation for various periods of time, leading to potentially distorted hydration rim measurements.

Layton has demonstrated through comparison of surface and subsurface projectile points in the northern Great Basin, that the effect of direct exposure to sunlight was to greatly elevate the temperature of the obsidian and accelerate the hydration process (1973). On the other hand, in a similar comparison of artifacts from surface and subsurface contexts in the Santa Rosa plain of the North Coast Range of California, Origer and Wickstrom (1982) report only slightly higher hydration measurements for the surface specimens. Citing differences in soils and vegetation composition, they suggest that the environment of the Great Basin is "sufficiently dissimilar" to that of their study area to reduce the effect of solar radiation on the Santa Rosa artifacts. The environment of the central Cascades of Oregon is probably more similar to that of northern California Coast Ranges than the Great Basin, so perhaps the effects of solar radiation would be minimal here.

Recently, the Willamette National Forest has incorporated characterization and hydration analyses into the archaeological research program (Davis 1987a, b). This will contribute to the development of an obsidian data base for the central Cascades of Oregon, and enable the chronological ordering of open lithic sites not previously placed in a temporal context due to lack of datable material.

At this point it is essential that a meaningful research design be developed to make use of these data in the Western Cascades. In light of the success demonstrated by application of Fredrickson's obsidian strategy in Northern California, and given the general similarities of the archaeological manifestations and environment, it would be prudent to apply an analogous approach for the Cascades area. To this end, the following chapter discusses the methodology applied to the investigation of six upland lithic scatter sites in the central Western Cascades of Oregon.

CHAPTER 5

RESEARCH METHODS

The research design implemented herein is in part the product of impressions and experiences of other researchers employing the obsidian hydration method to improve chronological control on archaeological sites in other areas. As yet, there appears to be no clear, consistent methodology for selecting a sample, therefore the sample must be derived according to the specific research problem(s) addressed and site(s) under investigation (cf. Mueller 1979). In an area such as this, where comparable hydration data are virtually nonexistent, the element of internal comparability becomes critical. It is equally important that the methods employed reflect the long-range archaeological goals of obsidian hydration applications; that is, the construction of a temporal framework for open lithic sites in the central Oregon Cascades, which in turn will permit the elucidation of cultural process (Rowe 1959).

Specifically, the objectives of this research project are:

1. to evaluate the stratigraphic integrity of selected open lithic sites in the Western Cascades;

2. to assess the occupational histories of the individual sites in terms of temporal components and tenure of site use;

3. to determine what temporal ordering is possible among the sites;

4. to identify patterns of obsidian procurement in the area; and

5. to examine the long-range applicability of the obsidian hydration dating method for improving temporal control in the Western Cascades.

Thomas Origer, who has been active in hydration studies for some time, supports Fredrickson's approach (1984) to establish temporal control and refine cultural chronologies (personal communication, 1988). For areas where stratigraphic integrity is uncertain and cultural components are as yet undefined, Origer recommends the examination of obsidian from several sites to address these questions. Drawing a sample of ten source-specific obsidian artifacts, five from each of two discontinuous excavation levels (one shallow, one deep) of a single excavation unit permits a preliminary evaluation of both stratigraphic integrity and temporal components through hydration analysis (cf. Ericson and Berger 1976) Pending the confirmation of integrity and components, a second sample could be taken from intermediate levels to more specifically define the stratigraphic break(s) of the components.

Selection of Study Sites

Fundamentally, the selection of sites for the study is based upon their potential for addressing the research problem. Although it would be ideal to randomly select a representative sample of sites (Binford 1964) for study, the fact of the matter remains that the CRM-generated inventory of sites is primarily a product of U.S.D.A. forest management practices and does not include sites on private land; as such, it is not assumed to constitute an accurate reflection of the actual population of archaeological sites in the area (i.e., a representative sample of the universe). Nonetheless, for the study to be meaningful and generally applicable to other sites in the area, an attempt has been made to select sites which are characteristic of the known population of sites, in the sense that they exhibit some degree of the variability recognized among these open lithic sites, in terms of environmental setting, depth of deposit, artifact density, and so forth.

In the study area, 47 sites have been test-excavated for the purpose of determining eligibility to the National Register of Historic Places (NRHP) or avoidance of forest management impacts, and some more intensively through mitigative data recovery. The six sites used for this pilot study were selected from those with extant subsurface collections. Technically, any site containing obsidian in the assemblage could be used for the study; however, in order to confidently evaluate stratigraphic integrity and cultural components, certain criteria (or site attributes) were deemed most critical. Those sites with the most complete information, especially pertaining to depth, size, and assemblage characteristics, were preferred.

Another element considered relevant to site selection is the ratio of obsidian artifacts relative to other lithic materials. It is preferable that obsidian constitute at least 50 percent, and ideally, a greater proportion of the excavated assemblage. It is suggested that if obsidian was the preferred material for production of stone implements, it will be a better temporal indicator than if it is the rare (or exotic) material present at the site, because it would be used more consistently through time. This element becomes less critical for sites with a higher density of lithic artifacts overall; for even with a low ratio of obsidian to other lithic materials, the absolute number of obsidian specimens may be adequate for the analyses.

Another factor considered in site selection relates to the extent to which comparisons of hydration readings can be made between the sites. Temperature is known to have a significant effect on the hydration rate of obsidian (Friedman and Smith 1960; Friedman and Trembour 1983; Michels 1973; Trembour and Friedman 1984). Furthermore, variation in elevation is known to affect atmospheric temperature. The solar aspect of site exposure and other microenvironmental factors also affect the temperature of the local environment. Therefore, it is important to account for variations between sites when inter-site comparisons are attempted. In order to address this factor, both air and soil temperature data was gathered for the study area and from nearby weather stations. This information is summarized and presented in Tables 1 and 2, and in Figures 5 and 6 (Chapter 2). Site-specific temperature data will eventually be available from thermographs emplaced at the individual study sites.

Although the sites lie primarily within the range of 365 to 1295 meter (1200 to 4240 feet) elevations, they share similar (generally southerly) exposure and thermal cover provided by the forest canopy. Therefore, it is possible to maintain sufficient control of the temperature variable. That variation which cannot be controlled in site selection will be taken into account in the analysis of hydration results.

Another consideration applied to site selection was the presence of identifiable cultural components, as suggested by other types of archaeological evidence. For example, excavations and subsequent lithic analyses at some sites, provided evidence for multiple components at each site, primarily indicated by the density distribution of lithics (Spencer 1987; Bergland 1987; Jenkins and Churchill 1987). Obsidian hydration data are used to evaluate the validity of these components as presently defined. Similarly, sites currently "dated" through association with "temporally-diagnostic" projectile points (cf. Minor et al. 1987:41-50) could have their occupational histories revised as well.

Of the 47 test-excavated sites, 28 were rejected from further consideration due to the limited limited collections or the low density of cultural materials. Collections from five other sites are currently being used for other archaeological investigations. Of the remaining 14 sites, six were selected which were best-suited to the research objectives outlined above. The sites chosen for study and pertinent geographical information are provided below.

Representativeness of Study Sites

This research sample is typical of the site location pattern throughout the Forest (Winkler 1984; Nissley 1987). For example, Nissley's correlation indicates that the highest frequencies of known for sites are associated with ridgetops, saddles, streamsides, and benches. Sites

Table 6. Study sites and selected geographic attributes.

Site Name/Number	Topographic Setting	Elevation (meters)	General Solar Aspect
Tombstone Summit 35 LIN 341	Ridgeline Saddle	1295	Southeast
Dane Saddle 35 LIN 320	Midslope Spring	1190	South
Monument Peak 35 LIN 342	Ridgeline Saddle	1130	South
Lost Prairie 35 LIN 322	Riverside Terrace	1020	South
Soda Fork II 35 LIN 230	Midslope Spring	945	South
Yukwah 35 LIN 118	Riverside Terrace	365	South

occurring near cold springs or on terraces are also well represented. Nissley's study also provides information on the distribution of sites through four forest zones (1987:17), which are defined primary by elevation and slope aspect following Franklin and Dyrness (1973). Most sites are recorded in the Pacific Silver fir zone in the 3501 to 5500 foot (1065 to 1675 meters) elevation range, while 26 percent occur below 3500 feet.

Furthermore, the majority of the known sites are located on flat areas with generally southerly aspects. Therefore, when compared with the general WNF data base analysis, the sites selected for study here exhibit the same dominant environmental characteristics as the majority of known sites on the Forest.

While the open lithic sites in this area are seemingly simple and rather redundant in cultural content, they actually display a wide range of variability in terms of size, depth, artifact density, and lithic material type ratios (see Table 7).

Table 7. Selected archaeological attributes of study sites.

Site	Estimated Size (m^2)	Maximum Depth (cm)	Extrapolated Density (Lithics/m^3)	Frequency of Obsidian(%)
Tombstone Summit	7000	120	63	85
Dane Saddle	4500	110	42	100
Monument Peak	2500	60	92	35
Lost Prairie	15000	120	70	97
Soda Fork II	3000	85	30	79
Yukwah	20000	175	130	50

However, the sites incorporated in this study do not display this full range of variability, because sites with very low densities of cultural material or low ratio of obsidian were intentionally avoided.

Obsidian Sample Selection

Following the selection of the study sites and in recognition of the variation between the individual deposits, it was clear that the obsidian sample from each site would differ both in terms of absolute numbers of specimens and distribution within the stratigraphic matrices. Given the primary objectives of evaluating the stratigraphic integrity and identifying cultural components of the individual sites, it seems justifiable to tailor the the obsidian sample to the characteristics of the particular deposits.

In order to evaluate stratigraphic integrity and identify the presence of multiple components, Thomas Origer (personal communication, 1988) recommends taking five (source-specific) specimens from two separate excavation levels (one shallow, one deep) of a single excavation unit. As opposed to a simple random selection or a stratified sample of specimens from each unit, this method may provide greater control of obsidian source variability (i.e., chemical composition). This assumes that artifacts from a single excavation level are most closely associated with a discrete period of time, and that the prehistoric peoples may have preferred or used the obsidian from one distinct source at a particular time. A sample drawn randomly from all the levels might exhibit too much variability in obsidian source (and thereby hydration readings) to allow for a meaningful evaluation of the data.

Origer's approach may be best suited to sites (or excavation units) with a moderate depth and density of lithic materials. However, in sites with deep and relatively dense deposits (e.g., Yukwah, Lost Prairie, Dane Saddle), a larger sample was desired (at least 10 percent of the obsidian recovered from the excavation unit). Additionally, at the deeper and most dense sites, Yukwah and Lost Prairie, the sample was taken from more than two excavation levels. In contrast, at Monument Peak, where the deposit is relatively shallow and obsidian is less prevalent, it was not possible to obtain five obsidian artifacts from two distinct levels. Therefore, specimens were selected from all excavation levels which yielded obsidian, in frequencies relative to those exhibited by the deposit. The deposit at the Soda Fork site also warranted a modified selection process. Here the obsidian specimens below Level 5 (i.e., 55 to 85 cm) all proved to be too small to submit for the analyses; therefore, specimens were taken from Levels 2 through 5. Tables 7 through 12 display the distribution of all lithic artifacts for each site and obsidian alone by level, as well as the provenience of specimens selected for the sample.

It was expected that by developing a sample which reflects the actual frequency of obsidian in the deposit, as well as other intricacies of the sites, a more accurate assessment of the stratigraphic integrity will be obtained. A minimum of 10 percent of the obsidian from each excavation unit was examined, as well as the minimum of ten per site/unit as recommended by Origer (personal communication, 1988). This should provide a fairly representative sample from each excavation unit. If multiple components are present at the sites the range of hydration rim measurements should reflect this.

Site Locations and Descriptions

35 LIN 118 (Yukwah) occupies most of a 15-acre terrace on the north bank of the South Santiam River about 10 kilometers (6 miles) east of Cascadia Cave (Newman 1966) (see Figure 14). Nearby, the historic Santiam Wagon Road once passed, which is believed to have followed existing Indian trails (Guminski et al. 1983). Located an elevation of about 365 meters (1200 feet) above sea level, this is the lowest in elevation of the study sites. It is associated with the Western Hemlock climax zone as defined by Franklin and Dyrness (1973), and is dominated by an overstory of Douglas-fir, western hemlock and western redcedar, and an understory of red alder, vine maple, big-leaf maple, Pacific dogwood, huckleberry, Oregon grape, and bracken fern.

The site area receives about 100 inches (254 cm) of precipitation annually, primarily in the form of rain. Although site-specific temperature data is not yet available, mean temperatures typical of this plant associations setting range from slightly below freezing to around 20 degrees Celsius (70 degrees Fahrenheit), slightly warmer than the higher elevation sites.

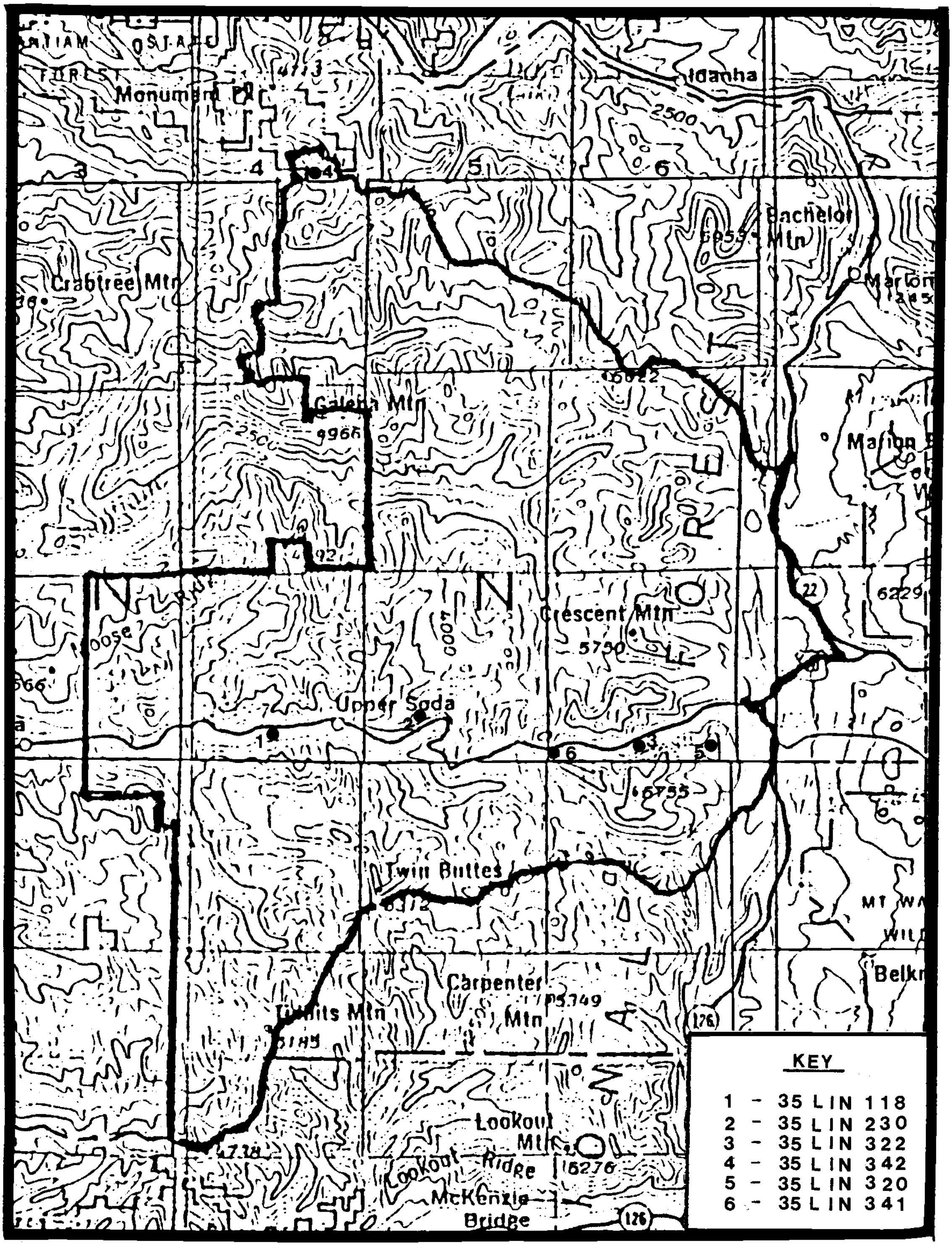


Figure 14. Location of six study sites. Map adapted from USGS State of Oregon (original scale 1:500,000).

Soils at Yukwah are classified as Landtype 75 (Legard and Meyer 1973) and are generally a deep non-plastic landtype derived from alluvial, glacial outwash and glacial till. The soils are thin loams and sandy loams. The site's stratigraphy reveals unbedded uniform, tan to gray brown, silty fine sand overlying a dense, well-compacted layer of rounded gravels and cobbles at a depth of about 150 cm. Geologically, this appears to be a point bar or flood plain deposit overlying stream bed gravels (Shank 1984).

Excavations at the Yukwah site revealed that it consists of a light to moderately dense lithic deposit of obsidian (50 percent), CCS (40 percent), basalt (6 percent), and unidentified (3 percent) lithic tools (15 percent) and debitage occurring to a depth of 175 cm. Tool classes include bifaces (complete and fragments), unifacially retouched artifact, utilized flakes, and one core (Lindberg-Muir 1984). Density of cultural material was found to vary across the site with a maximum of $371/m^3$ recovered from the 1x1 meter test unit located near the northeast end of the terrace. A few (seven) unidentifiable bone fragments and a hammerstone were also recovered.

A detailed lithic analysis was also performed on the Yukwah assemblage (Spencer 1987). Two temporal components are suggested with similar patterns of use. The earlier period of use represented by Levels 9-17 reflects a greater use of obsidian than the later component (Levels 1-8) where CCS dominates. Furthermore, the deeper component yielded more biface thinning flakes but fewer tools and preforms, suggesting lighter use of the site. Spencer suggests that the presence of specialized unifacially retouched tools sets the deeper component apart from the upper component. A broader range of artifact types were recovered from the upper levels (1-8) of the deposit; biface tools are more prevalent, and unifacially retouched scrapers absent.

The two complete projectile points recovered from the site are small, leaf-shaped obsidian, resembling a diminutive "Cascade-type" which Spencer proposes were probably manufactured "sometime in the last 6900 years" (1987:74). This point type is commonly attributed to the Early Archaic period, 6000 to 9000 BP (Minor et al. 1987). The points were recovered from Level 1 and Level 10 of distinct excavation units; that is, they are separated stratigraphically by one meter of sediment.

The specimens selected for obsidian hydration analysis include ten flakes from Level 3 (25 to 35 cm), ten flakes from Level 8 (75 to 85 cm), and ten specimens from five levels below 95 cm constitute the sample for Yukwah. (It was not possible to obtain ten artifacts from any one level below 95 cm due to small flake size and low frequencies in these levels.)

Table 8. Yukwah (35 LIN 118). NE 1x1m unit lithic frequencies and obsidian sample distribution.

Level		Total Lithics	Obsidian	Sample
Duff:	0-5 cm	0	0	
1:	5-15 cm	25	8	
2:	15-25 cm	54	20	
3:	25-35 cm	46	19	10
4:	35-45 cm	62	25	
5:	45-55 cm	62	21	
6:	55-65 cm	54	23	
7:	65-75 cm	76	35	
8:	75-85 cm	53	23	10
9:	85-95 cm	64	37	
10:	95-105 cm	44	29	1[a]
11:	105-115 cm	33	17	
12:	115-125 cm	20	12	
13:	125-135 cm	25	9	3
14:	135-145 cm	13	7[b]	4
15:	145-155 cm	12	5[b]	1
16:	155-165 cm	4	1	
17:	165-175 cm	2	1	1
Total		649	292	30

[a]Obsidian biface (3-210)

[b]Mostly very small flakes (less than 1.0 cm)

35 LIN 230 (Soda Fork Way Trail II) is a lithic scatter consisting of two concentrations of debitage located on small knolls on either side of a cold spring. The site lies midslope on the southeast side of a broad southwest trending ridge surrounded by hummocky, gently sloping terrain. The site is named for an historic (early Forest Service) trail, the Soda Fork Way Trail, which passed nearby.

The Soda Fork site lies at an elevation of 945 meters (3,100 feet) above sea level within the Western Hemlock climax zone (Franklin and Dyrness 1973). The canopy, formed by a combination of Douglas-fir, western redcedar, and western hemlock, is fairly dense. Vine maple, red alder, rhododendron, salal, western swordfern, and a sparse cover of herbs and grasses constitute the understory vegetation. The climate here is slightly cooler and wetter than Yukwah primarily because of the site's higher elevation. Yet, it is still mild enough to be classified as big game winter range.

The soils are designated as Landtype 231 and are derived primarily from residuum and colluvium (Legard and Meyer 1973). Surface soils are thin gravelly loams; subsoils are also thin gravelly loams and clay loams. Bedrock is composed of breccias and tuffs. The site stratigraphy appears to be consistent with this designation with decomposing bedrock occurring about at 75 cm below surface.

Excavations revealed a moderately dense deposit, composed of obsidian (79 percent) and CCS (21 percent) artifacts, including two obsidian preforms, a CCS biface fragment, and one obsidian scraper (Lindberg-Muir 1983a). The cultural deposit reached a depth of 85 cm, although the density dropped off markedly below 50 cm. No cultural strata were visible, but densities peaked in Levels 1 and 3 when averaged across the various excavation units. The Soda Forks site may have functioned as a seasonal hunting camp, as suggested by the tool assemblage. One obsidian preform (3-147) is fairly complete and roughly leaf-shaped with the suggestion of a broad-stemmed base. This style is temporally equated with the Middle Archaic period, 2000 to 6000 BP (Minor et al. 1987), yet was recovered from the surface of the undisturbed forest floor.

Ten obsidian artifacts were selected for analysis from the 2x2 meter data recovery unit on the west knoll. This unit was excavated to a depth of 95 cm and yielded 68 lithics, 64 of which are obsidian. Specimens were drawn from four contiguous intermediate levels (2 to 5) in numbers relative to their occurrence in the archaeological deposit.

Table 9. Soda Fork Way Trail II (35 LIN 230). West 2x2m lithic frequencies and obsidian sample distribution.

Level	Total Lithics	Obsidian	Sample
Duff: 0-5 cm	2	1	
1: 5-15 cm	0	0	
2: 15-25 cm	12	12	2
3: 25-35 cm	15	22	3
4: 35-45 cm	17	17	3
5: 45-55 cm	8	8	2
6: 55-65 cm	2	2[a]	
7: 65-75 cm	2	2[a]	
8: 75-85 cm	1	1[a]	
9: 85-85 cm	0	0	
Total	68	64	10

[a]Very small flakes (less than 1.0 cm)

35 LIN 322 (Lost Prairie West) is located about one kilometer (0.6 miles) west of Lost Prairie, a natural meadow where according to historic lore, Andrew Wiley and his party of scouts became lost while pioneering the route of the Santiam Wagon Road (Figure 14). Hence, the site acquires its name by association with Lost Prairie. The Santiam Wagon Road is still evident along the northern margin of the site (Farque' 1981). The Wagon road's association with pre-existing Indian trails is well-documented (e.g., Guminski et al. 1983).

The Lost Prairie site lies just east of the Old Cascades crest at an elevation of 1005 meters (3350 feet). It occupies the river terrace and a small knoll on the north bank of Hackleman Creek, a Class I tributary, which flows east into the McKenzie River drainage. Subsurface evidence indicates that the site extends across the creek, and occupies some part of the smaller terrace on the south bank. The site falls within the Pacific Silver Fir climax zone (Franklin and Dyrness 1973) and supports relatively sparse vegetation consisting of huckleberry, beargrass, and vine maple, and a fairly open canopy of Douglas-fir and western hemlock. The climate is considerably cooler than the lower elevation sites previously discussed, but drier, perhaps due to the rainshadow effect of the Old Cascades crest.

Soils (SRI landtype 66) are derived from volcanic ejecta and glacial till. They are further characterized by thin sandy loams as surface soils and thicker gravelly/cobbly sandy loams as subsoils (Legard and Meyer 1973). Archaeological excavations revealed sediments very similar to those encountered at Yukwah. That is, the soils are light and sandy, uniform and unbedded, to a depth of about one meter, where a dense, compact layer of rounded gravels and cobbles is encountered.

Exploratory test excavations and intensive surface survey (with duff removal) indicate that the site is about 100 by 150 meters in size, but could be much larger. Obsidian lithics dominate the assemblage with densities ranging from $15/m^3$ to $208/m^3$. The assemblage consists largely of debitage, primarily small finishing flakes, one ovate obsidian biface, two fragments of larger obsidian bifaces, and several utilized or slightly modified flakes.

The 18 specimens submitted for hydration analysis and XRF source identification were obtained from the 1x2 meter excavation unit in the southerly portion of the site near Hackleman Creek. A sample of six specimens was taken from each of three separate levels (3, 7, and 10).

35 LIN 342 (Monument Peak Trail One) is located on a ridgeline saddle just south of the major divide which separates the North Santiam drainage from the Quartzville/ Middle Santiam drainage (Figure 14). To the north small

Table 10. Lost Prairie West (35 LIN 322). 1x2 meter unit frequencies and obsidian sample distribution.

Level	Total Lithics	Obsidian	Sample
Duff: 1 cm	0	0	
1: 0-13 cm[a]	19	18	
2: 13-23 cm	8	8	
3: 23-33 cm	11	11	6
4: 33-43 cm	16	15	
5: 43-53 cm	20	20	
6: 53-63 cm	17	16	
7: 63-73 cm	19	19	6
8: 73-83 cm	19	19	
9: 83-93 cm	6	6	
10: 93-103 cm	12	12	6
11: 103-113 cm	4	3	
12: 113-123 cm	2	2	
Total	153	149	18

[a]Leveling-level; Unit on slight slope.

springs and wet meadows form the headwaters of Thomas Creek. To the south lie the steep canyons of Elk and Canal Creeks.

Unfortunately, as much as 50 percent of the site was destroyed as a result of road construction some 30 years ago. Remnants of the Gates-Quartzville wagon route (Forest Maps 1913, 1920) are evident to the northeast of the site in the undisturbed timber stand. Some trees have been harvested from the extant portion of the site, resulting in little significant disturbance to the surface soils, but apparent alteration of the composition of the understory vegetation.

The Monument Peak (Trail One) site lies at an elevation of 1130 meters (3700 feet) above sea level, within the Pacific Silver Fir climax zone (Franklin and Dyrness 1973). The canopy is moderately dense, comprised of western hemlock and Douglas-fir, as well as a few grand fir. The understory is primarily rhododendron and huckleberry with a ground cover which includes beargrass, bunchberry, lupine, lousewort, and other species in lesser amounts. This vegetative pattern is indicative of cool, but comparatively dry climatic conditions (Hemstrom et al. 1985).

The soils are fairly typical of a ridgeline setting, in that they are shallow and rocky. Designated as Landtype 641 (Legard and Meyer 1973), surface soils are brown gravelly, sandy loams giving way to darker more gravelly or cobbly loams. A compact gravelly light yellow-brown substratum of decomposing andesite and basalt parent rock is encountered around 50 cm depth.

Evaluative test excavations conducted at the Monument Peak site indicated a rich cultural deposit of moderate depth (60 cm). A variety of lithic materials and artifacts were obtained from intact subsurface and disturbed surface components. The site is distinctive in that it has yielded a sample of large core tools and exotic types of CCS, tool types and lithic materials not usually found at sites in this area. Obsidian is present as well, comprising about 35 percent of the subsurface collection (and 45 percent of the surface collection).

A detailed lithic analysis of the Monument Peak assemblage suggests that the assemblage reflects a "full-spectrum of CCS reduction but only intermediate to late stage reduction for basalt and obsidian" (Bergland 1987:13). Several of the obsidian artifacts exhibit modification consistent with the refurbishing of exhausted or broken tools, perhaps with later site occupants recycling the discarded remains from an earlier occupation. Debitage densities "hint at a dual component site" (1987:13), perhaps a temporary residential camp or resource processing station. Thermal alteration is evident on 25 percent of the CCS specimens obtained from subsurface sediments. This evidence compliments field observations of a burned horizon (5 to 10 cm thick) present in Levels 1 and/or 2 just below the humus rich A horizon of the test units concentrated near the center of the excavated area of the site. Most likely this is the result of a fairly intense naturally occurring fire, although cultural significance cannot be ruled out. Cultural material is present above, below, and within the burned horizon.

A sample of ten obsidian specimens from the Monument Peak Trail One 1x1 meter unit were submitted for XRF and hydration analyses. Due to the comparatively low frequency of obsidian and limited depth of the archaeological deposit, one to five specimens were drawn from four contiguous excavation levels, roughly in proportion to the absolute frequency of obsidian per level. This constitutes a sample of 35 percent of the obsidian, 12 percent of all lithics, recovered from the 1x1 m unit. Given the site's westerly location, it will be interesting to identify the source(s) of obsidian used at the site.

Table 11. Monument Peak Trail One (35 LIN 342). 1x1 meter unit lithic frequencies and obsidian sample distribution.

Level	Total Lithics	Obsidian	Sample
Duff: 1 cm	1	0	
1: 0-19 cm[a]	14	8	2
2: 19-29 cm	32	14	5
3: 29-39 cm	14	4	1
4: 39-49 cm	17	3	2
5: 49-59 cm	3	0	
Total	81	29	10

[a]Leveling-level; Unit on slight slope. (Burned horizon occurs between the end of Level 1 and the top of Level 2, about 15-25 cm below surface.)

35 LIN 320 (Dane Saddle) lies to the east of the Old Cascades crest at an elevation of 1190 meters (3900 feet) above sea level. The area of interface between the Old Cascades and the more recent High Cascades is characterized by gentle terrain, small lakes, and meadows. The site offers an impressive view of the Three Sister com-

plex and Mt. Washington to the southeast. It is situated below a major saddle in a broad basin with a southerly aspect. A reliable cold spring is central to the site; a confluence of two Class III streams forms about 150 meters south of the site.

The vegetation of the Dane Saddle site, and surrounding area, is characteristic of the Pacific Silver Fir climax zone (Franklin and Dyrness 1973). Douglas-fir, Pacific silver fir, noble fir, western hemlock, and Engelmann spruce are present in the overstory. Vine maple, bracken fern, bear grass, prickly currant, trailing blackberry, salmonberry, huckleberry, twinflower, and Dogwood bunchberry contribute to the understory. However, the native vegetation composition is presumed to have been altered significantly by previous (1973) tractor logging through and around the site. Although this was a "partial cut", compaction and pedoturbation to depths of 20 to 30 cm over about 75 percent of the surface area of the site have resulted from the tractor activity (Cole 1986). Generally, areas immediately surrounding the remaining standing trees are unaffected by the disturbance.

