DOOLEY MOUNTAIN OBSIDIAN:

A CHRONOLOGY OF ABORIGINAL USE

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ABSTRACT

Dooley Mountain is located in the Blue Mountains of northeast Oregon and is part of a long east-west divide separating the Powder and Burnt rivers. Although the occurrences of obsidian in the Dooley Mountain vicinity were reported in the geological literature as early as 1937, it was not until the 1970s that Dooley Mountain obsidian was identified as aboriginal toolstone. Research utilizing x-ray fluorescence analysis places aboriginal use of these volcanic glasses in a chronological framework. The data include obsidian artifacts and debitage from the Pilcher Creek, Marshmeadow, and Ladd Canyon archaeological sites and temporally diagnostic projectile points from archaeological sites in the adjacent Wallowa Whitman National Forest. The analysis indicates that aboriginal people first used Dooley Mountain obsidian from 8000 to 10,000 years ago to historic times. Results also suggest that the aboriginal inhabitants of northeast Oregon made rational economic decisions by relying on local lithic sources to minimize travel and effort.

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I. INTRODUCTION

Dooley Mountain is located in the Blue Mountains of northeastern Oregon. At just over 6100 feet elevation, it [Dooley Mountain] is a somewhat indistinct part of a long east-west divide separating the Powder River on the north and the Burnt River on the south (Figs. 1, 2).

Obsidian in the Dooley Mountain vicinity was first reported in 1937 during a geological reconnaissance of the area by James Gilluly (Gilluly 1937). Thirty years later, during excavations of archaeological sites near the Powder River, obsidian was found to be the dominant material used for the manufacture of aboriginal stone tools (Cole and Rice 1965), but the probable source for these artifacts--located only a few miles away--went undetected. In 1975, an archaeological reconnaissance (Mead 1975) on the Burnt-Powder river divide documented aboriginal use of the Dooley Mountain obsidian for the first time.

In subsequent excavations at the Stockhoff Basalt Quarry fifty miles north of Dooley Mountain, Womack (1977:73-74) recovered obsidian debitage and submitted five specimens to D. E. Nelson of Simon Fraser University for chemical analysis. Using x-ray fluorescence to analyze the trace element chemistry unique to each obsidian flow, and thus to each artifact manufactured from that flow, Nelson correlated all five specimens to the Dooley Mountain source. This not only

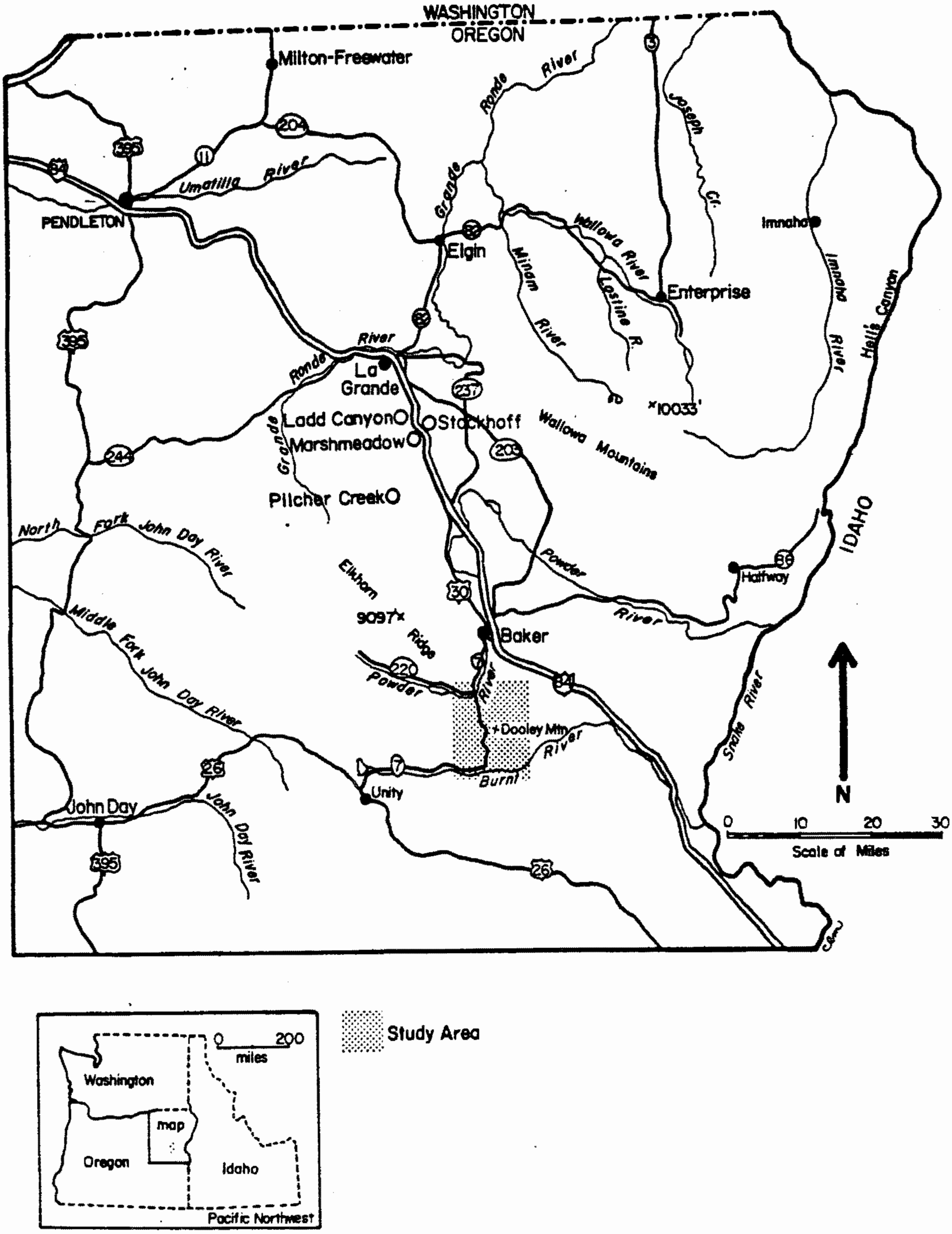

Fig. 1. Map of Study Area Vicinity.

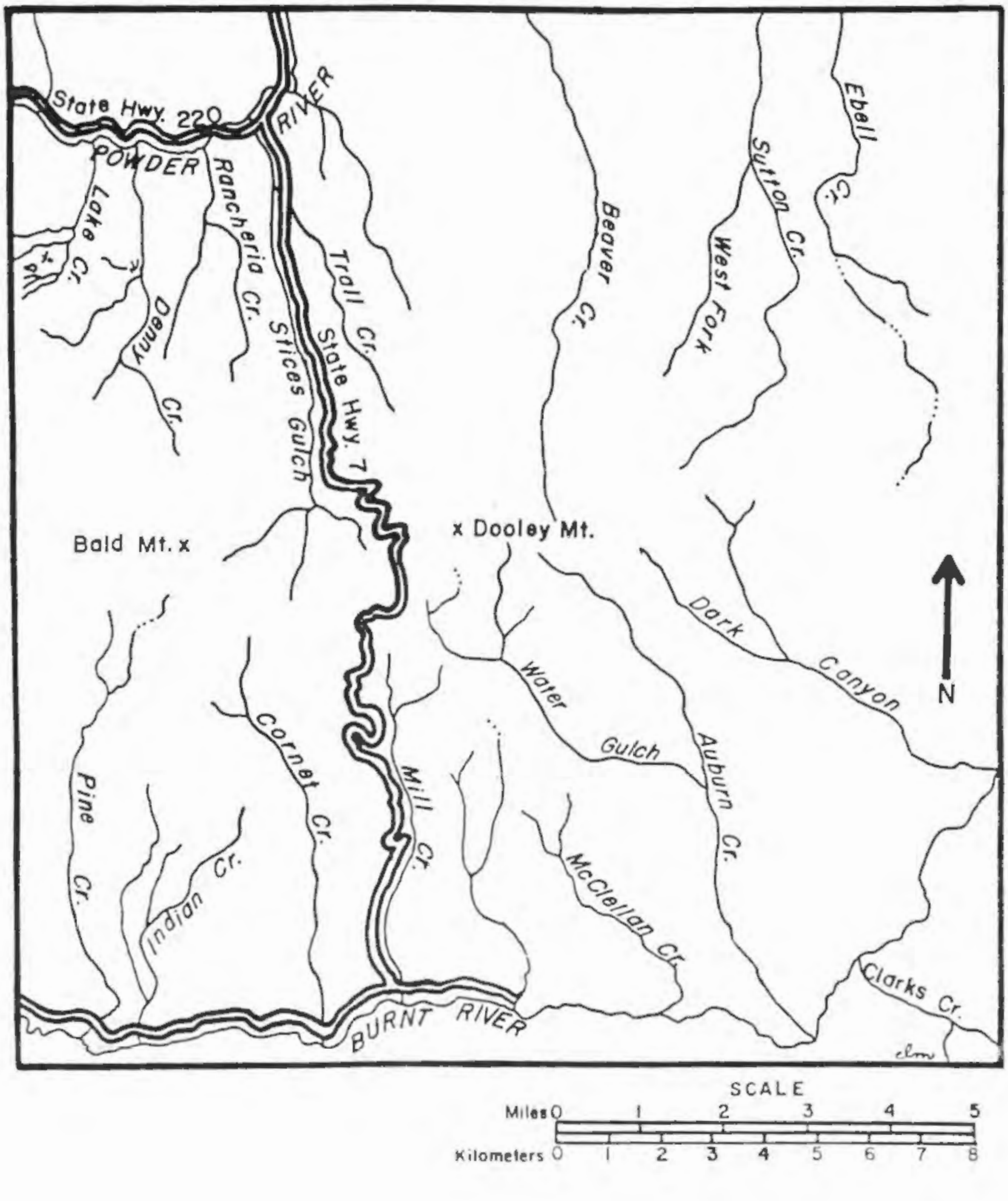

Fig. 2. Map of Study Area.

documented the aboriginal use of Dooley Mountain obsidian some distance away, but its association with Cascade phase (8000-5000 BP) cultural material also suggested a considerable antiquity for that use.

Between 1977 and 1980, archaeological surveys by the U.S. Forest Service and Bureau of Land Management located additional obsidian sources (and several associated workshops) in the vicinity. In general, these reports indicated that obsidian had a patchy distribution over a large area extending from Ebell Creek on the east to Pine Creek on the west, a distance of about 12 miles (20 km). Further chemical analysis by Robert Lee Sappington at the University of Idaho suggested that at least two different chemical sources were present in the area. Sappington (1981:139) warned however, that one of the sources was problematical in that its chemical identity was based on waste flakes and that its location had not been adequately determined.

Archaeological work in the Dooley Mountain vicinity began in the mid-1970s and has been of a very limited nature, focused largely on the identification of archaeological sites. Significantly, though, the survey reports suggested a rather intensive exploitation of Dooley Mountain obsidian. At many workshops and inferred base camps, entire stone tool reduction sequences were present. Reported in the surface assemblages were cores, bifaces, scrapers, awls, projectile points, and large amounts of waste flakes. The reported artifacts and debitage consisted almost entirely of obsidian. While some testing and surface collecting of these lithic scatters was conducted, the primary objective of these investigations was to collect data for federal land management purposes rather than the resolution of specific research questions. In general, there were very few attempts at placing these sites or the obsidian quarries within a chronological framework.

By 1981, over one-hundred temporally diagnostic obsidian artifacts had been collected from sites in the Blue Mountains during surveys of the Wallowa Whitman National Forest. While the relative chronology provided by these artifacts was a potentially useful source of data, most were from surface contexts. Alone, the sample was not adequate enough to accurately assess the human exploitation of Dooley Mountain obsidian from a diachronic perspective.

Between 1980 and 1983, additional data became available which were potentially applicable to this problem. In 1980, Hall and Nachtwey (1980a; 1980b) and McPherson (1980) determined that proposed plans for the construction of the Pan-Alberta natural gas pipeline from southwest Idaho to north-central Oregon, would have an adverse effect on three archaeological sites near La Grande, Oregon and that archaeological mitigation would be neccessary. Areas of the Marshmeadow (35UN95), Ladd Canyon (35UN74), and Stockhoff (35UN52) sites that would be impacted by pipeline construction were excavated during 1980-1981 by Western Cultural Resource Management of Boulder, Colorado. Among the predominant basalt tools and debitage that were recovered during excavation of these three sites, obsidian tools and debitage were recovered in archaeological contexts dating from 7600 to 100 BP (McPherson and others 1981).

Later in 1981, Reckendorf, Gelbrud, and Scott (1982) determined that construction of Pilcher Creek Dam in the Baker Valley about 40 miles (64 km) north of Dooley Mountain would innundate the Pilcher Creek archaeological site (35UN147) and that excavation would be required to salvage the data. In subsequent investigations obsidian debitage and tools were recovered in contexts pre-dating the deposition of Mt. Mazama Ash at the site (ca. 6700 BP) and in association with artifacts similar to those found during the Windust Phase (10,000-8000 BP) on the Lower Snake River (Brauner, Satler, and Havercroft 1981).

Although the lithic assemblages from these sites consisted predominantly of the locally available and abundant basalt, a sizeable obsidian sample from the Pilcher Creek, Marshmeadow, and Ladd Canyon sites was available which could potentially be correlated with their original geologic source by x-ray fluourescence analysis.

On the basis of geographic proximity, I reasoned that the majority of these obsidian samples should be derived from the closest source of available raw obsidian--Dooley Mountain. Thus, with obsidian artifacts and debitage from more precisely dated contexts, the Dooley Mountain obsidian resource could be placed within a more accurate chronological framework.

The Problem

The central objective of this research is to place the aboriginal use of the Dooley Mountain obsidian sources within a chronological framework. This could be accomplished through extensive excavation of obsidian quarry areas and/or numerous archaeological specimens from the source areas could be dated through hydration rim dating. Due to limited funds and manpower, neither approach was feasible. However, the recovery of obsidian tools and debitage during excavations at the Marshmeadow, Ladd Canyon, and Pilcher Creek sites and the collection of temporally diagnostic artifacts in the adjacent national forest, suggested another and more attainable approach to the problem.

By chemically analyzing obsidian specimens from archaeological contexts with radiocarbon age determinations, stratigraphic horizon markers, and typologically dated artifacts, and then comparing these specimens with known obsidian sources in the region, those items correlated with the Dooley Mountain sources could then be used to place the use of the Dooley Mountain obsidian within a chronological framework. Thus, if an artifact dated in excavations at 1200 BP was correlated to the Dooley Mountain vicinity, then it could be demonstrated that the Dooley Mountain obsidian was being used by aboriginal people by at least 1200 BP. Less costly and methodologically appropriate, this approach was selected for investigating the problem of chronology.

The placement of the Dooley Mountain obsidian sources within a chronological framework contains the following problems.

(1) To compare and correlate obsidian artifacts and debitage from the Marshmeadow, Ladd Canyon, and Pilcher Creek sites with known sources in the adjacent region.

(2) To describe and place temporally diagnostic obsidian projectile points from the Wallowa Whitman Forest into a chronological framework.

(3) to compare and correlate the Wallowa Whitman projectile points with known obsidian sources in the adjacent region.

Obsidian is particularly suitable for this type of study because of its unique chemical nature. Obsidian is primarily an aluminosilicate, with a minor amount (1% to 2%) of trace elements. While each obsidian flow is relatively homogenous (Nelson 1984:27), it is these trace elements that differ in each pyroclastic flow which consequently allow it to be "fingerprinted" through x-ray fluorescence analysis (Ambrose 1976:83; Jack and Carmichael 1969:17). Thus by collecting and chemically analyzing geologic specimens from known obsidian occurrences, each source's chemical "fingerprint" can be compared with other sources in the region. Artifacts made from these raw material sources can then be correlated to their geologic origin. Thus, before artifacts can be traced to the Dooley Mountain sources it is necessary to:

(1) collect source samples from known obsidian occurences in the study area, and

(2) to chemically characterize these sources by x-ray fluorescence analysis

Although there are several methods which can be used to characterize obsidian sources and artifacts, x-ray fluorescence has been selected for two reasons. First, x-ray fluorescence instrumentation of the Idaho Geological Survey at the University of Idaho was made available by Charles Knowles for this research project. Second, and importantly, the obsidian sourcing project implemented by Sappington through the Idaho Geological Survey has built up a substantial data base on known obsidian sources throughout eastern Oregon and adjacent regions. Without these data, this study would not have been possible.

Assumptions of the Study

The approach employed in this study is based to a large degree on anthropological and economic spatial theory. The essence of anthropological spatial theory maintains that archaeological remains are "spatially patterned as the result of the patterned behavior of the members of an extinct society." These patterns contribute to the formation of the archaeological record and are potentially informative about the ways in which a society was organized (Clarke 1977:18).

Economic spatial theory is often used to explore the relationships between sites and is based on the assumption that "over a span of time and experience, people move to choices and solutions which minimize costs and maximize profits" (Clarke 1977:19). Economic spatial theory underlies many geographic subtheories, including the "least-cost" models of von Thunen and Weber.

Von Thunen's locational sub-theory maintains that human groups tend to use the land in concentric patterns around a center. As one moves further out through these zones, increased energy must be expended to maximize returns. In its application, von Thunen considered the site center in isolation with no resources coming in from other centers and no resources going out. He also assumed a uniformity of the surrounding topography and assumed rational human behavior to maximize returns for minimum effort (Clarke 1977:22).

Weber's sub-theory is quite similar to von Thunen's and asserts that the location of a site depends "on the distance to and from external resources, the weight of the material to be moved and the competitive costs of all movements" (Clarke 1977: 22). These models clearly underlie many archaeological models (e.g. Vita-Finzi and Higgs 1970; Jochim 1978) of optimal site location. The drawback to these theories though, is that they rest on the assumptions of a consciously optimizing society, static sites, and uniformly distributed and unchanging external resources. While they cannot possibly account for the wide variety of archaeological and anthropological spatial patterning of extinct cultural systems, they do provide a useful starting point for the investigation of archaeological phenomena (Clarke 1977:23).

As noted above, the lithic assemblages from the sites being investigated in this study consist predominantly of the locally available and abundant basalt, with lesser amounts of non-local cryptocrystalline material and obsidian. In a general way, lithic procurement at these sites tend to support the economic spatial theories of least-cost. That is, since very little effort was required to obtain the local basalt, it is entirely expected (under the assumptions of the economic models) that basalt is the dominant material in these assemblages. Other non-local materials such as obsidian would require more investment to procure; it thus comes as no surprise that obsidian accounts for less than 2% of the raw material at these sites. Ignoring such factors as material quality, availability, abundance, and access to raw material sources, the economic spatial theories of von Thunen and Weber would seem to be strongly supported by the archaeological data at these sites.

If these assumptions about human behavior and the formation of the the archaeological record are valid, then it is expected that the obsidian sample from these sites will contain higher frequencies of obsidian from the nearest source and lower frequencies of obsidian from those sources located further away. Since the Dooley Mountain sources are the closest known obsidian occurrences to these sites, its frequency should be greater than raw material from more distant sources. The potential for obtaining raw obsidian or obsidian artifacts from more distant sources through neighboring groups and trading partners is largely ignored in this approach. Significantly though, the analytical tools used in this study can potentially indicate the occurrence of items originating from sources not included in the analysis.

Summarizing then, in this study I assume that the aboriginal inhabitants of the Marshmeadow, Ladd Canyon, Pilcher Creek, and other sites in the adjacent uplands made rational economic choices to procure obsidian toolstone in a manner which minimized costs and maximized profits. I further assume that this behavior will be recorded in the archaeological record and that the analytical procedures employed in this study will be adequate to detect such behavior through the study of that record.

The Physical Environment, Past and Present

Geology

A brief discussion of the geology of the study area is especially germane to this study. Not only have geological processes controlled and shaped the landforms of the study area, but they are responsible for the formation and deposition of obsidian on the landscape.

Geologically, the Blue Mountains are quite complex. For convenience of discussion, some authors (Baldwin 1964; Franklin and Dryness 1973) divide the Blue Mountains into an eastern and western province placing the dividing line near the Dixie Summit about 30 miles (48 km) west of the study area (Baldwin 1964:103). Using this division, the following discussion will focus on the eastern Blue Mountains in general and the Dooley Mountain area in particular.

The earliest identified geologic units within the region date to the late Paleozoic and early Mesozoic eras. Within the Dooley Mountain area, the Burnt River Schist originally defined by Gilluly (1937) has been interpreted as representing fragmented oceanic crust. Rock units of similar age in adjacent areas include sedimentary and volcanic rocks of abyssmal marine origin and limestone deposits indicative of relatively shallow marine environments.

Many of these early marine rock units are separated from younger rock units by faults and shear zones. Such large scale dislocation suggests that this fragmented oceanic crust was broken and deformed by plate tectonic forces, probably near a subduction zone (Brooks, McIntyre, and Walker 1979:73).

Supracrustal rocks from the folowing Early or Middle Triassic are conspicuously absent from northeast Oregon and Brooks (1979) has suggested that these missing strata may have been subducted and magmatically assimilated in the roots of volcanic island arcs. Uplift of the area, combined with large scale block faulting during the Cenozoic produced some substantial graben valleys, most notably the Grande Ronde and the Baker valleys to the north.

A discussion of geological activity during the Miocene is of particular importance to this study for it was during this period that much of the obsidian was formed and deposited in the area. During the Miocene, the Columbia Plateau was innundated by voluminous outpourings of low viscosity lava erupted through numerous small fissures. In some areas of the Columbia Plateau, these flow-on-flow lavas exceed 5000 feet (1515 meters) in thickness (Thornbury 1969:492). Although on a regional basis these lava flows are composed almost entirely of basalt, local variations of rhyolitic and andesitic lavas and small patches of welded tuff are not uncommon (Brooks, McIntyre, and Walker 1976:15). One of these variants, is the Dooley Rhyolite Breccia.

First reported in 1937 by geologist James Gilluly, the formation was described as a "rhyolitic and subordinate andesitic breccia" (Gilluly 1937:49). Gilluly (1937:49-50) noted that the formation "is soft and readily eroded, but it contains enough inhomogeneites, such as obsidian flows and large boulders to form a somewhat irregular topography in detail." From Stices Gulch and Mill Creek near the center of the study area, he observed that the formation thinnned rapidly away in all directions and concluded that it is "doubtful whether the formation ever extended more than a very few miles from the present center near Dooley Mountain"(1937:49-50). Gilluly further speculated that the volcanic center for the Dooley Rhyolite Breccia lay just north or south of Dooley Mountain, possibly concealed beneath basaltic flows or fluviatile deposits (1937:50). Gilluly also observed that "locally black or green obsidian, spherulitic rhyolite flows , pumice or glassy flow breccias" were the dominant features of the Dooley Rhyolite Breccia. Although specific localities of obsidian were not mapped, "a few outcrops of resplendent black obsidian" were noted in the highway cuts near Mill Canyon (1937:50).

Nearly forty years later, another geological reconnaissance of the area was undertaken and the Dooley Rhyolite Breccia reported in more detail (Brooks, McIntyre, and Walker 1976) (Figs. 3, 4). In their analysis of the unit, they concurred with Gilluly's (1937:51) contention that most of the rhyolitic rocks appeared to represent the "coarsely fragmental and subordinate fluid ejecta of a volcanic center." Furthermore, vitrophyre flows were "best exposed on the south flank of the range [the divide between the Powder and Burnt Rivers] from Pine Creek.....eastward to Mill and Auburn Creeks" (Brooks, McIntyre, and Walker 1976:15). A potassium-argon date of 14.3 million years for a rhyolite sample placed the time of deposition as middle to upper Miocene (Walker, Dalrymple, and Lanphere 1974). Brooks (personal communication 1982) notes that the obsidian-like vitrophyre

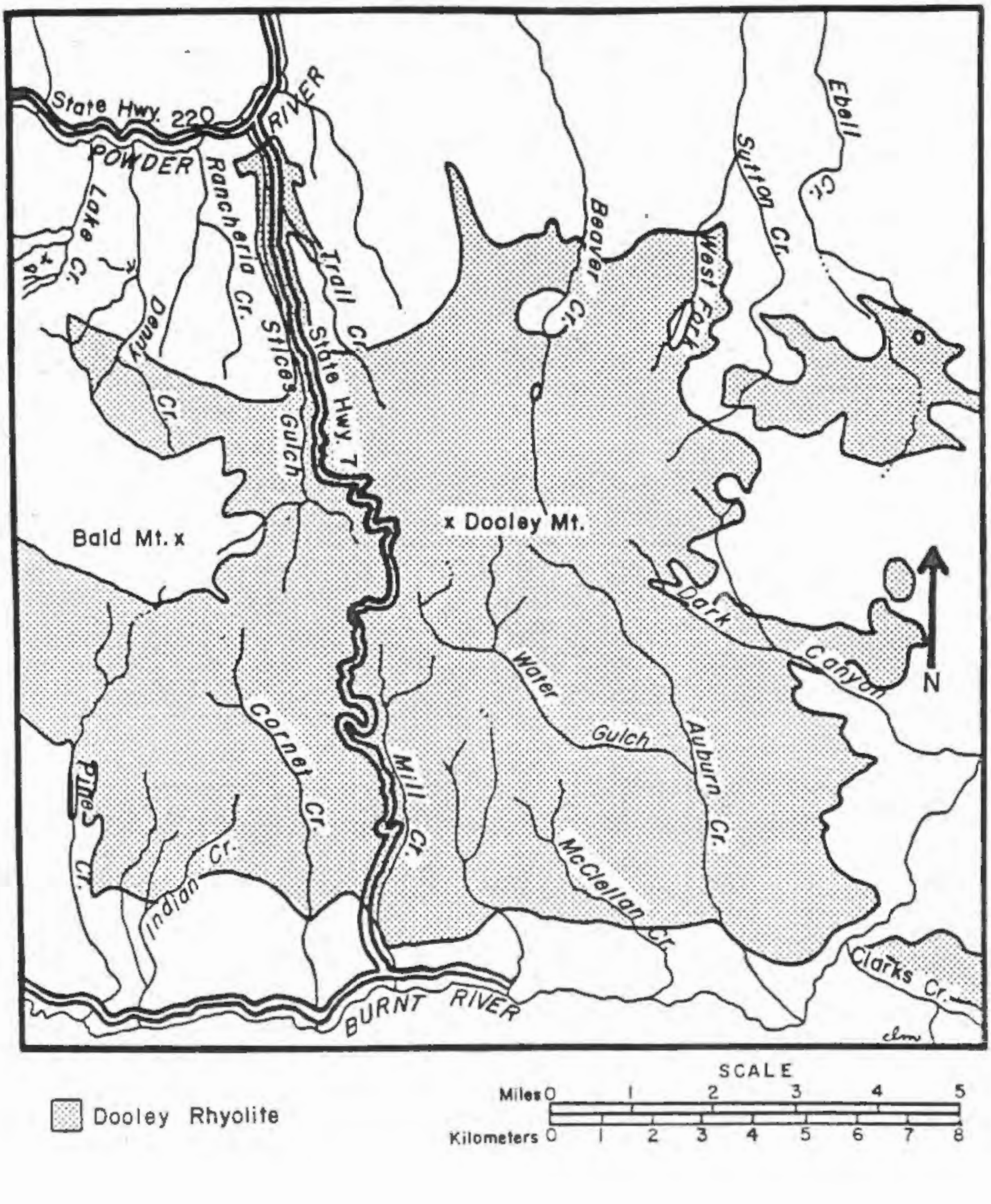

Fig. 3. Map of Dooley Rhyolite, (after Brooks, McIntyre, and Walker 1976).

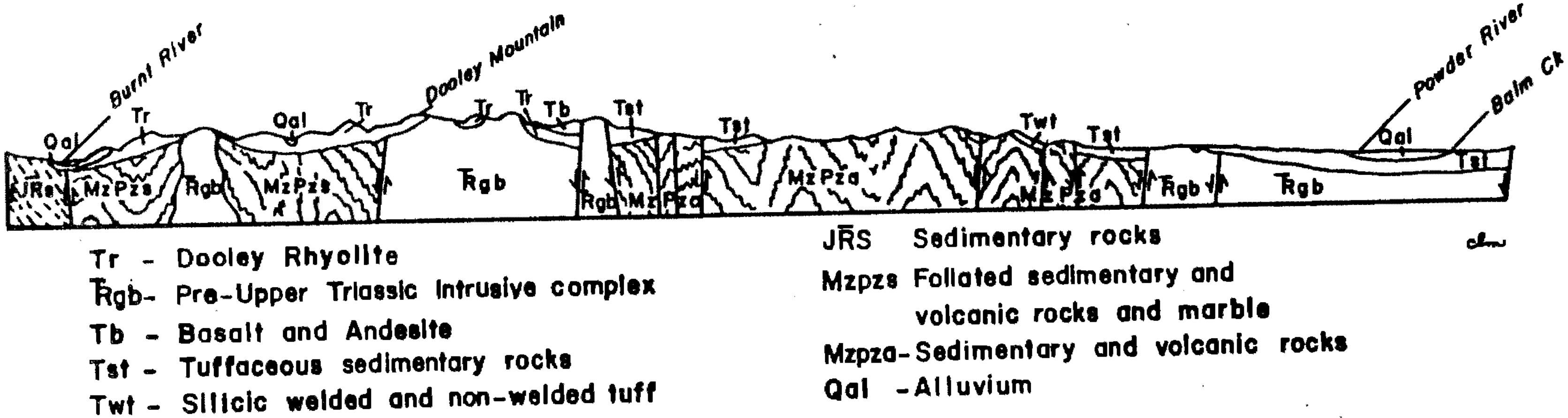

Fig. 4. Geologic cross-section of study area. Adapted from Brooks, McIntyre, and Walker (1976).

deposits are associated with the rhyolite and must therefore, be approximately the same age.

As demonstrated by major faults within the Columbia River Basalt group, uplift of the area continued well into the Miocene and probably until the close of the Pliocene. Some of the structural basins became the sites of temporary lakes which were filled with tuffaceous sediments eroded from the adjacent mountain slopes. Accelerated uplift, though, increased the stream gradients and the lakes were drained. It was probably during this time that the present topographic basins of the region were defined (Brooks, McIntyre, and Walker 1976:19-22).

Climate and Paleoclimate

In conjunction with elevation, aspect, and slope, the climate of given region largely defines the ability of the land to support a living population, including man.

The climate of the area is influenced by the local topography, the topography of surrounding areas and pressure systems originating largely in the Pacific Ocean. The area has a semiarid climate and experiences wide seasonal variations in temperature. Summers are generally hot and dry while winters are cool and somewhat moister. The annual precipitation varies with elevation but averages about 11 inches (27.5 cm) within the study area (Wade:1975:164).

Fall and winter conditions are generally determined by air masses originating in the north Pacific Ocean moving into the area from a west or northwesterly direction. Incoming low pressure cells are usually preceded by heavy precipitation and result in prevailing southwest or westerly winds. The coldest winter temperatures occur when air from a cold high pressure system in central Canada moves southwest across the Rockies and flows down into the Columbia Basin (Wade 1975:162). During the winter months, much of the precipitation falls as snow and accumulations of up to 169 inches (422 cm) have been reported at nearby locations (Department of Commerce 1965). Winter daily maximum temperatures average just barely above freezing and temperatures well below zero are not uncommon during the winter months.

Summers, on the other hand, are characterized by high temperatures and little precipitation. Only eleven percent of the total annual precipitation occurs during the months of June, July, and August. Summer daily maximum temperatures average 85° F (47° C) and temperatures exceeding 100° F (55° C) are not uncommon. Summer winds are divided fairly evenly between southeast and northwest, depending upon the locations of pressure cells near the coast and in Idaho. Unstable air moving in from northern California brings precipitation in conjunction with local convectional storm activity during the summer (Wade 1975:162). It is during this time that the area is most susceptible to forest and grass fires. This danger lasts until the first significant rainfall which normally occurs sometime in September.

Available paleoeclimatic data from sites throughout the Pacific Northwest suggests that there have been several climatic fluctuations during the last ten to fifteen thousand years. This idea stems largely from the pioneering palynological work of Henry Hansen and the European trained glaciologist Ernst Antevs. From the analysis of pollen profiles collected throughout the Pacific Northwest, Hansen (1947) posited that there were at least three major climatic changes since the glacial recession. This idea was elaborated upon by Antevs (1948) and coined the Neothermal Sequence.

The first period lasting from about 9000 to 7000 years ago was termed the Anathermal by Antevs and interpreted to be similar to the climatic conditions of today but growing warmer. This period was followed by a distinctly warmer and drier period called the Altithermal which lasted from about 7000 to about 4500 years ago. The final period with climatic conditions roughly similar to the present began 4500 years ago and was called the Medithermal (Antevs 1948). Work in adjacent areas supports these early views of climatic change, but indicate much more complexity than envisioned in Antevs tripartite Neothermal model.

Using faunal assemblages from Owl Cave at the Wasden site in southeastern Idaho, Butler (1977 and 1978) has proposed a model of climatic change for the upper Snake and Salmon rivers which may have some general applicability for the northeast Oregon area. From about 15,000 to 10,800 BP, the climate was generally cold though a warming trend had begun by about 13,000 years ago. A gradual warming trend continued and by about 7200 BP the climate was quite warm. By 6500 BP, the alpine glaciers had completely retreated. The long warming trend reached its peak about 3800 years ago. During the last 7000 years, Butler suggests that short climatic cycles of less than 1000 years in length became increasingly important as the region experienced slight changes in temperature and effective moisture (1978:45).

Based on rockfall frequency in caves, pollen data from bogs and lakes, and the inferred distribution of big game in the Columbia Basin during the Holocene, Gustafson (1972) suggests that similar climatic change has occurred in southeast Washington during post-glacial times. This evidence indicates that a cool, moist period existed from about 10,000 to 8000 BP and was followed by a warm, dry period from 8000 to 4000 BP. Generally cooler and moister conditions existed from about 4000 to 2000 BP which was followed by a short warm and dry interval. After 2000 BP, the climate is characterized by a transition to present climatic conditions (Gustafson 1972:fig. 6.2). While the evidence is supportive of these climatic trends, Gustafson (1972:125) notes that none of the paleoecological studies "quantitatively" show the extent of these changes or demonstrate that climatic change resulted in the "simple movement of vegetation communities or zones."