The soils in the area are classified as Landtype 66 (Legard and Meyer 1973), technically the same as those at Lost Prairie West. The nonplastic soils are derived from volcanic ejecta and glacial till. Surface and subsoils consist primarily of damp, sandy-gravelly loams with occasional large boulders and varied amounts of smaller subangular gravels and cobbles present throughout the matrix.

Evaluative test excavations demonstrated that considerable intact deposits exist below the disturbed horizon to a depth of 110 cm. The assemblage collected from site excavation consists entirely of obsidian lithics, including one biface fragment and several utilized flakes. No evidence of cultural stratigraphy was apparent in the soil profiles. Like Yukwah and Lost Prairie, the soil matrix appears unbedded and uniform, except for a general increase in gravels and rock with depth. The 1x1 meter unit was terminated in a dense layer of compacted gravel and cobble.

The obsidian sample submitted for XRF source identification and hydration analysis was derived from the 1x1 meter test unit located about 35 meters northeast of the spring. Twelve (10 percent) of the lithics from this unit comprise the sample, six each from Levels 2 and 7. These results will provide a preliminary indication of the integrity of the deposit, as well as the potential for multiple components. It may also be possible to ascertain the temporal relationship between this site and the Lost Prairie West site, located about 4 kilometers (2.5 miles) to the northwest at a slightly lower elevation.

Table 12. Dane Saddle (35 LIN 320). NE 1x1 meter unit lithic frequencies and obsidian sample distribution.

Level		Total Lithics	Obsidian	Sample
Duff:	1 cm	0	0	
1:	0-10 cm	0	0	
2:	10-20 cm	10	10	6
3:	20-30 cm	13	13	
4:	30-40 cm	16	16	
5:	40-50 cm	24	24	
6:	50-60 cm	14	14	
7:	60-70 cm	17	17	6
8:	70-80 cm	14	14	
9:	80-90 cm	4	4	
10:	90-100 cm	6[a]	6[a]	
11:	100-110 cm	2	2	
Total		120	120	12

[a]Mostly very small flakes (less than 1.0 cm), Levels 8-11.

35 LIN 341 (Tombstone Summit) is located in a major ridgeline saddle at Tombstone Pass, part of the divide between the South Santiam and McKenzie drainages (see Figure 14). The Pass provides an opening through the crest of the Old Cascades, and as such, was used by the indigenous peoples, by early settlers as the route of the Santiam Wagon Road, and presently as the route of State Highway 20. This most recent transportation development is estimated to have obliterated as much as 50 percent of the archaeological site.

Tombstone Summit lies at an elevation of 1260 meters (4240 feet) above sea level which places it within the

Pacific Silver Fir forest zone (Franklin and Dyrness 1973). A combination of old-growth Douglas-fir, western hemlock, and true fir compose the canopy. The balance of vegetation includes rhododendron, trailing blackberry, huckleberry, Prince's pine, wild rose, and twinflower, as well as other less conspicuous species. The Pass is commonly cold and wet, as weather fronts tend to back up against the crest and release their moisture. Low clouds and fog often cling to the ridges and mountains of the Old Cascades crest.

Soils are classified as Landtypes 13 and 61 (Legard and Meyer 1973), derived from glacial, colluvial, and residual processes. Surface soils are thin gravelly loams, and subsoils are thicker gravelly loams. Weak to moderately compacted till occurs intermittently in this landtype. Depth to bedrock is generally at least 3 meters.

Excavations in 1983 indicated a lithic-dominated assemblage of variable intra-site density to a depth of 120 cm. The assemblage is predominantly obsidian (87 percent) with the balance of artifacts of CCS and basalt manufacture. Debitage constitutes the major class of artifacts, although bifaces, modified/utilized flake tools, three projectile point fragments, and a core tool were also recovered (Lindberg-Muir 1983b). A lithic analysis performed on the collection suggested that the site was probably a seasonal/temporary camp with tool manufacture (or maintenance) the primary activity represented in the assemblage (Hoard and Harvey 1984). The distribution of lithics through the depths of the deposit suggests that two components may be represented at the site with a low density break around Levels 7 and 8.

Ten specimens were selected from Unit A (1x1 m), representing 17 percent of the obsidian from the unit. The sample was taken from two levels (2 and 10) in groups of five, in order to obtain an assessment of stratigraphic integrity and potential components, as discussed previously.

Table 13. Tombstone Summit (35 LIN 341). Unit A 1x1 meter lithic frequencies and obsidian sample distribution.

Level		Total Lithics	Obsidian	Sample
Duff:	1 cm	0	0	
1:	0-10 cm	1	1	
2:	10-20 cm	13	13	5
3:	20-30 cm	10	7	
4:	30-40 cm	6	4	
5:	40-50 cm	1	0	
6:	50-60 cm	9	7	
7:	60-70 cm	2	1	
8:	70-80 cm	3	3	
9:	80-90 cm	6	6	
10:	90-100 cm	9	7	5
11:	100-110 cm	5	5	
12:	110-120 cm	4	4	
	Total	69	59	10

In summary, by selecting a sample of at least 10 percent of the obsidian artifacts recovered from a single excavation unit at each site, hydration values are used to assess: 1) the stratigraphic integrity of individual excavation units; 2) the potential for single or multiple episodes of occupation represented at each site; and 3) the temporal associations among the sites, in terms of relative ordering, accounting for expected variations in EHT at the individual site locations. Chemical composition is controlled by obtaining source determinations through XFR analysis for each obsidian specimen. The results of this study will be evaluated in terms of the methodology employed and recommendations for continued research made.

Obsidian Analyses

Obsidian analyses of the sample of 90 specimens of artifactual obsidian from six sites in the central Cascades study area were made possible through a U.S.D.A. Purchase Order issued by the Willamette National Forest (WNF) to the Sonoma State University Academic Foundation, Inc. Obsidian hydration rim measurement (HRM) was accomplished at the University's Obsidian Hydration Laboratory under the direction of Thomas M. Origer. X-ray flourescence (XRF) chemical characterization was conducted by Richard E. Hughes, Senior Research Archaeologist, affiliated with the same institution. Details of the respective laboratory analyses (and the results) are presented in the letter reports provided in Appendices C and D. These reports furnish a discussion of the methodologies applied, and a general explanation of the resultant data (Hughes 1988b; Origer 1988b).

The data derived from these technical analyses provide valuable insight into aspects of archaeological research in a forested upland environment. In this study, the data are applied to the understanding of the stratigraphic integrity of the archaeological deposit, and the nature of temporal components. While XRF spectrometry is requisite to hydration analysis applications, it also provides important information regarding the prehistoric procurement of obsidian. Recognition of numerous primary and secondary sources of obsidian in the area (Skinner 1983, 1986) precludes the assumption of homogeneous chemical composition of artifactual obsidian in these sites. Although Obsidian Cliffs glass is a prevalent component of artifact assemblages in the few sites which have been the subject of obsidian fingerprinting, artifacts from several other sources have appeared in upland sites in the area (cf. Hughes 1986b, 1986c, 1988a).

Data Analysis

Results of the XRF analysis (Hughes 1988b) provide the first reported data of this nature for this study area. These data are evaluated in terms of the geologic sources represented in the sample as a whole, as well as at the individual sites. A preliminary assessment of obsidian procurement in this area is suggested, and compared with similar data from adjacent regions of the Cascades.

The following questions guide the evaluation of the hydration data at each site, in terms of the primary research goals.

1. Are the hydration rim measurements (HRM) consistent with the principle of superposition whereby levels associated with thinner hydration rim measurements overlie levels with thicker HRM?

2. Are there clusters of HRM which might represent distinct temporal components, or a range of HRM which might reflect a continuum of prehistoric occupational episodes?

3. Are there anomolies among the hydration values which might be explained through complimentary archaeological evidence?

Various exploratory data analysis techniques were applied in the evaluation of the hydration data (Origer 1988b). Basic descriptive statistics (i.e., range, mean, and standard deviation) are used to characterize the source-specific hydration rim measurements (HRM) of the entire sample, as well as the individual site samples. The range of HRM is interpreted as an indication of a site's span of occupation, while the means provide an indication of the temporal ordering of the sites. The standard deviation affords a measure of the dispersion of the HRM around the mean, and thereby an estimation of the homogeneity of the data (Dixon and Massey 1983). For example, if the sample represents a discrete, or brief occupational episode, the standard deviation will be quite small.

Bivariate scatter plots were prepared for each site in order to visually evaluate the stratigraphic integrity of the particular excavation units. The individual graphs for each site depict source-specific hydration values (y-axis) by excavation level (x-axis). The stratigraphic integrity of the excavation units sampled at each site is assessed following the concept of "net stratigraphic value" introduced by Michels (1969). The term refers:

> to the degree to which the superimposed subdivisions of the... deposit...accurately reflect the order of cultural succession. Tests of superposition, artifact mixing, and artifact reuse contribute information that can be used to measure the degree to which contrasts in cultural content between deposition units represent valid stratigraphy.
>
> (Michels 1969:15)

The degree of overlap of hydration values in different stratigraphic levels is interpreted as a measure of stratigraphic integrity. However, a certain range of variation of HRM is expected among artifacts of the same age (Origer 1982; Raymond 1985; Scott et al. 1986).

In order to compare the net stratigraphic value of the particular sites, best-fit least-squares regression lines were plotted through the site-specific scattergrams following Michels (1969). The resultant regression line expresses the central chronological tendency of each deposition unit. The degree of slope of the trend line is interpreted as a reflection of the long-term chronological patterning of the unit. The greater the positive slope of the trend line, the greater the unit's tendency toward superposition (Michels 1969:16). The correlation coefficient statistic (r) provides an indication of how well the data fit the regression line. The means of HRM in individual levels are also used an an estimate of the stratigraphic value of the excavation unit. A unit with reliable stratigraphy should exhibit level mean HRM which increase with depth.

The hydration data from the individual sites are also used to make inferences about the occupational histories of the sites. The range of HRM reflects the temporal span of site use. That is, the site which exhibits a wide range of HRM is assumed to have experienced a longer history of occupation (or several discrete occupational episodes) than the site with a narrow range of HRM represented.

A population of flakes created during a distinct occupational event should exhibit a narrow distribution of HRM which is approximately normal (Raymond 1985). Thus, multiple occupations may be indicated by the clustering of HRM around more than one discrete value. Whereas a tight clustering of HRM around a single value may represent a discrete occupational episode (i.e., a single component site).

Box and whisker plots provide a useful method of exploratory data analysis for visually evaluating the normality of a particular distribution of values (Raymond 1985). These are used to assess the site-specific samples, as well as subsets (e.g., levels), in terms of occupational episodes. In this way the data can be manipulated in order to isolate discrete temporal units (Michels and Bebrich 1971; Fredrickson 1984; Raymond 1985). The assessments of site occupational histories presented herein is considered preliminary in that the sample drawn from each site is not necessarily representative of the entire deposit.

Anomalies which appear among the obsidian hydration data have also been considered in this analysis. These are individual HRM or patterns of hydration values which appear to be inconsistent with associated HRM or other archaeological evidence. An attempt has been made to offer alternative explanations derived from other sources of information (e.g., geological).

Additionally, preliminary analysis of inter-site variation of HRM is attempted. However, the limited understanding of temperature (EHT) variation in this area, combined with our current inability to determine the hydration rate for local obsidians (especially Obsidian Cliffs glass), allows only tentative comparisons among the sites at this time. Finally, recent hydration and XRF data are presented from two other local open-lithic sites. These data are discussed in terms of the results of the current study. Recommendations are made for continued application of the obsidian hydration method in this area of the Cascades of Oregon.

CHAPTER 6

RESULTS AND DISCUSSION

In the discussion which follows, the results of the obsidian analyses are evaluated in terms of the research objectives advanced in Chapter 1. Two primary questions have directed this research project:

1. What degree of stratigraphic integrity is possessed by open lithic upland sites in the study area?

2. What is the nature of temporal components or occupational episodes represented at these sites?

Prior to an examination of the results on a site-specific basis, a few general observations have been made on the basis of the data as a whole.

XRF Results

A total of six distinct obsidian sources are represented in the sample (Hughes 1988b) (Figure 15). Four of the sources are "unknown"; that is, the chemical profiles of the specimens (n=5) did not correlate with any known geochemical types of obsidian contained within Hughes' comparative data base. They are also distinct from the

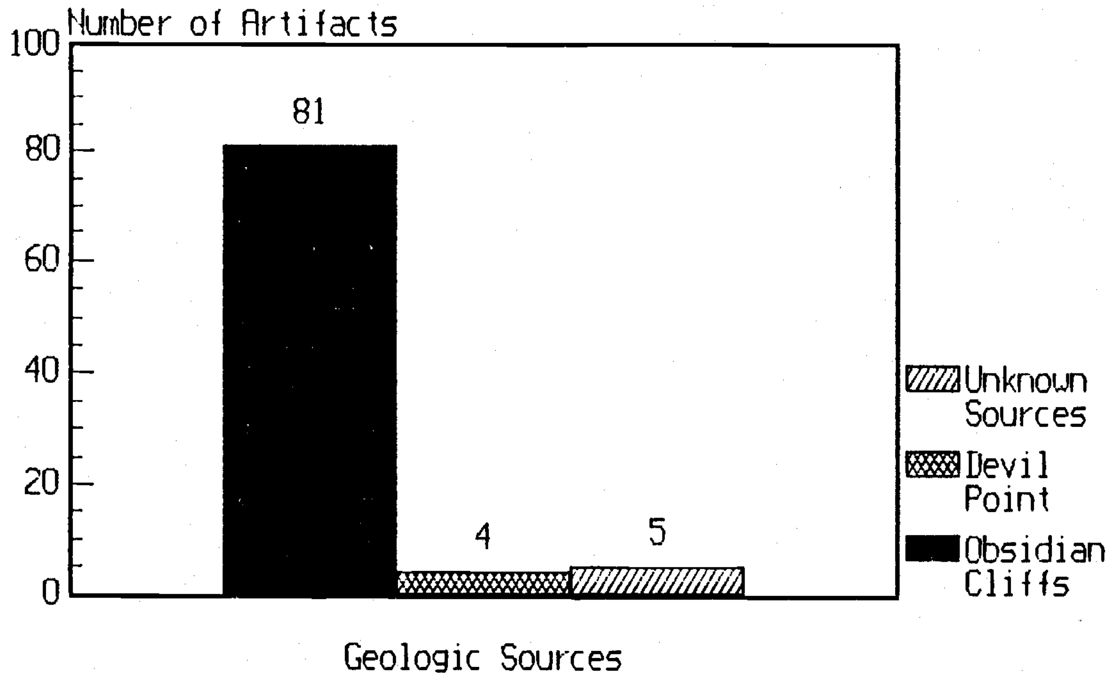


Figure 15. Geologic sources of obsidian artifacts from the six study sites (n=90).

unknown sources represented at the Colt and Saddle sites (35 LA 599, 35 LA 529) to the south (Craig Skinner, personal communication, 1988). Figure 16 provides a visual representation of the differentiation among sources when two trace elements, Zirconium (Zr) and Strontium (Sr), are plotted against each other. The six distinct sources represented in the sample can be fairly easily identified. Quantitative concentrations of several trace elements are generally correlated to identify geologic sources (Hughes 1986a).

Four specimens in the sample match the trace element profile of Devil Point obsidian. This source and prehistoric quarry site is located north of the study area in southeast Marion County about 9.6 km (6 miles) northwest of Mt. Jefferson at an elevation of 1555 meters (5,100 feet) (see Figure 9). Limited geologic work to date indicates almost exclusively rocks of basaltic to andesitic composition in the immediate area of Devil Point; the occurrence of rhyolitic obsidian is unexpected. The geologic history of the area is as yet incompletely known, however, and the soil and vegetative cover make it difficult to determine whether this is a primary or secondary obsidian source (Skinner 1988).

The two study sites where Devil Point obsidian occurs are 33.6 km (21 miles) west (Monument Peak) and 51.2 km (32 miles) southwest (Yukwah) of the source. The Devil Point source was only recently recognized (Parrella 1980), and characterized (Hughes 1986b), so little is

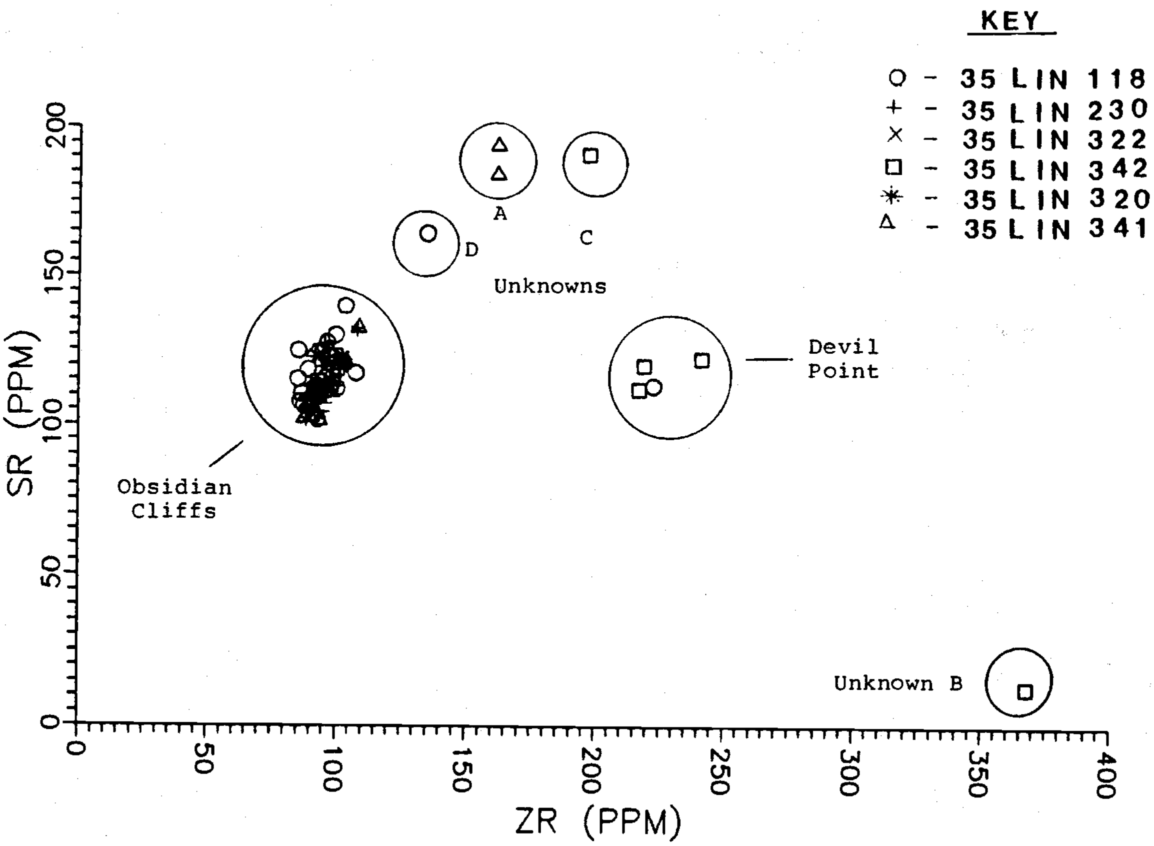


Figure 16. Scatter plot of XRF trace element data for obsidian specimens from Obsidian Cliffs, Devil Point, and four unknown sources. These trace element pairs graphically differentiate the distinct sources.

known archaeologically of the spatial and temporal distribution of this glass. However, it has been identified at several archaeological sites in the North Santiam drainage (Hughes 1986b, 1988a), but is so far absent at sites in drainages to the south. Apparently limited in its regional distribution, Devil Point obsidian may eventually prove useful in tracing subsistence-settlement patterns of local prehistoric peoples.

Results of the XRF analysis demonstrate that 90 percent of the obsidian sample correlates with the chemical composition of the Obsidian Cliffs flow (Hughes 1988b). This is perhaps not surprising, considering the proximity of the source to the study area (see Figure 9). However, with numerous obsidian sources potentially available to prehistoric peoples (Skinner 1986), the predominance of Obsidian Cliffs glass is significant.

The Obsidian Cliffs source is located at an elevation of 1830 meters (6,000 feet) about 4.8 km (3 miles) west-northwest of the summit of the North Sister in the Three Sisters Wilderness, 29 to 67 km (18 to 42 miles) from the study site. Originating near the base of the North Sister, the flow extends for 2.4 km (1.5 miles) and culminates in prominent cliffs some 70 to 90 meters high (Skinner 1983). Although the exact age of the flow is not unknown, it most certainly dates to the late Pleistocene.

Obsidian Cliffs glass has been identified at many sites in the Cascades (Hughes 1986b, 1986c, 1988a;

Sappington 1986), as well as parts east (Sappington 1982), and west (Sappington 1985; Toepel and Sappington 1982) of the range. However, obsidian samples from McKenzie and Willamette River gravels exhibit trace element configurations (esp. Rb, Sr, and Zr) identical to that of the Obsidian Cliffs flow (Hughes 1988a; Skinner 1986). Therefore, it cannot be assumed that all artifactual obsidian was obtained directly from the primary source, but may have been acquired from these secondary sources as well.

Site-specific obsidian source utilization is demonstrated in Figure 17. Again, the dominance of Obsidian Cliffs glass is obvious. By arranging the data according to the distance of the sites from Obsidian Cliffs, the proximity of the site to the source is reflected in the prevalence of glass in the assemblage. The distance-decay model (cf. Renfew 1977) compares the quantity of Obsidian Cliffs glass at a particular site as a function of the distance from the geological source (Figure 18). In that only six sites are represented, little interpretation is possible. However, the regression line (fall-off curve) supports the expectation that the frequency of Obsidian Cliffs glass is greater at sites closer to the geologic source. Undoubtedly, other factors besides air-distance from the source have influenced its distribution (cf. Fredrickson 1987). It will be interesting to determine if source data from other local sites support the trend indicated by this data set.

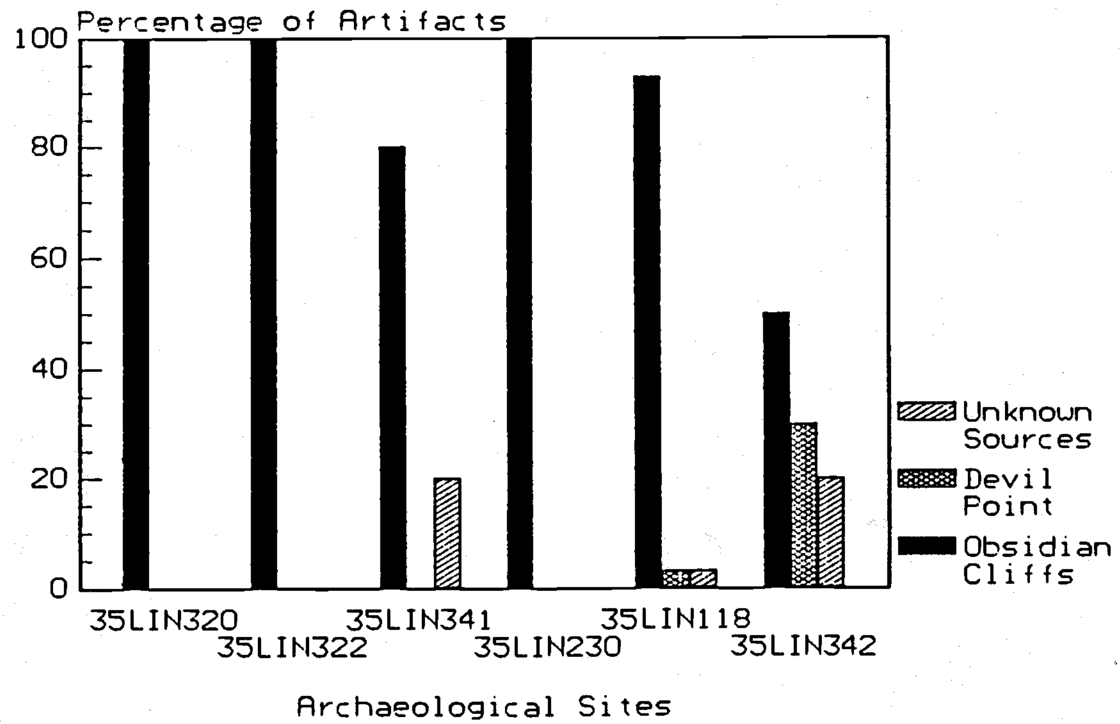


Figure 17. Frequency of geologic obsidian sources at individual study sites. Site 35 LIN 320 is most proximate to Obsidian Cliffs, while 35 LIN 342 is most distant.

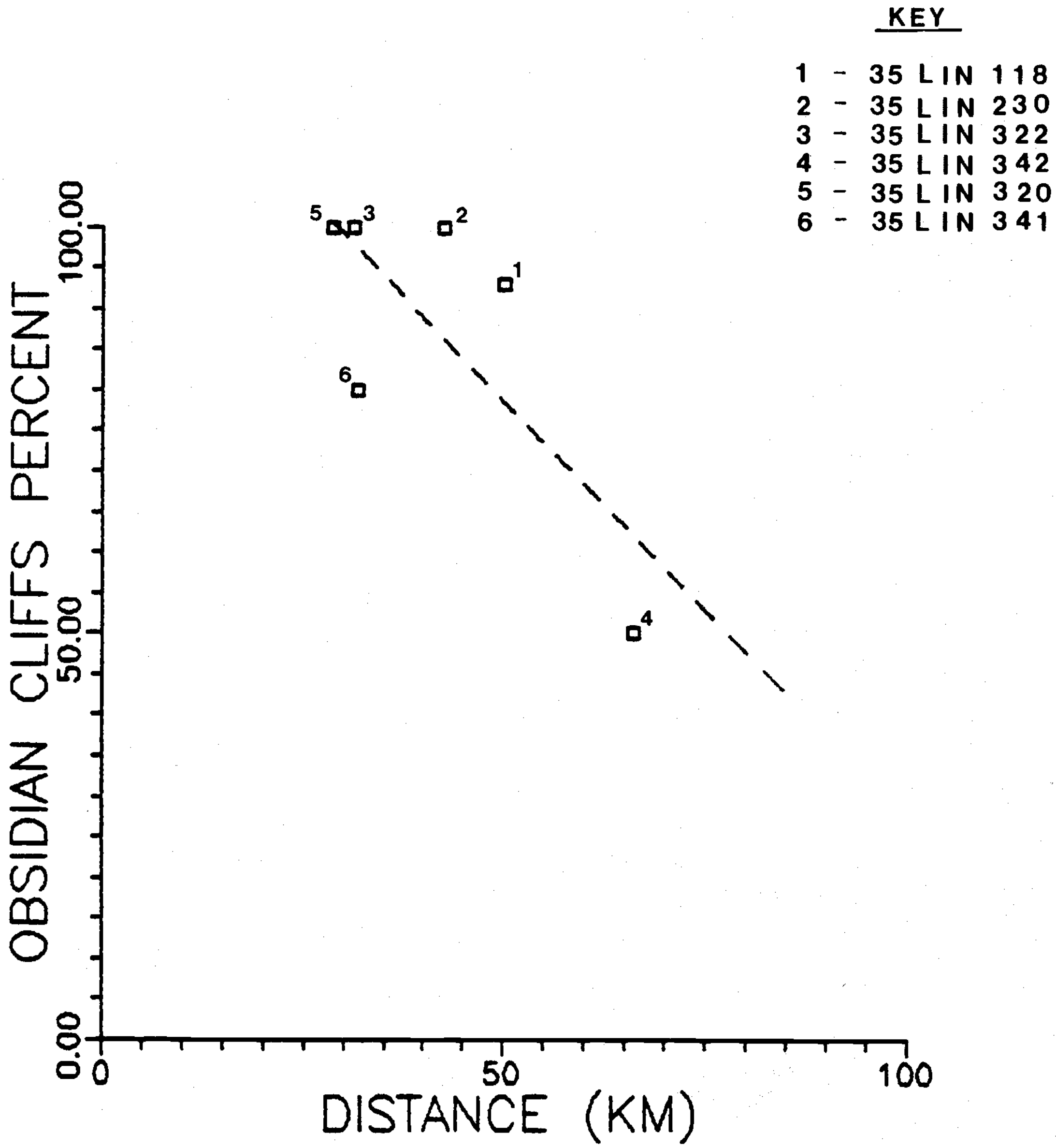


Figure 18. Distance-decay model (Renfrew 1977) for the Obsidian Cliffs flow employing XRF data from six study sites.

Aside from the archaeological implications of Obsidian Cliffs volcanic glass being dominant in the current sample, this situation greatly facilitates the interpretation of the associated hydration data. Considering only one chemical variety of obsidian reduces the need to make assumptions about differential hydration rates of distinct sources of obsidian. This in turn eliminates one potential source of error in the evaluation of hydration data, while focusing on other variables such as site settings and temperature.

Hydration Results

The data generated by hydration analysis (Origer 1988b) have been evaluated in several ways. Little comparable data from local sites exist, so this study provides some baseline information on the range of hydration values which might be expected in this area. The distribution of hydration rim measurements (HRM) of Obsidian Cliffs specimens from the six study sites (n=81) is presented in Figure 19. The sample exhibits a range of 1.1 to 5.8 microns (discounting one of two measurements from specimen MP-1-1, which is believed to be a flake resulting from the rejuvenation of an older artifact). Eighty-four percent of the Obsidian Cliffs specimens measured between 2.0 and 4.0 microns; the mean value for the Obsidian Cliffs specimens is 2.9 microns. The histograph suggests that obsidian deposition generally reflects Middle Archaic site occupation with relatively

Microns	Number of Specimens
5.9 - 6.0	
5.7 - 5.8	X
5.5 - 5.6	
5.3 - 5.4	X
5.1 - 5.0	X
4.9 - 5.0	X
4.7 - 4.8	
4.5 - 4.6	
4.3 - 4.4	X
4.1 - 4.2	XX
3.9 - 4.0	XXX
3.7 - 3.9	XXX
3.5 - 3.5	XXXXXX
3.3 - 3.4	XXXXXXXXX
3.1 - 3.2	XXXX
2.9 - 3.0	XXX
2.7 - 2.8	XXXXXXXXXX
2.5 - 2.6	XXXXXXXXXX
2.3 - 2.4	XXXXXXXXXXXXX
2.1 - 2.2	XXX
1.9 - 2.0	XXXX
1.7 - 1.8	
1.5 - 1.6	X
1.3 - 1.4	X
1.1 - 1.2	XXXX
less than 1.0	

X = one specimen
n = 81

Figure 19. Histograph of total sample of artifacts correlated with the Obsidian Cliffs source (n=81). Eighty-four percent of the specimens exhibit hydration rims of 2.0 to 4.0 microns.

Range of sample: 1.1 - 5.8 microns
Mean of sample: 2.9 microns

few HRM indicative of particularly early (greater than 6.0 microns) or especially late (less than 2.0 microns) occupations. This remains a tentative estimate of site ages in that no corroborative dates are available for the sites, nor has an obsidian hydration curve yet been established for this area. Nonetheless, this seems to be a safe assessment based on comparison with obsidian curves elsewhere (cf. Fredrickson 1987; Huberland 1987).

Examination of site-specific hydration data sets (Table 14) indicates that each site exhibits a distinct range and mean of HRM, reflecting the unique occupational histories of the individual sites. In the table below, sites are ordered beginning with the lowest elevation setting (35 LIN 118) and proceeding to the highest elevation (35 LIN 341).

If the sites are assumed to be single component deposits, the mean may be taken as a measure of their relative ages. Relative ages suggested by mean HRM alone, without adjustment for temperature/elevation or other possible variables indicate that Yukwah (35 LIN 118) is the most ancient, while Monument Peak (35 LIN 342) is most recent. These mean HRM values could be a function of sample size, temperature, or other variables. More definitive evaluation must be based on these factors.

Table 14. Summary of site-specific hydration values in microns (Obsidian Cliffs glass only).

Site Number	Sample Size*	Range	Mean	Standard Deviation
35 LIN 118	28/30	2.2-5.8	3.6	0.8
35 LIN 230	10/10	2.3-3.8	3.1	0.6
35 LIN 322	18/18	1.3-2.8	2.4	0.3
35 LIN 342	5/10	1.2-2.6	1.8	0.6
35 LIN 320	12/12	1.1-3.6	2.6	0.8
35 LIN 341	8/10	1.6-3.1	2.3	0.5
Total	81/90	1.1-5.8	2.9	0.9

*Number of Obsidian Cliffs specimens/total number of specimens in sample.

Site 35 LIN 118: Yukwah

Of the obsidian sample (n=30) analyzed from Yukwah, twenty-eight (93 percent) of the specimens were characterized as Obsidian Cliffs glass, while one each were assigned to Devil Point (Y-3-10) and an unknown D (Y-14-2) source. Hydration rim measurements from specimens correlated with Obsidian Cliffs exhibit a range of 2.2 to 5.8 microns, and a mean of 3.6 microns. This site displays the greatest range of HRM of the study sites, perhaps indicative of the longest span of occupation.

The mean HRM values for individual excavation levels at Yukwah increase with depth of deposit and demonstrate a general conformity with the principle of superposition. The regression line also supports this trend (Figure 20), although the r-value is indicative of a weak correlation. The ranges of HRM by level also suggest that the deposit

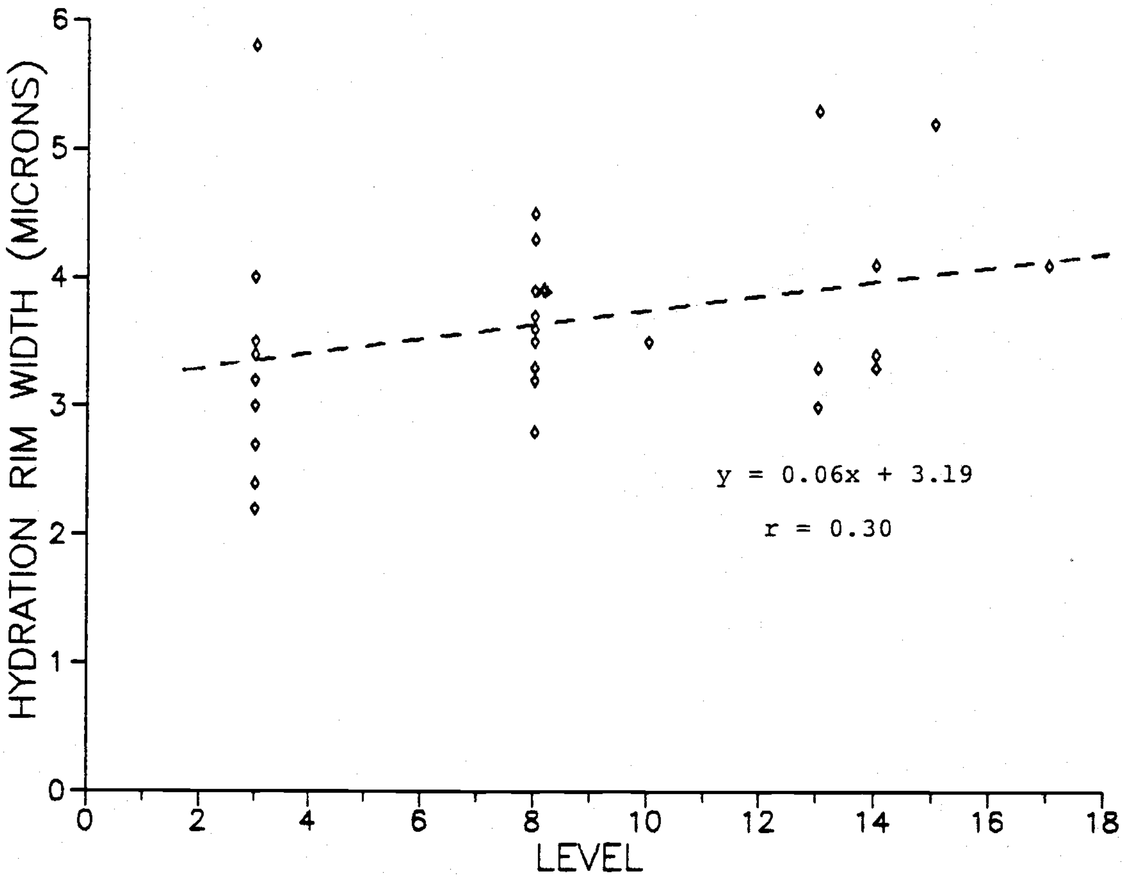


Figure 20. Scatter plot of Yukwah (35 LIN 118) Obsidian Cliffs hydration values (n=28) against the deposition units from which the artifacts were recovered. Units are arbitrary 10 cm levels.

Table 15. Summary of Yukwah Hydration Data (35 LIN 118).

Level:Depth	Sample	Range	Mean	Standard Deviation
3: 25-35 cm	9	2.2-5.8	3.4	1.1
8: 75-85 cm	10	2.8-4.5	3.7	0.5
3+8: 25-85 cm*	19	2.2-5.8	3.5	0.8
13-17:125-175 cm*	8	3.0-5.3	4.0	0.9
Total Sample	27	2.2-5.8	3.6	0.8

*The lower levels have been combined due to the small sample derived from individual levels at these depths. Specimen Y-10-1, a small biface from Level 10, has not been included in the tabulation as it may represent an event distinct from the activities which produced the debitage which constitutes the remainder of the sample.

is not completely consistent with the principle of superposition, and some mixing is suggested by the distribution of HRM throughout the deposit.

While some of the disparity of HRM within the individual levels may be attributable to post-depositional disturbance (or mixing), a certain range of variability is expected even among artifacts of the same approximate age, as previously discussed (cf. Origer 1982; Raymond 1985; Scott et al. 1986). A population of obsidian flakes created during a distinct occupational event should exhibit a narrow distribution of HRM which is approximately normal. While the hydration data from Yukwah appear to represent a fairly normal distribution, it seems unlikely that this span of hydration values is representative of a single occupational episode. The data are more indicative of a continuum of events over a prolonged period of time, or several distinct but successive occupations.

As a test of the presence of two temporal components at Yukwah suggested by Spencer (1987), the data have been divided accordingly. Combining Levels 3 and 8 to represent the upper, more recent component, and the lower levels (13-17) to form the lower component, the subsets are evaluated to determine the degree to which each represents a normal distribution (Table 15). In this case, the box and whisker plots (Figure 21) suggest that the sample from Yukwah (Plot e) is not normal, as indicated by the long whiskers. However, box plots of the subsets (Plots a-d) are more representative of a normal distribution, except for a single outlier (Y-3-8 which exhibits an HRM of 5.8 microns). Further manipulation of the data may allow the definition of two or more sets of hydration values which conform to a normal distribution and may be representative of distinct occupation periods.

On the basis of the distribution of hydration values in the Yukwah sample, it is tentatively suggested that two periods of more or less intensive use are represented. One cluster of HRM around 4.0 microns, and one around 3.4 suggest heavier site use around the time(s) represented by these values. Intermittent site use is suggested by the range of values occurring earlier (represented by 5.0 to 6.0 microns) and later (represented by 2.0 to 3.0 microns). The distribution of hydration values may

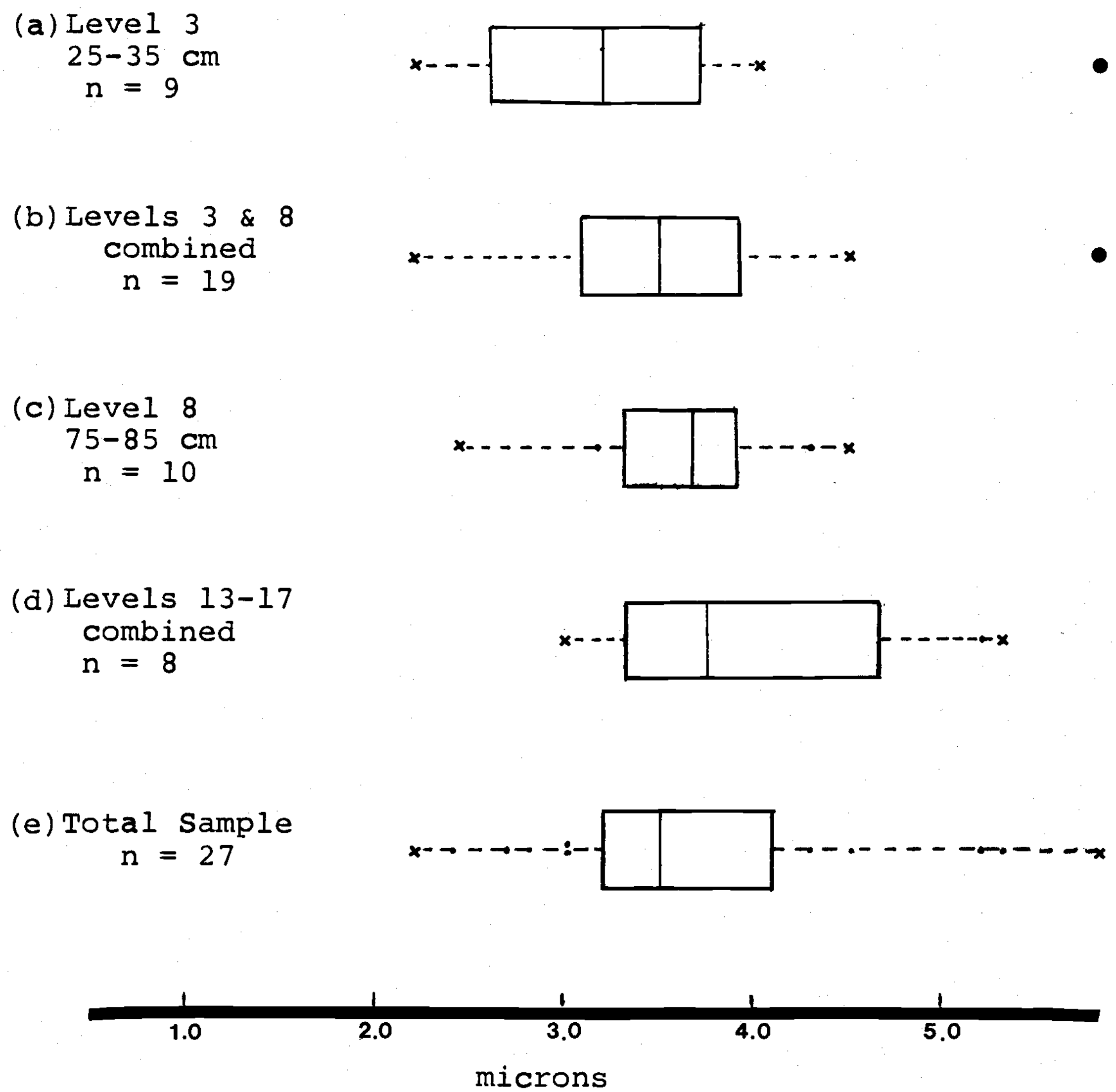


Figure 21. Box and whisker plots of Yukwah hydration values representing various subsets of the data which may represent distinct occupational episodes.

also be a function of the sample, in that not all levels of the deposit are represented. It would be interesting to compare the results from several sampling methods to determine if different distributions would be produced.

Site 35 LIN 230: Soda Fork Way Trail II

All ten specimens analyzed from the Soda Fork site were correlated with the Obsidian Cliffs flow. No specimens were analyzed from the lower levels (6 through 9) due to the small size (less than 1.0 cm) and lower frequency of flakes in those levels. Hydration values for the sample range from 2.3 to 3.8 microns; the mean is 3.1 and the standard deviation, (s), is 0.6 microns. Each level provides a discrete range of hydration values, but there is a distinct trend of decreasing HRM with increased depth (Figure 22). This is suggestive of reversed stratigraphy, contrary to the principle of superposition. The r statistic indicates a very strong correlation of the data with the regression line, as well.

Site excavations yielded no indication of disturbance, but there may be a geological explanation for this apparent inversion of the strata. The site area is characterized by hummocky terrain and is surrounded by some fairly steep side slopes above and to the east of the site. It is possible that the archaeological deposit could have been displaced by a slump-earth flow (a deep-seated, slow-moving rotational failure resulting in vertical and lateral displacement) (Fredriksen and Harr

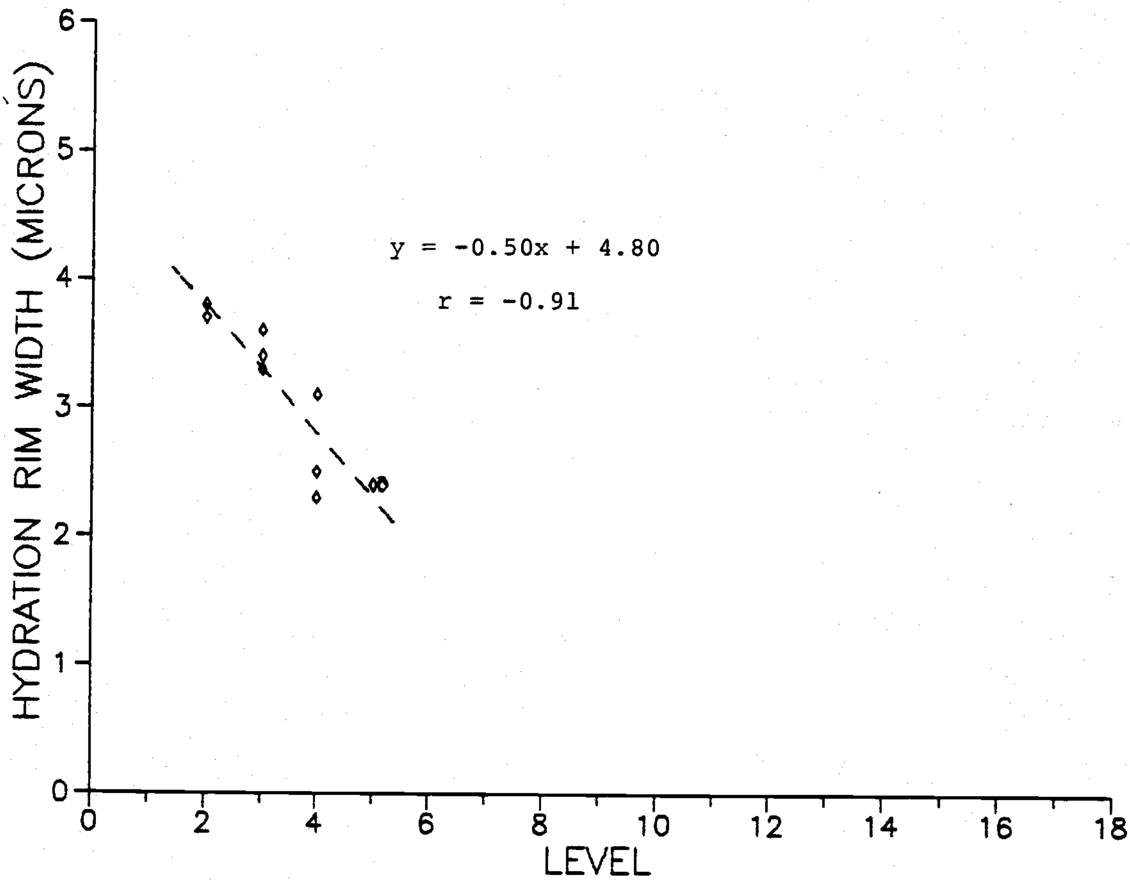


Figure 22. Scatter plot of hydration values against depositional level at Soda Fork Way Trail II site (35 LIN 230), (n=10).

Table 16. Summary of Soda Fork hydration data (35 LIN 230).

Level:Depth	Sample	Range	Mean	Standard Deviation
2:15-25 cm	2	3.7-3.8	3.8	0.1
3:25-35 cm	3	3.3-3.6	3.4	0.2
4:35-45 cm	3	2.3-3.1	2.6	0.4
5:45-55 cm	2	2.4	2.4	0
Total Sample	10	2.3-3.8	3.1	0.6

1979). Slumping of this nature is not uncommon in this land type (Legard and Meyer 1973) and has been previously recognized in this area (Douglas Shank, personal communication, 1988)

The hydration values cluster neatly with four specimens in the 2.3 to 2.5 micron range and the remaining six ranging 3.1 to 3.8 microns. This may represent two distinct occupational episodes, as each cluster forms a normal distribution with means separated by over one micron (Figure 23). This assessment is somewhat tentative, as a larger sample might bridge the gap between the two clusters of HRM. Nonetheless, the overall range of hydration values probably reflects a shorter span of occupation than what was indicated at the Yukwah site.

<u>Site 35 LIN 322: Lost Prairie West</u>

The total sample derived from the Lost Prairie site (n=18) correlated with the chemical composition of the Obsidian Cliffs source. Figure 24 displays the dis-

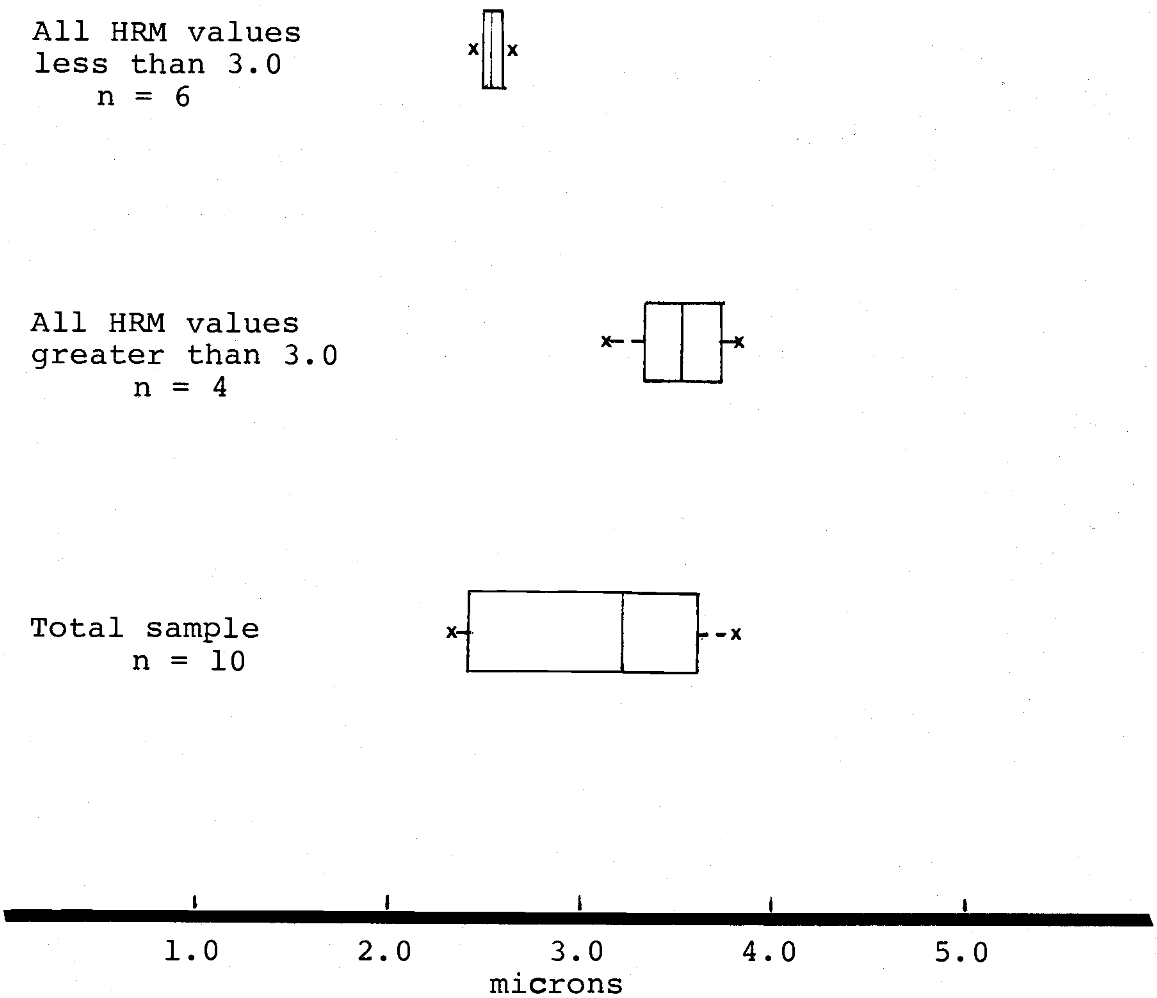


Figure 23. Box and whisker plots for Soda Fork hydration data.

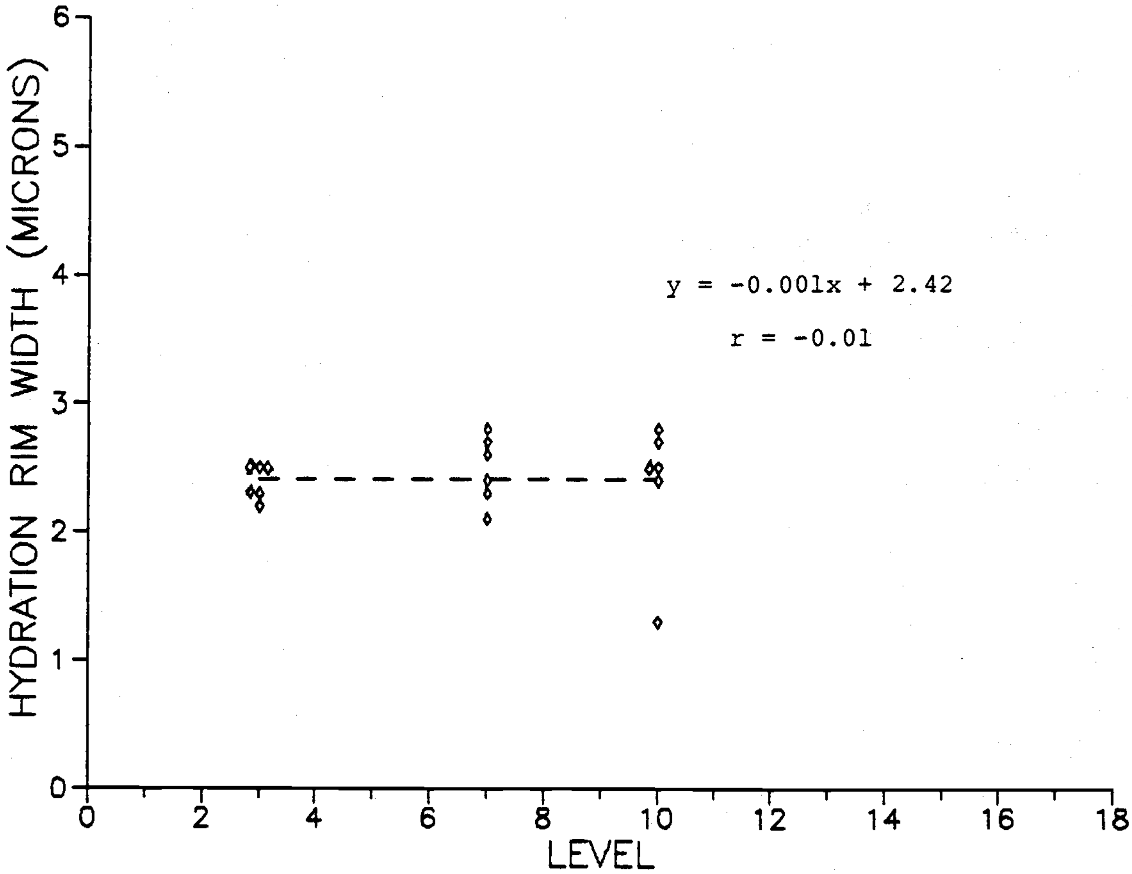


Figure 24. Scatter plot and best-fit regression line of hydration values against deposition level at Lost Prairie West (35 LIN 322), (n=18).

tribution of hydration values according to excavation level. The data exhibit a relatively narrow range of 2.2 to 2.8 microns, with the exception of one outlier (LP-10-3) with a low value of 1.3 microns in Level 10.

Table 17. Summary of Lost Prairie West hydration data (35 LIN 322)

Level:Depth	Sample	Range	Mean	Standard Deviation
3:23-33 cm	6	2.2-2.5	2.4	0.1
7:63-73 cm	6	2.1-2.8	2.5	0.3
10:93-103 cm	6	1.3-2.8	2.4	0.5
Total	18	1.3-2.8	2.4	0.3

If the low value is excluded, the level means would increase by 0.1 micron with increased depth in the deposit; however, with all HRM values considered, there is no significant difference between the level means. The internal consistency demonstrated by this site distinguishes it from the other study sites and provides strong evidence for a single temporal component at this site.

If this inference is valid, it presents interesting implications for the evaluation of the stratigraphic integrity of the site. That is, if the assemblage was deposited as the result of a single episode, what explanation might be offered for the depth of dispersal of the artifacts? Given the site's forested setting on a low river terrace subject to frequent flooding, the distribution of artifacts throughout over one meter of sediments may be a function of various pedoturbative processes (Wood and Johnson 1982).

Site 35 LIN 342: Monument Peak Trail One

At this site, five of the ten specimens in the sample are correlated with the Obsidian Cliffs source, three are of Devil Point origin, and two were assigned to two unknown sources (B and C). This factor of multiple obsidian sources, combined with archaeological evidence of fire, complicates the interpretation of hydration data from the Monument Peak site. It may not be possible to distinguish the influences of the these factors on hydration rim development from the depositional anomolies (Figure 25).

Nonetheless, it is significant in and of itself that four distinct obsidian sources are represented at 35 LIN 342, more than at any other site in the study. This is also the site most distant from Obsidian Cliffs. Furthermore, the site assemblage as a whole is dominated by non-obsidian lithics, including several varieties of CCS. The presence of such a wide range of lithic materials might suggest site use by peoples with comparatively far reaching cultural affiliations or procurement strategies. Perhaps the site is associated with travel as it is located on a major ridge system dividing the North and Middle Santiam River drainages. This issue may be clari-

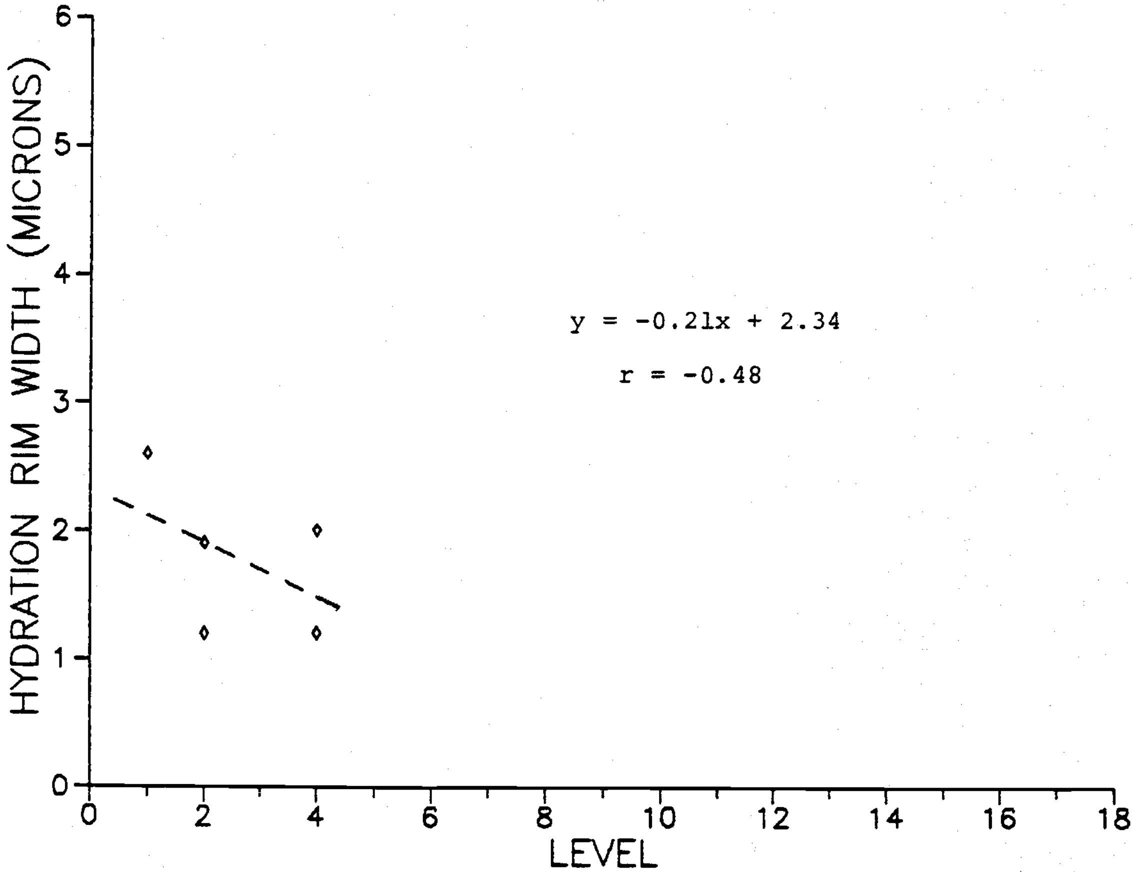


Figure 25. Scatter plot and best-fit regression line of hydration values and deposition level at Monument Peak Trail I (35 LIN 342. Graph includes Obsidian Cliffs specimens only (n=5).

fied through geological research directed toward identification and chemical characterization of the presently unknown sources of artifactual obsidian and CCS alike. Additionally, XRF analysis at other sites along this ridge system may confirm a pattern of multiple-source utilization associated with this potential travel route.