From the analysis of the stratigraphic sequences at the Marshmeadow, Stockhoff, and Ladd Canyon sites, Leonhardy and Cochran (1981) report five Holocene alluvial cycles essentially contemporaneous with the Holocene alluvial chronologies of the Mid-Columbia and Clearwater river regions. The first cycle began sometime after 10,700 BP, continued to about 6700 BP, and is capped by an erosional unconformity. The erosional episode responsible for this unconformity was regional and probably synchronous (Leonhardy and Cochran 1981:35). This unconformity has also been reported at the Pilcher Creek site (David Brauner: personal communication, 1985). The second alluvial cycle lasting from 6700 to 5700 BP began with a period of stability and ended with an erosional episode. The third alluvial cycle lasted from 5700 to 4200 years ago. The fourth cycle dates sometime after 4200 BP and lasted until about 1500 BP. The last cycle began around 1550 BP and ended around AD 1890. Leonhardy and Cochran (1981:36-38) conclude that:

> since the alluvial cycles (deposits, paleosols, and erosional unconformities) at the LaGrande sites correspond to the other radiocarbon dated alluvial cycles along the Clearwater, Snake, and Columbia rivers, there must have been dominate forces controlling the synchronous gradational processes of streams in the Pacific Northwest. These contemporaneous alluvial events suggest that climate or magnitude of climate change may have been the major force controlling runoff, and, hence, stream regimens.

In general, these and other (Mack, Rutter, and Valastro 1983; Mehringer, Arno, and Petersen 1977; Grayson 1979) studies demonstrate that climatic fluctuations since the end of the Pleistocene have occurred on a regional basis. However, the intensity and effects of these changes on the regional biota is far from clear. Consequently, extrapolations about human behavior from the paleoclimatic data must be made with considerable caution.

Biota

Soils are an important part of the ecosystem providing the natural bodies on which plants grow and provide the physical base for human subsistence. Unfortunately, adequate soils data for the Dooley Mountain area are conspicuously lacking. In general, the soils of the Dooley Mountain area are strongly influenced by the bedrock which is pyroclastic and underlies most of the study area (Loy and Allan 1975:206). These rocks have little resistance to weathering are often associated with unstable soils and "have been weathered so extensively that they are no longer recognizable as rock" (Wade 1975:155). Two broad soils occur in the study area. Inceptisols and Mollisols are found primarily at the upper elevations in the study area. Light colored, silty inceptisols forming on volcanic ash occur on broad plateaus and northerly slopes. At lower elevations, mollisols formed on bedrock hills and plateaus may be found. These soils are mostly shallow and stony. Some areas have deeper soils formed from clayey sedimentary rock or aeolian deposits (Loy and Allan 1976:124).

Generally speaking, the vegetation of the study area is quite diverse. Three major life zones are found within the study area (Bailey 1936). From the lowest to highest elevation these are the Upper Sonoran, the Semiarid Transition, and the Canadian life zones.

The Upper Sonoran is found only at the lowest elevations, particularly near the Burnt River and at low elevations along the eastern periphery of the study area. This zone is characterized by little rainfall (10 inches; 25 cm per year) and shares many similarities of the Great Basin physiographic province (Bailey 1936:12). Common plants to this zone include rabbitbrush (Chrysothamus nauseous), sagebrush (Artemesia tridentata), juniper (Juniperus occidentalis), bitterroot (Lewisia rediviva), service berry (Amelanchier cusicki), chokecherry (Prunus demissa), hawthorn (Crataegus douglasii), wild rose (Rosa spp.), and several members of the genus Lomatium (Mahar 1953:27-29). Fauna common to this zone include several species of small, desert adapted mammals, black-tailed jack rabbits, and several species of reptiles. It is an important wintering range for antelope, mountain sheep, and mule deer (Bailey 1936:15).

The semiarid Transition zone extends from about 3500 to 5500 feet (1060 to 1660 meters) in elevation (Bailey 1936:23) and is the dominant life zone in the study area. The climatic conditions of this zone throughout eastern Oregon are fairly uniform with the annual rainfall averaging about 20 inches (50 cm). This zone is best characterized by the presence of

Ponderosa Pine (Pinus ponderosa). Other floral resources include western tamarack (Larix occidentalis), western birch (Betula frontinalis), and many different kinds of willows (Salix spp.) along riparian habitats. Shrubs include bitterbrush (Purshia tridentata), buckbrush (Ceanothus velutinus), snowberry (Symphoricarpos recemosus), and bearberry Arctostaphylos uva-ursi). Common fauna include mule deer (Odocoileus hemonus), elk (Cervus canadensis), and several small species of small mammals (Bailey 1936:23).

The Canadian life zone is found only at the extreme upper elevations of the study area and is more common to the north slopes. Dominant tree species include lodgepole pine (Pinus contorta), white fir (Abies grandis), mountain alder (Alnus incana), mountain ash (Sorbus scopulina), and mountain maple (Acer glabrum). Mammals common to this life zone include mule deer (Odocoileus hemonus), elk (Cervus canadensis), white-tailed deer (Odocoileus virginianus), snowshoe hare (lepus americanus), beaver (Castor canadensis), cougar (Felis concolor), coyote (Canis latrans), bobcat (Lynx rufus), fox (Vulpes fulvus), badger (Taxidea taxus), and black bear (Euractos americanus) (Bailey 1936).

Ethnohistoric records indicate that changes in the regional flora and fauna have occurred since Euro-American settlement of the area in the nineteenth century. Generally speaking, the most heavily impacted areas in the region have been the upper Burnt and Powder rivers. Early accounts suggest that much of the river bottoms were lush meadowlands with abundant bunchgrass, alder and birch trees. The Burnt River Valley was bordered by foothills covered with sagebrush and bunchgrass, while the Powder River was largely bounded by open yellow pine forests (Gehr, Nelson, and Walke 1978:12)

Reported fauna in the Burnt River Valley during the nineteenth century included deer, cougar, lynx, badger, muskrat, beaver, otter, and rabbit (Gehr, Nelson, and Walke 1978:12). Jewett reported white tailed deer as common to the Powder River around 1900 (Bailey 1936:92), while herds of up to twenty antelope were observed near the upper Burnt River in 1908 (Bailey 1936:77). Earlier than these accounts, Townsend (1836:58-59) reports killing an antelope in the upper reaches of the Powder River Valley. Ogden reported two bands of mountain sheep in the upper Burnt River in 1825 (Rich 1950:122-126) and seventy years later, Merriam killed a bighorn sheep near the same area (Bailey 1936:63).

Today, most of the upper Burnt River floodplain is under cultivation. Those portions of the upper Powder River floodplain not being cultivated or grazed are generally covered with extensive placer tailings from dredging of the river during the early part of the century. The foothills of both rivers are generally heavily grazed. While deer and elk are common to the area, antelope and mountain sheep are rare.

Ethnographic Background

Ethnographic information for the study area is notably lacking. The information that does exist, suggests the area was used primarily by Northern Paiute and secondarily by Southern Plateau cultural groups, mainly the Cayuse and Umatilla (Ray 1938; Steward and Wheeler-Voeglin 1974; Blyth 1938). Additionally, there is some evidence to indicate Northern Shoshoni may have occasionally visited the area (Steward and Wheeler-Voeglin 1974:14). Since the ethnographic data indicate that the Northern Paiute were the primary aboriginal group to utilize the study area, this section will focus mainly on the social organization, subsistence, and settlement of the Northern Paiute.

The Northern Paiute spoke a language known as Mono-Paviotso and maintained a pedestrian way of life long after neighboring groups had acquired the horse. Organized loosely into small bands consisting of a few families, they traveled over vast expanses of the interior of Oregon from the Cascade Mountains eastward into southwest Idaho. Named after principal elements in their diet, these small bands were quite fluid in their composition, so that individuals or even nuclear families with a few extended relatives often became affiliated with neighboring groups (Blyth 1938:405; Whiting 1950:16). In these instances, individuals or families would often identify themselves as a part of their new band or cultural group rather than as a part of their former band (Steward and

Wheeler-Voeglin 1974:18). Thus, intermarriage between bands was common and provided "the only real and enduring bonds" among the Northern Paiute (Steward and Wheeler-Voeglin 1974:22).

As among many of the Southern Plateau groups (Anastasio 1955), the Northern Paiute shared the use of fishing, hunting, and other resource sites with neighboring groups. Quite frequently this was with horseless bands of Shoshoni with whom the Northern Paiute shared a close relationship.

> Throughout the entire length of the Northern Paiute-Shoshoni contact area there was a complete absence of intertribal hostility. Local feuds might be brought on by witchcraft or woman stealing, but there were no territorial claims and no organized groups speaking either language which might defend against such claims [Steward and Wheeler-Voeglin 1974:9].

The close contact between Shoshoni and Northern Paiute groups fostered a certain amount of bilingualism and scattered throughout the mountains and valleys of eastern Oregon and southwest Idaho "were foot people, probably speaking both Shoshoni and Northern Paiute who also visited the Snake River to fish" (Steward and Wheeler-Voeglin 1974:199). Evidently

> there was an extremely broad zone of intermixture and interpenetration of the unmounted Paiute and Shoshoni in the general area to the west [of the Snake River] and perhaps to the east of the Snake River. But it is impossible to delimit this zone by

showing where the people spoke only Paiute or Shoshoni Steward and Wheeler-Voeglin 1974:14 .

Early reports of aboriginal groups in the Blue Mountains suggest a dispersed population consisting of aggregations of two or three nuclear families. Since the writers of these early accounts indiscriminately referred to these aboriginal groups as "Diggers" or "Snakes", it can be generally assumed that these groups were in all probability Northern Paiute. Fur trapper Peter Skeene Ogden observed Northern Paiute fishing for salmon in the John Day River Valley west of the study area (Rich 1950). Along the Middle Fork of the John Day near Austin in 1832, John Work found "a family of mountain Snakes, three men and their wives and six children and had a few fresh salmon from them and two beaver. They spear the salmon in the river." Further on, Work "passed three more families of Indians, only the women and children were in the huts, and the men were off hunting" (Lewis and Phillips 1923:171). Work noted that the upper Burnt River had been recently hunted by the Indians and that he traded beaver with a group encamped there (Lewis and Phillips 1923:169-170).

Northern Paiute informants living near Burns and interviewed by Blyth between 1936 and 1938 cited the existence of one and possibly two Northern Paiute bands in the upper Burnt and upper Powder river region. These were the

> Hu'nipwi'tika (huni'bui: root) whose winter camps....centered around Canyon City Creek, the town of John Day and the valley of the John Day River to the west....As to their easternmost extension of their terrain there was disagreement. Some informants cited a separate band of Elk Eaters (Pa'tichi'tika) to the east of the Hunibui Eaters in the vicinity of Prairie City and Baker. Others however, stated that these people were part of the Huni'bui Eaters band. In any case, the information would seem to indicate the presence of camps as far east as Baker [Blyth 1938:403].

According to Blyth (1938), the northern bands (the Huni'bui and the Pa'tichi'tika) were very similar to the Wada Eaters of the Harney Basin. The dialectic differences were slight. The groups differed primarily in aspects of the food quest and material culture.

In general, ethnographers have stressed the importance of gathering over other economic pursuits in the Great Basin Culture Area. Steward (1938) also emphasized the importance of fishing and gathering of root crops among groups living near the Snake River. In the region around the study area, salmon fishing along the Burnt and Powder rivers is reported to have been supplemented by hunting opportunities in the foothills of the Blue Mountains (Steward and Wheeler-Voeglin 1974:25). Bonneville, writing of the Paiute (or possibly Shoshoni) living near the mouth of the Powder River in 1834 states that they subsist

> in a great measure, on the roots of the earth, though they likewise take fish in great quantities, and

> hunt in a small way....Besides the roots on which they mainly depend for subsistence, they collect great quantities of seeds of various kinds, beaten with one hand out of the tops of the plants into wooden bowls....The seed thus collected is winnowed and parched and ground between two stones into a kind of meal or flour; which when mixed with water forms a very palatable paste or gruel...[Irving 1849:257-261].

Some of the people "lay up a stock of dried salmon, and other fish for winter; with these they were ready to traffic with the travellers for any objects of utility..."(Irving 1849:257-261).

Overall, the ethnographic and ethnohistoric data suggest that root crops were a primary, if not the most important item in the diet of the Northern Paiute. This data also furnishes repeated evidence of the Northern Paiute's intricate familiarity with the available food resource in their environment. Not surprisingly, the Northern Paiute vocabulary reflects this close relationship. Whereas, the form, color, texture, taste,and various stages of growth of food plants could be described in detail, non-utilitarian plants were often unnamed. As one Paiute woman said "no names for violets or things like that. We got names for roots, medicine" (Mahar 1953:129). While the subsistence patterns of the Northern Paiute in the southern Blue Mountains can only be roughly sketched, their hunting and gathering way of life can be characterized as one well adapted to meet a variety of specific conditions presented by local environmental conditions. Abundance or failure of a resource could be accomodated for by shifts in group size. When temporally and spatially restricted resources competed with one another (e.g. a simultaneous salmon run and root harvest), the sexual division of labor allowed the population to segregate to harvest the competing resources. Storage of food mitigated against periods of scarcity.

Other groups known to have occasionally visited the area were the Umatilla and Cayuse. Winter villages for these Southern Plateau peoples were located along the Columbia River and its tributaries north of the Blue Mountains. During late spring and early summer, the Cayuse and Umatilla left their winter villages to hunt, fish, and gather roots in the Blue Mountains (Suphan 1974:58). Near the study area, they are reported to have exploited only a few sites. These consisted of fishing and hunting sites along the Powder River which were jointly shared between the two groups. Further south, near the Strawberry Mountains were resource areas said to be of paramount importance (Suphan 1974). However, the ethnographic data indicate far more intense use of resources to the north of the study area by the Cayuse and Umatilla, primarily the Grande Ronde Valley which was "habitually used by the Nez Perce, Walla Walla, Umatilla and Cayuse " (Suphan 1974:25). The Grande Ronde was also an important meeting place for Plateau and Great Basin groups (Anastasio 1972:158).

In summary, the ethnographic data for the study area, while scant, do indicate that the Hu'nipwi'tika and/or the Pa'tachi'tika bands of the Northern Paiute were the primary users of the study area and adjacent region during the ethnographic period. Subsistence was largely based on collection of roots, fishing for anadramous and perennial fish, and hunting of big game.

II. RESEARCH METHODS

Volcanic Glass: Composition, Formation, and Distribution

Volcanic glass is a common constituent of acidic magmas (rhyolite, rhyodacite, and dacite) and was widely used by aboriginal peoples for the manufacture of stone tools. However, only those glasses relatively free of inclusions and mineral fragments were suitable for such use (Jack 1976:184).

Lavas are a mixture of several oxides with silicon dioxide (SiO^2) usually present in excess over all others. Typically, the amount of silicon dioxide (SiO^2) has been used to group lavas into three gradational categories. Those lavas containing 66% or more silicon dioxide are referred to as acidic, those consisting of 52-66% intermediate, and those with less than 52% silicon dioxide are called basic lavas (Ballard 1976:51).

The amount of silicon dioxide critically affects the viscosity of the lava and its distribution over the landscape. Acidic lavas are more viscous than their counterparts, the fluid basic lavas (e.g. basalts) and tend to congeal before they have travelled far from their source of eruption. Consequently, the distribution of acidic lavas is primarily dependent upon its magmatic composition and the topography over which it flows. Significantly, when viscosity is high during the cooling of the liquid magma, the migration of ions is inhibited, crystallization is stopped and obsidian is formed (Ballard 1976:64). Thus, obsidian deposits tend to be fairly localized.

An important aspect of acidic lavas though, is that their high viscosity inhibits the release of the primary force behind volcanic eruptions--volcanic gases. This often results in very explosive eruptions (Ballard 1976:64). Such eruptions are very common when rhyolitic magmas are involved. These eruptions also can potentially produce another volcanic glass--vitrophyre.

Vitrophyre is the end product in the welding process of ash flows or ash falls erupted violently from open craters, fissures, or vents superimposed on volcanic domes. Though no eruptions of ash flows that have produced welded tuffs have ever been directly observed, these flows are believed to consist of a turbulent mixture of gas and pyroclastic materials erupted at very high temperatures (Ross and Smith 1961:16). Much of the pyroclastic material is erupted high into the air and falls to be incorporated as volcanic ash, pumice, and crystal fragments in tuffs and tuffaceous sediments. Significantly though, a large part is erupted as hot, high density suspensions that retain much of their internal heat and flow as turbulent mixtures down the slopes of volcanic cones (Walker 1970:98). The areal extent of these flows depends primarily on the volume of ash erupted and the terrain over which they travel and can exceed distances of 60 miles (100 km) (Ross and Smith 1961:22). In extremely violent eruptions, ash flows can cover a thousand square miles in a matter of hours or days. Others related to small fissure vents and domal complexes may be quite localized (Walker 1970:97-98).

As the ash flow settles still retaining much of its inherent heat, it welds together in three gradational zones. The top zone of welding is typically unconsolidated. Directly below this layer, is the partial zone of welding. The zone of dense welding comprises the basal layer of the ash flow and is defined as the zone "in which complete coalescence of the glassy fragments has resulted in the elimination of all pore spaces. A dense black glass or vitrophyre is the normal end product of this process" (Smith 1966:154). Generally speaking, rhyo-dacitic magmas characteristic of the ash-flows of eastern Oregon contain 73-74% silicon dioxide and are typically very glassy, containing only a few crystals (Walker 1970:109).