Table 18. Monument Peak Trail One (35 LIN 342) hydration data by source.

Source	Sample	Range	Mean	Standard Deviation
Obsidian Cliffs	5	1.2-2.6*	1.8	0.6
Devil Point	3	1.8-2.6	2.3	0.5
Unknowns B&C	2	4.3-4.9	4.6	0.4
All Sources	10	1.2-4.9	2.5	1.2

*Excludes second band measurement of 8.0 microns on specimen MP-1-1.

The results of the hydration analysis as summarized in Table 18 exemplify the potential for differential hydration rates of obsidians of distinct chemical compositions. The mean hydration values of the individual sources suggest that Obsidian Cliffs glass hydrates at a slower rate, while Devil Point hydrates slightly faster and the obsidian from the two unknown sources (B and C) hydrate at an even faster rate. This comparison of HRM assumes contemporaneous creation of the obsidian debitage which constitutes the sample, and does not account for the potentially distorting effect of fire. This pattern could be tested at other sites where multiple obsidian sources are represented.

The hydration analysis has not proven very useful at the Monument Peak site for the purposes of evaluating stratigraphic integrity and identifying temporal components (see Figure 25). Perhaps a portion of the site unaffected by the fire could be isolated and more reliable hydration data obtained.

The presence of two distinct hydration bands on specimen MP-1-1 measuring 2.6 and 8.0 microns is diagnostic of artifact reuse or rejuvenation. In this case, it is a debitage flake which may have been removed from an older tool, resulting in the development of a new hydration band on the ventral surface of the flake, as well as the freshly exposed surface of the refurbished artifact. This interpretation is consistent with Bergland's (1987) recognition of several refurbished obsidian artifacts within the assemblage at the Monument Peak Trail One site.

<u>Site 35 LIN 320: Dane Saddle</u>

The Dane Saddle site sample of twelve pieces of debitage correlated with the Obsidian Cliffs source. Hydration values range from 1.1 to 3.6 microns for the sample as a whole. This full range is reflected in the sample from Level 2 alone, while Level 7 evidences a smaller range of 2.6 to 3.4 microns. Examination of the scattergram for this site (Figure 26) reveals some overlap of hydration values between the two levels, although the smallest HRM are found in specimens from Level 2. The slope of the regression line is positive, but the r-statistic indicates a weak correlation. Nonetheless, the level means of the hydration values indicate that greater HRM tend to occur in the lower level. This suggests that the excavation unit has a tendency to conform to the principle of superposition, although some mixing is evident.

Table 19. Summary of hydration data at Dane Saddle (35 LIN 320).

Level:Depth	Sample	Range	Mean	Standard Deviation
2:10-20 cm	6	1.1-3.6	2.4	1.0
7:60-70 cm	6	2.6-3.4	2.9	0.4
Total Sample	12	1.1-3.6	2.6	0.8

When provenience of the particular specimens is disregarded, plotted hydration values cluster loosely around 3.0 microns suggesting the associated time period might be the period of the most extensive site use. A later, apparently less intense, occupation may have followed around the 1.1 micron temporal equivalent.

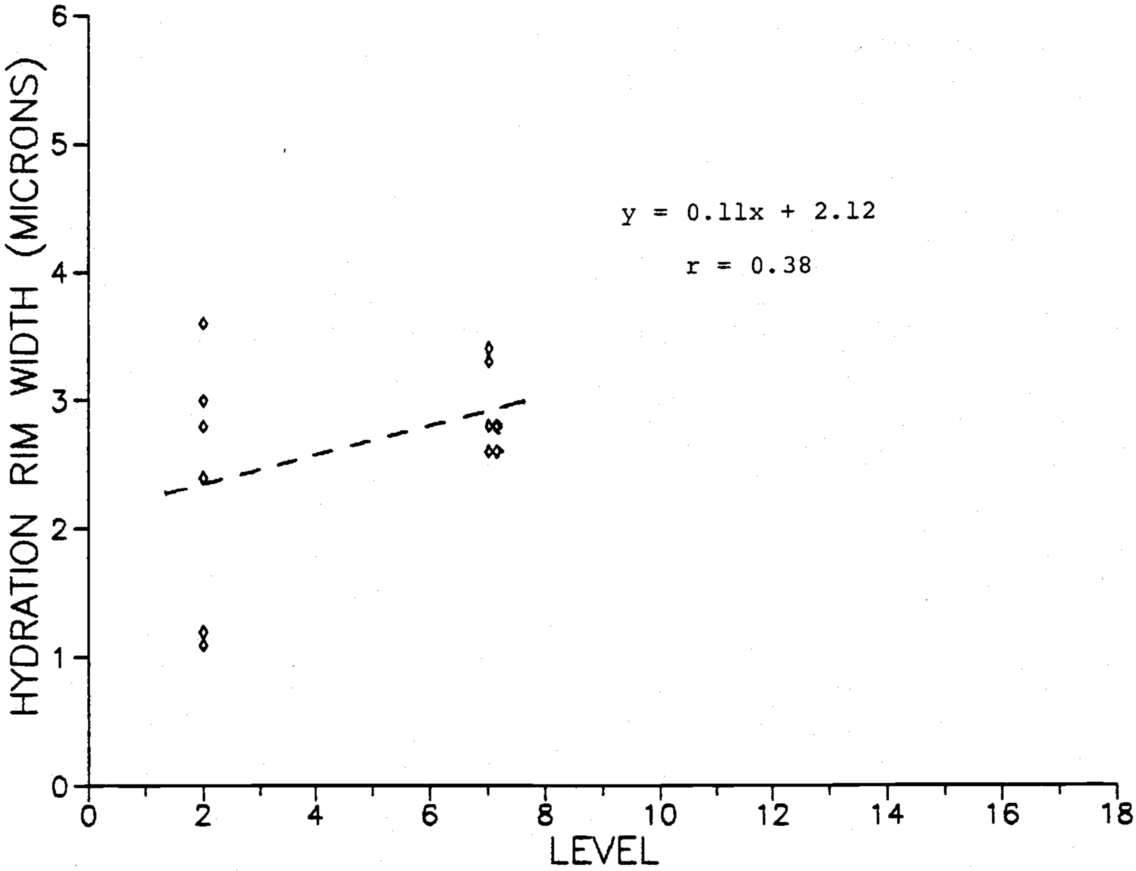


Figure 26. Scatter plot and best-fit regression line of hydration values and associated deposition levels at Dane Saddle (35 LIN 320). This sample consists of Obsidian Cliffs specimens (n=12).

Site 35 LIN 341: Tombstone Summit

Of the sample (n=10) analyzed from this site, Obsidian Cliffs was the source identified for 80 percent of the specimens. The remaining two flakes display chemical composition of a presently unknown or uncharacterized source (Hughes 1988b). Both specimens (TS-10-3, TS-10-5) were recovered from Level 10; neither provided HRM values because no hydration band was visible ("nvb") (Origer 1988b). Apparently the obsidian from this unknown source (A) hydrates much more slowly than Obsidian Cliffs glass. Specimens correlated with the Obsidian Cliffs source display a range of hydration values of 1.6 to 3.1 microns with no clear clustering of values.

Table 20. Summary of Tombstone Summit (35 LIN 341) hydration data (Obsidian Cliffs specimens only).

Level:Depth	Sample	Range	Mean	Standard Deviation
2:10-20 cm	5	1.6-2.4	2.1	0.3
10:90-100 cm	3	2.3-3.1	2.7	0.4
Total Sample	8	1.6-3.1	2.3	0.5

For the purpose of evaluating the stratigraphic value of this site/excavation unit, only Obsidian Cliffs specimens and their associated HRM are considered. Although some overlap of the hydration values between excavation levels is evident in the scattergram (Figure 27),

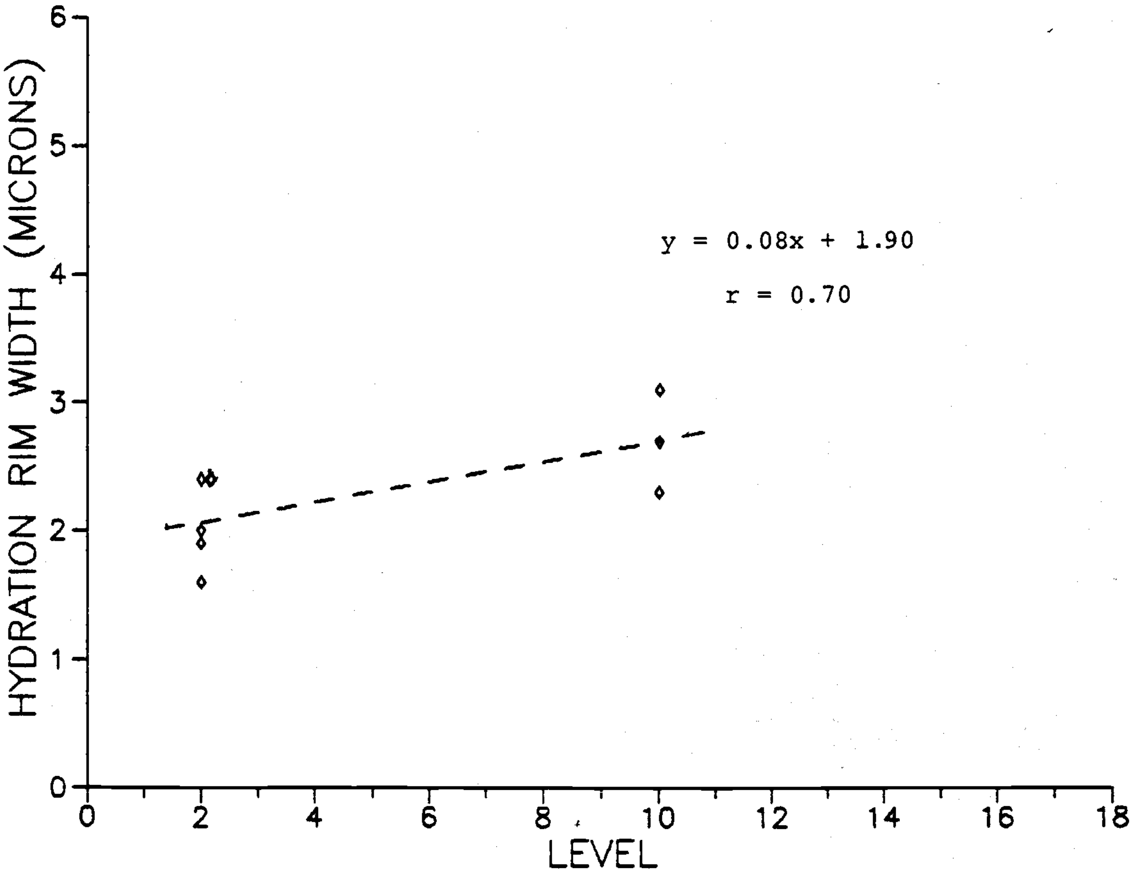


Figure 27. Scatter plot and best-fit regression line of hydration values and associated deposition levels at Tombstone Summit (35 LIN 341). Graph includes only Obsidian Cliffs specimens (n=8).

the regression line has a positive slope and the r-value supports the correlation. Generally greater HRM values occur deeper in the deposit (i.e., Level 10); although some mixing is apparent the deposit seems to conform with the principle of superposition. Additional hydration measurements of specimens in intermediate levels would enable a more confident assessment of stratigraphic integrity to be made.

The hydration data for the Tombstone Summit site provide no indication of distinct temporal components. A history of intermittent site occupation through the period of time represented by the 1.6 to 3.1 micron range is posited, although a larger body of hydration data may serve to refine this preliminary assessment.

Summary of Results

Application of XRF source identification and obsidian hydration analysis has provided meaningful insights into the nature of archaeological deposits in this area of the western Oregon Cascades. One of the most significant findings is the predominance of artifactual obsidian attributable to the Obsidian Cliffs flow (see Figure 16). At the six sites under study, the frequency of Obsidian Cliffs glass over other sources generally decreases with increased distance from the Obsidian Cliffs flow (see Figure 18). Future source determinations of artifactual obsidian from sites in this area may clarify the trends suggested by these data. The presence of four "unknown" sources in the data set supports the need for more extensive geologic studies of local and regional obsidian sources.

Obsidian hydration analysis has proven successful in evaluating the stratigraphic integrity of the six study sites. It is evident that some mixing of the deposit has occurred at these sites, as indicated by the degree of overlap of hydration values between distinct levels of the sample units. This situation is more pronounced at some sites (e.g., Yukwah) than others (e.g., Tombstone Summit).

In order to compare the "net stratigraphic value" of the individual sites, best-fit least-squares regression lines were plotted through the site-specific scatter diagrams (Michels 1969). The resultant regression line expresses the central chronological tendency of each deposition unit. The degree of slope of the trend line is interpreted as a reflection of the long-term chronological patterning of the unit; the strength of the relationship is indicated by the value of the correlation coefficient (r).

Among the study sites, Yukwah, Dane Saddle, and Tombstone Summit, all exhibit positive (though not steep) regression lines. The r-value at Tombstone Summit ($r = 0.70$) shows a strong correlation between the data and the regression line, while at Dane Saddle and Yukwah the correlation is weaker with values of 0.38 and 0.30, respectively. At Lost Prairie, the trend line is nearly flat (i.e., zero slope), and the r-value (-0.01) is indicative of a weak relationship. The Soda Fork site exhibits a definite negative slope, but a very strong correlation is suggested by the r-value (-0.91). The Monument Peak exhibits a negative trend, as well, but may be distorted by the effects of fire; the correlation indicated by the r-value (-0.48) is not particularly weak or strong.

In terms of identifying temporal components in these archaeological deposits, level provenience is temporarily disregarded. The range of hydration values has been used as a proxy measure of occupation span (Table 14). Box and whisker plots have also been employed to evaluate occupational histories (Figures 21, 23, and 28). It appears that the Yukwah site experienced the longest temporal span of occupation with the greatest intensity of use occurring in the timeframe represented by the 3.0 to 4.0 micron range. Lost Prairie, in contrast, exhibits a relatively narrow cluster of hydration values (2.5 ± 0.3 microns) suggesting a shorter use-history or single-component occupation for the site. The distributions of hydration values at the Dane Saddle, Soda Fork, and Tombstone sites may represent intermittent episodes of site use over time, with minor clusters perhaps representative of periods of more intensive occupation. The hydration data from Monument Peak has not been evaluated in terms of temporal components due to considerations previously mentioned.

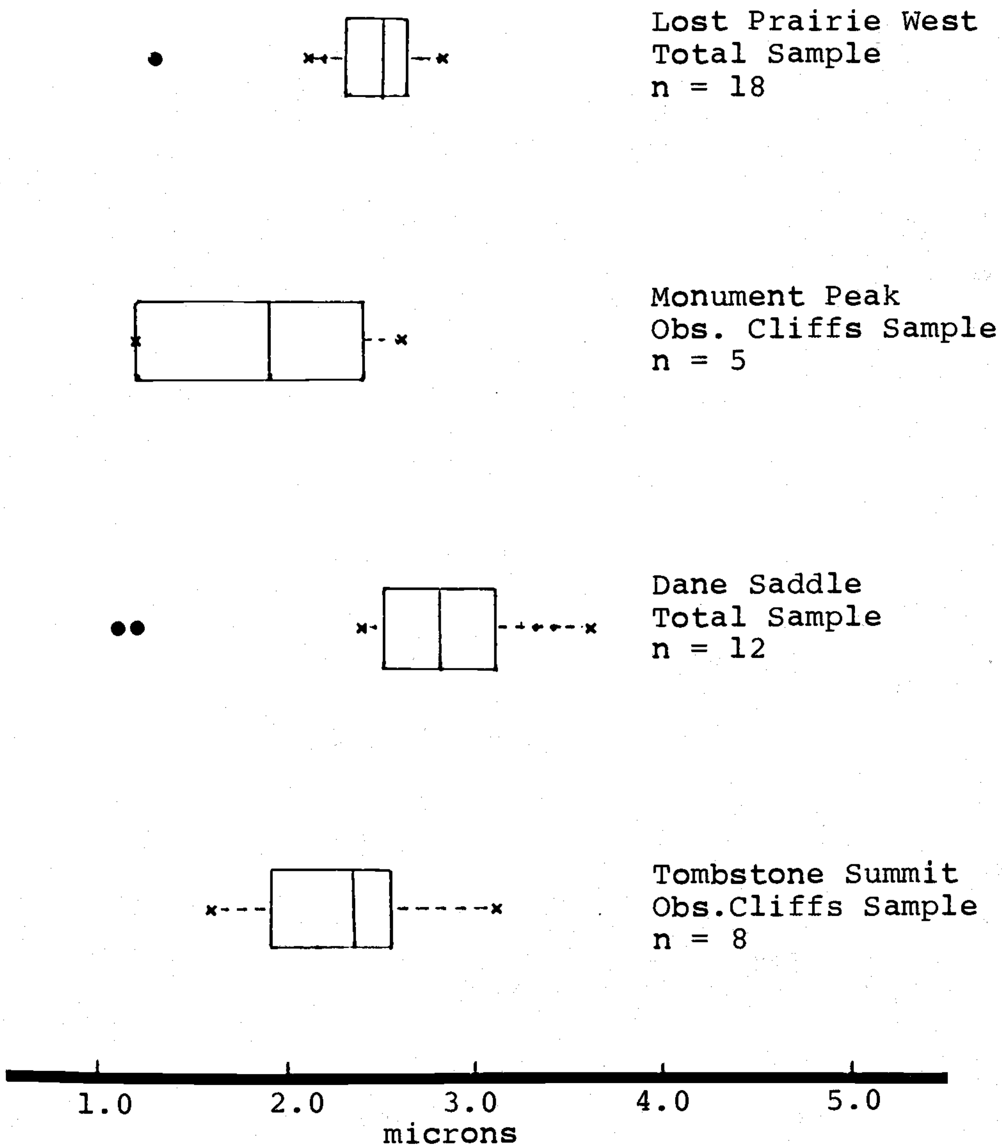


Figure 28. Box and whisker plots for Lost Prairie West, Monument Peak, Dane Saddle, and Tombstone Summit, providing a visual representation of the distribution of the site-specific hydration data, and allowing an evaluation of the normality of the distributions.

These hydration data have enabled a preliminary assessment of the temporal context of these sites. For a more accurate chronological interpretation, it would be important to devise a more representative sample of obsidian from the sites. While the controlled systematic sample employed in this study has been successful for the purpose of evaluating individual units, a more reliable representation of site chronology might be obtained through a random sample of the entire site assemblage.

Potential for Inter-Site Comparisons

The preceding discussion has focused on individual site-specific analysis and interpretation, and only the most general parallels have been drawn between sites. In order to directly compare individual sites in terms of "ages" represented by hydration values, it would be necessary to 1) assume climatic homogenity for the area, or 2) adjust for hydration rate differences caused by various temperature regimes. To operate under the first condition of assumed climatic homogenity may lead to inaccurate inferences of the temporal relationships of the sites. Estimations of site-specific effective hydration temperature (EHT) can be equally tenuous without specific knowledge of the hydration rate of the particular source of obsidian. The use of thermographs to determine actual EHT at the individual sites is the most reliable approach. It is also the most time consuming, as the instrument should remain in place for at least one full year to account for seasonal as well as diurnal variation. Ryan thermographs are being employed at the study sites, but these data are not yet available.

In order to examine the hydration data with respect to individual site climatic regimes, HRM are plotted according to site elevation (Figure 29). Environmental (air and soil) temperature is known to be largely a function of elevation, although topography, soil type, and vegetative composition may be significant variables as well. At Mount Rainer National Park on the western slopes of the northern Cascades, Washington, research has shown that mean soil temperatures decrease by a factor of 2 to 3 degrees Celsius per 1000 meter increase in elevation (Greene and Klopsch 1985:14). A similar temperature lapse rate would be expected for this area of the Cascades. Therefore, a difference of 2 to 3 degrees (C) would be expected for the soil temperatures at these study sites, which fall within a range of 1000 meters. The effect of this temperature difference on hydration values is in part a function of the source-specific hydration rate of the particular obsidian, which is currently unknown.

The bivariate scatter plot and associated regression line (Figure 29) indicates a definite trend toward decreasing hydration rim depth with increasing elevation, and a fairly strong correlation is suggested by the r-value (-0.64). Still, temperature is only one

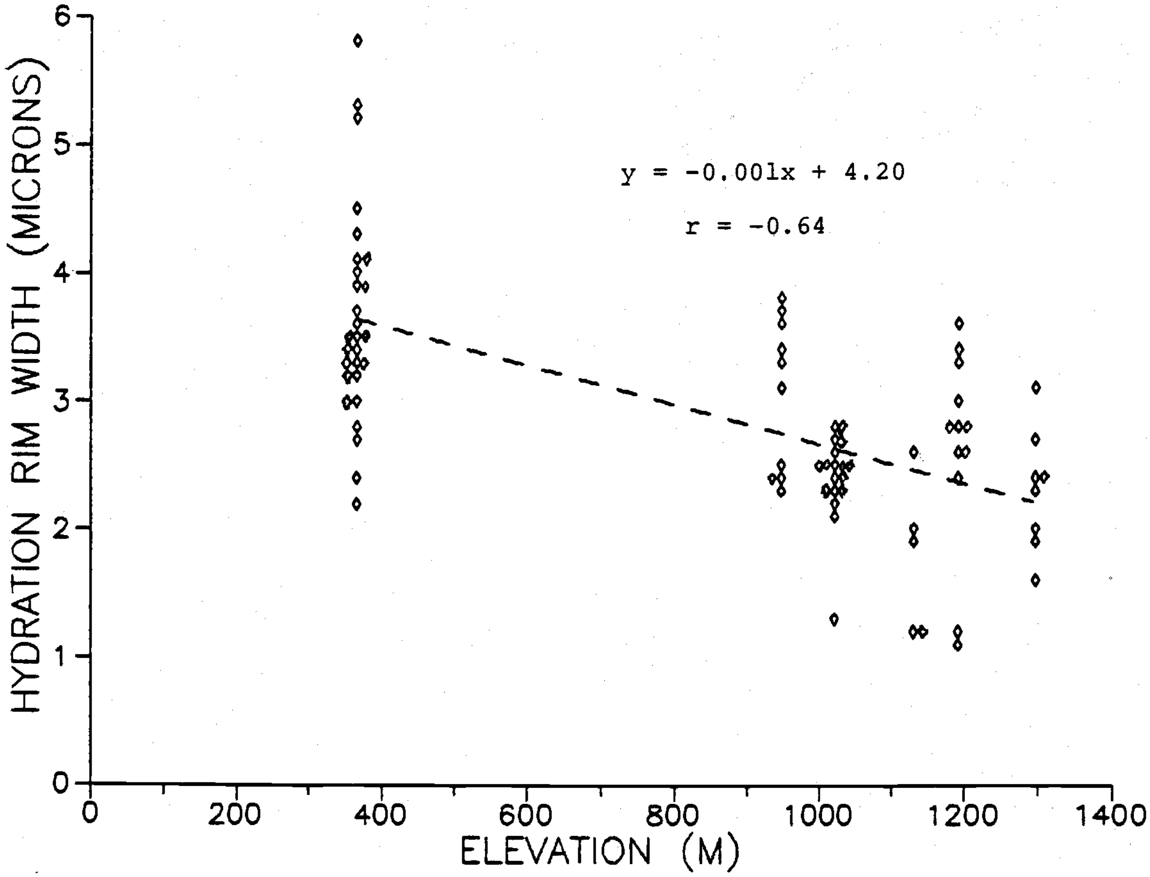


Figure 29. Hydration values of all sites correlated with site elevation. Only Obsidian Cliffs specimens are represented (n=81). Range and distribution of site-specific hydration values is used to infer occupational history. Regression line reflects the relationship between site mean HRM and elevation.

potential variable that could account for this trend. Alternatively, the data might suggest that sites of more recent occupation are found at higher elevations. A better understanding of source-specific hydration rates and site-specific temperature regime is requisite to inter-site comparisons of hydration data when site ages are unknown. Once inter-site temperature differences are determined, a better explanation of the HRM variation may be possible.

Finally, the hydration data from all six study sites are plotted according to their respective excavation level depth (Figure 30). This correlation reflects a trend toward larger HRM with increased depth in the deposit, although the r-value (0.39) is not particularly high. It is also evident that the greatest range of hydration values is found in the shallowest levels of the excavation units, a phenomenon which has been recognized elsewhere (Huberland 1987). Generally, a wide range of hydration values can be found at any given depth. These data provide corroborative evidence for post-depositional disturbance resulting from pedoturbative processes recognized in the forest environment (cf. Wood and Johnson 1982; Schiffer 1987).

Obsidian Analyses from Other Local Sites

Recently source-specific hydration data have been obtained from two other archaeological sites within and near the study area. Cougar Ridge Way Trail 4

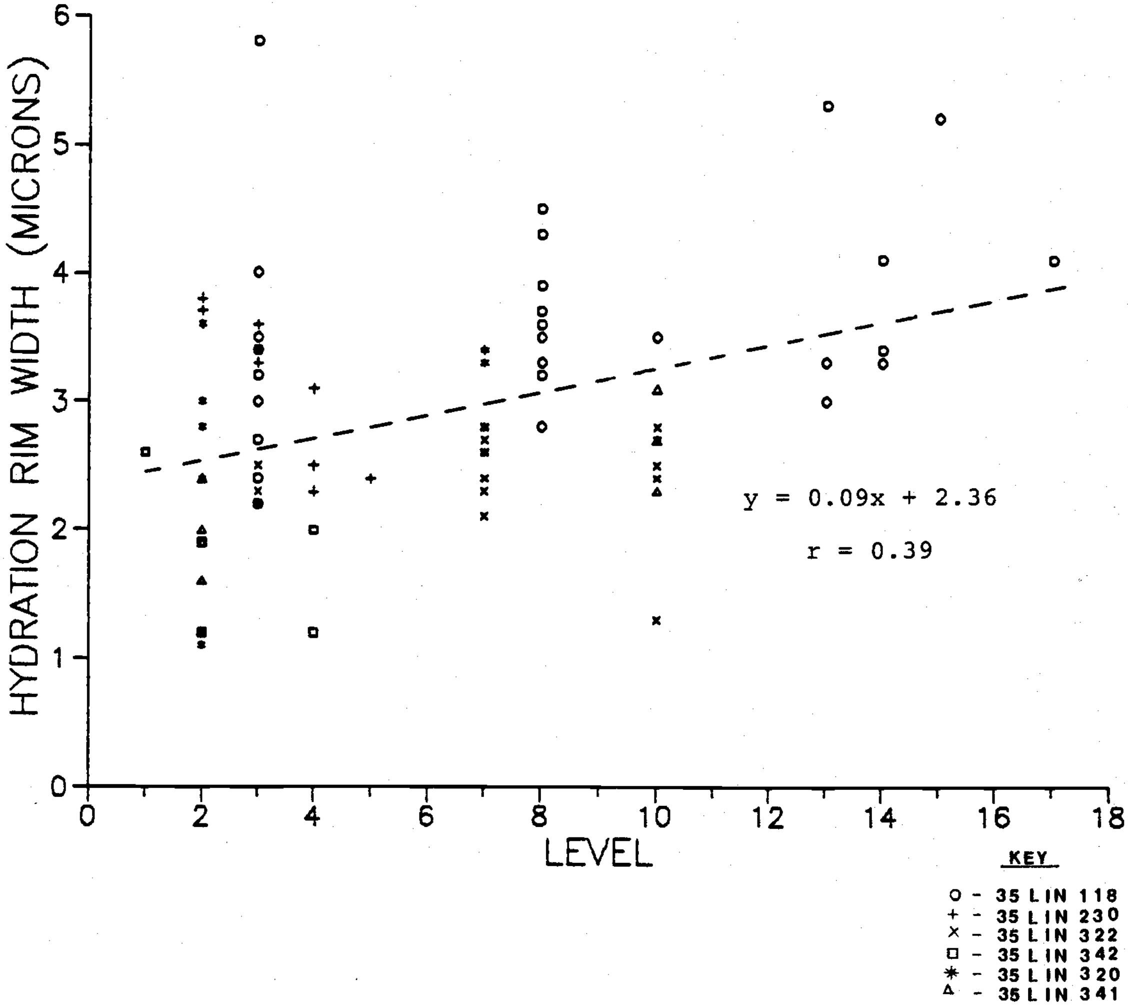


Figure 30. Scattergram representing hydration values of Obsidian Cliffs specimens from all six study sites correlated with deposition level. Regression line indicates a positive relationship between greater HRM and increased depth in the deposit. No adjustments have been made for site-specific temperature variations.

(35 LIN 116) is located at an elevation of 1056 meters about 4 kilometers (2.5 miles) north of Tombstone Summit (35 LIN 341) at the headwaters of the Middle Santiam drainage. A sample of 20 obsidian lithics were submitted for XRF and hydration analyses in accordance with specifications for contracted data recovery excavations (Flenniken and Ozbun 1988). Results of these analyses were compatible with those produced through this study.

All twenty of the specimens were found to match the geochemical profile of the Obsidian Cliffs flow, which is located about 36 kilometers southeast of the site (Flenniken and Ozbun 1988:55). These data support the trend indicated by the distance-decay model developed with data from the six study sites (Figure 18).

Hydration data from the Cougar Ridge site exhibit a range of 1.1 to 3.5 microns and a mean of 2.5 microns (Flenniken and Ozbun 1988:57). The investigators found the HRM to be comparable to other sites of middle to late Archaic age. Although hydration values generally increased with greater depth in the deposit, a fairly wide range of values was found at all levels. These data support the sedimentological interpretation of mixing of deposits at the site.

The majority (70 percent) of the hydration values cluster around 3.0 $\pm$ 0.5 microns, while the remaining six values are distributed between 1.0 and 2.0 microns. Apparently, the occupation of this site occurred primarily during the time period equivalent to 3.0 microns, with perhaps intermittent site use continuing up to the time period represented by the 1.0 micron value. Other archaeological evidence suggested to researchers that Cougar Ridge was a single component occupation, but they conceded that the site could have been "occupied at two different times at the same location where the same lithic reduction activities were performed" (Flenniken and Ozbun 1988:59).