Often called ignimbrite by many archaeologists, vitrophyre is frequently confused with obsidian. Generally, the two are macroscopically distinguished on the basis of transparency or translucency. If the material is transparent or translucent it is referred to as obsidian. If it is opaque, it is termed a vitrophyre (Sappington 1981:133). Additionally, vitrophyre contains distinct crystals which can be detected macroscopically. On a microscopic basis, these crystals often appear flattened. This flattening results from the crystals being squeezed and distorted by the overlying pressure and weight of the ash flow (Ross and Smith 1961:4). Obsidian, on the other hand is a true glass free of any crystalline structure. However, there are cases when macroscopic distinction becomes difficult (Smith 1960:824). While crystals may comprise up to 25% of the rock mass of a vitrophyre, some obsidian-like vitrophyres have been found to contain only 0.1% phenocrysts in their mass (Ross and Smith 1961:36) and can thus be easily confused with obsidian. While the volcanic glass associated with the Dooley Rhyolite Breccia is best classified as an obsidian-like vitrophyre, I refer to this material as obsidian.

X-Ray Fluorescence

Although there are other methods (e.g. neutron activation) which can be used to analyze obsidians, x-ray fluorescence has been the most widely used. Because this analytic technique provides the basis for this study, some description of the method is necessary.

X-ray spectrography originated nearly seventy years ago with the study of the x-ray spectra of the elements, but "the method had to await the technological adavances of the 1950s and 1960s ...before it could be taken from the physics laboratory and used as a simple and reliable method of chemical analysis" (Norrish and Chappell 1967:162). With the increased demonstration of its utility since the 1960s, x-ray fluorescence has been used to investigate trade networks and related archaeological problems in many diverse regions.

Archaeologists have used the technique in the Middle East (Cann and Renfrew 1964), New Zealand (Reeve and Ward 1976), California (Jack 1976; Ericson, Hagan, and Chesterman 1976; Hughes 1983), the Great Plains (Frison and others 1968; Davis 1972), Utah (Nelson 1982), and the Pacific Northwest (Sappington 1981).

X-rays may be considered as individual photons of energy and are produced when electrons of sufficient energy strike any matter. When matter is irradiated with primary x-rays, secondary x-rays are produced; the term fluorescent is generally applied to these secondary x-rays (Norrish and Chappell 1967:163). The way in which fluorescence occurs is relatively simple. All matter is made up of atoms. As described by the Bohr model, the atom is best visualized as a spehrical shell structure. At the center of the atom is the nucleus around which negatively charged particles (electrons) orbit. Certain fundamental principles allow the electrons to occupy only well defined shells or orbits. Importantly, the characteristic energy of a given shell is related to the charge of the nucleus (i.e., the atomic number), which also effectively characterizes the atomic element.

Fluorescence, or secondary x-ray emission occurs when matter (e.g., an obsidian specimen) is irradiated with incident x-ray photons of sufficient energy to dislodge an electron from its atomic shell around the nucleus of the atom. This creates a void that is immediately occupied by an electron from an outer shell. Since the fundamental requirement of energy conservation does not permit the loss of energy, this condition (the transference of electrons between atomic shells) is accomodated by the emission of electromagnetic radiation carrying an amount of energy equivalent to the difference between the two shells of the electron transition (Woldseth 1973:1.5). Statistically, over a large number of electron transitions, a characteristic emission spectrum is produced. The emitted radiation from secondary fluourescence is momentarily absorbed by the semi-conductor detector which allows the energy characteristic of each element to be measured. Thus the proportionality between the charge and the energy which is deposited in the semiconductor detector "is the key to the energy spectroscopy by which these systems permit measurement of the spectra" (Woldseth 1973:2.2).

The semiconductor "by definition...is a very poor conductor (i.e high resistivity) of electrical charge"(Woldseth 1973:2.2). Two materials, silicon and germanium are usually used in their construction. However, the capability of the semiconductor can be affected by even small amounts of impurities and some compensation is usually necessary. This is accomplished by drifting lithium atoms into the silicon material which effectively creates intrinsic material with high resistivity (Woldseth 1973:2.4). As lithium is highly mobile at room temperatures and can affect the desired performance of the detector, the detector is cooled with liquid nitrogen (-190° C). Cooling of the detector thus maintains the lithium compensation for impurities within the detector (Woldseth1973:2.4).

Because the electrical pulses produced during fluorescence are usually very small, they must be amplified proportionally to the energy of the detected x-rays by an amplifier. The amplifier conditions the electrical signal for its eventual presentation to a multi-channel analyzer (MCA). The multi-channel analyzer then sorts the energy from secondary fluorescence into the appropriate energy ranges characteristic of each particular element. "In order to transmit the relative quantitative information contained in the pulse amplitude distribution, it must be transformed to a digital form that can be accepted and stored in the MCA memory" (Woldseth 1973:2.6). This function is accomplished by the analog-to-digital convertor. The digital values are then semi-quantitatively processed and analyzed by a computer which determines the intensity of the peak energy by totaling the recorded counts within a particular elements spectral area. The net count thus reflects the elemental concentration within a particular sample (Woldseth 1973:2.36).

The energy dispersive system employed in this study is housed at the Idaho Bureau of Mines and Geology at the University of Idaho and has been described by Sappington (1981). Instrumentation consists of a Tracor Northern NS-880 energy dispersive instrument, a Nuclear Semiconductor 512 amplifier system, with a lithium-drifted silicon detector, a New England Nuclear americium-241 100 millicurie radioactive source, and a dysprosium secondary target. These components are linked with a Tracor Northern NS-623 8192 analog-to-digital convertor, a PDP 11/05 computer, and a Decwriter II printer. The system can effectively obtain data for approximately 70 elements between the ranges of calcium (atomic number 20) and uranium (atomic number 92).

The XRF instrument at the University of Idaho is presently programmed to obtain data for ten elements. These elements are iron (Fe), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), tin (Sn), Barium (Ba), lanthanum (La), and cerium (Ce) (Sappington 1981:134). Archaeological specimens and source standards are fluoresced for a 300 second counting period in free air.

Experimental Variables

Several conditions can potentially influence the measured intensities of elements within a given sample. These conditions include specimen geometry, weight, density, condition, distance from detector, counting time, proximate time, and atmosperic conditions.

Specimen geometry as used here refers to specimen size, shape, and surface morphology. Because lithic artifacts are extremely variable in their geometry and the analytical system employed in this study is non-destructive, specimen geometry is impossible to control. If all specimens were prepared by crushing, specimen geometry could be more closely controlled.

As most archaeologists wish to preserve artifacts for future study, the non-destructive method of analysis provides an attractive alternative. Efforts were made to at least partially control for variability introduced by specimen geometry by placing relatively flat surfaces, usually the ventral surfaces of flakes, facing the detector window. As a general rule, analysis of non-cortex surfaces of source pieces was strived for.

In general, specimens less than 1 cm in diameter were excluded from the analysis. It has been a general assumption that specimens less than 1 cm yield such weak intensity readings so as to cause statistical misclassifications. In the test case described in the following pages, the classification results tend to support this assumption. While most (80%) of the specimens slightly larger than 1 cm were correctly classified, the one specimen which was smaller than this required size was misclassified. While variation in size was tested for, other variables such as weight and density were not.

Other experimental conditions can generally be held much more constant than specimen geometry. Specimen condition refers to the general cleanliness of the specimen prior to analysis. Elements within adhering substances such as soil particles will also be detected by the instrument and this can be a source of error in the measured peak intensities. This problem is mitigated by washing the analyzed specimens in normal tap water before analysis.

Specimen distance from the detector refers to the physical space between the detector window and the artifact being analyzed. This distance remains roughly the same, although the distance does vary somewhat with the differing surface morphologies of various artifacts. As noted above, attempts are made to partially control for this variable by selecting for flat surfaces.

Proximate time refers to the period of time during which both artifacts and geologic source standards are analyzed. The radioactive source used to initiate specimen excitation, (americium-241) has a relatively short half-life of 458 years (Woldseth 1973:Table 2.3). Consequently, specimen excitation and resultant peak intensity readings will not remain the same over a period of years. To alleviate any fluctuations in intensity readings all specimens and source standards used in this study were analyzed during a relatively short period of time; this period extended from January 1983 to September 1984, a period of one year and nine months.

As the specimens are analyzed in "free air," atmosperic conditions are another variable which might potentially affect analytic results. However, I did not test this variable or attempt to adjust for differing atmospheric conditions.

Discriminant Analysis

"Discriminant analysis begins with the desire to statistically distinguish between two or more groups of cases" (Klecka 1975:435). Cases refer to individual obsidian specimens (either artifacts or unmodified rock specimens collected from their geologic source). Groups are formed from these cases and are selected by the researcher and defined by the particular research situation.

The researcher then selects a set of discriminating variables that measure characteristics on which the group is expected to differ. In this analysis, the discriminating variables consist of relative proportions of the measured peak intesities for seven elements (Fe, Rb, Zr, Sr, Nb, Sn, and Ba). The mathematical objective of discriminant analysis is to weight and linearly combine these discriminating variables in some fashion so that the groups are forced to be as statistically distinct as possible. In other words, we want to be able to "discriminate" between the groups in the sense of being able to tell them apart (Klecka 1975:435).

These combinations of variables are referred to as the discriminant functions. Significantly, these functions are formed in such a way that intergroup differences are maximized and intragroup differences are minimized (Klecka 1975:435). Once this has been accomplished, the two research objectives of discriminant analysis, analysis and classification can be pursued.

The analysis aspect of the program provides several tools for interpreting the data and measuring the success of the discriminating functions. The tools provided in the analysis aid in identifying those variables which contribute most to the differentiation of the groups (Klecka 1975:436).

The criteria by which independent variables are selected for inclusion in the analysis are controlled by the researcher. In many cases, the full set of variables will contain "excess information" and some variables will provide only minimal information useful for separating the groups (Klecka 1975:446-447). While the entire set can be entered directly and the derived discriminant functions used regardless of the discriminating power of the independent variables, a more prudent and efficient alternative is provided by the Mahalanobis Stepwise Selection Method. This method

> begins by choosing the single variable which has the highest value on the selection criterion. This initial variable is then paired with each of the other variables one at a time, and the selection criteria is computed. The new variable which in conjunction with the initial variable produces the best criterion value is selected as the second variable to 'enter the equation' . These two are then combined with each of the remaining variables one at a time to form triplets which are evaluated on the criterion. The triplet with the best criterion value determines the third variable to be selected. This procedure of locating the next variable that would yield the best criterion score, given the variables already selected continues until all variables are selected or no additional variables provide a minimum level of improvement [Klecka 1975:447].

Variable selection in the SPSS (Statistical Program for the Social Sciences) subprogram DISCRIMINANT can also be controlled by a partial F-ratio. The F-ratio tests the statistical siginificance of the amount of group separation added by a particular variable above and beyond the separation produced by the previously entered variables (Klecka 1975:453). To reduce the number of redundant and insignificant variables which contribute very little to group separation, establishing minimum F levels (F-to-enter, F-to-remove) can help to "streamline" the analysis of variables.

> Users who want to keep the minimum F's at a fixed and known significance level can do so with the PIN and POUT specifications. . . . The significance level in this case is the probability of obtaining the differences in the centroids as large or larger than are found in the data due to chance when the centroids are actually equal in the population [Klecka 1975:454].

Only when a variable has passed the minimum F-to-enter and F-to-remove criterion can it be considered for inclusion in the analysis. As the process of selecting the best variables proceeds, some previously "good" variables may lose their discriminating power and be excluded from the analysis. This occurs because new information may be available in some other combination which provides more useful information for separating the groups.

After the most important discriminant functions are determined, two measures are available to judge the functions' contribution to group discrimination (Klecka 1975:442). These are the eigenvalue and the canonical correlation coefficient. The eigenvalue is a measure of the relative importance of the discriminating function. The relative percentage of each eigenvalue provides an easy refernce for assessing the importance of the associated function in achieving group separation. The function with the largest eigenvalue is the most powerful discriminator while the one with the smallest eigenvalue is the weakest discriminator. The canonical correlation coefficient is a measure of association which summarizes the degree of relatedness between the groups and the discriminant function " (Klecka 1980:36). A high coefficient indicates a strong relationship between the groups and the discriminant function being measured (Klecka 1975:442).

The discriminating variables might best be viewed as axes that define a p-dimensional space.

> Each data case is a point in this space with coordinates that are the case's value on each of the variables. If the groups differ in their behavior with respect to these variables, we can imagine each group as being a swarm of points concentrated in some portion of this space. While the groups may overlap somewhat, their respective "territories" are not identical. To summarize the position of a group we can compute its "centroid." A group centroid is an imaginary point which has coordinates that are the group's mean on each of the variables [Klecka 1980:16].

As groups are described and characterized, they are compared one at a time to all of the group centroids and

F-statistics are computed which provide a means to test the validity of the separation between each group's centroid. Consultation with a table of F-statistics indicates whether or not the amount of separation between groups is statistically significant. Consequently, as the group centroids become more separate, the F-ratio increases (Klecka 1975:454).

Once the most powerful discriminating variables have been located and the groups separated, the discriminant functions are then used to predict the group to which the case most likely belongs. In this classification aspect of the program, a decision based on the discriminating variables is made as to which group a case (e.g. an artifact or a source standard) most closely resembles or "belongs to" (Klecka 1980:42). In general, this involves measuring the distance between the case and each group's centroid.

Assuming that each group comes from a population with a multivariate normal distribution, "we know that most of the cases will be clustered near the centroid and that the density of cases will diminish in a precise fashion as we get further away from the centroid" (Klecka 1980:45). By knowing that distance we can calculate the proportion of cases that are closer and the proportion of cases that are further away from the centroid. Consequently, this makes it possible to establish probabilities for group membership.

SPSS output provides two probability estimates for classifying each individual case. These probability estimates are P(X/G) and P(G/X), where P represents the probability, X the individual case and G the group. The probability of a case actually being in its assigned group is represented by P(G/X) (Klecka 1975:458). P(G/X) is also computed for the second closest group when the probability estimate exceeds .005. P(X/G), on the other hand "is an estimate of the proportion of cases in that group's population " which are located even further away from the centroid than X (the individual case) is (Klecka 1980:46). If the value of P(X/G) is small, "it signals the the possibility that this case *might* not belong to the populations from which these groups were drawn, even though it is 'closest' to the group indicated"(Klecka 1975:446).

Under discriminant procedures, it is assumed that an ungrouped case is *in fact* a member of one of the groups in the sampling universe. Accordingly, unknown cases are *forced* to belong to one of these groups. However, it is never possible to be absolutely certain if an individual case is in fact a member of the group to which it is assigned. This is simply the best estimate based on the discriminating variables used to distinguish the predetermined groups.

Once the groups have been separated by the discriminant functions, cases or artifacts of unknown group affiliation can be classified into one of these groups. Here, the possibility of misclassified or poorly classified cases are a matter of considerable importance. In general, misclassifications can occur in one of the following two ways. First, an unknown source group or groups may exist which overlap (chemically) with a known source group in the sampling universe. Thus, while artifacts from unknown sources may be classified into sources included in the analysis, these may be incorrect assignments nevertheless. In this circumstance, the best way to detect a misclassification would be through inspection of the P(G/X) value which signals the possibility that the case may not belong to the assigned group even though the estimate of group membership P(X/G) is very high. Secondly, "misclassifications can occur when two or more groups exist in the sampling universe which are nearly identical or at least overlap to a significant extent . . . on the basis of discriminating variables measured in the study"(Hughes 1983:73).

Whereas archaeological researchers in the Pacific Northwest have only recently become interested in problems of obsidian procurement, it is unlikely that all obsidian source locations have been located or reported. For example, while 97% of all the analyzed artifacts from Dirty Shame Rockshelter (Sappington 1982) were correlated with source groups at acceptable probabilities, only 59% of the 283 items from central Oregon sites were so correlated (Sappington and Toepel 1981:241). This suggests that for the southeast Oregon area and the sources near Dirty Shame Rockshelter, most obsidian sources have been located and/or these sources are very well characterized. Conversely, the central Oregon areas obsidian resources may not be well known or some of these sources may chemically overlap.

Another possible source of error could result when two chemically and geologically distinct sources become mixed either through the initial deposition of volcanic flows or through the erosion of one source and its subsequent depositon with another source. The result in this instance would be a group which might exhibit more chemical variability and overlap with other groups to a significant degree. Under discriminant analysis procedures, unknown artifacts situated on the border of two groups would normally be assigned to the more dispersed of the two groups (Klecka 1980).

In summary, discriminant analysis is a method which can be used to statistically distinguish between obsidian source groups and classify artifacts of unknown source affiliation into one of these groups. It must be remembered that these groups are formed and selected by the researcher. The researcher also selects a set of discriminating variables to statistically define these groups. These variables are then combined with other variables in a stepwise method to form discriminant functions which seek to maximize the separation between the two closest groups. Scores from these discriminant functions are used to characterize and identify these groups by deriving certain allocation rules. These allocation rules are then used to classify unknown cases into one of the groups included in the analysis.

Discriminant analysis procedures mandate that ungrouped cases be classified into one of these groups. Probability estimates for these classifications are then made which the researcher can use to assess the liklihood of these classifications.

Analytical Procedures

It is assumed in this study that aboriginal obsidian procurement was focused on those sources nearest to the sites being utilized. In general, eastern Oregon contains probably more obsidian sources than any other area of North America of comparable size (Fig. 5). Because it is not feasible to compare the archaeological specimens in this study to all of these sources, I selected known sources within approximately 100 miles (160 km) of the sites under investigation. Sources selected for inclusion in the analysis are the Drewsey, Shumway Ranch, Coyote-Buckboard, Petroglyphs, Gregory Creek, Seneca-Glass Mountain, Owyhee A, Owyhee B, Timber Butte, Reynolds Creek, Indian Creek, and Ebell Creek sources (Fig. 6). While this approach excludes many east and central Oregon sources, particularly those in the Burns vicinity, I believe this selection is justifiable given the assumptions of the study. However, the inclusion of the P(X/G) probability estimate in the analysis makes it possible to detect classifications to source groups which might not be included in the analysis.

In general, all source groups used in the analysis consist of 20 source standards. Exceptions to this include the Owyhee B and Reynolds Creek sources where only 10 items were available

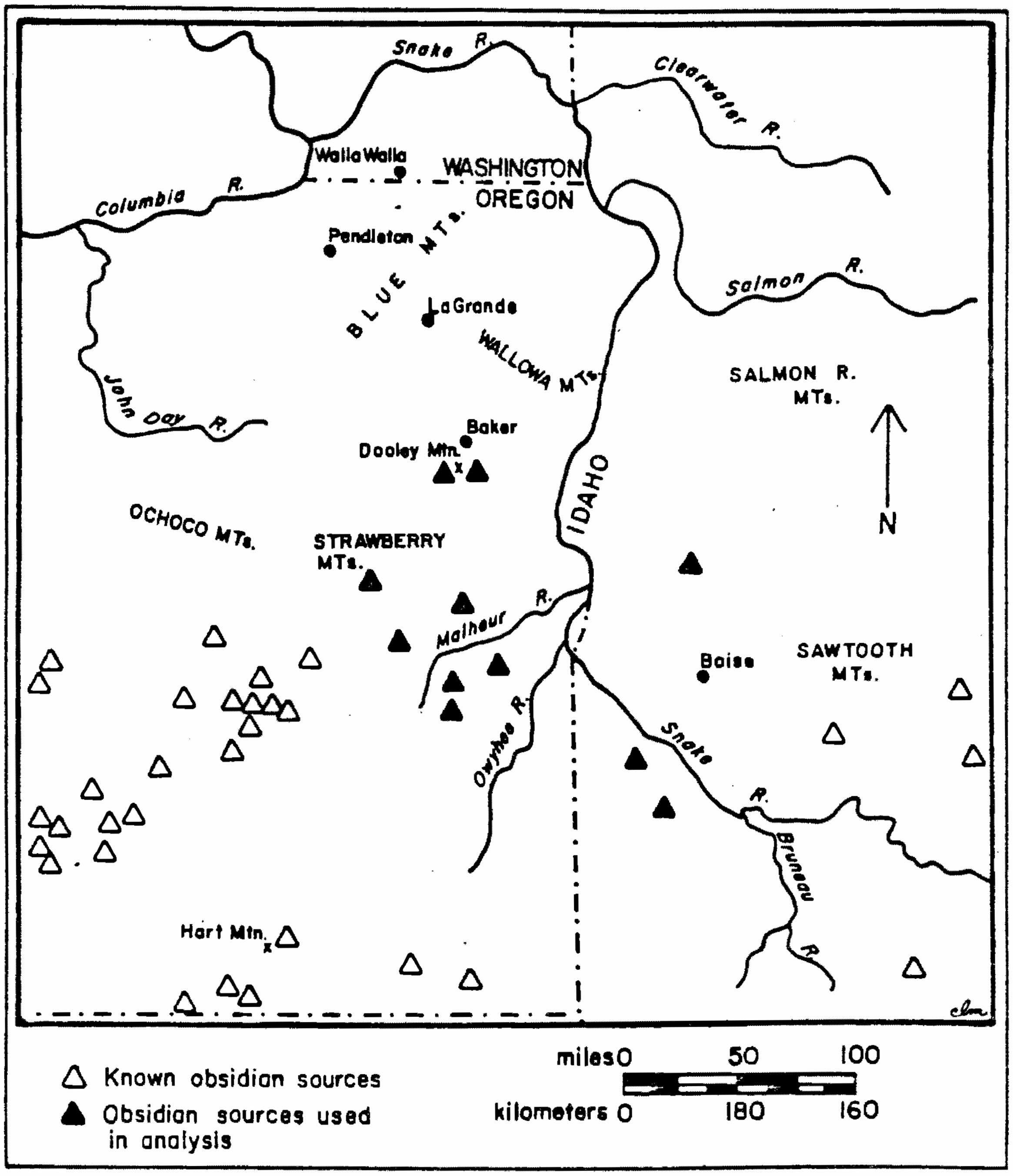

Fig. 5. Map of known obsidian sources in eastern Oregon and southwest Idaho.

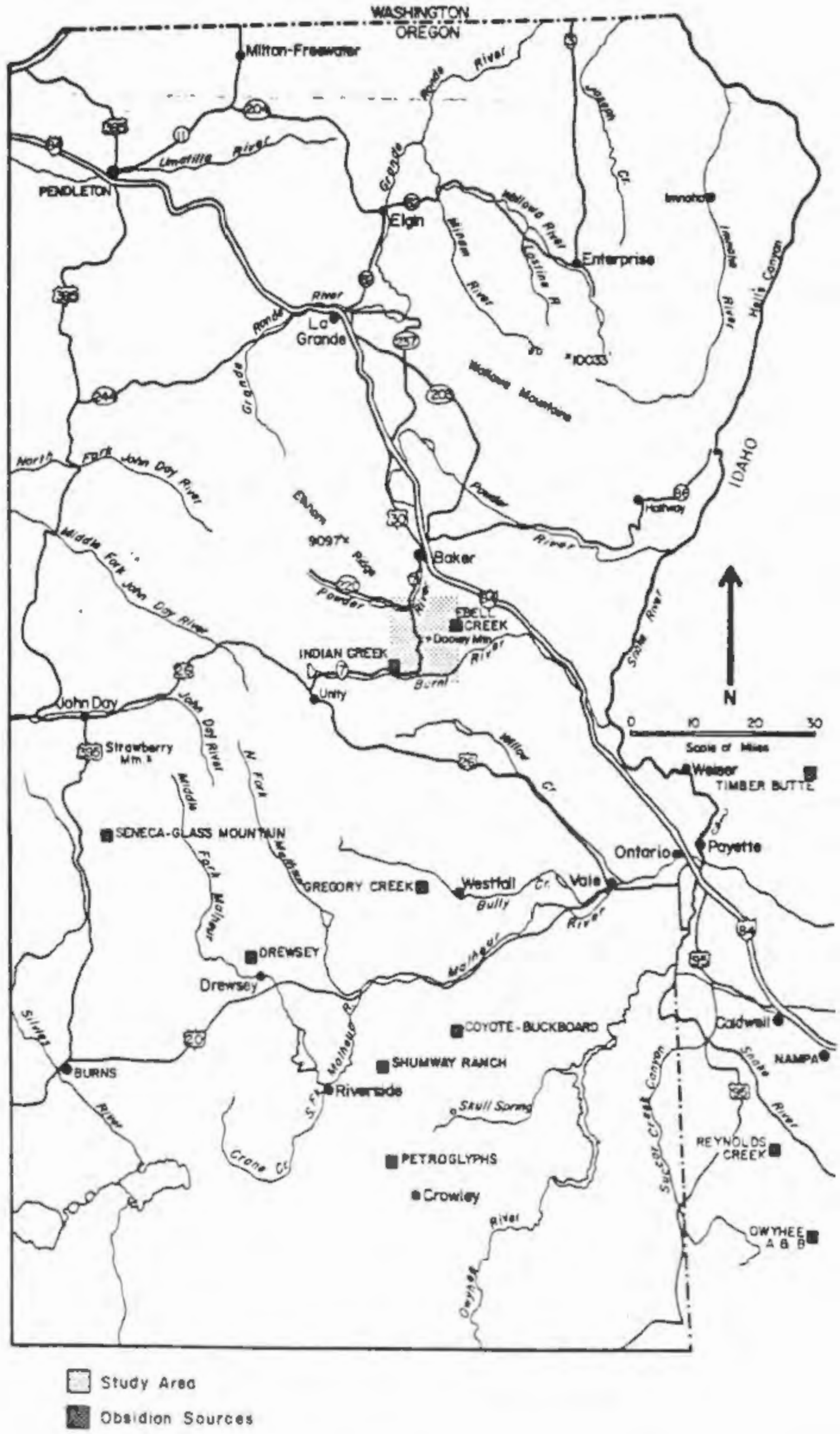

Fig. 6. Map of obsidian sources used in study.

for analysis. The other exception is the Indian Creek source which contained 40 source standards. While absolute group size can affect the classification results in some procedures, the SPSS PRIORS=EQUAL option specifying that unknown cases have an equal probability of belonging to any of the groups was included in the analysis.

As previously noted, discriminant analysis requires that all groups exhibit a multivariate normal distribution. Multivariate normality for groups used in the analysis was confirmed using the Kolmogorov-Smirnov goodness-of-fit test which tests "the degree of agreement between a sample of observed values and a hypothesized probability distribution" (Mendenhall and others 1974:254). Results indicated that at the .05 confidence level, there was no significant difference between the observed values of the source groups and the hypothesized values of a normally distributed population.

All source standards and artifacts were analyzed for a 300 second counting period with the XRF hardware described previously. Peak intensities were corrected for counter dead-time and background noise. Because the peak intensities recorded for each element are of a relative nature, they were converted to proportional variables prior to their submission for discriminant analysis. Discriminating variables selected for inclusion in the stepwise discriminant procedure include the following:

(1) the proportions of iron (PFe), rubidium (PRb), strontium (PSr), Zirconium (PZr), niobium (PNb), barium (PBa), and tin (PSn) relative to the sum of the peak intensities of Fe, Rb, Sr, Zr, Nb, Ba, and Sn;

(2) the proportion of iron (PFe1), zirconium (PZr1), and barium (PBa1), relative to the sum of the peak intensities of Fe, Zr, and Ba;

(3) the proportions of rubidium (PRb2), strontium (PSr2), and zirconium (PZr2) relative to the sum of the peak intensities of Rb, Sr, and Zr;

(4) the proportion of zirconium (PZr3) and tin (PSn3) relative to the sum of the peak intensities of Zr and Sn.

For inclusion in the analysis, the degree of group separation added by a particular variable had to be significant at the .05 confidence level. This requirement was specified using the PIN=.05 and POUT=.05 option.

According to the discriminant analysis, the proportion of zirconium (PZr2) relative to Zr, Rb, and Sr alone accounts for 80% of the variance between groups. The proportion of barium (PBa) relative to Fe, Rb, Sr, Zr, Nb, Sn, and Ba in conjunction with PZr2 account for 92% of the observed variance and five of the variables account for over 99% of the observed variance between source groups (Tables 1, 2).

A review of the pairwise matrix of F-ratios (Table 3) and inspection of a table of F-statistics indicates that with 8 and 215 degrees of freedom, the differences between all groups at the .05 confidence level is statistically significant.

TABLE 1

Summary table of between group differences

STEP	ACTION ENTERED	ACTION REMOVED	VARS IN	WILKS' LAMBDA	SIG.	MINIMUM D SQUARED	SIG.	BETWEEN GROUPS		LABEL
1	PZR2		1	0.310605	0.0000	0.189690-01	0.7225	802	810	
2	PBA		2	0.006070	0.0000	0.33943	0.1870	801	806	
3	PZR3		3	0.004225	0.0000	0.97488	0.0236	801	806	
4	PSR2		4	0.000617	0.0000	1.3033	0.0157	801	813	
5	PSN		5	0.000534	0.0000	1.5846	0.0743	808	813	
6	PZR		6	0.000310	0.0000	2.0986	0.0037	801	813	
7		PSN	5	0.000335	0.0000	1.5297	0.0140	801	813	
8	PFE		6	0.000153	0.0000	1.7868	0.0112	801	813	
9	PFE1		7	0.000026	0.0000	2.3506	0.0032	801	813	
10	PSN		8	0.000023	0.0000	2.5157	0.0036	801	813	

TABLE 2

Canonical Discriminant Functions

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION	:	AFTER FUNCTION	WILKS' LAMBDA	CHI-SQUARED	D.F.	SIGNIFICANCE
					:	0	0.0000226	2385.3	88	0.0000
1*	80.97536	80.32	80.32	0.9938819	:	1	0.0018544	1402.7	70	0.0000
2*	11.87982	11.78	92.10	0.9603953	:	2	0.0230846	832.80	54	0.0000
3*	4.74690	4.71	96.81	0.9088416	:	3	0.1372623	442.85	40	0.0000
4*	1.88922	1.87	98.69	0.8086318	:	4	0.3965804	206.25	28	0.0
5*	1.16320	1.15	99.84	0.7332951	:	5	0.8578825	34.183	18	0.0120
6*	0.11551	0.11	99.96	0.3217846	:	6	0.9569725	9.8077	10	0.4575
7*	0.04261	0.04	100.00	0.2021664	:	7	0.9977519	0.50190	4	0.9733
8*	0.00225	0.00	100.00	0.0474144	:					

TABLE 3

Pairwise matrix of F-ratios and significance of differences between group centroids

F STATISTICS AND SIGNIFICANCES BETWEEN PAIRS OF GROUPS AFTER STEP 10
EACH F STATISTIC HAS 8 AND 215.0 DEGREES OF FREEDOM.

GROUP	801 DREWSEY	802 SHUMWAY RANCH	803 COYOTE-BUCKBOARD	804 PETRO-GLYPHS	805 GREGORY CREEK	806 SENECA	807 OWYHEE A	808 OWYHEE B	809 TIMBER BUTTE	810 REYNOLDS CREEK	812 INDIAN CREEK
802 SHUMWAY RANCH	49.257 0.0000										
803 COYOTE-BUCKBOARD	36.241 0.0000	92.109 0.0000									
804 PETRO-GLYPHS	167.57 0.0000	230.98 0.0000	62.410 0.0000								
805 GREGORY CREEK	102.23 0.0000	13.188 0.0000	167.52 0.0000	345.65 0.0000							
806 SENECA	7.6352 0.0000	25.721 0.0000	39.708 0.0000	179.44 0.0000	65.301 0.0000						
807 OWYHEE A	54.484 0.0000	116.52 0.0000	21.912 0.0000	35.278 0.0000	204.77 0.0000	70.663 0.0000					
808 OWYHEE B	5.8506 0.0000	47.896 0.0000	16.555 0.0000	75.337 0.0000	94.384 0.0000	17.018 0.0000	15.977 0.0000				
809 TIMBER BUTTE	342.94 0.0000	409.48 0.0000	217.10 0.0000	95.609 0.0000	535.54 0.0000	356.69 0.0000	156.94 0.0000	188.43 0.0000			
810 REYNOLDS CREEK	1278.7 0.0000	1315.2 0.0000	994.22 0.0000	781.21 0.0000	1440.0 0.0000	1280.4 0.0000	970.77 0.0000	886.21 0.0000	584.75 0.0000		
812 INDIAN CREEK	15.385 0.0000	44.869 0.0000	28.934 0.0000	186.52 0.0000	109.24 0.0000	4.7490 0.0000	70.725 0.0000	17.955 0.0000	404.50 0.0000	1439.4 0.0000	
813 EBELL CREEK	2.9674 0.0036	56.088 0.0000	31.223 0.0000	140.06 0.0000	115.54 0.0000	14.925 0.0000	40.444 0.0000	2.3177 0.0210	306.25 0.0000	1227.8 0.0000	20.188 0.0000

Overall, 85% of all individual cases within the source groups were correctly classified (Table 4). Classification results indicate that 100% of the individual cases in three groups are correctly classified. Most (75%-95%) of the cases within seven of the groups are correctly classified. Two source groups, Drewsey and Ebell Creek exhibit low (50%-63%) correct classification results.

SPSS provides no set guidelines for determining when to accept or reject classification of an unknown case. For the researcher whose main interest is in a model "which can predict well or serve as a reasonable description of the real world, the best guide is the percentage of correct classifications" (Klecka 1980:62). While this percentage nearly always overinflates the estimate of correctly classified cases (Hughes 1983:60), this percentage does "indicate" the accuracy of the classification procedure and "indirectly confirms the degree of group separation" (Klecka 1980:49).