In comparison with the six sites currently under investigation, the range of HRM of the Cougar Ridge site is nearly equivalent to that of Dane Saddle (35 LIN 320); somewhat greater than Soda Fork, Lost Prairie, and Tombstone Summit (35 LIN 230, 322, and 341); and considerably less than that exhibited by the sample from Yukwah (35 LIN 118). Again, it is difficult to address the question of contemporaneity of these sites without control of the site temperature variable. However, the range of HRM and elevation of Cougar Ridge and Lost Prairie are quite close, which may indicate that these two sites are roughly contemporaneous.

Twenty obsidian artifacts from the Bear Saddle site (35 LIN 301) were subject to XRF and hydration analyses (Hughes 1988a; Origer 1988a). This site is situated on the same ridge system as the Monument Peak site (35 LIN 342) along the divide between the North and Middle Santiam drainages. Like Monument Peak, the Bear Saddle assemblage includes artifacts from several obsidian sources. Results of XRF analysis indicate that nine specimens match the Obsidian Cliffs trace element profile, nine correlate with Devil Point, and two specimens originated from Newberry Volcano obsidian. Bear Saddle is located nearly 100 km from the Newberry source, approximately 50 km from Obsidian Cliffs, and 15.5 km from Devil Point. It roughly fits the distance-decay model (Figure 18) for Obsidian Cliffs glass devised from the data obtained through the current study. The presence of Newberry Volcano obsidian distinguishes the Bear Saddle site from the six sites included in this study.

In terms of hydration data, the Obsidian Cliffs specimens exhibit an HRM range from 1.0 to 1.6 microns, with a mean value of 1.3 microns (s=0.20). The specimens from Devil Point range of 1.1 to 2.3 microns, with a mean of 1.6 microns (s=0.54). The relatively small HRM values for the Obsidian Cliffs specimens suggest that this site experienced a more recent occupation than most of the study sites. The Devil Point obsidian HRM exhibit a broader range, perhaps indicative of an earlier and longer period of use. If Devil Point glass hydrates at a faster rate than Obsidian Cliffs, as was suggested by the Monument Peak hydration data, then perhaps the ranges of HRM of the two obsidians are representative of the same period of time. It is interesting that both specimens attributed to the Newberry Volcano source are projectile points (or fragments of points). They display HRM of 2.1 and 1.4 microns. Little information is currently available about this site, which inhibits further interpretation of the results of the obsidian analyses. Generally, the results seem to be compatible with the findings of the current study.

As obsidian studies receive increased application in this area of the Oregon Cascades, resultant data can be employed to test some of the relationships suggested by this exploratory study. This information will contribute to a better understanding of prehistoric obsidian procurement and distribution, as well as facilitating the development of a temporal framework for upland lithic sites. Additionally, obsidian hydration analysis can be a valuable tool for studying the effects of various predoturbative processes in the forest environment, in turn enabling better control of these variables in archaeological research.

CHAPTER 7

SUMMARY AND CONCLUSIONS

Promising results have been obtained through obsidian analyses of assemblages from six archaeological sites in the Santiam drainage of the central western Cascades of Oregon. While this study is largely exploratory in nature, it represents one of the first attempts to apply this type of methodology to specific archaeological problems in this area of the Cascades. Open lithic sites in the study area are characterized by a lack of temporal context and questionable depositional integrity. The method proved quite successful in evaluating the stratigraphic integrity of open lithic sites which prevail in the study area. Furthermore, the value of obsidian hydration analysis for assessing the occupational histories of these sites has been demonstrated. The study also provided important information on prehistoric obsidian utilization in these locales.

Six sites from various elevations and topographic settings were selected for the study. A total of 90 specimens of artifactual obsidian from various depths in the deposit comprised the sample. These were subjected to XRF characterization and hydration analyses in order to determine if patterning of hydration values would provide an indication of: 1) the degree to which the archaeological deposits have been mixed; 2) the unique occupational histories of the sites; 3) the relative ages of the sites; and 4) HRM differences related to elevation, setting, or depositional depth.

The results of the XRF analysis indicated that the majority (90 percent) of obsidian specimens had originated from the Obsidian Cliffs flow (Hughes 1988b). This was somewhat unexpected, given the number of sources of obsidian potentially available in the vicinity. Nonetheless, the predominance of the Obsidian Cliffs source in the sample provides a preliminary indication of prehistoric procurement patterns in the Santiam area. The dominance of this single source also facilitates the interpretation of the hydration data, in that the variable of chemical composition is controlled.

The hydration data display a range of 1.1 to 5.8 microns, with a single high value of 8.0 microns which represents one of two rims on a single specimen (Origer 1988b). (This is believed to be indicative of refurbishment of an older artifact.) The mean hydration value of the sample is 2.9 microns; 87 percent of the HRM fall between 2.0 to 4.0 microns. These data suggest that the sites represent primarily Middle Archaic occupations; no particularly early or late habitations are indicated.

Comparison of specimen provenience (i.e., excavation level depth) with hydration values suggests that these sites have experienced some degree of post-depositional disturbance, probably related to pedoturbative processes. Generally the sites exhibit a tendency toward superposition with greater HRM occurring at greater depth in the deposit. Yukwah, Dane Saddle, and Tombstone Summit reflect the highest degree of stratigraphic integrity. In contrast, Soda Fork and Monument Peak exhibit a negative correlation between specimen provenience and hydration value. In the case of each site there are non-archaeological explanations for the disparities of the hydration data. The Lost Prairie site displays the greatest internal consistency of the study sites. Not only is a limited range of HRM present, but there is no correlation between depth and hydration value. The data support the common assumption that each site has experienced distinct post-depositional processes, the effects of which have resulted in varying degrees of stratigraphic integrity.

The hydration data also provide valuable insight into the occupational histories of the individual sites, demonstrated by the range and distribution of hydration values. Yukwah, for example, appears to have experienced the longest period of use, with an HRM range of 2.2 to 5.8 microns. The period of time represented by the 3.0 to 4.0 microns range may have been an era of more intensive site use. The Lost Prairie site, on the other hand, exhibits a relative short tenure of occupation, as reflected in a tight clustering of HRM between 2.1 and 2.8 microns. The other sites display various ranges of HRM and little clear clustering of values, which could represent periods of intermittent use at these sites. At

Dane Saddle and Soda Fork, the hydration data suggest that a period of intermittent use was followed by a hiatus, then another brief occupation some time later. Some of the patterning exhibited by the hydration data could be a reflection of the sampling design, however, as not all levels of each site/excavation unit were sampled.

Exploratory analysis of the hydration data provided little indication of patterning with relation to elevation, setting, or depth. Least-squares linear regression analysis was used to test the relationship between the hydration data and the variables elevation and provenience (depth). A positive relationship was demonstrated between hydration rim measurement and provenience (Figure 30). A negative relationship was indicated between HRM and site elevation (Figure 29). Although the data exhibit the expected trends, not all variables could be controlled in the correlations (e.g., site age and effective hydration temperature). Three distinct topographic settings are represented by the six sites, two sites in each setting type (Table 4). It was not possible to detect any distinct patterns of stratigraphic integrity among the sites in various settings. Again, other variables such as fire history, and unstable soils (slump activity) may have had irregular effects on the HRM or deposits at certain sites.

Although this work is preliminary and exploratory in nature, important baseline data has been obtained which will be of increasing value as more comparable data are accumulated. Obsidian hydration and chemical characterization analyses are being more aggressively applied in this area of the Cascades, increasing the interpretive value of open lithic sites and contributing to the development of a temporal framework for this area. Furthermore, obsidian hydration analyses provide a means for studying the effects of pedoturbative processes on archaeological deposits in various settings.

In spite of the level of success achieved through this research, much work is still needed to realize the full potential of the obsidian hydration method in this area, even as a relative dating tool. Basic ground-level research would greatly enhance the applicability of the hydration method locally. First and foremost is the need to identify and characterize the composition of currently "unknown" sources. This would require geologic field work and systematic sampling of new sources that are located.

To render hydration data more valuable for developing a chronological framework for the area, an effort should be made to correlate obsidian hydration values with other archaeologically associated temporal data. For example, when the elusive radiocarbon datable materials are encountered at a site, a sample of obsidian directly associated with the potential C-14 date should be obtained for concurrent hydration analysis and chemical characterization. A test of the excavation unit's stratigraphic integrity would also be appropriate.

Adherence to this approach may eventually enable the determination of source-specific hydration rates, or at least provide a useful correlate for the hydration data. Similarly, an analysis of hydration values of "temporally-diagnostic" projectile points might provide a "yardstick" to compare other hydration data, while serving as an empirical test of proposed typologies (cf. Origer 1982). A study of this nature could be fairly easily executed through the use of extant collections.

Research is also recommended to ascertain the significance of the range of temperature variation relative to source-specific hydration rates. Friedman and Trembour (1983) have suggested that an increase of only 1 degree (Celsius) in site-specific effective hydration temperature could affect the hydration rate by as much as a factor of 10 percent. Tremaine (1987) found that the effect of temperature on the hydration rate is source-specific, not constant at 10 percent, but decreases with increasing temperature. Support for this is also found in Origer's study (1982) of projectile points in the North Coast Range of California where two sources are codominant. Comparison of hydration values from inland and coastal sites, where the difference in mean air temperature between the two areas was found to be on the order of only a few degrees (Celsius), resulted in no statistically significant difference in hydration values of contemporaneous projectile point forms (Origer 1982).

Generally positive results were obtained from the current application of obsidian hydration analysis, though it is recommended that the data be viewed critically because of the rather limited sample employed. While the sample proved satisfactory for purposes of evaluating the stratigraphic integrity of the particular excavation units, it may not adequately represent the full range of time-depth or source utilization represented at the individual sites. The present data should become more meaningful as more well-provenienced, source-specific hydration data are accumulated. There is currently very little in the way of comparable evidence available from local sites, although there is a growing emphasis on obsidian analyses in archaeological investigations in this area of the Cascades.

The obsidian hydration method offers a valuable tool for improving chronological control in the Cascades study area, as well as in other areas where dating is problematic and obsidian is prevalent in archaeological assemblages. The method has not been aggressively pursued locally, due perhaps to the complexity of the hydration process and the difficulties encountered in earlier attempts to derive "absolute" dates. It is important to better control the critical variables: differential chemical composition of obsidian sources, and effective hydration temperature. Systematic application of the method will provide data with the capacity to define (or refine) chronological sequences, identify settlement patterns, and examine other aspects of human behavior in a temporal framework, greatly enhancing the interpretive value of open lithic sites in the central Western Cascades of Oregon.

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APPENDIXES

Appendix A. Common vegetation of the Willamette National Forest with important microenvironmental species identified. Adapted from Hemstrom et al. (1985:28-31).

TREES

SCIENTIFIC NAME	COMMON NAME	INDICATION
Abies amabilis	Pacific silver fir	cool
Abies concolor	White fir	
Abies grandis	Grand fir	
Abies lasiocarpa	Subalpine fir	cool
Abies procera	Noble fir	
Alnus rubra	Red alder	
Arbutus menziesii	Madrone	dry, warm
Castanopsis chrysophylla	Chinquapin	dry
Calocedrus decurrens	Incense cedar	hot
Chamaecyparis nootkatensis	Alaska cedar	cold, wet
Larix occidentalis	Western larch	
Pinus albicaulis	Whitebark pine	very cold
Picea engelmannii	Engelmann spruce	cold
Pinus contorta	Lodgepole pine	
Pinus lambertiana	Sugar pine	
Pinus monticola	Western white pine	
Pinus ponderosa	Ponderosa pine	hot, dry
Pseudotsuga menziesii	Douglas-fir	
Quercus garryana	Oregon white oak	hot, dry
Taxus brevifolia	Pacific yew	
Thuja plicata	Western redcedar	
Tsuga heterophylla	Western hemlock	
Tsuga mertensiana	Mountain hemlock	cold

SHRUBS

SCIENTIFIC NAME	COMMON NAME	INDICATION
Acer circinatum	Vine maple	
Acer glabrum douglasii	Rocky Mt. maple	
Arctostaphylos nevadensis	Pinemat manzanita	dry
Arctostaphylous uva-ursi	Kinnickinick	dry
Berberis aquaefolium	Tall Oregon grape	warm, dry
Berberis nervosa	Dwarf Oregon grape	
Castanopsis chrysophylla	Chinquapin	warm
Ceanothus velutinus	Snowbrush	disturbance
Chimaphila menziesii	Little prince's pine	
Chimaphila umbellata	Prince's pine	
Corylus cornuta	California hazel	warm

SHRUBS (continued)

SCIENTIFIC NAME	COMMON NAME	INDICATION
Cornus nuttallii	Pacific dogwood	warm
Gaultheria ovatifolia	Wintergreen	
Gaultheria shallon	Salal	
Holodiscus discolor	Ocean-spray	dry
Lonicera hispidula	Hairy honeysuckle	hot, dry
Menziesia ferruginea	Fool's huckleberry	cool
Oplopanax horridum	Devil's club	wet
Pachistima myrsinites	Oregon boxwood	
Rhododendron albiflorum	Cascades azalea	cold,wet
Rhododendron macrophyllum	Rhododendron	
Rhus diversiloba	Poison oak	hot, dry
Ribes lacustre	Prickly currant	
Rosa gymnocarpa	Baldhip rose	
Rubus lasiococcus	Dwarf bramble	cool
Rubus leucodermis	Black raspberry	
Rubus nivalis	Snow dewberry	
Rubus parviflorus	Thimbleberry	
Rubus pedatus	Five-leaved blackberry	cool
Rubus spectabilis	Salmonberry	warm, wet
Rubus ursinus	Trailing blackberry	warm
Sorbus sitchensis	Sitka mountain ash	
Symphoricarpos mollis	Snowberry (trailing)	warm, dry
Vaccinium spp.	Huckleberry species	
Vaccinium alaskaense	Alaska huckleberry	cool
Vaccinium membranaceum	Big huckleberry	cool-cold
Vaccinium ovalifolium	Oval-leaf huckleberry	cool
Vaccinium parvifolium	Red huckleberry	warm
Vaccinium scoparium	Grouse huckleberry	cold, dry
Whipplea modesta	Whipple vine	warm, dry

HERBS AND GRASSES

SCIENTIFIC NAME	COMMON NAME	INDICATION
Achlys triphylla	Vanilla leaf (deerfoot)	moist
Actaea rubra	Baneberry	
Adenocaulon bicolor	Pathfinder	
Adiantum pedatum	Maidenhair fern	wet
Anemone deltoidea	Three-leaved anemone	moist
Anemone lyallii	Nine-leaved anemone	moist
Aquilegia formosa	Sitka columbine	
Aralia californica	California aralia	
Arenaria macrophylla	Bluntleaf sandwort	
Arnica latifolia	Broadleaf arnica	
Asarum caudatum	Wild ginger	moist
Athyrium filix-femina	Ladyfern	moist, wet
Blechnum spicant	Deerfern	moist
Calypso bulbosa	Calypso orchid	
Campanula scouleri	Scouler's bluebell	
Carex pensylvanica	Long-stolon sedge	
Circaea alpina	Alpine circaea	
Cirsium spp.	Thistle	
Clintonia uniflora	Queencup beadlily	cool, moist
Coptis laciniata	Goldthread	moist
Corallorhiza maculata	Coral-root	
Cornus canadensis	Dogwood bunchberry	cool, moist
Dicentra formosa	Pacific bleeding heart	moist
Disporum hookeri	Fairybells	
Erythronium montanum	Avalanche lily	cold
Equisetum spp.	Horsetail	moist
Erythronium oregonum	Giant fawnlily	warm
Festuca californica	California fescue	
Festuca occidentalis	Western fescue	
Festuca subulata	Bearded fescue	
Fragaria spp.	Strawberry	
Frageria vesca	Strawberry	
Galium oreganum	Oregon bedstraw	
Galium triflorum	Sweetscented bedstraw	
Goodyera oblongifolia	Rattlesnake plantain	
Gymnocarpium dryopteris	Oak fern	moist
Hieracium albiflorum	White hawkweed	
Hydrophyllum capitatum	Ballhead waterleaf	
Hypopitys monotropa	Pinesap	
Iris tenax	Oregon iris (purple)	
Linnaea borealis	Twinflower	
Listera borealis	Twayblade	
Luzula spp.	Luzula	
Maianthemum dilatatum	False lily-of-the-valley	moist
Mitella breweri	Brewer miterwort	moist

HERBS AND GRASSES (continued)

SCIENTIFIC NAME	COMMON NAME	INDICATION
Montia sibirica	Miner's lettuce	moist
Osmorhiza chilensis	Sweet cicely	
Oxalis oregana	Oregon oxalis	moist
Pedicularis racemosa	Stickletop pedicularis	cool, moist
Polystichum munitum	Western swordfern	
Pteridium aquilinum	Bracken fern	disturbance
Pyrola picta	White vein pyrola	
Pyrola secunda	Sidebells pyrola	cool, dry
Pyrola asarifolia	Alpine pyrola	
Satureja douglasii	Yerba buena	warm, dry
Saxifraga mertensiana	Mertens saxifrage	
Smilacina racemosa	Feather solomonplume	moist
Smilacina stellata	False solomonseal	moist
Streptopus roseus	Rosy twistedstalk	moist
Synthyris reniformis	Snow queen	warm, dry
Tiarella unifoliata	Coolwort foamflower	moist
Trientalis latifolia	Western starflower	
Trillium ovatum	Pacific trillium	
Valeriana sitchensis	Sitka valerian	moist, cool
Vancouveria hexandra	Inside-out-flower	
Veratrum californicum	False hellebore	moist, cold
Viola glabella	Pioneer violet	moist
Viola orbiculata	Vetch violet	moist
Viola sempervirens	Redwoods violet	
Xerophyllum tenax	Beargrass (common)	cold, dry

Environmental indication is strong when several similar species are present and their cover is high. Opposite indications should be weighed by number of indicators present and their percent cover.

Appendix B. Site record forms for study sites, U.S.D.A. Forest Service, Region Six.

CULTURAL RESOURCE INVENTORY
Record Form

(Perm) 35 LIN 118

Type: Archaeological District ( )Yes (X) No

Forest 18 County 043 District 03 State 41 USGS Quad 15 MIN Cascadia 1955

Legal: NW¼ of NW¼, Sec. 33 T.13S., R.4E., W.M.

TRI: Compartment name: Blood
Compartment no. 3306
Cell no. 45C4

Elevation: 1200 ft./365 m.
UTM: Zone 10
Easting 5 52 850 m.
Northing 49 16 325 m.

Lat. 44° 24' Long. 122° 20'

Plant Community: Second growth conifers with mixed brushy understory
Terrain: Riverside flat

Soils/Sediments: Sandy loams

Water Source: South Santiam River

Environmental Features (see instr)

Easy access to South Santiam River
Class III stream on opposite South Santiam River bank

Site Name Yukwah
Size 6.3 hectares (15.5 acres) Date of Use Prehistoric
Function/use Campsite
How determ.? lithic evidence

Present Condition:
(X) Excellent ( ) Fair
( ) Deteriorated/disturbed
( ) Hazardous ( ) Usable
( ) Vandalized (X) Altered

Physical data (see instructions)

This site was located when work crews turned in lithic evidence to their crew leader. Additional material was found on the surface of the cleared ground being readied for full campground construction.

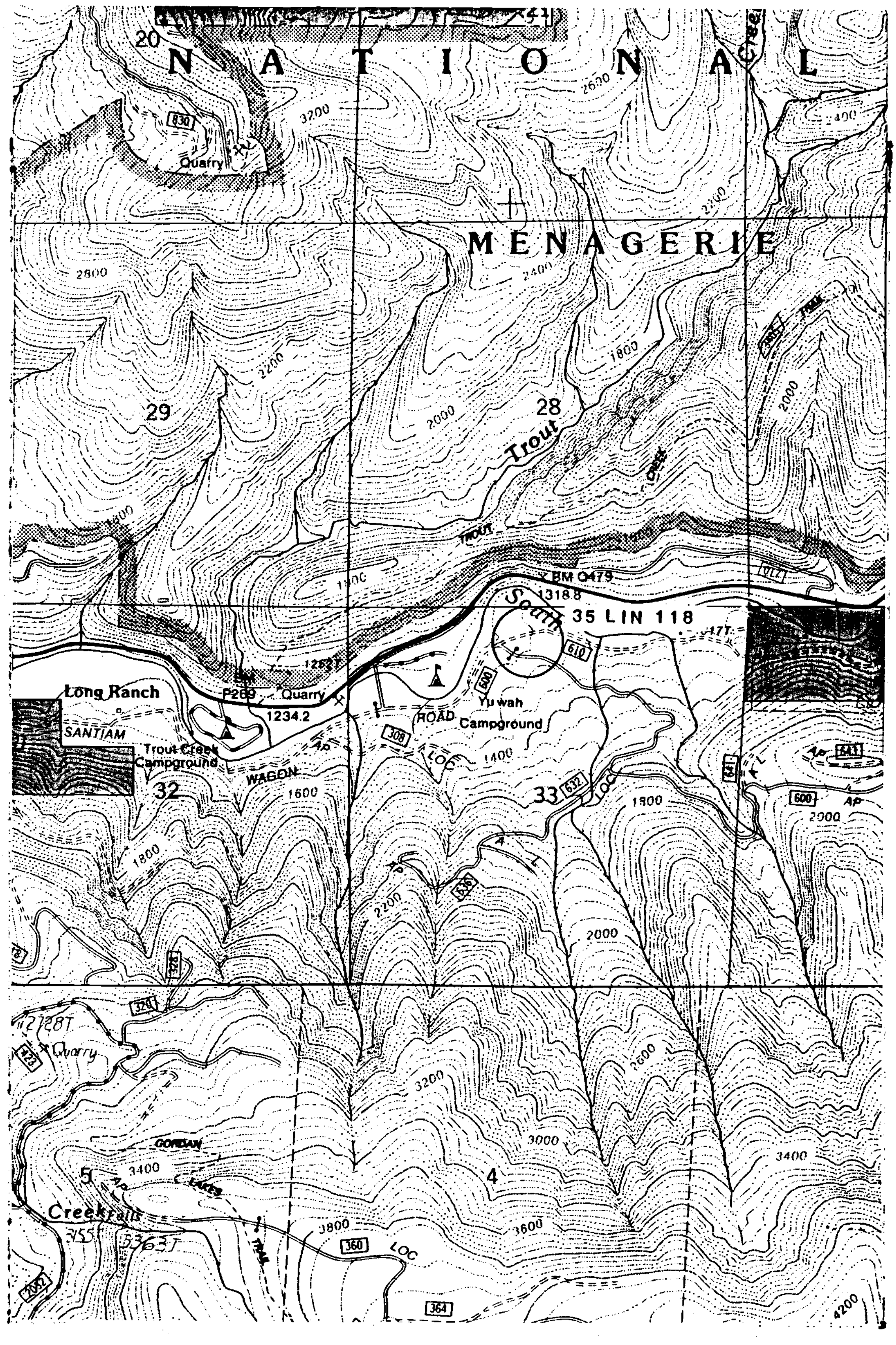
Finds include: one partial obsidian spear point, one partial obsidian projectile point, one complete red and black obsidian knife, thirty-nine obsidian surface flakes, 3 obsidian subsurface flakes, one chunk flaked red jasper, one chuck flaked obsidian. (See attached campsite find map)

Archaeological Test Evaluation: In June 1984, test excavations were conducted on the Yukwah site. Site boundaries & depth were determined. The site was found to be eligible for nomination to the National Register of Historic Places. Completion of the proposed public campground will result in a minor impact to a less dense area of the site. Data Recovery Excavations and monitoring were recommended, and accomplished in the Fall, 1984. For further information see: Archaeological Test of the Yukwah Site, by C. Lindberg-Muir, 1984.

Expected impacts: (X) Yes ( ) No ( ) Maybe
Source Campground construction
Mitigation recommendations:

1) Close monitoring of any further work, all ground work is done already.

Recorded by A.E. Farque' Date 10-79
Inventory type: ( ) Tickler (Verified ?) ( ) Yes ( ) No
( ) Overview (X) Recon
( ) Survey ( ) Incidental
Reference: Yukwah Campground CR Report
Attachments: ( ) Sketch Map ( ) Photo
(X) USGS ( ) Catalog
( ) Report ( ) site map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308
632
641
360
364

CULTURAL RESOURCE INVENTORY (Perm) 35 LIN 230
Record Form

Type: Archaeological District ( ) Yes (x) No

Forest 18 County Linn District 03 State OR USGS Quad Echo Mt.15 min

Legal: NE¼ of SW¼, Sec. 29 T.13 R.5E , W.M.

TRI: Compartment name Crazy
Compartment no. 3314
Cell no. 75C3

Lat. 44° 24' 24" Long. 122° 14' 6"

Elevation: 3100 ft./945m.
UTM: Zone 10
Easting 5 60 575mE.
Northing 49 17 125mN.

Plant Community: Douglas-fir, hemlock cedar, vine maple, Oregon grape.

Environmental Features (see instr)
Soda Fork Way Trail runs along this ridge system. Historical and possibly aboriginal significance. This trail connects with the Harter Mt. area which has documented aboriginal use.

Terrain: Gentle benches below ridge line.
Aspect 230°

Soils/Sediments: SRI 231, thin gravelly loams

Water Source: Spring/tributary to Sheep Creek within site area.

Site Name Soda Fork Way II
Size 250m² Date of Use undetermined

Present Condition:
(x) Excellent ( ) Fair
( ) Deteriorated/disturbed
( ) Hazardous ( ) Usable
( ) Vandalized ( ) Altered

Function/use probably a travel camp
How determ.? about 100m southeast of trail route (Soda Fork Way Trail)

Physical data (see instructions)

This site has loci on small knobs east ond west of a spring which forms the headwaters of Sheep Creek. The Soda Fork Way Trail is located along the ridge approximately 100m northwest of the site area. This trail, if it was in existence in prehistoric times, would have provided easy access from the Harter Mt. area.

The material found at this site during the surface survey includes: Part of an obsidian projectile point, a utilized obsidian fragment, 2 obsidian finishing flakes, and 1 basalt thinning flake. These lithics were located at a depth of about 2cm during duff clearance. The majority of the lithic material was found to the west of the spring, while only 2 obsidian waste flakes were found to the east.

Expected impacts: (x) Yes ( ) No ( ) Maybe
Source Crazy Taylor TS FY 85
Mitigation recommendations:

Avoid site by changing unit layout or test and evaluate site, plan data recovery if necessary.

Recorded by C.Lindberg-Muir Date 11/4/82
Inventory type: ( ) Tickler (Verified ?)
( ) Yes
( ) No
( ) Overview ( ) Recon
(x) Survey ( ) Incidental
Reference: Crazy Taylor TS CRR
Attachments: (x) Sketch Map (x) Photo
(x) USGS ( ) Catalog
( ) Report ( ) ________

ARCHAEOLOGICAL SITE RECORD
CONTINUATION SHEET

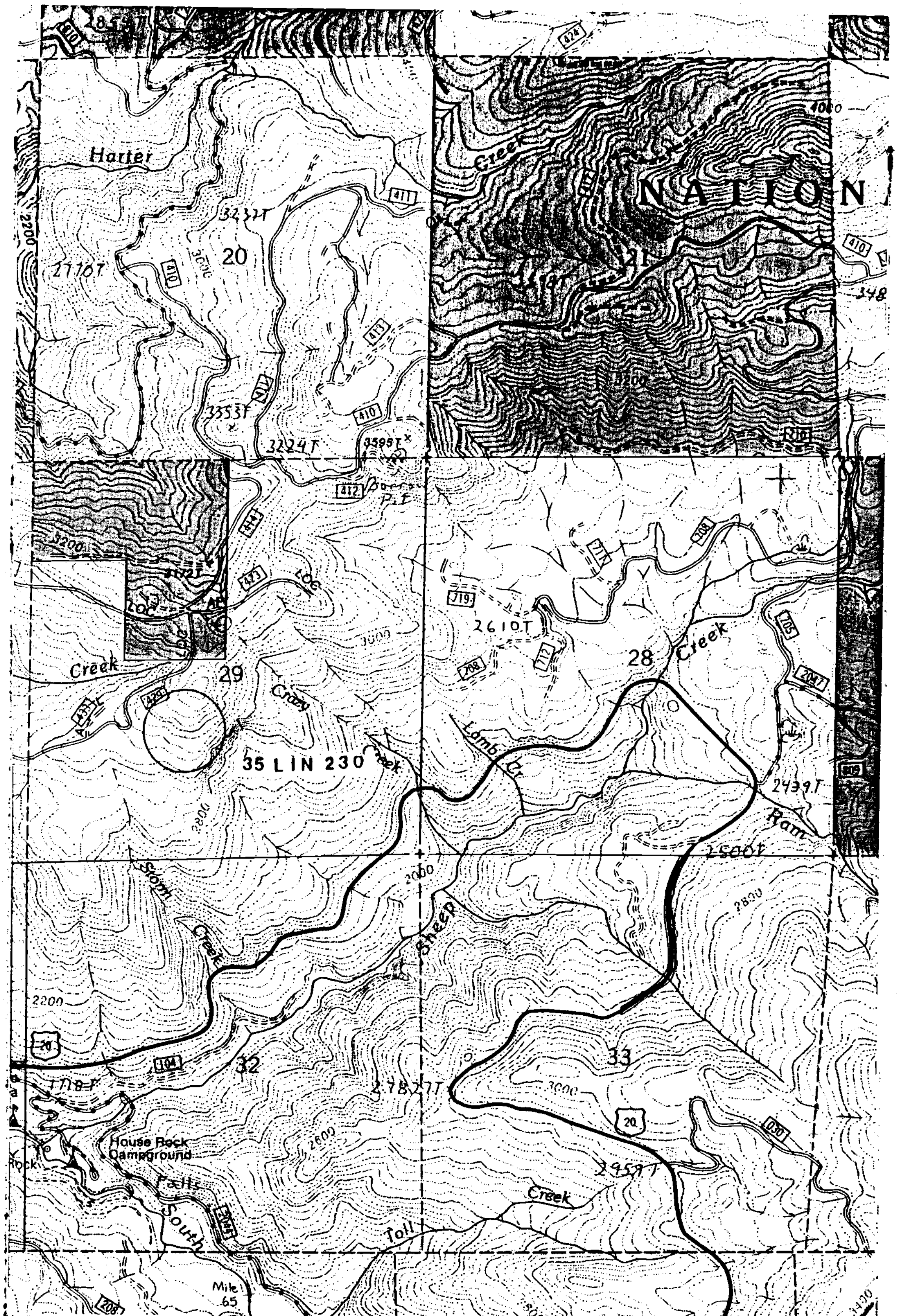
SITE NO. 18-03-88

TEMPORARY [X] PERMANENT [ ]

(Make Entries in Soft Pencil Only)

BLOCK/ITEM

Archaeological subsurface testing was conducted on the Soda Fork Way II Site during the 1983 field season. Testing results indicate that this was a seasonally occuppied travel camp. The depth of the site is at least 40 cm. Through subsurface testing 28 lithics were recovered; 79% obsidian and 21% CCS. Only 21% of the lithics were tools or utilized flakes, while the remaining were mostly thinning and finishing flakes. The site was determined eligible for the National Register of Historic Places on the Grounds that it could yield information significant to local prehistory. The site has been recommended for Data Recovery during the 1984 field season, prior to the sale of Crazy Taylor Timber Sale. For further information on the site testing see the Archaeological Test of Soda Fork Way II Site Report, C. Lindberg-Muir, 1983.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Crazy
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House Rock
Campground
Mile
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18-03-182 — Forest Service Number

Cultural Resource Site Report
Region 6-USDA-Forest Service

35 LIN 320 — Permanent Number

Forest: Willamette Ranger District: Sweet Home County: Linn
Site Name (if any): Dane Saddle

LOCATION DATA: TRI Compartment: Name: Dane (Cell #35D2) Number: 3503
Legal Description: ___1/4 ___1/4 SW 1/4 SW 1/4, sec. 36, T. 13S., R. 6E., W.M.
___1/4 ___1/4 ___1/4 ___1/4, sec. ___, T. ___, R. ___, W.M.
Aerial Photo: Number 12 6161 80 Flight 878-79 Date 7/31/79
UTM: Zone 10 Easting 5 75 850 mE Northing 49 15 580 mN
U.S.G.S. Quad.: Name Echo Mt., OR. Series 15 min. Date 1955
Elevation: Feet: 3900 to ___. Meters: 1190 to ___.
Describe access to the site and site datum:
Hwy 20 to Hackleman Creek Road #2672 - 1 mile turn onto 2672 410
Site is Northeast of Junction of 410 and 2672-420. Datum: 12m north of junction of Roads 2672-410 and 2672-420 on a stump, visible from the road, on east side of un-named creek. Stump under a 12' hemlock. Site is on Unit 1 of Dane Smith TBV Sale. On-Site datum: approximately 70 meters north of large slash pile; datum 10 meters north of westerly drainage.