In this analysis, I arbitrarily established minimum levels for acceptance or rejection of unknown cases. I required that the probability estimate of group membership P(G/X) be greater than .65 *and* the probability estimate of P(X/G) be greater than .10. Unknown cases fulfilling both of these requirements were accepted. Those that did not were rejected. An exception to this is the Timber Butte source, which while having all but one of the 20 source pieces classified correctly at P(G/X) estimates of .97 or greater also had P(X/G) values of .00 values reported in over 65% of the

TABLE 4

Classification results for source samples
from the 12 sources used in the analysis

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP 801	802	803	804	805	806
GROUP 801 DREWSEY	20	10 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4 20.0%
GROUP 802 SHUMWAY RANCH	20	0 0.0%	17 85.0%	0 0.0%	0 0.0%	2 10.0%	1 5.0%
GROUP 803 COYOTE-BUCKBOARD	19	0 0.0%	0 0.0%	15 100.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 804 PETROGLYPHS	20	0 0.0%	0 0.0%	0 0.0%	20 100.0%	0 0.0%	0 0.0%
GROUP 805 GREGORY CREEK	20	0 0.0%	1 5.0%	0 0.0%	0 0.0%	19 95.0%	0 0.0%
GROUP 806 SENECA	20	3 15.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	15 75.0%
GROUP 807 OWYHEE A	19	0 0.0%	0 0.0%	1 5.3%	1 5.3%	0 0.0%	0 0.0%
GROUP 808 OWYHEE B	10	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 809 TIMBER BUTTE	17	0 0.0%	0 0.0%	0 0.0%	1 5.9%	0 0.0%	0 0.0%
GROUP 810 REYNOLDS CREEK	10	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 812 INDIAN CREEK	40	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	3 7.5%
GROUP 813 EBELL CREEK	19	2 10.5%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.3%
UNGROUPED CASES	575	11 1.9%	11 1.9%	91 15.8%	74 12.9%	20 3.5%	17 3.0%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 85.34%

Table 4 (continued)

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP 807	808	809	810	812	813
GROUP 801 DRESSEY	20	0 0.0%	1 5.0%	0 0.0%	0 0.0%	1 5.0%	4 20.0%
GROUP 802 SHUPWAY RANCH	20	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 803 COYOTE-BUCKBOARD	19	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 804 PETROGLYPHS	20	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 805 GREGORY CREEK	20	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 806 SENECA	20	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 10.0%	0 0.0%
GROUP 807 OWYHEE A	19	15 78.9%	2 10.5%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
GROUP 808 OWYHEE B	10	0 0.0%	9 90.0%	0 0.0%	0 0.0%	0 0.0%	1 10.0%
GROUP 809 TIMBER BUTTE	17	0 0.0%	0 0.0%	16 94.1%	0 0.0%	0 0.0%	0 0.0%
GROUP 810 REYNOLDS CREEK	10	0 0.0%	0 0.0%	0 0.0%	10 100.0%	0 0.0%	0 0.0%
GROUP 812 INDIAN CREEK	40	0 0.0%	0 0.0%	0 0.0%	0 0.0%	37 92.5%	0 0.0%
GROUP 813 SHELL CREEK	19	0 0.0%	3 15.8%	0 0.0%	0 0.0%	1 5.3%	12 63.2%
UNGROUPED CASES	575	121 21.0%	32 5.6%	11 1.9%	2 0.3%	174 30.3%	11 1.9%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 85.04%

correctly classified cases. The reason for this apparent discrepancy is unknown at this time, but it is appears to be related to the broad distribution of cases reported in the scatterplot for this group. Thus, for items assigned to Timber Butte (11 of 575 or 1.9% of all unknown cases), a minimum value of 1.00 for the P(G/X) estimate of probable group membership was required for acceptance.

The Test Case

As another measure of the program's ability to correctly classify unknown items, a test case was included in the analysis. In this test case, I selected an obsidian nodule from the Indian Creek source and reduced it by direct free-hand percussion to a large biface. One large flake from this core was also selected and bifacially flaked with an antler billet and an antler pressure flaker into a small corner-notched point (Table 5). The projectile point, biface and ten flakes were then analyzed using the same procedures described above and submitted in the same discriminant analysis.

Classification results (Appendix A) indicate that nine of the twelve items (75%) are correctly classified into the Indian Creek source group. Of the items which were misclassified, one (720.1.9) did not fulfill the minimum size requirement and was not expected to be correctly classified. The probability estimate P(X/G) of .00 indicated that the assignment might not be correct and should probably be rejected. Similarly, the

Table 5

Test Case Description

Description	Reg. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Source Assignment [a]
Secondary decortication flake	720.1.1	51	54	17	21.5	812-
Secondary decortication flake	720.1.2	45	53	18	43.5	812+
Tertiary flake	720.1.3	15	8	1	.3	812+
Secondary decortication flake	720.1.4	20	15	3	.7	812+
Tertiary flake	720.1.5	31	15	3	1.7	812+
Secondary decortication flake	720.1.6	32	35	9	5.8	813-
Secondary decortication flake	720.1.7	36	43	13	16.0	807-
Tertiary flake	720.1.8	13	17	2	1.0	812-
Non-diagnostic shatter	720.1.9	8	5	1	.1	812-
Corner-notched point	720.1.10	28	20	4	2.4	812+
Non-diagnostic shatter	720.1.11	45	9	6	2.6	812-
Biface	720.1.12	96	107	19	95.4	812+

[a]Source Assignment
807 Owyhee A
812 Indian Creek
813 Ebell Creek

\+ indicates accepted source assignment by established criteria
\- indicates rejected source assignment by established criteria

P(G/X) value of .01 for a large secondary decortication flake (720.1.7) suggested that its classification to the Owyhee A source was suspect and should be rejected. Thus in these two cases even though the probability estimates P(G/X) of group membership (.96 and .69 respectively) are sufficiently high enough for acceptance, the P(X/G) probability estimate indicates that the probability of these assignments being correct ones is low and that they should be rejected. In the last misclassification from this test case, another large secondary flake (720.1.6) was assigned to Ebell Creek at a probability of .37. This estimate was too low for acceptance and would have been rejected under the criteria used in this study. If the one case which was not expected to be correctly classified (because of its diminutive size) is not considered in the tally of correctly classified items, then 9 of 11 or 82% of the test sample is correctly classified. In conjunction with the classification results of individual cases from the source groups indicating an 85% correct classification rate, it would appear that the program can correctly classify with approximately 80% accuracy.

III. OBSIDIAN SOURCES IN THE STUDY AREA

Most of the reported obsidian occurences in the Dooley Mountain vicinity are associated with Gilluly's (1937) Dooley Rhyolite Breccia (Fig. 3). Most of the rocks in this unit are classed as flow of tuff breccias and are typically aphanitic. Sources of raw material have been reported in several dispersed localities and prior to analyzing artifacts from unknown sources, it was essential that samples from these localities be collected and analyzed. During the fall of 1982, raw material samples were collected from reported and some non-reported locales and subsequently analyzed with the XRF hardware described above.

As noted previously, x-ray fluorescence analysis by Sappington (1981:139) indicated that two discrete sources were present in the Dooley Mountain vicinity. One source termed the Ebell Creek source was based on small pebbles and cobbles collected from the Ebell Creek drainage. The other source, called Wallowa was based on waste flakes and was something of an enigma because the source of raw material had not been located. X-ray fluorescence analysis in this study support Sappington's (1981:139) contention that two raw material sources are located in the area (Appendix B). While the use of the Ebell Creek source is maintained, I refer to the previously hypothetical Wallowa source as Indian Creek (Fig. 7).

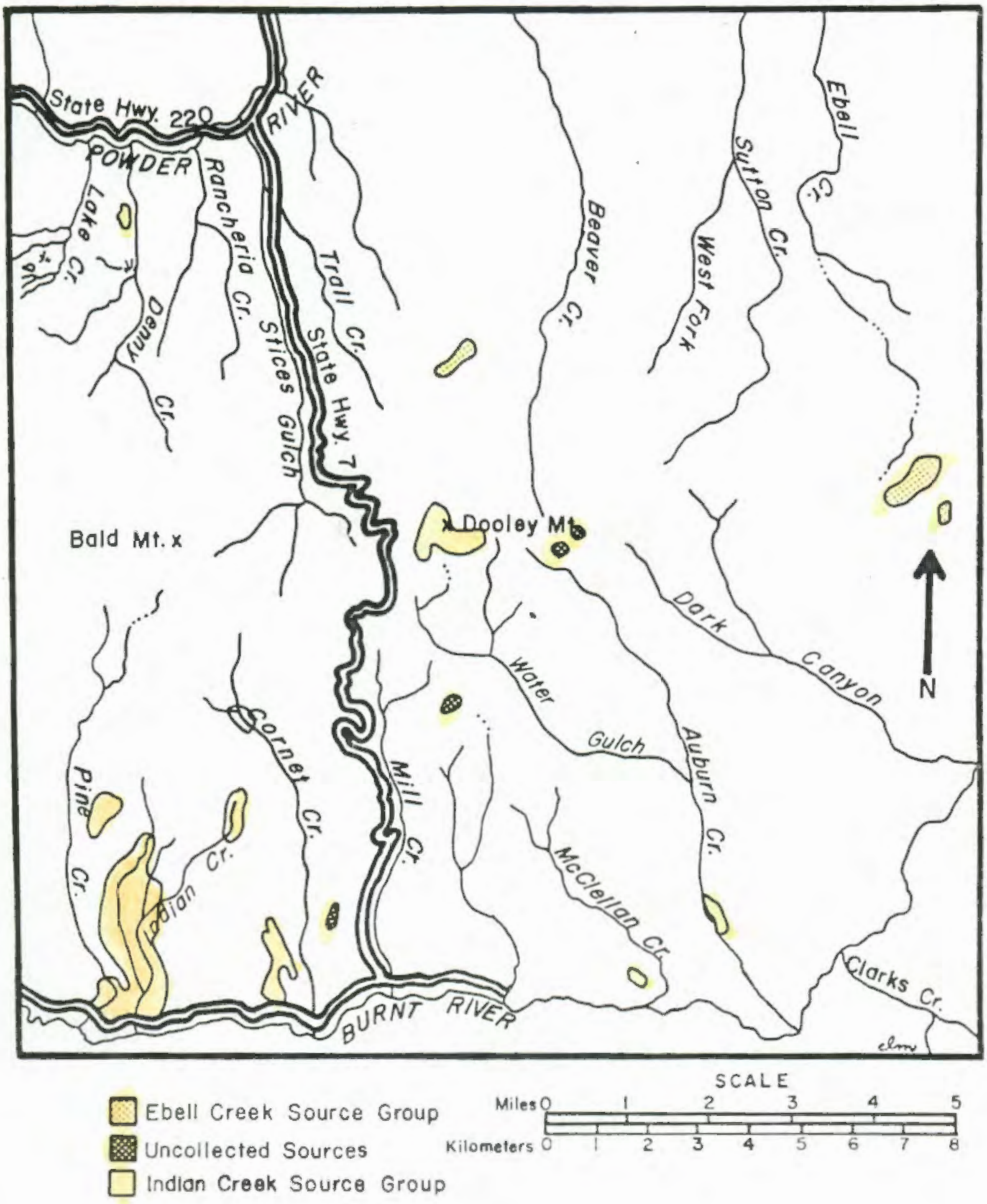

Fig. 7. Obsidian sources in study area.

The Indian Creek source

The obsidian or obsidian-like vitrophyre included with the Indian Creek source group occurs in several localities with the densest concentrations being located within the drainages of Indian and Pine creeks (Figs. 8, 9). Other locales are located near Cornet, Auburn, and McLellan creeks in the foothills north of the Burnt River; sporadic pebbles and small cobbles are found on the north side of the divide near Denny and Rancheria creeks; an isolated and very limited outcrop is situated on Sheephead Mountain 15 miles (25km) southwest of the Dooley Mountain vicinity; and small cobbles and pebbles are located near the summit near Dooley Buttes and further east along the divide.

Raw material near the postulated volcanic center at the Dooley Mountain summit (Gilluly 1937) consist of dispersed subangular cobbles and pebbles averaging 2-3 cm. in size. Cobbles as large as 5-6 cm. are only occasionally found in the Dooley Buttes vicinity. Cobbles exhibiting flow-banded cortex, thermally fractured cobbles displaying a granular cortical surface, and some with a weathered chromium patina were observed. Flakes from these cobbles are mainly black, opaque and contain small phenocrysts. Some thin flakes are slightly translucent near the edges.

Fig. 8. View of Lower Pine Creek toward the Burnt River. Small obsidian cobbles occur along the lower slopes of and in the small ephemeral tributary in the foreground.

Fig. 9. Eroded slope near the confluence of the West Fork and main stem of Indian Creek. Large cobbles are particularly abundant on this eroded slope.

Some of the cobbles have been apparently "tested" by aboriginal knappers and have only one flake removed. Whereas evidence for intensive exploitation of the naturally occuring cobbles is generally lacking at the source area, inferred base camps or task-specific sites near here provide evidence for the performance of entire reduction sequences. However, its diminutive size undoubtedly placed limits on the range of artifact forms that could have been produced from this material.

In contrast to the small cobbles and pebbles observed along the summit, the raw material occuring within the Indian and Pine Creek drainages is generally much larger in size. While pebbles and small cobbles are found throughout the area, cobbles ranging from 7-10 cm and weighing up to 1.5 kg (3.5 pounds) can occasionally be found in the creek beds and along the open sagebrush ridges bordering the streams. Less frequently, cobbles as large as 25 cm and weighing up to 4 kg (9 pounds) can be found. These cobbles are typically angular to sub-angular. The cortex on some cobbles is slightly vesicular which can cause some irregular fracture patterns in the removal of the cortex. Many of the smaller cobbles are thermally fractured and have highly polished surfaces, probably caused from wind-aided sand-blasting. Obsidian can be occasionally found in thick tephra deposits along with perlite, a water-rich and crumbly obsidian in roadcuts in this vicinity. Obsidian has also been reported along a small gulch just west of Pine Creek (Field notes of James Gilluly, 1930).

The interior of these cobbles is somewhat varied. Some cobbles containing relatively large phenocrysts exhibit a light-gray and black wavy flow-banding and are slightly translucent near flake edges. Other cobbles with both flow-banded cortex and interiors contain no perceptible phenocrysts and are wholly opaque. In many of the thermally fractured and wind polished cobbles, the absence of phenocrysts can serve as an aid to the interior of the stone, but in those with a natural cortex, a flake must be driven off to assess the stone's interior. Numerous cobbles with only one or two flakes removed were observed throughout the area and tentatively suggest that aboriginal knappers may have been somewhat restrictive in their selection of raw material. Alternatively, these cobbles may have been used as cores for the production and procurement of large flakes which were then transported.

Obsidian in the Indian and Pine creek vicinity apparently occurs in lag deposits and is sporadically distributed along the low, open ridges bordering these creeks. Cobbles can be found eroding out of the adjacent slopes and secondarily deposited cobbles can be collected from the stream beds. The material distribution is also highly variable. The densest concentrations so far known appears to be centered near the West Fork of Indian Creek. In some small areas there is a literal pavement of obsidian pebbles and cobbles. More commonly, cobbles are found about every five to ten meters apart.

Raw material also occurs along a small, steep ridge west of Cornet Creek. The material is similarly variable in morphology, cortex, and interior composition. The material at this locale is not nearly as abundant as in the Indian and Pine creek area, but small lithic reduction stations within this source locale do indicate its use. Gilluly (Field notes, 1930) reports obsidian on a small ridge between Cornet and Mill creeks about 1.5 miles (2 km) north of the Burnt River. While the northern and southern limits of locale are reasonably well known, its western boundary is not. Small cobbles and pebbles have been reported about 3 miles (4.8 km) further upstream in the Cornet Creek stream gravels, but archaeological reconnaissance by the U.S. Forest Service has not located any additional sources in this immediate vicinity. Discarded projectile points recovered nearby and correlated to the Indian Creek source additionally suggest that the material may have been used to fashion expediency tools (Binford 1979) for use in immediate hunting tasks in the area.

Further east, small sub-angular cobbles and pebbles were incidentally found during personal reconnaissance near McLellan and Auburn Creeks. However, the material here appears to be very limited in supply. Because there has been no intensive reconnaissance of these private lands, the extent of obsidian occurrences in this vicinity is unknown.

All of the source locales so far discussed occur from the Dooley Mountain summit south toward the Burnt River. One exception to this is the apparently very limited supply near

Denny Creek located on the north side of the divide about 2 miles (3.2 km) from the Powder River. Samples collected from a small drainage west of Denny Creek were generally quite small pebbles, 1-2 cm in diameter. This material had been heavily stream rolled and battered. Local residents indicate that small pebbles occur over the long ridges adjacent to Denny and Rancheria creeks to the east, but that chipping stations in this area are extremely limited (Bill Kline, personal communication 1982).

The last locale within the Indian Creek source to be discussed is the Sheephead Mountain locale situated 15 miles (25km) southwest of the study area. This source was located by Pam Stephenson and me during a reconnaissance of the area in 1980 (McDonald 1980). Raw material occurs in a small saddle north of Sheephead Mountain and is extremely localized and limited in quantity. No more than 40 cobbles larger than 1-2 cm were observed in the area. These cobbles are generally angular to subangular and have a natural cortex. Flakes struck from this material are dense, black, and opaque and exhibit no discernible flow-banding. Some grayish-black glassy basalt cobbles also occur at this locale. Because this material could not be distinguished from other Indian Creek material at the .05 confidence level, this material is considered to be of the same source group. Obsidian on Sheephead Mountain may have been erupted through a fault zone near the area (Lee Ehmer, personal communication 1980).

Though the supply of raw obsidian is very limited here, lithic reduction stations are present indicating its use by aboriginal people. It is probable that some artifacts, especially from sites near this locale, and assigned to Indian Creek, have been manufactured from obsidian obtained at Sheephead Mountain.

The Ebell Creek source

Locales for raw material included within this source group are primarily located in the eastern portion of the study area (Fig. 7). Small nodules and pebbles smaller than 5 cm are generally characteristic of the material in this source group. Thin flakes from these nodules typically display a smokey transluscence with weakly developed flow-banding. Large, thick flakes appear jet-black and exhibit no discernible phenocrysts. These small cobbles and pebbles are sub-rounded with smooth to slightly rough natural cortex. Some of these display a silvery patina.

Natural cobbles and pebbles are widely scattered over Ebell Creek Divide but one archaeological survey reported "no recognizable chipping station" in conjunction with these deposits (Mead 1975:14-21). Personal reconnaissance along the divide also failed to locate any distinct lithic reduction areas. Small pebbles can be found near the heads of Sutton Creek and the east fork of Dark Canyon and a few small cobbles were noted in the an ephemeral stream channel between French

Gulch and Dead Horse Canyon. However, their diminutive size was probably a major hinderance to artifact production.

Slightly larger cobbles can be found near the historic settlement of Rogers located between Trail and Beaver creeks (Fig. 7). Small sub-rounded cobbles occur in the stream channel, but the bulk of the material appears to be located to the east along the adjacent slope up to a small saddle. While obsidian may be present further east toward the head of Beaver Creek (Bob Cunningham, personal communication 1982), an early October snow prevented any further investigation of this source locale. Personal reconnaissance along the middle reaches of Beaver Creek revealed the presence of small pebbles. Local residents indicate that these small pebbles can be found in many areas of the Upper Beaver Creek drainage, but pebbles larger than a quarter are conspicuosly lacking (Tim Jones, personal communication 1984).

IV. ARCHAEOLOGICAL DATA

Wallowa Whitman National Forest Artifacts

Introduction

The Wallowa Whitman National Forest encompasses nearly two million acres within the Blue Mountains of northeast Oregon (Fig. 10). The Forest extends from the Snake River on the east to the Elkhorn Mountains on the west and from the Grande Ronde River on the north to the Burnt and Malheur River divide on the extreme southern edge. The forest is drained by the Grande Ronde, Imnaha, North Fork John Day, Burnt, Powder, and Snake rivers. All of these rivers support anadramous fish populations. The Forest includes the Elkhorn, Wallowa, and portions of the Greenhorn Mountains. Elevation ranges from less than one thousand feet along the Snake River to over 10,000 feet (3030 meters) in the Eagle Cap Wilderness. The forest encompasses many diverse environmental regimes ranging from the semi-arid Hells Canyon to open Ponderosa Pine forest to spruce and subalpine forest in the upper elevations of the glacially carved Elkhorn and Wallowa Mountains.

Since the mid-1970s, the Wallowa Whitman National Forest has conducted numerous cultural resource inventories which has resulted in the identification of approximately one thousand prehistoric sites (Robert Nisbet, personal communication

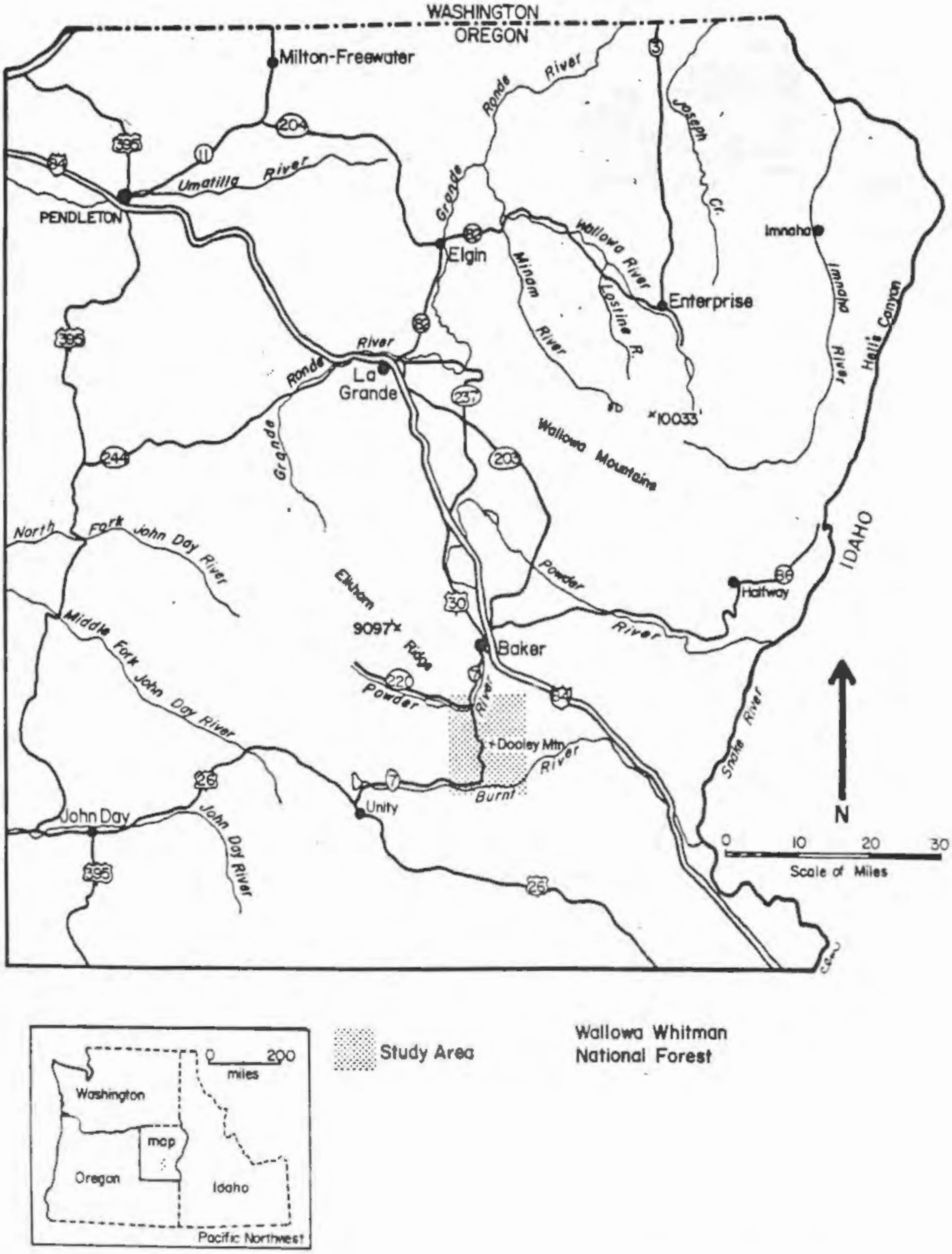

Fig. 10. Map of Wallowa Whitman National Forest.

1983). These sites range from substantial house pit villages to small, localized lithic scatters and isolated finds. The temporally diagnostic artifacts collected from these sites suggests that aboriginal use of the eastern portion of the Blue Mountains occurred possibly as early as 10,000 BP and lasted until historic times (Nisbet 1982).

Sample Selection

The analyzed artifact sample from the Wallowa Whitman National Forest includes 134 obsidian projectile points and projectile point fragments (Tables 6, 7). Nearly all are from surface collected contexts and all are treated as such. These artifacts are compared with regional typologies from the Columbia Plateau and Great Basin and with diagnostic projectile points from archaeological sites in the adjacent region where stratigraphic and radiocarbon dates are available. Also included in the artifact sample are several bifaces, scrapers, unifaces, and an awl.

Large Stemmed Lanceolate Projectile Points

This category consists of large, shouldered lanceolate projectile points with straight to convex bases (Fig. 11). Two points exhibit limited basal and stem grinding presumably to facilitate hafting.

TABLE 6

Wallowa Whitman Forest projectile points:
attributes and source assignments

Wallowa Whitman Forest Site No.	Smithsonian Site No.	Artifact Registration No.	General Morphology	Cortex [a]	Original Object [b]	Condition [c]	Transverse Section [d]	Bifacial Flaking [e]	Unifacial Flaking [f]	Breakage [g]	Pressure Flaking [h]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base [i]	Margins [j]	Neck Width (mm)	Stem [k]	Serration [l]	Elevation (ft.)	Environment [m]	Source Assignment [n]	Illustration No.
14-37-34-1		101	Large stemmed lanceolate	2	3	1	1	2	3	8	7	87	26	5	13.4	1	2	-	1	2	5000	4	808-	11a
Crater Lk. 1		1	" "	2	3	1	2	2	3	8	7	72	30	8	17.7	1	2	-	2	0	-	-	812+	11c
Amelia 10	35BA293	0.1	" "	2	3	1	3	2	3	8	6	93	29	10	25.1	3	3	-	1	0	-	-	805+	11b
-		3-48-9-1.F.	Large lanceolate point fragment	2	3	2	1	2	3	5	2	19	20	7	2.6	1	2	-	4	0	-	-	812+	11g
2-48-29-1		2-48-29-1	" "	2	3	2	1	2	3	6	2	37	25	6	6.1	1	2	-	4	0	5460	2	812+	11f
11-37-17		11-37-17	" "	2	3	2	1	2	3	3	7	64	28	9	18.4	7	2	-	5	0	-	-	812-	-
11-37-36-7		11-37-36-7.2	" "	2	3	2	1	2	3	5	3	37	28	7	7.6	7	3	-	5	1	5190	4	812+	11e
15-37-3		SM-21	" "	2	3	2	1	2	3	3	1	50	23	7	11.3	7	2	-	5	0	-	-	802+	11d
Sheep 4	35BA281	0.1	" "	2	3	2	1	2	3	1	3	25	26	5	4.6	7	2	-	5	0	-	-	812+	-
3-44-19-1		3-44-19-1	Large square shouldered	2	3	2	1	2	3	3	2	51	22	7	9.5	1	3	8	1	2	7700	7	808-	12e
7-36-28-2		7-36-28-2	" "	2	3	2	1	2	3	5	7	46	25	5	6.4	7	3	14	4	0	6660	4	813-	12b
10-38-1-1		10-38-1-1.3	" "	2	3	2	1	2	3	3	2	45	25	5	6.7	7	2	0	4	0	5040	4	807+	-
11-37-36-3	35BA411	11-37-36-3.1	" "	2	3	2	1	2	3	5	2	73	27	8	12.7	7	3	0	4	2	5180	4	806-	12c
11-37-36-3	35BA411	11-37-36-3.2	" "	2	3	2	1	2	3	5	6	36	24	6	7.0	7	3	14	2	0	5180	4	812+	12d
11-38-13-14		11-38-13-14	" "	2	3	2	1	2	3	5	6	44	21	6	17.4	7	3	11	4	0	5380	4	812+	12a
11-39-7-5		11-39-7-5	Square shouldered, concave base	2	3	2	1	2	3	5	2	39	21	8	7.0	2	3	16	1	0	5200	1a	812+	12f
14-37-34-1		14-37-34-1	" "	2	3	2	2	2	3	3	6	24	23	4	3.1	2	4	15	2	0	5000	4	812+	12g
9-36-35-1	35BA497	9-36-35-1.1	Lanceolate, concave base	2	3	2	1	2	3	5	2	15	17	5	1.6	2	3	-	4	0	5800	5	806+	13b
10-39-7-1		10-39-7-1.5	" "	2	3	2	1	2	3	3	2	20	20	7	3.3	2	3	-	4	0	4800	2	812+	13c
12-39-2-1		12-39-2-1.2	" "	2	3	2	2	2	3	3	2	17	16	5	1.6	2	4	-	4	0	-	5	807-	13a
10-35½-28-2		10-35½-28-2	Small lanceolate	2	1	1	2	4	2	8	2	44	16	5	3.0	1	2	0	4	0	[illegible]560	6	812+	13e
10-38-1-1		10-38-1-1.2	" "	2	3	2	1	2	3	3	6	31	15	5	2.9	9	2	0	5	0	5040	4	806+	-
Amelia 15	35BA298	35BA298 1	" "	2	3	1	2	2	3	8	2	52	20	9	9.3	9	2	0	5	0	-	-	802+	13d
7-36-13-6	35BA459	7-36-13-6	Small, broad stemmed	2	3	2	1	2	3	8	2	27	20	5	2.8	1	3	17	3	0	7600	2	812+	13g
11-40-27-1		11-40-27-1.7	" "	2	3	1	1	2	3	8	6	27	26	4	2.7	2	2	13	3	0	5400	2	807-	13f

[a] Cortex:
1. Present
2. Absent

[b] Original Object:
1. Flake
2. Cobble
3. Indeterminate

[c] Condition:
1. Complete
2. Incomplete

[d] Transverse section:
1. Bi-convex
2. Plano-convex
3. Diamond-shaped
4. Indeterminate

[e] Bifacial flaking:
1. One margin
2. Both margins
3. Indeterminate
4. None

[f] Unifacial flaking:
1. One margin
2. Both margins
3. Not applicable
4. Indeterminate

[g] Breakage:
1. End shock fracture
2. Perverse fracture
3. Transverse fracture
4. End shock and perverse fracture
5. End shock and transverse fracture
6. Perverse and transverse fracture
7. Indeterminate
8. None

[h] Pressure flaking:
0. None
1. Very regular parallel
2. Less regular parallel
3. Diagonal parallel
4. Collateral
5. Double diagonal or chevron
6. Random

[i] Base:
1. Straight
2. Concave
3. Convex
4. Straight and notched
5. Concave and notched
6. Convex and notched
7. Indeterminate
8. Not applicable

[j] Margins:
1. Incurvate
2. Excurvate
3. Straight
4. Indeterminate

[k] Stem:
1. Expanding
2. Contracting
3. Straight
4. Indeterminate
5. Not applicable

[l] Serration:
0. None
1. One margin
2. Both margins

[m] Environment. These are very generalized descriptions of the site environment and are adapted from available information contained within site records of the Wallowa Whitman National Forest.
1. Meadow
1a. Dry meadow
2. Spring
3. Slope
4. Stream or riparian zone
5. Ridge
6. River. This generally includes those rivers and streams with access to anadramous fish runs.
7. Glacial lake

[n] Source Assignment:
801 Drewsey
802 Shumway Ranch
803 Coyote-Buckboard
804 Petroglyphs
805 Gregory Creek
806 Seneca-Glass Mountain
807 Owyhee A
808 Owyhee B
809 Timber Butte
810 Reynolds Creek
812 Indian Creek
813 Ebell Creek

\+ indicates accepted source assignment
\- indicates rejected source assignment

TABLE 6 (continued)

Wallowa Whitman Forest Site No.	Smithsonian Site No.	Artifact Registration No.	General Morphology	Cortex [a]	Original Object [b]	Condition [c]	Transverse Section [d]	Bifacial Flaking [e]	Unifacial Flaking [f]	Breakage [g]	Pressure Flaking [h]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base [i]	Margins [j]	Neck Width (mm)	Stem [k]	Serration [l]	Elevation (ft.)	Environment [m]	Source Assignment [n]	Illustration No.
2-48-21-1		2-48-21-1	Side notched	2	1	2	2	2	3	3	6	17	11	2	.6	5	3	6	1	0	5600	3	809+	14i
3-43-34-1		3-43-34-1.2		2	3	2	1	2	3	3	6	28	16	4	1.5	2	3	11	1	0	-	-	812-	14e
3-48-33-1		3-48-33-1.1		2	3	1	1	2	3	8	2	27	19	4	2.1	2	2	11	3	0	5450	2	803-	14c
4-47-22-08		4-47-22-08.1		2	1	1	2	2	3	8	6	23	13	3	.6	2	3	7	1	0	-	-	812+	-
5-48-20-1		5-48-20-1		2	1	2	2	1	1	3	6	23	15	5	1.6	1	3	10	2	0	5400	2	812+	14h
10-38-1-1	35BA248	10-38-1-1.1		2	3	1	1	2	3	8	6	27	17	5	2.0	2	2	11	1	0	5040	4	812+	-
10-39-7-1	35BA246	10-39-7-1.4		2	3	2	1	2	3	5	6	24	16	5	1.7	2	3	11	1	0	4800	2	805+	14f
11-37-16-1	35BA504	11-37-16-1		2	3	2	1	2	3	5	2	26	14	4	1.2	2	4	9	1	0	4920	4	812+	14d
11-38-13-3		11-38-13-3		2	3	2	1	2	3	3	6	29	14	4	1.9	2	3	10	5	0	-	-	803-	14g
11-40-27-1		11-40-27-1.1		2	3	2	1	2	3	3	2	21	17	3	1.1	2	1	6	3	0	5400	2	812+	-
12-36-9-1	35BA423	12-36-9-1		2	3	2	2	2	3	3	9	11	16	3	.6	2	4	10	4	0	4700	1a	809+	-
11-40-28-3		11-40-28-3		2	3	2	1	2	3	3	6	24	19	5	2.6	1	3	13	1	0	6060	2	805+	-
-	35WA8	35WA8.2		2	3	2	1	2	3	3	6	10	10	2	.4	5	3	6	1	0	-	-	806-	14j
5-43-22-1		5-43-22-1.1	(large)	2	3	2	1	2	3	6	6	38	22	7	5.7	2	3	-	5	0	-	-	802+	14a
10-39-7-1	35BA246	10-39-7-1.2	(large)	1	3	2	1	2	3	5	6	30	21	4	3.3	2	5	13	2	0	4800	2	812+	14b
3-47-34-2		3-47-34-2 b	Corner notched, notched base	2	3	2	2	2	3	8	6	29	17	4	1.6	8	6	10	1	0	-	-	812+	-
-		12-40-19 a		2	3	2	1	2	3	8	6	34	17	4	2.7	8	3	10	1	0			812+	15c
-		12-40-19 b		2	3	2	1	2	3	3	6	24	17	5	1.7	8	3	9	1	0			812+	-
Amelia 13	35BA296	Amel. 13 lt.a		2	1	1	2	2	3	8	6	32	22	4	2.5	8	3	13	3	0	-	-	801-	15b
Amelia 19	35BA302	Amel. 19		2	3	2	2	2	3	8	6	29	17	4	1.6	2	6	10	1	0			805+	15d
-		102		2	3	1	1	2	3	8	6	44	27	5	5.0	8	3	12	1	0	-	-	806+	15a
3-48-21-1		3-48-21-1.08	Large, triangular stemmed	2	3	2	1	2	3	3	6	36	25	5	5.2	7	2	12	4	0	-	-	812-	-
3-48-33-1		3-48-33-1.2		2	1	2	1	2	3	3	6	32	31	5	4.9	7	5	9	3	0	5450	2	807+	15f
11-39-18-6		11-39-18-6		2	1	2	2	2	3	3	6	37	35	5	5.8	1	5	10	3	0	5520	2	812+	15g
11-40-27-2		11-40-27-2.2		2	3	2	2	2	3	3	6	41	29	6	5.5	1	2	10	3	0	5200	2	812+	15e
-	35WA8	35WA8.8		2	1	2	2	2	3	3	6	43	31	5	6.9	7	2	12	4	0			802+	15h
2-48-21-1		2-48-21-1	Corner-notched	2	3	2	1	2	3	6	2	20	17	4	2.2	2	3	9	1	0	5600	3	809+	-
3-47-29-1	35WA553	3-47-29-1		2	1	1	3	2	3	8	6	29	15	5	2.0	2	3	8	1	2	4540	2	804-	16j
3-48-5-1		3-48-5-1		2	3	2	1	2	3	6	6	23	21	5	2.4	7	3	10	4	0	5260	1a	812+	-