SETTING:
Terrain: General Topography: Saddle (site lies below, near spring) Slope 3-10 %
Land Form: High Cascades Plateau Aspect SE
Soils: Surface: dark brown - dk yellowish brown sandy loams Depth: 6-21"
Subsurface: dk yellowish brown, dk brown, reddish brown gravelly sandy loams Depth: 61-136"
SRI 66
Bedrock: Hard andesites and basalts > 6'

Flora:

	On-site	Surrounding Site
Overstory	Doug fir, true fir, W. hemlock	same
Understory	Vine Maple, Ceanothus	same
Ground Cover	Bracken Fern, Huckleberry	Twin Flower, Bunchberry

Water Sources:

Name	Type	Distance	Direction	Drainage Basin
East unnamed Ck.	Class III	adjacent	South	To Unnamed tributary then
West unnamed Ck.	Class III	350'	South	Smith River then McKenzie River

Relation to major drainage: 1 1/4 mile South of Hackleman Creek
1 3/4 mile North of Smith River

Other Environmental Features:
Looking south and east from this point, the Three Sisters and Mt. Washington lie on the horizon.
Confluence of 2 Creeks under "Water Sources".
Spring to the north of sale unit boundary.

Site Dimensions: 150mNS by 30mWE approx. Acres 4500 m2 Depth: 110cm (1x1m unit)
Date(s) of Use (as specific as possible): unknown
How Date Determined: NA
Site Type/Function/Use: open lithic scatter/possible travel-hunting camp
How Determined: Based on artifacts, area topography, ethnographic analogs, historic documentation and regional research.
Physical Data:
F.S. Road 2672-410 ends at Browder Ridge, possible aboriginal trail route.

1913 Santiam National Forest map shows historic trail running east - west around the south side of Browder Ridge - possible aboriginal trail route which is intersected by trail above.

R6-FS-2300-18
7/85

18-03-182 Cultural Resource Site Report 35 LIN 320
Forest Service Number Region 6-USDA-Forest Service Permanent Number

Physical Data/Other Data Continued:

Formal assessment of the Dane Saddle site has consisted of preliminary reconnaissance, and excavation of 24 - 50x50cm test units and one 1x1m test pit. Fourteen of the test pits produced a total of 45 lithics, including utilized flakes and debitage. The 1x1m test unit, dug to a depth of 110cm, yielded 120 lithics. Subsurface units were placed approximately northeast and southwest across an intermittent drainage, in disturbed and undisturbed contexts. The majority of the units were within the saddle itself with few test pits situated on less than level ground.

The saddle slopes down to the southeast, terminating at the confluence of two Class III creeks and a series of gentle benches to the south. Soils consist primarily of damp sandy-gravelly loams with rock hampering excavation in some cases. No features were detected, subsurface or surface.

A trail (shown on current FS map compiled in 1974, but not duplicated on 1940 edition of McKenzie Bridge quad topographic map or 1913 edition of Santiam National Forest map) is believed to lie under FS Rd. 2672-410 and appears to intersect with a prehistorically and historically utilized trail running along the south side of Browder Ridge.

Present Condition of Site:

Previous partial cut harvest - 1973
Slash piles, tractor skidding caused soil disturbance and subsequent erosion, moderately dense vegetation.

Expected Impacts/Present Use:

Short-term: Dane Smith TBV timber sale activities

Long-term: Future Logging; erosion from creek, slope wash
Site to be protected from further impacts.

Continuation Sheet No.(s)

Maps-pg(s). ______ Test Pit(s)-pg(s). ______
Photographs-pg(s). ______ Aerial Photos-pg(s). ______
Features-pg(s). ______ Other: ______ pg(s). ______
Artifact Drawings-pg(s). ______ ______ pg(s). ______

References: Dane Saddle Testing and Evaluation Report - Mandy Cole 1986

Material Collected: Yes X No ___

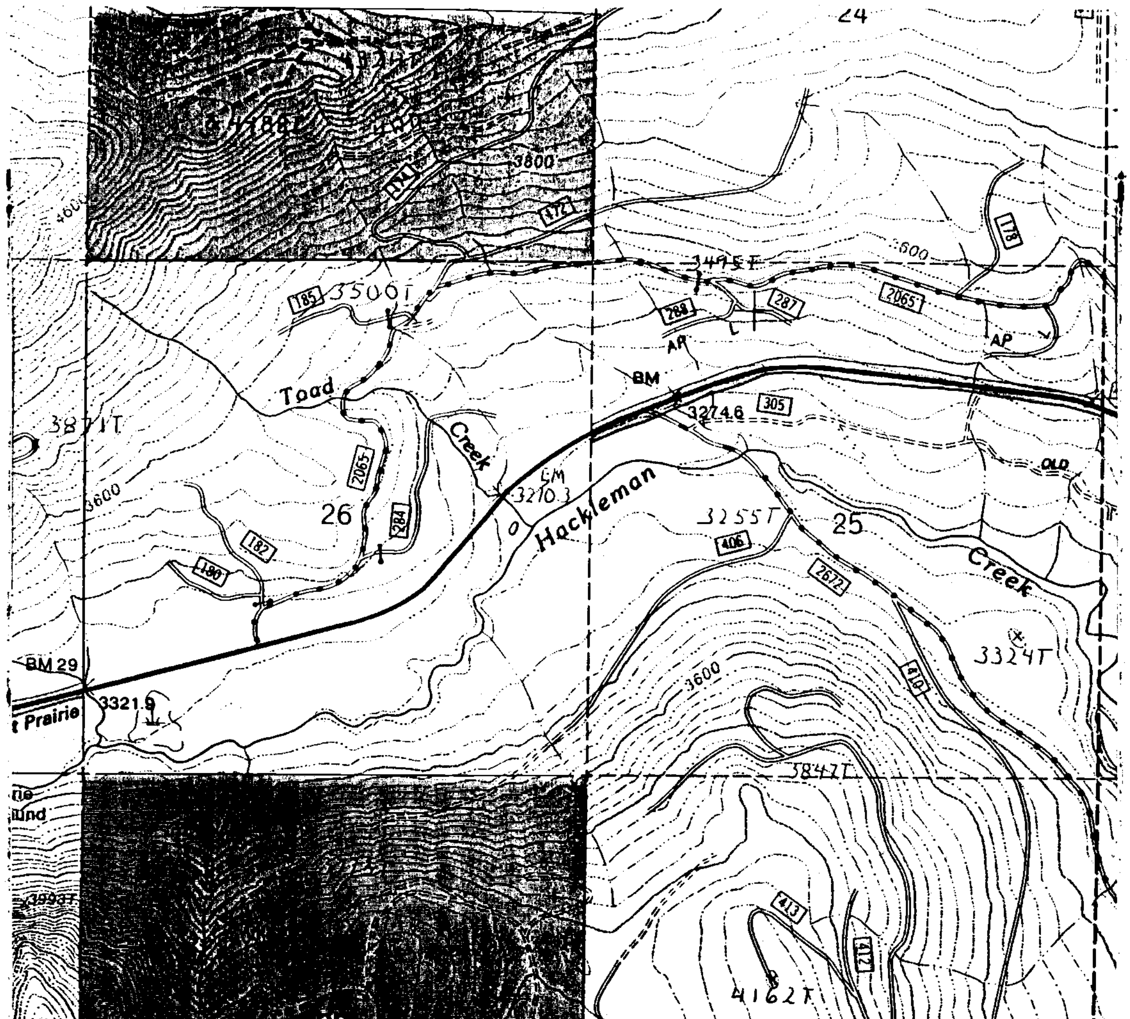
Present Location of Collection: Sweet Home Ranger District
Date(s) Collected: July 1 -23, 1986
Description of Collected Material:

Through subsurface test excavations, 165 lithics were collected; collected cultural material consists of obsidian flakes ranging in length from 0.5cm to 4.0cm. Total yield of modified lithics was one tool fragment and five utilized flakes; no temporally diagnostic artifacts.

18-03-182	Cultural Resource Site Report	35 LIN 320
Forest Service Number	Region 6-USDA-Forest Service	Permanent Number

Inventory Report Title: Cultural Resource Report for Dane Smith TBV
Author: Anthony Farque' Date: 1986
Name of Recorder: Catherine Lindberg-Muir Date: 15 Oct. 86
NRHP Eligible Determination: Eligible X Not Eligible ____
Date Formal Determination Completed: ____

Approved: __________ : __________
Name of Professional Reviewer Title



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3600
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Prairie

18-03-73	Cultural Resource Site Report	35 LIN 322
Forest Service Number	Region 6-USDA-Forest Service	Permanent Number

Forest: Willamette Ranger District: Sweet Home County: Linn
Site Name (if any): Lost Prairie West

LOCATION DATA: TRI Compartment: Name: Dane Number: 3503
Legal Description: ____1/4 ____1/4 NE 1/4 NW 1/4, sec. 34 , T.13S.,R.6E., W.M.
____1/4 ____1/4 ____1/4 ____1/4, sec.____, T.__S.,R.__E., W.M.
Aerial Photo: Number 12 616180 Flight 778-183 Date 7-25-79
UTM: Zone 10 Easting 5 73 700 m. Northing 49 16 825 m.
U.S.G.S. Quad.: Name Echo Mtn. Series 15 min. Date 1955
Elevation: Feet: 3350 Meters: 1005
Describe access to the site and site datum:

The site is located due south of mile post marker "67" of Highway 20 beginning about 50m to the south, extending at least 125m. southwest across Hackleman Creek and approximately 100 meters from east to west. The site can also be reached easily from the Forest Service Campground (Lost Prairie). Heading west about 300 meters from the campground's west edge through a large clearing along a path which remains from the Santiam Wagon road, the site lies along the broad terrace on the north bank of Hackleman Creek in the lightly wooded area around and on a small knoll. The site datum is located on the southerly exposure near the top of this knoll, about 90m. southwest of the milepost marker "67". The datum consists of a 4x4 inch metal tag stapled to the top of a stump which is about 36" in diameter. It is engraved with the site's temporary number (18-03-73) the word "Datum", the initials "CLM", and the date "7-30-87".

SETTING:
Terrain: Slope 0-5 % Aspect south/flat
General Topography: High Cascades Plateau
Land Form: riverside terrace
Soils: Surface: Thin sandy loams, scattered large boulders Depth: ~30cm
SRI Subsurface: Thin sandy loam mixed with cobble Depth: ~1-2 meters
#66 Bedrock: competent, hard andesites and basalts

Flora:	On-site	Surrounding Site
Overstory	w.hemlock, Douglas-fir	Pacific Silver fir climax zone
Understory	huckleberry	huckleberry
Ground Cover	beargrass, moss, herbs	beargrass, moss, herbs

Water Sources:

Name	Type	Distance	Direction	Drainage Basin
Hackleman Crk.	Class I	adjacent	south	Smith River

Relation to major drainage: Hackleman Creek flows east into the Smith River, which in turn is a tributary of the McKenzie River.

Other Environmental Features:
Several large natural openings are nearby: Lost Prairie, 300 meters east, Tombstone about 9 km. west, and several smaller, unnamed "pr aires" are found within the surrounding area. Also, Hackleman Creek supports a native trout population which is unique to this drainage. The site area is protected to some extent from the minor weather fronts which tend to back up against the Old Cascades crest, at Tombstone Summit about 10 km. to the west. Sheltered from much of the wind, rain, and fog, fair weather is often encountered as one crosses to the east of the crest when it is otherwise foul to the west.

18-03-73 — Forest Service Number

Cultural Resource Site Report — Region 6-USDA-Forest Service

35 LIN 322 — Permanent Number

Site Dimensions: 14000 m^2 (estimated) Acres ______ Depth: 120cm
Date(s) of Use (as specific as possible): undetermined
How Date Determined: Obsidian hydration analysis in progress.
Site Type/Function/Use: Open lithic dominated site with predominance of debitage,
How Determined: a few biface fragments. Probably associated with travel and hunting activities, among others. The site is located along the Santiam Wagon road corridor which is reported to have followed extant Indian tribes.

Physical Data:

Site lies adjacent to the remains of the Santiam Wagon Road, a major early transporation route purported to have followed the route of extant Indian trails. Another more recent Forest Service access road further bisects the site from Highway 20 south, then east around the south exposure of the knoll, then continuing north and again east to Lost Prairie Campground. Exploratory test excavations (July 1987) examined 3 m^2 of the site in order to allow assessment of impacts of impending ski trail and winter bridge construction. Four 50 cm^3 units were excavated at arbitrary locations in and adjacent to the area of expected impacts. A 1x2m unit was excavated to the depth of 123cm below surface where culture material had dropped off markedly as compact glacial fill was encountered. The four small units (#1-4) yielded a total of 48 obsidian flakes only 3 of which exhibit any use-wear or modification. The 1x2 yielded 149 obsidian, 2 CCS, and 2 basalt artifacts, including one biface fragment.

A surface survey of the potential site area with systematic duff removal and soil examination revealed 50+ more flakes, a complete biface measuring about 2 x 1.5cm, another biface fragment, and a retouched flake. Most of this was found along the south and east sides of the knoll, and in the disturbed areas of the F.S. access roadbed.

No diagnostic artifact forms were identified, nor were potential C14 samples. However, 18 obsidian specimens from the 1x2m unit were submitted for XFR and hydration analyses, Feb. 1988 by C. Lindberg-Muir. Results are forthcoming under separate cover.

Present Condition of Site:

The site appears to have retained a high degree of contextual integrity in spite of the access road built through it. The road impacts (6%) 850m^2 to a maximum depth of 30cm and much less as an overall average. The disturbance is restricted to the road area; the surrounding area has experienced some cumulative effects of natural disturbance (pedoturbations, flooding and erosion) which are quantifiably undeterminable at this time. The general site setting is fairly pristine, except for the intrusion of Highway 20 which passes along outside the north margin of the site, and the F.S. Campground about 300 meters to the east.

Expected Impacts/Present Use:

Short-term: The proposed winter bridge construction will affect a loss of about 5m^3 adjacent to the creek. Data loss is considered to be minimal given the location of the impacts and minor amount of disturbance (0.03%).

18-03-73 Forest Service Number | Cultural Resource Site Report Region 6-USDA-Forest Service | 35 LIN 322 Permanent Number

Continuation Sheet No.(s)
Maps-pg(s). site,sketch; USGS topog.
Photographs-pg(s). N/A
Features-pg(s). N/A
Artifact Drawings-pg(s). N/A
Test Pit(s)-pg(s). N/A
Aerial Photos-pg(s). N/A
Other: ____ pg(s). ____
____ pg(s). ____

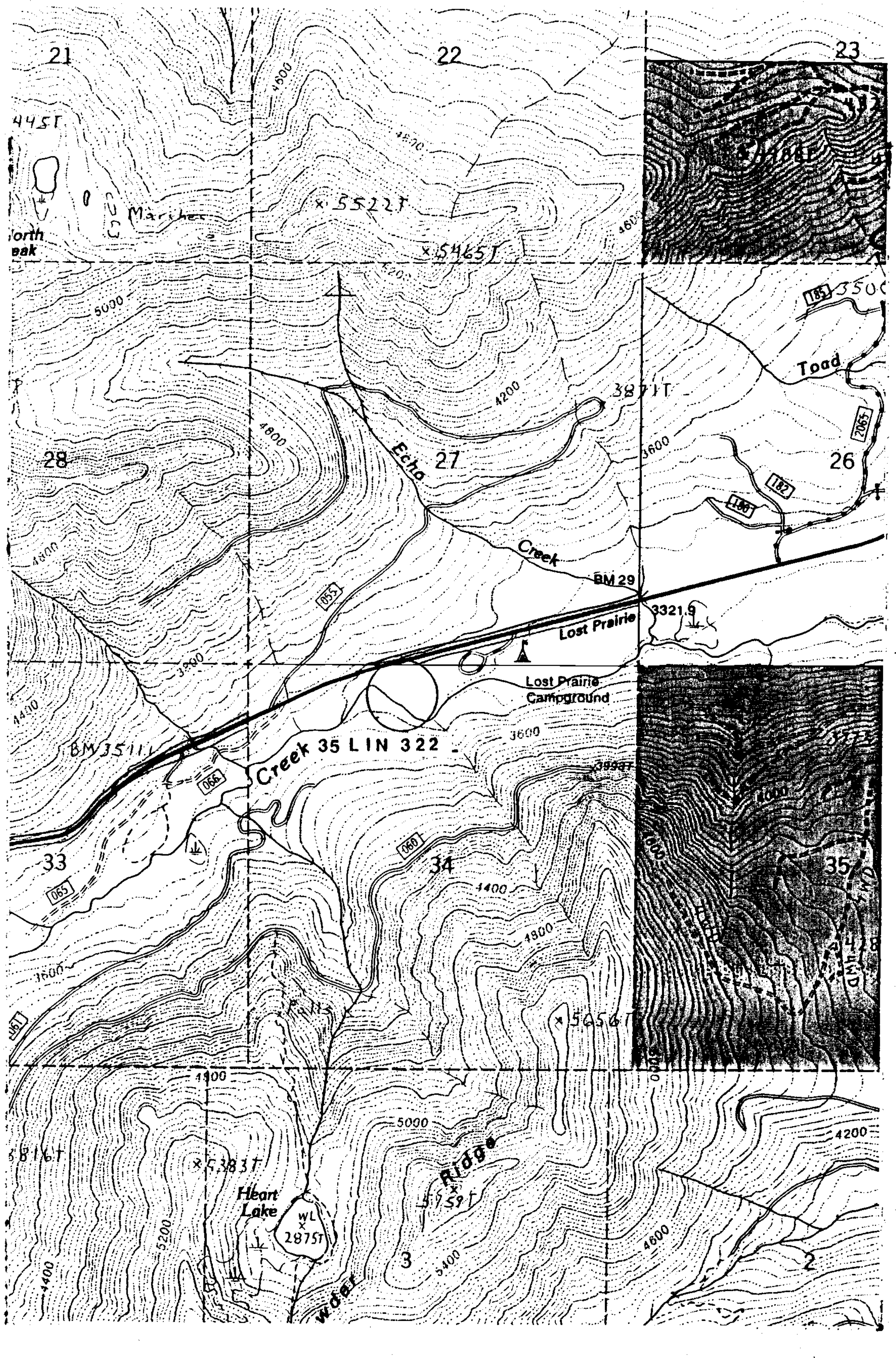
References Cited:

Guminski, Cynthia, Robert Brodsky, and Michael Gilmore (1983) The Santiam Wagon Road: An Historic Preservation Study. Dept. of Planning, Public Policy, and Management. University of Oregon, Eugene.

Material Collected: Yes X No ___
Present Location of Collection: Sweet Home Ranger District
Date(s) Collected: July 1988
Description of Collected Material:
202 lithics, primarily small debitage, collected through exploratory excavations. Three additional modified artifacts were collected in the surface inventory phase (District Catalog Numbers: 3-365,3 -366,3 -367).

Inventory Report Title: Exploratory Excavations at Lost Prairie West
Author: C. Lindberg-Muir Date: 1988
Name of Recorder: C. Lindberg-Muir (after Farque' 1981) Date: 1987
NRHP Eligible Determination: Eligible ____ Not Eligible ____
Date Formal Determination Completed: Potentially eligible, no formal determination at this time.

Approved: ____________________ : ____________________
Name of Professional Reviewer Title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Creek
Toad
BM 29
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Lost Prairie
Lost Prairie Campground
Creek 35 LIN 322
Heart Lake
Ridge
5000
4800
4200
4400
3600
4600
5200
5400

FOREST SERVICE - Region Six
CULTURAL RESOURCE INVENTORY
Record Form

SITE NO. (Temp) 18-03-96
(Perm) 35 LIN 341

Type: Archaeological — District ( ) Yes (X) No

Forest 18 — County LINN — District 03 — State OR — USGS Quad Echo Mtn. 15 Min 1955

Legal: NW¼ of SW¼, Sec. 31 T.13S. R.6E. , W.M.

TRI: Compartment name Browder
Compartment no. 3504
Cell no. 107D 3 & 124 E 3

Elevation: 4241 ft., 1272M.
UTM: Zone 10
Easting 5 68 550
Northing 49 15 900

Lat. 44° 23' 41" Long. 122° 08' 20"

Plant Community: Old-growth Douglas-fir, W. hemlock, true fir, rhododendron, huckleberry
Terrain: Major saddle on Old Cascades Crest

Soils/Sediments: SRI #13, thin gravelly loams

Water Source: Class IV stream - 440 m. 82°AZ

Environmental Features (see instr) Summit of major natural E/W travel corridor. Site approx. ½ mile SW of Tombstone Prairie, between Browder Ridge and Iron Mountain. Site lies at junction of State Hwy 20 and FS Road 060.
DATUM - B. M. 4241'

Site Name Tombstone Summit Site
Size 8000 M^2 — Date of Use Prehistoric

Function/use Seasonal Hunting/Travel camp
How determ.? Surface recon & subsurface testing; proximity to ridgeline travel route & Tombstone Prairie (known aboriginal use).

Present Condition:
( ) Excellent (X) Fair
(X) Deteriorated/disturbed
( ) Hazardous ( ) Usable
( ) Vandalized ( ) Altered

Physical data (see instructions)

Artifacts: Cascade points, uniface scrapers, core fragments, burned bone, core scraper/planer, and biface fragments.

Debitage: Obsidian, CCS, and basalt waste flakes; five black obsidian chunks and waste flakes with cortex present.

Site discovered during cultural resource survey Nov. 1982 in response to Forest Service proposal to construct a parking lot at the junction of State Highway 20 and Forest Rd. 060 (Heart Lake Road). Approximately 10 lithics were found eroding from cutbanks, rodent burrowings, and root wads from windthrown trees, as well as in abandoned trail tread and in reconnaissance survey scarification plots.

Subsurface testing (Determination of Eligibility) was conducted June/July 1983. This consisted of 23 30x30cm^2 shovel test holes screened in 10 cm levels to a depth of approximately 50 cm. The holes were placed at approximately 10m. intervals in 3 lines along the ridge. This testing was followed by Data Recovery Excavations of nine 1X1m^2 and one 1x2m^2 units. These were also screened in 10cm levels to a maximum depth of 130cm. More information and details of both subsurface testing and Data Recovery operations can be found in the Archaeological Test of the Tombstone Summit Site report (C. Lindberg-Muir, 1983).

Expected impacts: (X) Yes ( ) No ( ) Maybe
Source Tombstone Pass Parking Lot Const.
Mitigation recommendations:

Test for significance & perform data recovery if necessary & in consultation with SHPO/ACHP as appropriate.

Recorded by A.E. Farque' Date 7/11/83
Inventory type: ( ) Tickler (Verified ?) ( ) Yes ( ) No
( ) Overview (X) Recon
( ) Survey ( ) Incidental
Reference: Tombstone Summit Parking Lot
Attachments: ( ) Sketch Map ( ) Photo
(X) USGS (X) Catalog
( ) Report ( ) ____________

ARCHAEOLOGICAL SITE RECORD
CONTINUATION SHEET

! X !
!___! SITE NO. 18-03-96

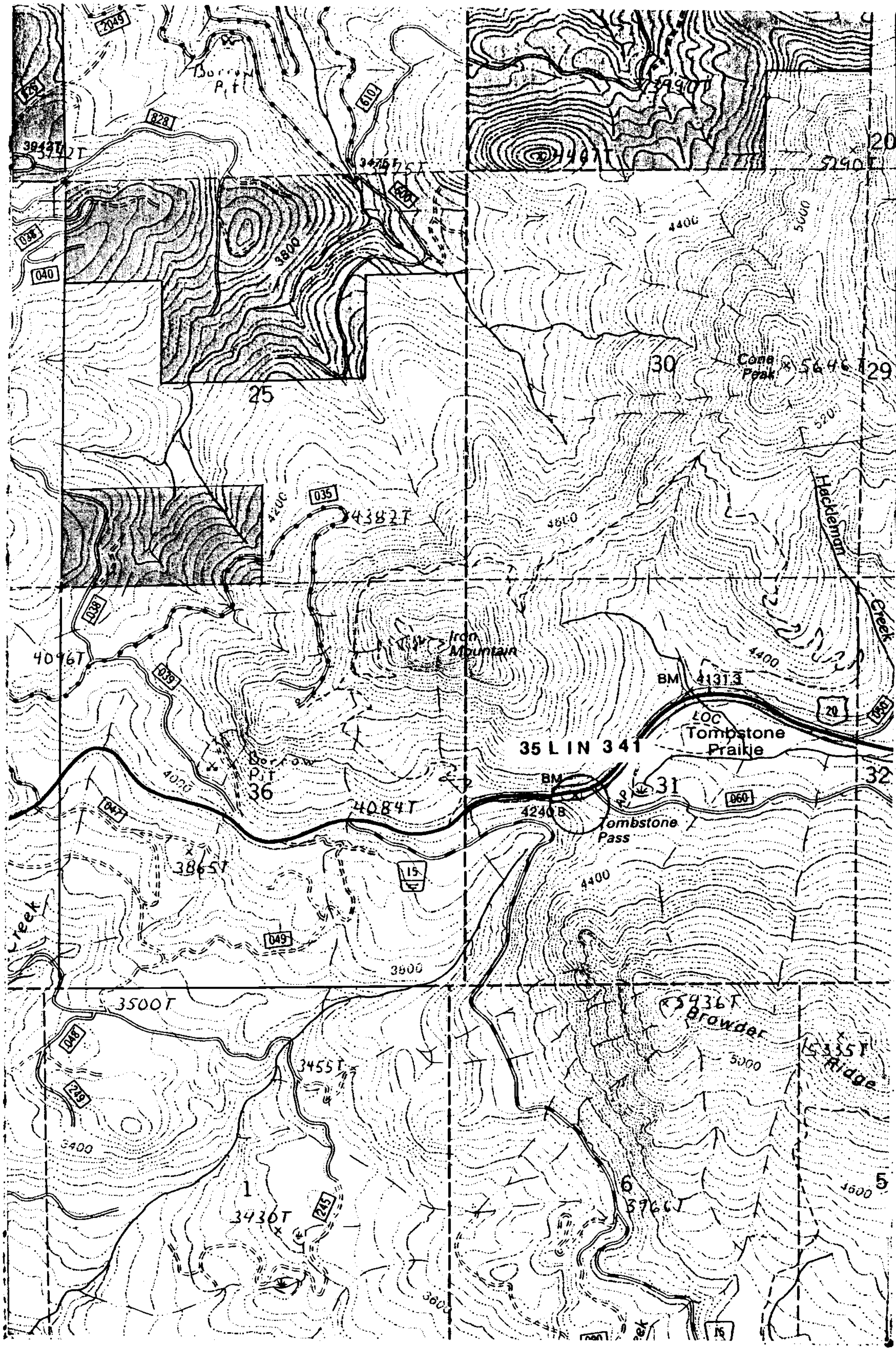
TEMPORARY ! X ! PERMANENT !___!

(Make Entries in Soft Pencil Only)

! X !
!___! BLOCK/ITEM

The construction of Highway 20 (prior to 1939) and Forest Road 060 (approximately 20 years ago) destroyed parts of the site; one flake was found north of Highway 20 and lithics were located east of Forest Road 060. Approximately 50% of the site was destroyed during these prior road building phases.

Andrew Wiley, during his 1859 search for an east/west wagon road route, recorded the Indian trail he was following to Tombstone Summit. From this point, the Indian travel route lead north over Cone Peak and then on to the Park Creek drainage. This historic reference indicates the use of Tombstone Summit as a probable travel route from the Warm Springs area to Squaw Mtn., a reported aboriginal summer grazing area.



Borrow Pit
20
5290T
3800
4400
5000
30
Cone Peak
29
5200
25
035
4382T
Hackleman Creek
Iron Mountain
4096T
4400
BM 4131.3
LOC
Tombstone Prairie
35 L I N 3 4 1
Borrow Pit
36
4000
4084T
BM
4240 B
31
32
Tombstone Pass
3865T
049
3800
3500T
5436T
Browder Ridge
5335T
5000
3455T
3400
1
3430T
6
5
3600
Creek

18-03-184 Forest Service Number | Cultural Resource Site Report Region 6-USDA-Forest Service | 35 LIN 342 Permanent Number

Forest: Willamette Ranger District: Sweet Home County: Linn
Site Name (if any): Monument Peak Trail One

LOCATION DATA: TRI Compartment: Name: Elk ~~Number~~: 3101
Legal Description: SE 1/4 SE 1/4 SW 1/4 NE 1/4, sec. 33 , T. 10S., R. 4E., W.M.

Aerial Photo: Number 12 616180 Flight 1178-14 Date 9-23-79
UTM: Zone 10 Easting 553850mE Northing 4945325mN
U.S.G.S. Quad.: Name Quartzville Series 15 min Date 1956
Elevation: Feet: 3800 . Meters: 1160 .

Describe access to the site and site datum:

The site can be accessed from Sweet Home via Highway 20 to Quartzville Rd (#11) to Yellowbottom Road. Proceed approximately 20 miles up Yellowbottom Rd. to the junction of Forest Service roads 2202-822 and 105. The site lies on either side of the fire control spur road west of the junction. The site and test units were tied into 3 primary data: A, B, C. Datum A was placed on the north side of Rd. 2202-822 to the west of the junction on a 3ft. high charred stump (~20" diam.) in an old clearcut unit (Detroit district), to the northwest of a slash pile. Datum B is located on a 36" diameter stump to the north of Rd. 2202-822 and northeast of the junction with Rd. 105 and Monument Salvage Unit 5 spur road in the same clearcut unit as Datum A. Datum C was placed on a lone western hemlock (~40 dbh) on a knob above a steep roadcut of the first hairpin turn of Rd. 105, south of the site and southeast of the northeast corner of Monument Salvage T.S. Unit 5.

From Datum A to TU #13 is approx. 15m at 220°SW (+5% slope). On-site datum is located north of the temporary spur road, approx. 15m west up the spur road from the junction. From Datum B to the 1x1m test unit is approx. 50m at 252°, +5% slope. On-site datum is approx. 2m northeast of the 1m x 1m test unit. Datum C to TU #15 is approx. 25m at 330°, +20% slope.

SETTING:
Terrain: General Topography: Deeply dissected ridges with steep narrow stream valleys.
Land Form: Ridgeline Saddle Aspect: SE Slope 0-15%
Soils: Surface: Dark-brown gravelly sandy loams and fine sandy loams Depth: 13-23"
SRI 641 Subsurface: Dark-brown to dark yellowish-brown gravelly or cobbly sandy loams Depth: 38-89 cm.
Bedrock: highly fractured andesites & basalts 3-6' in depth
Flora: On-site | Surrounding Site
Overstory Douglas fir, true fir, W. hemlock | same
Understory Rhododendron macrophyllum, Vaccinium spp., fireweed
Ground Cover Xerophyllum tenax, Cornus canadensis, Lupinus spp., Pedicularis spp.

Water Sources:

Name	Type	Distance	Direction	Drainage Basin
Thomas Cr. Hdwtrs.	:Class IV	:1/8 mi.	:North	:Thomas Creek
Unnamed tributary of Elk Creek	:Class IV	:1/16 mi.	:South	:Quartzville Creek

Relation to major drainage: all eventually drain into South Santiam River

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Other Environmental Features:

The site is located in the Thomas Creek headwaters subdrainage basin which is characterized by several springs, wet areas and meadows. Basically, the general topography is steep however, a flat ridge projects out into the center of the valley, and a flat wet meadow area (Mule Shoe Springs) at the northeast end of the drainage.

Site Dimensions: remaining component $1400m^2$ Depth: ~60cm
Date(s) of Use (as specific as possible): Unknown
How Date Determined:
Site Type/Function/Use: Open, lithic scatter / possible tool manufacture-maintenance or resource procurement-processing.

How Determined: Based on artifact assemblage, site topography and environment, and ethnographic analogs.

Physical Data:

The site, on the northeast slope of a ridge line facing Thomas Creek headwaters, is located near the old wagon road from Quartzville to Gates (shown on the Santiam National Forest 1913 Map). Two recorded archaeological sites, and one isolated find, are with one mile of the Monument Peak Trail One site. The first site, 18-04-82, is a prehistoric and historic site; a variety of CCS and obsidian artifacts were recovered from here as well as an old mule shoe, thus, the name Mule Shoe Springs. Apparently, packstrings of mules were utilized during mining activities in the Quartzville area in the nineteenth century.

Other historic roads and trails near the site include those shown on the SNF 1931 and Willamette National Forest 1937 maps.

Soils here are moderately deep, nonplastic deposits derived from glacial till and colluvium. Soils developed from glacial outwash and till proceed at a faster rate than residual soils, especially "A" horizons ("B" horizons develop slower than residual soils). In addition, surface soils (10-15cm depth) on the site appear to have been burnt in the past.

* Old Clearcut Unit on Detroit District

18-03-184 Forest Service Number | Cultural Resource Site Report Region 6-USDA-Forest Service | 35 LIN 342 Permanent Number

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Present Condition of Site:
The site has been seriously disturbed or removed altogether at the junction of Rds. 2202-822 and 105. Construction of a spur road for fire suppression had disturbed the surface soils, redepositing cultural material. A portion of the site remains in a relatively undisturbed condition.

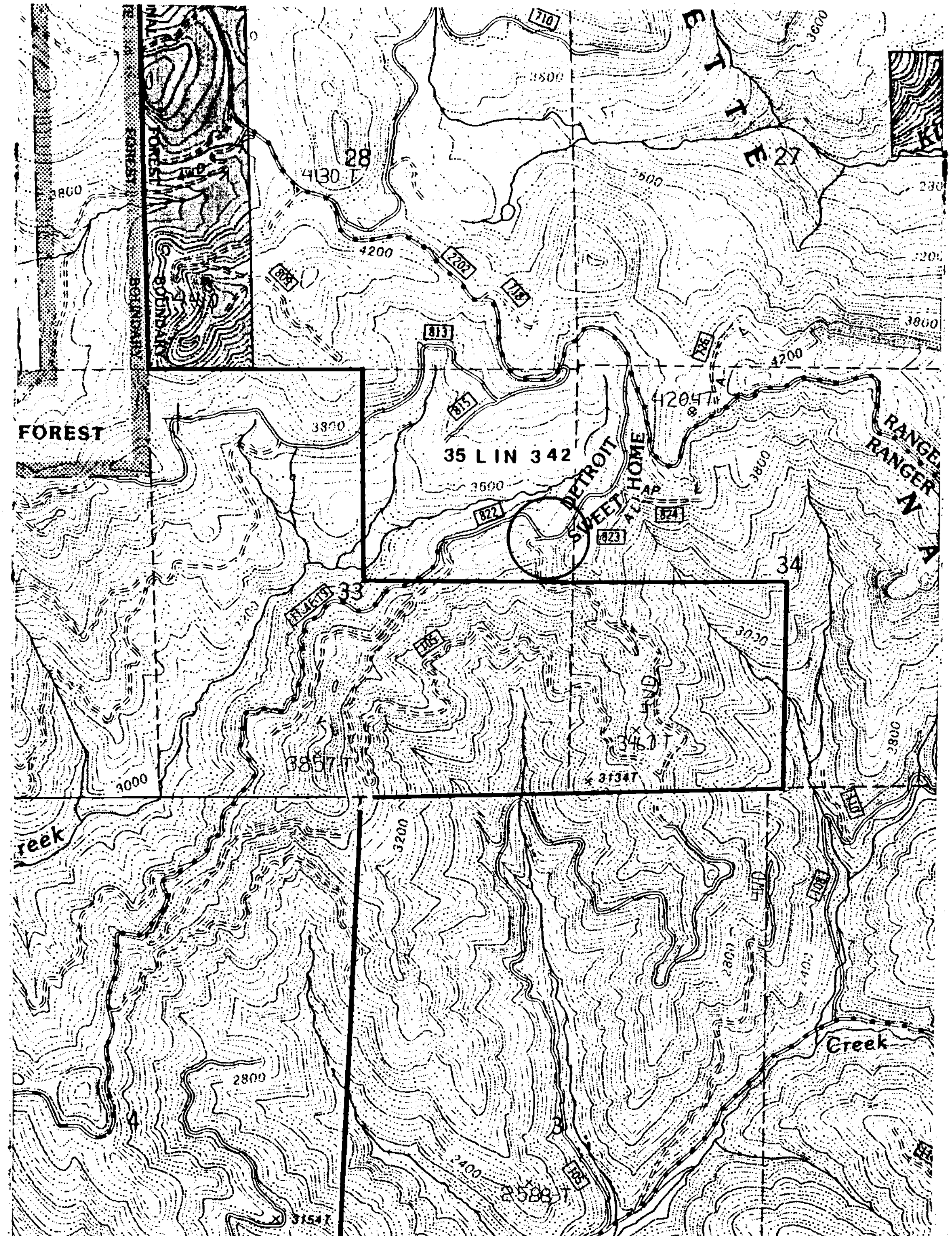
Expected Impacts/Present Use:
Short-term: Monument Salvage Units 3 and 5 will use existing spur road for access. If logging is accomplished when the road is in a completely dry state, there should be no further damage to archaeological deposits.
(site to be protected from...)
Long-term: Future logging and related ground disturbance activities, fire control construction; natural erosion and downslope movement.

Continuation Sheet No.(s)
Maps-pg(s).______ Test Pit(s)-pg(s).______
Photographs-pg(s).______ Aerial Photos-pg(s).______
Features-pg(s).______ Other:______pg(s).______
Artifact Drawings-pg(s).______ ______pg(s).______
References Cited: Monument Peak Testing and Evaluation Report, CLM, 1986.

Material Collected: Yes X No___
Present Location of Collection: SHRD
Date(s) Collected: 5 Aug. 86 - 15 Aug. 86
Description of Collected Material:
A total of 361 stone artifacts were recovered from Monument Peak Trail One: 17 from berm deposits, 176 from subsurface excavation and 168 from surface collection. Lithic material includes obsidian, CCS and basalt. Cataloged tools include 3 projectile points, 2 bifaces, 7 unifaces, 4 core tools and a utilized basalt flake. Tool total, including utilized flakes = 51.

Inventory Report Title: Cultural Resource Report for Monument Salvage Timber Sale
Author: Anthony Farque Date: 1986
Name of Recorder: Madeline ~~Cole~~ Date: ?
NRHP Eligible Determination: Eligible X Not Eligible______
Date Formal Determination Completed: 2/20/87

Approved:______:______
Name of Professional Reviewer Title


FOREST
35 L IN 342
DETROIT
SWEET HOME
28
27
33
34
4
3
4130 T
4204 T
3857 T
3467 T
2588 T
Creek
Creek
Elk
RANGER
RANGER
BOUNDARY
FOREST
3800
3600
4200
3000
3200
2800
2400
2200
2600

Appendix C. X-ray Flourescence analysis results, letter report from Richard E. Hughes (1988b).

SONOMA STATE UNIVERSITY
ACADEMIC FOUNDATION, INC.

ANTHROPOLOGICAL STUDIES CENTER
CULTURAL RESOURCES FACILITY
707 664-2381

May 24, 1988

Ms. Cathy Lindberg-Muir
Department of Anthropology
Oregon State University
Corvallis, OR 97331

Dear Ms. Lindberg-Muir:

Enclosed with this letter you will find copies of seven tables presenting x-ray fluorescence (xrf) data generated from the analysis of 90 obsidian specimens from six archaeological sites in the Sweet Home Ranger District, Willamette National Forest, Oregon. This research was conducted as a portion of U.S.D.A. (Willamette National Forest) Purchase Order No. 40-04R4-8-8363 under Sonoma State University Academic Foundation, Inc. Account 6081, Job X88-23.

Laboratory investigations were performed on a Spectrace™ 5000 (Tracor X-ray) energy dispersive x-ray fluorescence spectrometer equipped with a Rh x-ray tube, a 50 kV x-ray generator, with microprocessor controlled pulse processor (amplifier) and bias/protection module, a 100 mHz analog to digital converter (ADC) with automated energy calibration, and a Si(Li) solid state detector with 150 eV resolution (FWHM) at 5.9 keV in a 30 mm^2 area. The x-ray tube was operated at 30.0 kV, .30 mA, using a .127 mm Rh primary beam filter in an air path at 200 seconds livetime to generate quantitative data for the elements zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr) and niobium (Nb). Quantitative estimates of titanium (Ti), manganese (Mn) and iron ($Fe_2O_3^T$) composition were were computed from data generated by operating the x-ray tube at 15.0 kV, .30 mA, with a .127 mm Al filter in an air path at 200 seconds livetime. Data processing for all analytical subroutines is executed by a Hewlett Packard Vectra™ microcomputer, with operating software and analytical results stored on a Hewlett Packard 20 megabyte fixed disk. Trace element concentrations were computed from a least-squares calibration line established for each element from analysis of up to 25 international rock standards certified by the U.S. Geological Survey, the U.S. National Bureau of Standards, the Geological Survey of Japan, and the Centre de Recherches Petrographiques et Geochimiques (France). Further details pertaining to x-ray tube operating conditions and calibration appear in Hughes (n.d.).

Trace element measurements on the xrf data tables are expressed in quantitative units (i.e. parts per million [ppm] by weight), and matches between unknowns and known obsidian chemical groups were made on the basis of correspondences (at the 2-sigma level) in diagnostic trace element concentration values (in this case, ppm values for Rb, Sr, Y, Zr, and when necessary, Ti, Mn and Fe) that appear in Hughes (1985, 1986a, b), Hughes and Mikkelsen (1986), Jack and Carmichael (1969), and Skinner

(1983, 1986). I use the term "diagnostic" to specify those trace elements that are well-measured by x-ray fluorescence, and whose concentrations show low intra-source variability and marked variability across sources. In short, diagnostic elements are those whose concentration values allow one to draw the clearest geochemical distinctions between sources. Although Zn, Ga and Nb ppm concentrations also were measured and reported for each specimen, they are not considered "diagnostic" because they don't usually vary significantly across obsidian sources (see Hughes 1982, 1984). This is particularly true of Ga, which occurs in concentrations between 10-30 ppm in nearly all parent obsidians in the study area. Zn ppm values are infrequently diagnostic; they are always high in Zr-rich, Sr-poor peralkaline volcanic glasses, but otherwise they do not vary significantly between sources in the study area. Likewise, Nb typically occurs in low concentrations in most volcanic glasses in the study area.

The enclosed data tables present source attribution for each specimen, so I will not repeat individual assignments. As a group, this assemblage is dominated by artifacts that match the Rb, Sr, and Zr composition of volcanic glasses from the Obsidian Cliffs flows, which should not be surprising given the proximity of the sites to the source. Skinner (1983, 1986), however, recently has identified two geochemically distinct varieties of obsidian from the Inman Creek gravels and near mouth of the Suislaw River that are similar in Rb, Sr, and Zr composition to volcanic glasses from Obsidian Cliffs. To judge from Skinner's (1986: Table 1; also 1983: Table V-1) xrf data, despite similarities in Rb and Zr composition, the Inman Creek group with comparatively high strontium (Sr) content (ca. 140-160 ppm; Skinner's Inman Creek Group A") can be separated from Obsidian Cliffs using Sr ppm values (as well as Ti, Mn and Fe composition; see table on page 3). The second Inman Creek glass type (Skinner's "Inman Creek Group B") contains ca. 20-40 ppm less Sr than Group A but, <u>if</u> the small number of source samples adequately describes the parent population, Group B also can be distinguished from Obsidian Cliffs in that it contains ca. 20-30 ppm less Zr than Obsidian Cliffs.

I should add that I do not have an adequate number of Inman Creek geologic source standards in my possession to assess independently the range of compositional variation within each source type. My Inman Creek (Fern Ridge) sample, generously provided by Rick Pettigrew, consists entirely of the Group A variety (cf. Skinner 1986: 27, Table 1) and currently I have no specimens representative of Skinner's "Inman Creek Group B" geochemical type. For comparison, page 3 of this letter contains a table showing minor and trace element composition data for Obsidian Cliffs and Inman Creek (Fern Ridge) glasses to illustrate the contrasts between these two source types. As you will see Obsidian Cliffs and Inman Creek Group A are very distinct in terms of Ti, Mn, $Fe_2O_3^T$ and Sr composition. Nonetheless, since I lack <u>any</u> Inman Creek Group B samples, I have relied on Skinner's (1983, 1986) small (n=3) data set to identify inter-source contrasts.

Cat. Number	Minor and Trace Element Concentrations Ti	Mn	Fe	Rb	Sr	Zr	Ba*	Obsidian Source (Chemical Type)
7136:1	663.1 ±34.8	387.9 ±25.3	1.20 ±.09	79.6 ±5.0	104.5 ±3.1	92.4 ±4.2	917.6 ±16.0	OBSIDIAN CLIFFS
7136:2	544.2 ±35.1	379.9 ±25.3	1.21 ±.09	78.2 ±5.0	104.2 ±3.1	93.1 ±4.2	934.4 ±15.8	OBSIDIAN CLIFFS
7136:3	695.1 ±36.0	392.6 ±25.4	1.26 ±.09	74.0 ±5.0	99.6 ±3.2	84.7 ±4.3	908.4 ±16.0	OBSIDIAN CLIFFS
FR-1	585.7 ±36.2	642.4 ±25.7	1.95 ±.09	85.0 ±5.1	154.4 ±3.5	109.9 ±4.3	847.5 ±15.8	INMAN CREEK (FERN RIDGE)
FR-2	481.1 ±36.1	633.5 ±25.6	1.83 ±.09	83.6 ±5.1	144.5 ±3.4	95.6 ±4.3	855.8 ±16.0	INMAN CREEK (FERN RIDGE)
FR-3	543.4 ±35.5	621.2 ±25.6	1.89 ±.09	75.6 ±5.0	150.9 ±3.4	100.3 ±4.3	813.1 ±15.7	INMAN CREEK (FERN RIDGE)

All values in parts per million (ppm) except iron, expressed as total iron ($Fe_2O_3^T$) in weight percent. ± = pooled expression of x-ray counting uncertainty and regression fitting error at 200 and 300 (*) seconds livetime.

To corroborate the assignments, I selected a group of specimens from all six sites (n=32, see data table presenting Ti, Mn, and Fe measurements) with Sr ppm values near the lower limits of Skinner's (1986: Table 1) Inman Creek Group B obsidian. In all but three cases (specimens SF3-1, LP3-3, and LP7-6) the Ti, Mn and Fe concentration values for the artifacts matched those for parent source material from Obsidian Cliffs (cf. with measurements in the table above). The three exceptions all contain greater amounts of Ti and Fe than I have so far observed in Obsidian Cliffs glass; consequently I have appended a "?" to these attributions in the data tables.

It was of interest that Devil Point obsidian was identified in two of your sites (Monument Peak Trail One and Yukwah [35-LIN-118]). This distinctive glass type (see Hughes 1986b for trace element data) was first recognized archaeologically in a small sample of artifacts from the Detroit Ranger District (Hughes 1986b) and more recently I have identified it in archaeological assemblages from 35-LIN-312 (Hughes 1987) and 35-LIN-310 (Hughes 1988).

I hope this information will help in your analysis of these site materials. Unless I hear otherwise, I will retain these specimens and return them to Carl Davis.

Sincerely,

Richard E. Hughes

Richard E. Hughes, Ph.D.
Senior Research Archaeologist

cc: Carl Davis, Willamette National Forest

References

Hughes, Richard E.

1982 Age and Exploitation of Obsidian from the Medicine Lake Highland, California. **Journal of Archaeological Science**, Vol. 9 (2): 173-185.

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1985 X-ray Fluorescence Analysis of Obsidian from Five Localities Along the Sycan and Sprague Rivers, Winema National Forest, Klamath County, Oregon. Report on file at the Winema National Forest, Klamath Falls, Oregon.

1986a Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon. **University of California Publications in Anthropology**, Vol. 17.

1986b X-ray Fluorescence Analysis of Artifacts from the Rigdon and Detroit Ranger Districts, Willamette National Forest, Oregon. Letter report submitted to James Heid, Forest Archaeologist, Willamette National Forest, November 25, 1986.

1987 X-ray Fluorescence Analysis of Artifacts from 35-LIN-186, 35-LIN-312, and 35-MA-68, Oregon. Letter report submitted to Ron King, Coastal Magnetic Search and Survey, November 10, 1987.

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n.d. The Coso Volcanic Field Re-examined: Implications for Obsidian Sourcing and Hydration Dating Research. **Geoarchaeology**. In press.

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Jack, R.N., and I.S.E. Carmichael
1969 The Chemical 'Fingerprinting' of Acid Volcanic Rocks. **California Division of Mines and Geology, Special Report** 100: 17-32. San Francisco.

Skinner, Craig
1983 Obsidian Studies in Oregon: An Introduction to Obsidian and an Investigation of Selected Methods of Obsidian Characterization Utilizing Obsidian Collected at Prehistoric Quarry Sites in Oregon. M.A. Thesis in Interdisciplinary Studies, University of Oregon, Eugene.

1986 The Occurrence, Characterization, and Prehistoric Utilization of Geologic Sources of Obsidian in Central Western Oregon: Preliminary Research Results. Unpublished Manuscript.

May 24, 1988

Sweethome R.D. Xrf Data
Page 1 of 6

Specimen Number	Trace Element Concentrations							Obsidian Source (Chemical Type)
	Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	
TS2-1	39.0 ±16.0	16.5 ±6.8	96.1 ±5.3	122.0 ±3.6	15.5 ±3.0	103.6 ±4.6	6.0 ±4.1	OBSIDIAN CLIFFS
TS2-2	45.9 ±13.9	25.2 ±5.2	90.2 ±5.3	111.5 ±3.6	16.7 ±2.9	98.1 ±4.7	10.3 ±3.9	OBSIDIAN CLIFFS
TS2-3	67.6 ±12.2	22.3 ±6.0	91.2 ±5.6	124.8 ±4.1	21.5 ±3.0	91.3 ±4.9	1.8 ±3.0	OBSIDIAN CLIFFS
TS2-4	53.4 ±10.5	19.7 ±5.2	91.2 ±5.2	109.5 ±3.4	19.6 ±2.6	95.4 ±4.5	10.9 ±3.7	OBSIDIAN CLIFFS
TS2-5	43.8 ±11.3	18.8 ±5.1	79.3 ±5.1	102.2 ±3.3	19.4 ±2.4	93.4 ±4.4	10.4 ±3.6	OBSIDIAN CLIFFS
TS10-1	66.2 ±13.4	19.6 ±6.9	93.3 ±5.7	133.4 ±4.3	18.2 ±3.3	108.5 ±5.1	11.3 ±4.3	OBSIDIAN CLIFFS
TS10-2	35.6 ±16.1	21.9 ±4.8	79.0 ±5.2	103.0 ±3.5	16.2 ±2.8	87.6 ±4.5	8.5 ±3.8	OBSIDIAN CLIFFS
TS10-3	66.6 ±9.6	17.5 ±5.7	70.6 ±5.2	185.2 ±4.1	21.6 ±2.5	161.6 ±4.9	11.4 ±3.7	UNKNOWN A
TS10-4	64.1 ±11.5	23.2 ±5.8	95.9 ±5.6	115.9 ±3.9	20.5 ±3.0	93.9 ±4.9	1.8 ±3.0	OBSIDIAN CLIFFS
TS10-5	75.2 ±12.6	23.5 ±6.3	80.8 ±5.6	194.6 ±5.3	14.1 ±4.1	161.8 ±5.8	18.4 ±4.2	UNKNOWN A
MP1-1	60.1 ±10.3	20.4 ±5.3	80.3 ±5.3	103.3 ±3.5	17.0 ±2.8	90.8 ±4.6	10.5 ±3.8	OBSIDIAN CLIFFS
MP1-2	121.3 ±10.3	17.8 ±6.8	128.6 ±5.8	13.0 ±3.1	44.7 ±2.8	367.9 ±7.0	18.4 ±4.0	UNKNOWN B
MP2-1	59.4 ±10.7	10.4 ±19.8	95.8 ±5.4	123.3 ±3.7	16.7 ±3.0	99.4 ±4.7	10.8 ±3.9	OBSIDIAN CLIFFS
MP2-2	72.5 ±10.7	15.2 ±7.7	81.3 ±5.4	191.3 ±4.5	20.4 ±2.9	197.1 ±5.5	11.4 ±4.0	UNKNOWN C?
MP2-3	63.5 ±10.4	30.9 ±4.3	95.0 ±5.3	112.1 ±3.6	22.1 ±2.7	216.8 ±5.4	16.2 ±3.7	DEVIL POINT
MP2-4	59.3 ±12.7	18.6 ±6.4	91.2 ±5.6	120.4 ±4.0	17.3 ±3.2	101.9 ±4.9	11.7 ±4.1	OBSIDIAN CLIFFS
MP2-5	67.6 ±8.6	21.3 ±4.6	102.2 ±5.2	120.3 ±3.4	24.7 ±2.5	218.7 ±5.0	16.9 ±3.6	DEVIL POINT

* - trace element values in parts per million (ppm); ± - counting and fitting error uncertainty at 200 seconds livetime.

May 24, 1988

Sweethome R.D. Xrf Data

Specimen Number	Trace Element Concentrations Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	Obsidian Source (Chemical Type)
MP3-1	62.1 ±12.3	13.4 ±9.5	107.5 ±5.7	122.7 ±4.0	25.7 ±2.9	241.3 ±6.1	14.5 ±4.1	DEVIL POINT
MP4-1	71.0 ±12.5	27.5 ±5.5	90.6 ±5.9	121.7 ±4.6	16.8 ±3.9	94.1 ±5.4	1.8 ±3.0	OBSIDIAN CLIFFS
MP4-2	47.4 ±15.5	23.8 ±5.7	78.0 ±5.6	114.7 ±4.1	21.5 ±3.0	92.9 ±5.0	13.5 ±4.2	OBSIDIAN CLIFFS
SF2-1	44.4 ±10.7	17.0 ±5.4	91.6 ±5.2	113.0 ±3.4	16.0 ±2.8	89.9 ±4.5	10.3 ±3.7	OBSIDIAN CLIFFS
SF2-2	55.4 ±8.5	23.3 ±4.1	80.8 ±5.1	104.3 ±3.3	16.5 ±2.6	94.3 ±4.3	7.7 ±3.6	OBSIDIAN CLIFFS
SF3-1	60.3 ±9.4	16.2 ±5.7	86.4 ±5.3	120.4 ±3.5	18.3 ±2.7	98.9 ±4.5	5.5 ±4.1	OBSIDIAN CLIFFS?
SF3-2	55.2 ±10.4	23.7 ±4.5	102.3 ±5.3	127.0 ±3.7	17.7 ±2.9	95.5 ±4.6	10.3 ±3.8	OBSIDIAN CLIFFS
SF3-3	44.5 ±11.5	19.0 ±5.1	95.0 ±5.3	118.8 ±3.5	19.4 ±2.6	102.9 ±4.5	14.0 ±3.7	OBSIDIAN CLIFFS
SF4-1	51.2 ±10.3	13.4 ±7.5	88.8 ±5.3	121.4 ±3.5	20.0 ±2.6	94.7 ±4.5	7.9 ±3.8	OBSIDIAN CLIFFS
SF4-2	42.2 ±10.8	18.5 ±4.7	89.4 ±5.1	109.4 ±3.3	14.9 ±2.8	95.4 ±4.4	12.8 ±3.6	OBSIDIAN CLIFFS
SF4-3	51.5 ±10.0	19.6 ±4.9	85.2 ±5.2	113.2 ±3.5	19.3 ±2.6	100.0 ±4.5	13.2 ±3.6	OBSIDIAN CLIFFS
SF5-1	47.3 ±10.7	16.0 ±5.7	86.4 ±5.2	111.6 ±3.5	20.7 ±2.6	92.4 ±4.5	12.7 ±3.7	OBSIDIAN CLIFFS
SF5-2	52.1 ±8.5	18.7 ±4.4	85.6 ±5.1	113.9 ±3.2	21.0 ±2.4	92.1 ±4.3	5.3 ±3.8	OBSIDIAN CLIFFS
Y3-1	44.1 ±10.4	17.1 ±5.0	83.5 ±5.2	110.4 ±3.4	16.5 ±2.7	86.5 ±4.4	4.6 ±4.2	OBSIDIAN CLIFFS
Y3-2	67.1 ±11.1	17.8 ±6.0	79.4 ±5.5	101.8 ±3.9	18.7 ±3.0	92.7 ±4.9	7.4 ±4.3	OBSIDIAN CLIFFS
Y3-3	58.9 ±12.5	9.0 ±2.5	88.3 ±5.6	116.1 ±4.1	17.1 ±3.3	98.7 ±5.0	9.5 ±4.2	OBSIDIAN CLIFFS
Y3-4	53.6 ±12.9	20.8 ±6.0	95.8 ±5.8	130.3 ±4.3	13.1 ±4.3	99.6 ±5.1	1.8 ±3.0	OBSIDIAN CLIFFS

* = trace element values in parts per million (ppm); ± = counting and fitting error uncertainty at 200 seconds livetime.

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Sweethome R.D. Xrf Data
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Specimen Number	Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	Obsidian Source (Chemical Type)
	Trace Element Concentrations							
Y3-5	44.5 ±13.0	11.9 ±11.4	87.7 ±5.4	118.6 ±3.7	14.8 ±3.2	88.9 ±4.7	12.0 ±3.9	OBSIDIAN CLIFFS
Y3-6	49.7 ±11.3	21.9 ±5.0	75.1 ±5.3	107.7 ±3.6	19.5 ±2.7	85.9 ±4.6	8.5 ±3.9	OBSIDIAN CLIFFS
Y3-7	51.5 ±9.8	19.1 ±4.7	89.6 ±5.2	112.3 ±3.4	19.1 ±2.6	100.2 ±4.5	9.1 ±3.7	OBSIDIAN CLIFFS
Y3-8	64.8 ±9.4	17.7 ±5.5	87.8 ±5.3	127.7 ±3.7	17.9 ±2.8	96.4 ±4.6	13.9 ±3.8	OBSIDIAN CLIFFS
Y3-9	43.4 ±9.6	17.9 ±4.4	86.3 ±5.1	109.3 ±3.3	17.9 ±2.5	92.1 ±4.3	6.8 ±3.7	OBSIDIAN CLIFFS
Y3-10	61.2 ±9.2	19.5 ±4.7	101.7 ±5.3	113.4 ±3.4	25.9 ±2.5	222.5 ±5.1	12.9 ±3.7	DEVIL POINT
Y8-1	45.6 ±9.6	14.0 ±6.2	81.2 ±5.1	106.1 ±3.3	22.2 ±2.4	90.1 ±4.4	5.5 ±3.8	OBSIDIAN CLIFFS
Y8-2	42.9 ±11.2	14.9 ±5.7	87.0 ±5.2	112.6 ±3.4	16.0 ±2.7	92.3 ±4.4	6.5 ±3.8	OBSIDIAN CLIFFS
Y8-3	51.3 ±8.3	17.0 ±4.5	79.8 ±5.1	112.9 ±3.2	21.3 ±2.4	92.6 ±4.3	6.7 ±3.6	OBSIDIAN CLIFFS
Y8-4	48.6 ±10.2	13.2 ±7.4	76.8 ±5.2	106.4 ±3.5	16.3 ±2.8	87.4 ±4.5	5.4 ±4.1	OBSIDIAN CLIFFS
Y8-5	52.6 ±10.2	13.9 ±7.1	92.3 ±5.3	124.7 ±3.6	21.2 ±2.6	94.6 ±4.6	11.4 ±3.8	OBSIDIAN CLIFFS
Y8-6	53.8 ±10.4	19.5 ±4.8	88.2 ±5.3	122.8 ±3.6	20.9 ±2.6	96.8 ±4.6	6.8 ±3.9	OBSIDIAN CLIFFS
Y8-7	57.4 ±12.4	14.0 ±9.7	95.0 ±5.7	118.6 ±4.2	19.3 ±3.2	100.8 ±5.1	1.8 ±3.0	OBSIDIAN CLIFFS
Y8-8	75.3 ±11.1	16.5 ±7.4	90.2 ±5.7	117.3 ±4.3	17.7 ±3.3	107.5 ±5.1	13.7 ±4.2	OBSIDIAN CLIFFS
Y8-9	51.0 ±16.0	9.4 ±9.9	75.4 ±5.8	115.5 ±4.4	16.3 ±3.7	85.1 ±5.3	8.8 ±4.7	OBSIDIAN CLIFFS
Y8-10	45.4 ±11.8	21.5 ±4.7	88.0 ±5.3	110.5 ±3.6	15.1 ±3.1	95.5 ±4.6	8.2 ±4.0	OBSIDIAN CLIFFS
Y10-1	45.9 ±9.6	12.6 ±7.7	75.3 ±5.1	103.6 ±3.2	16.5 ±2.5	91.1 ±4.3	9.7 ±3.5	OBSIDIAN CLIFFS

* = trace element values in parts per million (ppm); ± = counting and fitting error uncertainty at 200 seconds livetime.

May 24, 1988

Specimen Number	Trace Element Concentrations Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	Obsidian Source (Chemical Type)
Y13-1	62.5 ±9.9	21.0 ±5.1	89.7 ±5.4	115.8 ±3.7	20.7 ±2.7	95.7 ±4.7	9.1 ±3.9	OBSIDIAN CLIFFS
Y13-2	45.6 ±13.3	12.9 ±9.6	82.5 ±5.4	113.1 ±3.8	19.2 ±2.8	98.1 ±4.7	8.1 ±4.1	OBSIDIAN CLIFFS
Y13-3	76.4 ±11.7	12.0 ±15.0	86.5 ±5.8	118.9 ±4.5	19.9 ±3.3	101.3 ±5.3	13.8 ±4.4	OBSIDIAN CLIFFS
Y14-1	74.6 ±12.1	18.3 ±6.6	94.2 ±5.8	140.0 ±4.4	20.1 ±3.3	103.3 ±5.2	1.8 ±3.0	OBSIDIAN CLIFFS
Y14-2	63.7 ±11.5	19.7 ±5.8	93.6 ±5.5	164.4 ±4.4	18.3 ±3.1	134.8 ±5.2	1.8 ±3.0	UNKNOWN D?
Y14-3	52.7 ±9.0	18.4 ±4.6	87.7 ±5.1	112.5 ±3.3	17.6 ±2.6	91.8 ±4.4	12.7 ±3.6	OBSIDIAN CLIFFS
Y14-4	65.7 ±11.3	12.6 ±10.3	86.7 ±5.5	109.6 ±4.0	16.0 ±3.4	93.6 ±4.9	9.0 ±4.2	OBSIDIAN CLIFFS
Y15-1	60.1 ±18.5	17.7 ±10.0	93.2 ±6.8	125.0 ±5.6	15.7 ±5.5	85.2 ±6.4	1.8 ±3.0	OBSIDIAN CLIFFS
Y17-1	46.8 ±9.0	13.2 ±6.2	78.8 ±5.1	106.8 ±3.2	14.6 ±2.6	90.8 ±4.3	6.6 ±3.6	OBSIDIAN CLIFFS
LP3-1	64.9 ±10.7	13.2 ±9.4	90.1 ±5.4	119.2 ±3.8	17.2 ±3.1	95.4 ±4.8	7.6 ±4.2	OBSIDIAN CLIFFS
LP3-2	47.6 ±18.1	17.1 ±8.5	91.8 ±6.0	115.3 ±4.6	22.7 ±3.4	97.3 ±5.5	1.8 ±3.0	OBSIDIAN CLIFFS
LP3-3	84.2 ±11.9	20.4 ±6.7	91.7 ±5.8	120.3 ±4.3	15.6 ±3.7	102.1 ±5.2	9.1 ±4.5	OBSIDIAN CLIFFS?
LP3-4	65.5 ±8.8	19.2 ±4.9	86.3 ±5.2	114.2 ±3.5	18.5 ±2.6	93.9 ±4.5	8.7 ±3.7	OBSIDIAN CLIFFS
LP3-5	35.9 ±17.4	18.6 ±5.6	84.0 ±5.3	108.9 ±3.7	14.7 ±3.2	95.5 ±4.7	5.3 ±4.3	OBSIDIAN CLIFFS
LP3-6	60.0 ±8.6	19.0 ±4.6	83.3 ±5.2	115.6 ±3.4	19.3 ±2.5	99.0 ±4.4	10.0 ±3.6	OBSIDIAN CLIFFS
LP7-1	44.7 ±11.6	17.0 ±5.4	79.3 ±5.2	107.6 ±3.5	19.0 ±2.7	88.0 ±4.6	12.7 ±3.7	OBSIDIAN CLIFFS
LP7-2	38.4 ±10.8	12.5 ±7.2	82.0 ±5.1	103.8 ±3.2	19.5 ±2.3	90.7 ±4.3	6.7 ±3.6	OBSIDIAN CLIFFS

* = trace element values in parts per million (ppm); ± = counting and fitting error uncertainty at 200 seconds livetime.

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Specimen Number	Trace Element Concentrations							Obsidian Source (Chemical Type)
	Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	
LP7-3	55.0 ±10.7	20.0 ±5.1	87.9 ±5.4	121.6 ±3.8	20.2 ±2.8	96.7 ±4.8	1.8 ±3.0	OBSIDIAN CLIFFS
LP7-4	58.6 ±10.2	23.2 ±4.7	92.8 ±5.4	121.6 ±3.7	18.7 ±2.8	101.9 ±4.7	9.4 ±3.9	OBSIDIAN CLIFFS
LP7-5	57.4 ±9.7	17.6 ±5.2	78.6 ±5.2	108.4 ±3.5	18.3 ±2.6	89.8 ±4.5	5.0 ±4.1	OBSIDIAN CLIFFS
LP7-6	49.5 ±11.6	21.0 ±5.0	94.4 ±5.4	122.8 ±3.8	17.1 ±2.9	92.3 ±4.7	15.1 ±3.8	OBSIDIAN CLIFFS?
LP10-1	47.2 ±8.8	18.4 ±4.3	84.5 ±5.1	112.3 ±3.2	19.0 ±2.4	91.8 ±4.3	10.0 ±3.5	OBSIDIAN CLIFFS
LP10-2	61.6 ±11.6	15.9 ±7.7	85.8 ±5.6	121.5 ±4.2	21.4 ±3.0	100.4 ±5.1	11.0 ±4.3	OBSIDIAN CLIFFS
LP10-3	60.5 ±11.6	19.0 ±5.7	87.9 ±5.5	114.5 ±3.9	17.5 ±3.1	99.6 ±4.9	12.3 ±4.0	OBSIDIAN CLIFFS
LP10-4	53.9 ±8.5	21.2 ±4.1	80.8 ±5.1	107.5 ±3.3	15.9 ±2.6	91.0 ±4.3	7.9 ±3.6	OBSIDIAN CLIFFS
LP10-5	47.4 ±10.3	22.9 ±4.2	82.9 ±5.2	112.4 ±3.5	20.7 ±2.5	96.6 ±4.5	11.4 ±3.7	OBSIDIAN CLIFFS
LP10-6	67.1 ±10.0	14.7 ±7.5	94.4 ±5.4	126.1 ±3.9	18.4 ±3.0	98.5 ±4.8	5.4 ±4.4	OBSIDIAN CLIFFS
DS2-1	41.8 ±9.5	19.6 ±4.0	83.6 ±5.1	105.1 ±3.2	16.5 ±2.5	91.3 ±4.3	8.5 ±3.5	OBSIDIAN CLIFFS
DS2-2	44.0 ±8.9	15.1 ±4.9	78.2 ±5.0	101.5 ±3.1	15.2 ±2.5	88.3 ±4.2	8.5 ±3.5	OBSIDIAN CLIFFS
DS2-3	59.9 ±11.5	12.9 ±10.6	89.8 ±5.5	123.1 ±4.0	21.6 ±2.9	102.3 ±4.9	8.0 ±4.2	OBSIDIAN CLIFFS
DS2-4	57.9 ±10.4	23.5 ±4.7	80.7 ±5.3	111.7 ±3.6	20.8 ±2.6	90.0 ±4.6	12.6 ±3.8	OBSIDIAN CLIFFS
DS2-5	65.4 ±11.8	16.0 ±7.3	98.9 ±5.6	120.1 ±4.0	19.2 ±3.1	96.1 ±4.9	8.9 ±4.2	OBSIDIAN CLIFFS
DS2-6	45.5 ±10.9	20.5 ±4.8	83.8 ±5.2	110.7 ±3.4	17.4 ±2.7	92.6 ±4.5	12.9 ±3.6	OBSIDIAN CLIFFS
DS7-1	45.4 ±10.2	14.9 ±5.6	87.0 ±5.1	120.5 ±3.4	16.6 ±2.7	98.7 ±4.4	12.6 ±3.6	OBSIDIAN CLIFFS

* = trace element values in parts per million (ppm); ± = counting and fitting error uncertainty at 200 seconds livetime.

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Specimen Number	Trace Element Concentrations							Obsidian Source (Chemical Type)
	Zn*	Ga*	Rb*	Sr*	Y*	Zr*	Nb*	
DS7-2	61.9 ±10.9	15.7 ±7.0	97.0 ±5.5	131.8 ±4.0	18.8 ±3.0	107.8 ±4.9	11.4 ±4.0	OBSIDIAN CLIFFS
DS7-3	36.7 ±14.6	13.7 ±7.2	84.4 ±5.2	110.4 ±3.5	17.5 ±2.7	94.3 ±4.5	1.8 ±3.0	OBSIDIAN CLIFFS
DS7-4	43.7 ±12.9	18.3 ±5.6	88.8 ±5.3	120.9 ±3.6	18.2 ±2.8	103.6 ±4.6	6.4 ±4.0	OBSIDIAN CLIFFS
DS7-5	47.6 ±9.0	15.8 ±4.8	83.1 ±5.1	109.2 ±3.2	16.8 ±2.5	90.9 ±4.3	11.9 ±3.4	OBSIDIAN CLIFFS
DS7-6	46.0 ±9.9	19.3 ±4.5	81.3 ±5.2	112.1 ±3.4	18.6 ±2.5	93.8 ±4.4	9.6 ±3.6	OBSIDIAN CLIFFS

* - trace element values in parts per million (ppm); ± - counting and fitting error uncertainty at 200 seconds livetime.

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Specimen Number	Element Concentrations Ti	Mn	Fe
TS2-1	566.5 ±35.5	341.0 ±25.4	1.11 ±.09
TS2-3	591.4 ±38.3	384.2 ±25.7	1.20 ±.09
TS10-1	590.5 ±39.8	360.1 ±26.0	1.16 ±.09
MP2-1	564.5 ±35.7	360.7 ±25.4	1.12 ±.09
MP2-4	529.2 ±39.0	352.0 ±25.9	1.10 ±.09
MP4-1	579.6 ±41.2	366.7 ±26.4	1.17 ±.09
SF3-1	852.4 ±39.4	430.5 ±25.8	1.32 ±.09
SF3-2	611.7 ±36.5	395.2 ±25.4	1.27 ±.09
SF3-3	536.7 ±37.8	360.3 ±25.7	1.13 ±.09
SF4-1	573.6 ±37.7	388.8 ±25.7	1.23 ±.09
Y3-4	545.6 ±40.4	383.3 ±26.1	1.23 ±.09
Y3-5	583.8 ±39.3	375.4 ±25.9	1.17 ±.09
Y3-8	561.5 ±38.0	368.7 ±25.7	1.20 ±.09
Y8-5	679.4 ±37.4	387.4 ±25.7	1.24 ±.09
Y8-6	627.4 ±36.4	365.8 ±25.6	1.17 ±.09
Y8-7	616.1 ±40.7	349.0 ±26.2	1.15 ±.09
Y8-8	524.6 ±42.6	352.9 ±26.5	1.08 ±.09

Specimen Number	Element Concentrations Ti	Mn	Fe
Y13-1	632.6 ±37.8	394.6 ±25.7	1.26 ±.09
Y14-1	655.8 ±42.0	425.4 ±26.3	1.31 ±.09
Y15-1	563.7 ±47.7	375.5 ±27.2	1.16 ±.09
LP3-1	654.6 ±38.9	374.9 ±25.8	1.23 ±.09
LP3-3	898.7 ±42.5	397.5 ±26.3	1.41 ±.09
LP7-3	620.7 ±38.2	356.9 ±25.9	1.16 ±.09
LP7-4	685.2 ±38.3	360.7 ±25.7	1.27 ±.09
LP7-6	867.6 ±39.4	380.4 ±25.8	1.41 ±.09
LP10-2	525.3 ±40.9	379.6 ±26.1	1.15 ±.09
LP10-6	551.5 ±38.4	365.4 ±25.8	1.24 ±.09
DS2-3	628.1 ±39.0	371.5 ±25.9	1.19 ±.09
DS2-5	550.6 ±41.5	374.4 ±26.2	1.17 ±.09
DS7-1	518.5 ±36.2	355.5 ±25.4	1.12 ±.09
DS7-2	573.8 ±37.5	362.7 ±25.7	1.20 ±.09
DS7-4	651.7 ±36.6	379.5 ±25.5	1.23 ±.09

Element values in parts per million (ppm) except iron, expressed as total iron ($Fe_2O_3^T$) in weight percent; ± = pooled expression of x-ray counting uncertainty and linear regression fitting error at 200 seconds livetime.

Appendix D. Obsidian hydration analysis results, letter report from Thomas M. Origer (1988b).

SONOMA STATE UNIVERSITY
ACADEMIC FOUNDATION, INC.

ANTHROPOLOGICAL STUDIES CENTER
CULTURAL RESOURCES FACILITY
707 664-2381

Cathy Lindberg-Muir
c/o Anthropology Department
Oregon State University
Corvallis, Oregon 97331

May 11, 1988

Dear Ms. Lindberg-Muir:

This letter reports hydration measurements obtained from 90 specimens from six sites on the Sweet Home Ranger District, Willamette National Forest, Oregon. This work was completed as requested in a letter from Carl Davis to Richard Hughes of our staff at the Anthropological Studies Center, Sonoma State University.

The analysis was completed at the Sonoma State University Obsidian Hydration Laboratory, an adjunct of the Anthropological Studies Center, Department of Anthropology. Procedures used by our hydration lab for thin section preparation and hydration band measurement are described below.

The specimens were examined in order to find two or more surfaces that would yield edges which would be perpendicular to the microslides when preparation of the thin sections was completed. Two small parallel cuts were made at an appropriate location along the edge of each specimen with a 4 inch diameter circular saw blade mounted on a lapidary trimsaw. The cuts resulted in the isolation of small samples with thicknesses of approximately 1 millimeter. The samples were removed from the specimens and then mounted with Lakeside Cement onto permanently etched petrographic microslides.

The thickness of the samples was reduced by manual grinding with a slurry of #500 silicon carbide abrasive on a glass plate. The grinding was completed in two steps. The first grinding was terminated when a sample's thickness was reduced by approximate 1/2, thus eliminating any micro-chips created by the saw blade during the cutting process. The slides were then reheated, which liquified the Lakeside Cement, and the samples inverted. The newly exposed surfaces were then ground until the proper thickness was attained.

The correct thin section thickness was determined by the "touch" technique. A finger was rubbed across each slide, onto the samples, and the difference (sample thickness) was "felt." The second technique employed for arriving at proper thin section thickness is termed the "transparency" test. Each microslide was held up to a strong source of light and the translucency of the thin sections observed. Samples were sufficiently reduced in thickness when the thin sections readily allowed the passage of light.

A protective coverslip was affixed over each thin section when all grinding was completed. The completed microslides are curated at our hydration lab under File No. 88-H667.

1801 East Cotati Avenue
Rohnert Park, California 94928

Hydration bands were measured with a 45X objective on an American Optical petrographic microscope equiped with a Bausch and Lomb 10X filar micrometer eyepiece. Six measurements were taken at several locations along the edges of the thin sections, and the mean of the six measurements was calculated and given on the enclosed data sheets. These hydration measurements have a range of +/- 0.2 due to normal limitations of the equipment.

The "fb" under the "remarks" column indicates the specimen's hydration band was faint and the "NVB" under the "mean" column indicates that no hydration band observed.

The 90 specimens were given to Richard Hughes today for XRF source analysis, and a copy of the hydration data tables and this letter were sent to Carl Davis for his files.

If you have questions regarding the hydration data, please do not hesitate to contact me.

Cordially,

Thomas M. Origer

Thomas M. Origer, Director
Obsidian Hydration Laboratory

enclosures: hydration data tables

OR-35-LIN-118 Submitted by: Carl Davis - Willamette NF May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
01	Y-3-1	debitage	X Unit/25-35	none	3.4 3.4 3.5 3.5 3.5 3.6	3.5	
02	Y-3-2	debitage	X Unit/25-35	none	2.1 2.1 2.2 2.3 2.3 2.3	2.2	
03	Y-3-3	debitage	X Unit/25-35	none	2.6 2.6 2.7 2.7 2.9 2.9	2.7	
04	Y-3-4	debitage	X Unit/25-35	none	3.1 3.1 3.2 3.2 3.3 3.4	3.2	
05	Y-3-5	debitage	X Unit/25-35	none	2.3 2.3 2.4 2.4 2.5 2.6	2.4	
06	Y-3-6	debitage	X Unit/25-35	none	3.8 3.8 4.0 4.1 4.1 4.2	4.0	
07	Y-3-7	debitage	X Unit/25-35	none	2.9 2.9 3.0 3.0 3.0 3.0	3.0	
08	Y-3-8	debitage	X Unit/25-35	none	5.7 5.7 5.7 5.8 5.8 5.8	5.8	
09	Y-3-9	debitage	X Unit/25-35	none	3.2 3.4 3.4 3.5 3.5 3.5	3.4	
10	Y-3-10	debitage	X Unit/25-35	fb	3.0 3.0 3.1 3.1 3.2 3.2	3.1	
11	Y-8-1	debitage	X Unit/75-85	none	2.7 2.7 2.7 2.7 2.9 2.9	2.8	
12	Y-8-2	debitage	X Unit/75-85	none	3.1 3.1 3.2 3.3 3.4 3.4	3.3	
13	Y-8-3	debitage	X Unit/75-85	none	3.7 3.8 3.8 3.8 4.0 4.0	3.9	
14	Y-8-4	debitage	X Unit/75-85	none	3.4 3.5 3.6 3.6 3.6 3.6	3.6	
15	Y-8-5	debitage	X Unit/75-85	none	3.3 3.3 3.5 3.6 3.6 3.6	3.5	
16	Y-8-6	debitage	X Unit/75-85	none	3.6 3.6 3.7 3.8 3.8 3.8	3.7	
17	Y-8-7	debitage	X Unit/75-85	none	4.4 4.5 4.5 4.6 4.6 4.6	4.5	
18	Y-8-8	debitage	X Unit/75-85	none	4.1 4.3 4.3 4.3 4.4 4.4	4.3	
19	Y-8-9	debitage	X Unit/75-85	none	3.8 3.8 3.8 4.0 4.0 4.0	3.9	
20	Y-8-10	debitage	X Unit/75-85	none	3.0 3.0 3.2 3.3 3.3 3.3	3.2	
21	Y-10-1	biface	X Unit/95-105	none	3.4 3.4 3.4 3.5 3.6 3.6	3.5	
22	Y-13-1	debitage	X Unit/125-135	none	3.1 3.2 3.3 3.3 3.4 3.4	3.3	
23	Y-13-2	debitage	X Unit/125-135	none	3.0 3.0 3.0 3.0 3.0 3.1	3.0	
24	Y-13-3	debitage	X Unit/125-135	none	5.2 5.2 5.3 5.4 5.4 5.4	5.3	
25	Y-14-1	debitage	X Unit/135-145	none	4.0 4.0 4.1 4.1 4.1 4.1	4.1	
26	Y-14-2	debitage	X Unit/135-145	none	2.6 2.6 2.7 2.9 2.9 2.9	2.8	
27	Y-14-3	debitage	X Unit/135-145	none	3.3 3.3 3.3 3.3 3.5 3.5	3.4	
28	Y-14-4	debitage	X Unit/135-145	none	3.1 3.2 3.3 3.3 3.3 3.3	3.3	
29	Y-15-1	debitage	X Unit/145-155	none	5.1 5.1 5.2 5.2 5.2 5.2	5.2	
30	Y-17-1	debitage	X Unit/165-175	none	4.1 4.1 4.1 4.1 4.2 4.2	4.1	

Lab Accession No.: 88-H667 Technician: Thomas M. Origer

OR-Lost Prairie

Submitted by: C. Davis - Willamette NF — May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
31	LP-3-1	debitage	X Unit/23-33	none	2.1 2.1 2.1 2.3 2.4 2.4	2.3	
32	LP-3-2	debitage	X Unit/23-33	none	2.4 2.4 2.4 2.6 2.7 2.7	2.5	
33	LP-3-3	debitage	X Unit/23-33	none	2.4 2.4 2.5 2.6 2.6 2.7	2.5	
34	LP-3-4	debitage	X Unit/23-33	none	2.1 2.1 2.3 2.3 2.3 2.3	2.2	
35	LP-3-5	debitage	X Unit/23-33	none	2.4 2.4 2.4 2.5 2.7 2.7	2.5	
36	LP-3-6	debitage	X Unit/23-33	none	2.1 2.3 2.3 2.4 2.4 2.5	2.3	
37	LP-7-1	debitage	X Unit/63-73	none	2.6 2.7 2.7 2.7 2.7 2.9	2.7	
38	LP-7-2	debitage	X Unit/63-73	none	2.3 2.3 2.3 2.3 2.4 2.4	2.3	
39	LP-7-3	debitage	X Unit/63-73	none	2.4 2.4 2.4 2.4 2.5 2.5	2.4	
40	LP-7-4	debitage	X Unit/63-73	none	2.6 2.6 2.7 2.9 2.9 3.0	2.8	
41	LP-7-5	debitage	X Unit/63-73	none	2.5 2.5 2.5 2.7 2.7 2.7	2.6	
42	LP-7-6	debitage	X Unit/63-73	none	2.0 2.0 2.0 2.1 2.3 2.3	2.1	
43	LP-10-1	debitage	X Unit/93-103	none	2.7 2.7 2.7 2.7 2.7 2.7	2.7	
44	LP-10-2	debitage	X Unit/93-103	none	2.7 2.7 2.7 2.7 2.9 3.0	2.8	
45	LP-10-3	debitage	X Unit/93-103	none	1.2 1.2 1.2 1.3 1.4 1.6	1.3	
46	LP-10-4	debitage	X Unit/93-103	none	2.4 2.4 2.4 2.5 2.6 2.6	2.5	
47	LP-10-5	debitage	X Unit/93-103	none	2.4 2.4 2.4 2.4 2.5 2.6	2.5	
48	LP-10-6	debitage	X Unit/93-103	none	2.3 2.4 2.4 2.4 2.5 2.5	2.4	

Lab Accession No.: 88-H667 — Technician: Thomas M. Origer

OR-Soda Frkwy Tr II

Submitted by: C. Davis - Willamette NF — May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
49	SF-2-1	debitage	X Unit/15-25	none	3.6 3.7 3.8 3.8 3.9 3.9	3.8	
50	SF-2-2	debitage	X Unit/15-25	none	3.6 3.6 3.7 3.7 3.7 3.8	3.7	
51	SF-3-1	debitage	X Unit/25-35	none	3.5 3.6 3.6 3.6 3.7 3.7	3.6	
52	SF-3-2	debitage	X Unit/25-35	none	3.2 3.3 3.3 3.5 3.5 3.5	3.4	
53	SF-3-3	debitage	X Unit/25-35	none	3.1 3.2 3.2 3.2 3.3 3.5	3.3	
54	SF-4-1	debitage	X Unit/35-45	none	3.0 3.0 3.0 3.1 3.1 3.2	3.1	
55	SF-4-2	debitage	X Unit/35-45	none	2.4 2.4 2.5 2.6 2.6 2.6	2.5	
56	SF-4-3	debitage	X Unit/35-45	none	2.3 2.3 2.3 2.3 2.4 2.4	2.3	
57	SF-5-1	debitage	X Unit/45-55	none	2.1 2.1 2.3 2.4 2.6 2.6	2.4	
58	SF-5-2	debitage	X Unit/45-55	none	2.3 2.3 2.3 2.4 2.5 2.5	2.4	

Lab Accession No.: 88-H667 — Technician: Thomas M. Origer

OR-Tombstone Summit

Submitted by: C. Davis - Willamette NF   May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
59	TS-2-1	debitage	X Unit A/10-20	none	1.6 1.6 1.6 1.6 1.7 1.7	1.6	
60	TS-2-2	debitage	X Unit A/10-20	none	2.3 2.3 2.3 2.3 2.4 2.5	2.4	
61	TS-2-3	debitage	X Unit A/10-20	none	2.3 2.4 2.4 2.4 2.4 2.4	2.4	
62	TS-2-4	debitage	X Unit A/10-20	none	2.0 2.0 2.0 2.0 2.1 2.1	2.0	
63	TS-2-5	debitage	X Unit A/10-20	none	1.8 1.8 1.8 1.9 2.0 2.0	1.9	
64	TS-10-1	debitage	X Unit A/90-100	none	2.5 2.6 2.6 2.7 2.7 2.9	2.7	
65	TS-10-2	debitage	X Unit A/90-100	none	2.1 2.3 2.3 2.4 2.4 2.4	2.3	
66	TS-10-3	debitage	X Unit A/90-100	none		NVB	
67	TS-10-4	debitage	X Unit A/90-100	none	3.0 3.0 3.1 3.1 3.2 3.3	3.1	
68	TS-10-5	debitage	X Unit A/90-100	none		NVB	

Lab Accession No.: 88-H667   Technician: Thomas M. Origer

OR-Dane Saddle

Submitted by: C. Davis - Willamette NF   May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
69	DS-2-1	debitage	X Unit/10-20	none	1.0 1.1 1.2 1.2 1.2 1.2	1.2	
70	DS-2-2	debitage	X Unit/10-20	none	2.7 2.7 2.7 2.9 2.9 2.9	2.8	
71	DS-2-3	debitage	X Unit/10-20	none	1.0 1.0 1.0 1.1 1.1 1.2	1.1	
72	DS-2-4	debitage	X Unit/10-20	none	2.3 2.4 2.4 2.4 2.5 2.5	2.4	
73	DS-2-5	debitage	X Unit/10-20	none	2.9 2.9 3.0 3.1 3.1 3.1	3.0	
74	DS-2-6	debitage	X Unit/10-20	none	3.6 3.6 3.6 3.6 3.7 3.7	3.6	
75	DS-7-1	debitage	X Unit/60-70	none	3.2 3.3 3.3 3.3 3.5 3.5	3.4	
76	DS-7-2	debitage	X Unit/60-70	none	2.4 2.4 2.6 2.6 2.7 2.7	2.6	
77	DS-7-3	debitage	X Unit/60-70	none	3.2 3.2 3.2 3.3 3.5 3.5	3.3	
78	DS-7-4	debitage	X Unit/60-70	none	2.5 2.5 2.5 2.6 2.7 2.7	2.6	
79	DS-7-5	debitage	X Unit/60-70	none	2.6 2.7 2.7 2.7 2.9 2.9	2.8	
80	DS-7-6	debitage	X Unit/60-70	none	2.7 2.7 2.7 2.9 2.9 3.0	2.8	

Lab Accession No.: 88-H667   Technician: Thomas M. Origer

OR-Monument Pk Tr I

Submitted by: C. Davis - Willamette NF   May 1988

Lab#	Catalog #	Description	Provenience	Remarks	Readings	Mean	Source
81	MP-1-1	debitage	0-19	1st band	2.6 2.6 2.6 2.6 2.7 2.7	2.6	
81	MP-1-1	debitage	0-19	2nd band	8.0 8.0 8.0 8.0 8.1 8.1	8.0	
82	MP-1-2	debitage	0-19	none	4.1 4.2 4.2 4.3 4.4 4.4	4.3	
83	MP-2-1	debitage	19-29	none	1.8 1.9 1.9 2.0 2.0 2.0	1.9	
84	MP-2-2	debitage	19-29	none	4.7 4.8 4.9 5.0 5.0 5.0	4.9	
85	MP-2-3	debitage	19-29	none	2.4 2.5 2.5 2.5 2.6 2.7	2.6	
86	MP-2-4	debitage	19-29	none	1.1 1.1 1.2 1.2 1.2 1.2	1.2	
87	MP-2-5	debitage	19-29	none	1.8 1.8 1.8 1.8 1.9 1.9	1.8	
88	MP-3-1	debitage	29-39	none	2.5 2.5 2.6 2.7 2.7 2.7	2.6	
89	MP-4-1	debitage	39-49	none	2.0 2.0 2.0 2.0 2.1 2.1	2.0	
90	MP-4-2	debitage	39-49	none	1.1 1.1 1.2 1.3 1.3 1.3	1.2	

Lab Accession No.: 88-H667   Technician: Thomas M. Origer