TABLE 6 (continued)

Wallowa Whitman Forest Site No.	Smithsonian Site No.	Artifact Registration No.	General Morphology	Cortex a	Original Object b	Condition c	Transverse Section d	Bifacial Flaking e	Unifacial Flaking f	Breakage g	Pressure Flaking h	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base i	Margins j	Neck Width (mm)	Stem k	Serration l	Elevation (ft.)	Environment m	Source Assignment n	Illustration No.
5-43-22-1	-	5-43-22-1	Corner-notched	2	3	1	1	2	3	8	1	24	18	4	2.0	2	3	11	1	0	-	-	802+	16b
5-47-8-4	-	5-47-8-4	"	2	1	2	2	1	1	3	6	22	18	4	1.6	4	4	11	1	0	-	-	808+	16n
5-48-33-4	-	5-48-33-4.9	"	2	1	1	2	2	3	8	2	34	21	5	2.7	2	3	12	1	0	-	-	808+	16a
7-35½-1-1	-	7-35½-1-1.2	"	2	1	2	2	2	3	5	6	30	25	4	2.9	7	3	14	4	2	5840	1	805+	-
7-35½-23-2	-	7-35½-23-2	"	2	3	2	1	2	3	5	9	20	28	6	2.5	1	4	14	1	0	5380	1	803+	17e
8-36-30-2	-	8-36-30-2	"	2	3	2	1	2	3	5	6	22	14	4	1.5	1	3	7	2	0	7160	3	801-	-
9-35½-27-1	35GR225	9-35½-27-1.2	"	2	3	2	1	2	3	3	6	30	20	5	2.5	1	3	11	1	0	-	-	812+	17b
9-36-20-2	-	9-36-20-2	"	2	3	2	1	2	3	3	6	21	20	5	1.9	2	1	12	1	0	5150	1a	812+	16o
10-35-27-4	35BA812	10-35-27-4	"	2	3	2	1	2	3	6	6	32	20	5	3.2	7	3	11	4	0	5480	3	805-	-
10-37½-32-1	-	10-37½-32-1	"	2	3	2	2	2	3	6	6	21	25	5	2.9	2	3	13	1	0	4380	1a	803-	-
10-38-36-3	-	10-38-36-3	"	2	3	2	1	2	3	6	6	15	18	4	1.1	7	2	10	4	0	4440	3	803+	-
10-39-7-1	-	10-39-7-1.1	"	2	3	2	1	3	3	5	9	19	21	5	1.4	2	4	12	1	0	4800	2	812+	-
11-37-10-2	-	11-37-10-2	"	2	1	2	2	1	1	4	3	36	22	4	3.9	7	3	9	1	0	5560	1a	809+	-
11-40-26-1	-	11-40-26-1	"	2	3	2	1	2	3	3	2	20	18	4	1.6	2	3	15	1	0	6240	4	812+	16l
11-40-27-1	-	11-40-27-1.3	"	2	3	2	1	2	3	5	6	13	20	4	1.1	2	4	12	1	0	5400	2	812+	16i
11-40-27-1	-	11-40-27-1.5	"	2	3	2	1	2	3	6	6	24	23	5	2.9	2	3	13	1	0	"	"	807+	16f
11-40-27-1	-	11-40-27-1.6	"	2	3	2	1	2	3	5	6	27	19	4	2.0	2	3	9	1	0	"	"	806+	16k
11-40-27-1	-	11-40-27-1.9	"	2	3	2	1	2	3	3	6	33	20	6	3.7	7	3	11	4	0	"	"	808+	-
11-40-27-1	-	11-40-27-1.10	"	2	1	2	1	2	3	7	6	33	21	5	3.1	2	3	13	1	0	"	"	801-	16g
11-40-31-3	35BA454	11-40-31-3	"	2	3	2	1	2	3	5	3	33	23	6	4.1	2	3	14	1	0	6200	5	812+	16h
12-39-2-1	-	12-39-2-1.1	"	2	3	2	2	2	3	3	2	17	16	5	1.6	2	4	12	4	0	-	5	812+	17c
12-39-3-3	-	12-39-3-3	"	2	1	2	2	1	1	4	6	36	22	4	2.6	7	3	10	1	1	4640	4	812+	17d
-	35WA8	35WA8.3	"	2	3	2	1	2	3	3	6	24	18	4	2.0	2	3	11	1	0	-	-	809+	16p
-	-	84.0.1	"	2	3	2	1	2	3	7	2	33	21	5	2.8	7	2	-	4	1	-	-	812+	17j
-	-	84.0.2	"	2	3	2	1	2	3	3	1	34	28	6	5.5	1	3	8	1	0	-	-	808+	17o
-	-	84.0.3	"	2	3	2	1	2	3	7	2	25	22	5	1.8	2	2	9	1	0	-	-	812+	16m
-	-	84.0.4	"	2	3	1	1	2	3	8	2	31	21	5	2.5	2	3	12	1	0	-	-	809+	16c
-	-	84.0.5	"	2	1	2	2	2	3	3	6	24	19	4	2.4	2	3	13	1	0	-	-	809+	16d
Sheep 4	35BA281	It. A	"	2	3	2	1	2	3	5	3	38	27	6	5.1	1	3	13	1	0	-	-	812+	17a
-	-	14-27-27 SM10	"	2	3	1	1	2	3	8	6	43	23	5	3.5	2	3	13	1	0	-	-	812+	16e
3-47-36-3	-	3-47-36-3	Large corner-notched	2	3	2	1	2	3	3	6	23	33	6	4.6	2	2	15	1	0	5440	3	805+	17f
11-37-36-7	-	11-37-36-7.1	" "	2	3	2	1	2	3	1	6	34	28	5	4.8	2	3	13	1	0	5190	4	801-	-
-	-	11-40-28a	" "	2	3	2	2	2	3	5	6	24	30	5	3.6	2	3	17	1	0	-	-	808+	17g
Amelia 14	35BA297	Amelia 14	" "	2	3	1	1	2	3	8	2	47	31	4	6.5	[illegible]	2	15	1	0	-	-	812+	17i

TABLE 6 (continued)

Wallowa Whitman Forest Site No.	Smithsonian Site No.	Artifact Registration No.	General Morphology	Cortex[a]	Original Object [b]	Condition [c]	Transverse Section[d]	Bifacial Flaking [e]	Unifacial Flaking [f]	Breakage [g]	Pressure Flaking [h]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base [i]	Margins[j]	Neck Width (mm)	Stem [k]	Serration [l]	Elevation (ft.)	Environment [m]	Source Assignment [n]	Illustration No.
-	-	84.0.6	Side/corner-notched	2	3	1	3	2	3	8	3	51	19	5	3.3	1	3	14	3	2	-	-	807-	171
3-43-34-1	-	3-43-34-1.1	" "	2	3	2	2	2	3	3	6	24	18	4	1.5	2	1	10	1	0	-	-	812-	-
3-48-9-2	-	3-48-9-2.13	" "	2	3	1	1	2	3	8	2	27	18	4	2.1	1	2	10	1	0	-	-	812+	-
4-45-28-1	-	4-45-28-1	" "	2	3	1	1	2	3	8	6	32	22	7	2.7	1	3	12	1	0	-	-	813+	-
7-35½-12-4	-	7-35½-12-4	" "	2	3	2	3	2	3	3	2	37	18	7	4.0	7	3	-	4	0	5760	1	812+	-
8-36-19-1	-	8-36-19-1	" "	2	3	2	1	1	3	2	6	20	14	4	1.1	7	3	-	4	1	-	-	-	-
9-39-20-5	-	9-39-20-5	" "	2	3	2	2	2	3	3	6	24	18	4	1.5	2	1	10	1	0	-	-	805+	-
10-39-7-6	35BA252	10-39-7-6	" "	2	3	2	3	2	3	7	6	26	17	8	3.1	7	3	-	1	0	4680	4	812+	-
11-39-25-1	35BA446	11-39-25-1	" "	2	3	2	1	2	3	5	3	29	17	5	3.0	7	3	-	1	0	-	-	803-	-
11-40-27-1-1		11-40-27-1.1a	" "	2	3	2	1	2	3	7	6	25	19	4	1.8	1	3	-	4	0	5400	2	801-	17n
12-39-2-4	35BA468	4703	" "	2	3	1	3	2	3	8	2	40	18	8	5.0	1	3	10	1	0	-	-	812+	17k
3-48-9-3	-	3-48-9-3	Small basal-notched/small stemmed	2	3	1	3	2	3	8	6	33	12	5	2.2	2	2	8	1	0	-	-	812+	18m
-	-	3-48-11	" " "	2	3	2	1	2	3	3	6	24	23	5	-	1	3	8	3	0	-	-	-	18r
7-35½-1-1	-	7-35½-1-1.1	" " "	2	3	2	1	2	3	3	6	17	16	2	.4	7	3	3	0	2	5840	1	812-	18a
7-35½-33-1	-	7-35½-33-1.1	" " "	2	1	1	1	2	3	8	6	24	18	2	.8	3	3	6	1	2	-	-	803+	18b
7-36-13-5	35BA458	7-36-13-5.1	" " "	2	3	1	1	2	3	8	3	39	16	4	2.8	1	3	9	2	0	7720	2	812+	181
9-38-36-2	35BA393	9-38-36-2	" " "	2	3	2	2	1	1	3	6	17	9	3	.6	1	3	-	2	0	6720	3	801-	-
10-35½-26-1	-	10-35½-26-1	" " "	2	3	2	2	2	3	3	6	12	13	2	.3	1	3	5	4	0	-	-	812+	18j
10-37-32-5	-	10-37-32-5	" " "	2	3	1	1	2	3	8	2	31	15	3	1.0	7	3	7	2	0	4410	4	812+	18k
10-39-7-1	35BA246	10-39-7-1.3	" " "	2	3	2	1	2	3	3	6	16	17	2	.6	1	4	5	3	0	4800	2	812+	18e
"	"	10-39-7-1.6	" " "	2	1	2	2	2	3	3	6	13	16	2	.5	1	4	6	1	0	"	"	806-	18g
10-39-18-1	-	10-39-18-1	" " "	2	3	2	2	2	3	3	6	10	14	2	.4	7	4	5	4	0	4600	1	812+	18i
11-38-12-1	-	11-38-12-1	" " "	2	3	2	3	2	3	3	6	22	13	4	1.2	1	3	8	2	0	6500	-	812+	18n
11-40-27-1	-	11-40-27-1.2	" " "	2	3	2	1	2	3	7	6	16	11	3	.5	1	4	5	1	0	5400	2	801-	18o
"	-	11-40-27-1.4	" " "	2	3	2	1	2	3	3	6	17	19	3	1.0	1	4	6	3	0	"	"	807-	18c
"	-	11-40-27-1.12	" " "	2	3	2	1	2	3	3	2	21	17	3	1.1	3	1	6	3	0	"	"	-	18d
11-40-27-2	-	11-40-27-2.3	" " "	2	3	2	1	2	3	3	6	17	16	2	.4	7	3	3	0	2	5840	1	812+	18h
"	-	11-40-27-2.4	" " "	2	3	2	1	2	3	3	6	19	16	4	1.3	7	2	7	4	0	5200	2	809+	18f
-	35WA2	35WA2.11	" " "	2	3	2	1	1	1	3	6	16	15	4	.8	1	4	5	1	0	-	-	809+	18p
Sheep 3	35BA280	Sheep 3, It.C	" " "	2	3	1	1	2	3	8	3	26	19	5	2.0	3	3	10	1	2	-	-	806+	18q

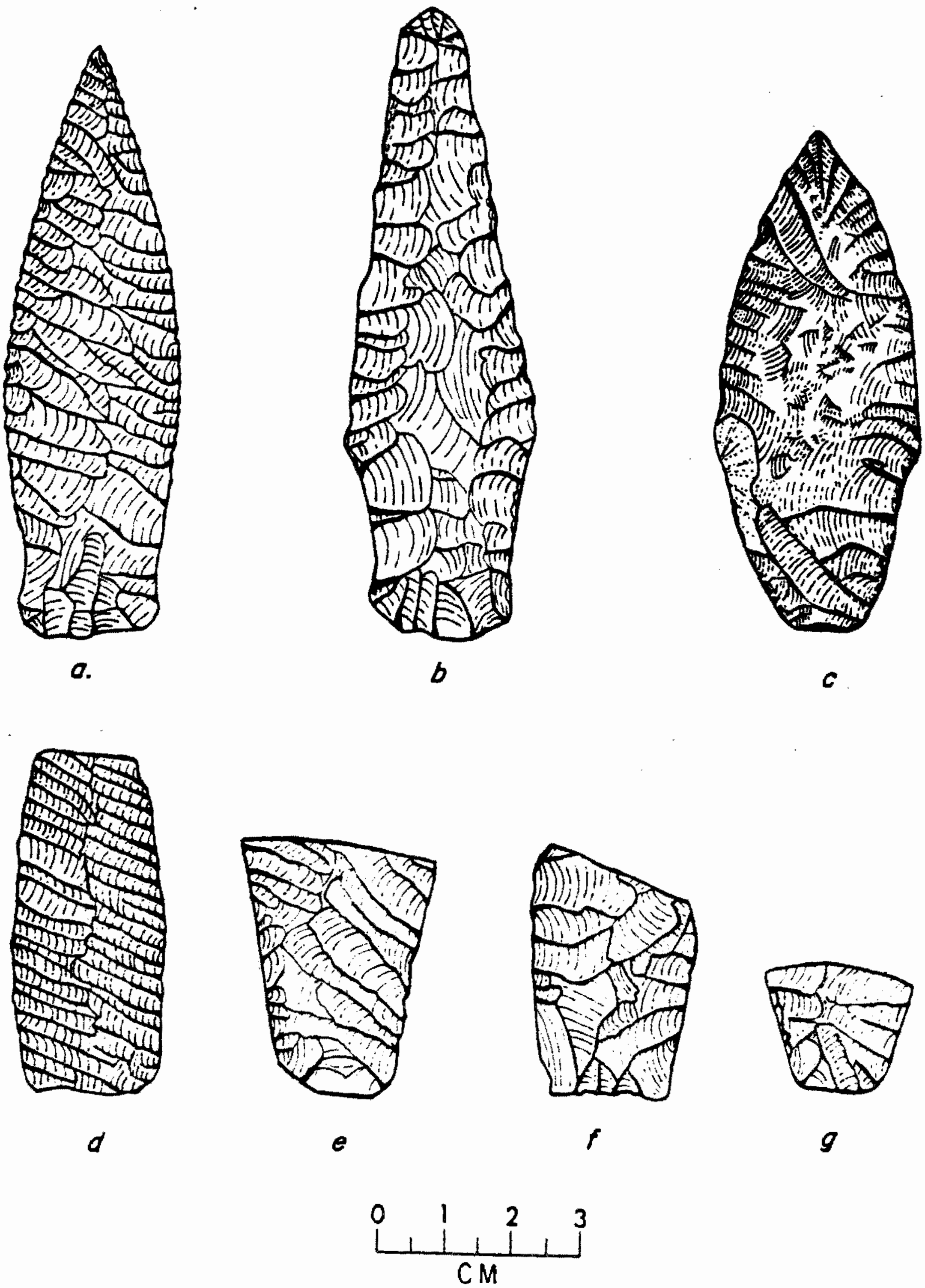

Fig. 11. Large stemmed lanceolate projectile points (a-c) and large lanceolate projectile point fragments (d-g).

Pressure flaking on these three projectile points consist of parallel to very regular parallel. Many of the flake scars on the first specimen (Fig. 11a) extend well beyond the medial axis and in some cases almost to the opposite margin. Morphologically, this projectile point shares similarities with projectile points from the Windust (10,000 to 8000 BP) and Cascade (8000 to 5000 BP) phases on the Lower Snake River (Leonhardy and Rice 1970; Rice 1972). It may be that this artifact represents something of a transition between the two phases in this portion of the Blue Mountains. Since the probablility estimate for the Owyhee A source assignment of .62 was rejected, the geologic source for this artifact is considered unknown at this time.

The second projectile point (Fig. 11c) appears to have been manufactured from a large flake. Stylistically, this artifact is very similar to shouldered lanceolate projectile points illustrated by Rice (1972: Fig. 4) from Windust Phase assemblages on the lower Snake River. This point was acceptably correlated with the Indian Creek source area. The last specimen (Fig. 11b) was correlated at acceptable probability estimates with the Gregory Creek source west of Vale, Oregon.

Large Lanceolate Projectile Point Fragments

This category consists of six large lanceolate projectile point fragments. Biconvex in cross section with convex margins, most exhibit well controlled pressure flaking. Four of these artifacts (Fig. 11d) exhibit flake scars which extend well beyond the medial axis. Of the two point fragments with remaining basal elements, basal grinding is prominent on one (Fig. 11g), while the other (Fig. 11f) is only slightly ground on the base.

Because the sample consists entirely of fragments with generally undistinctive bases, it is difficult to place them within any discrete chronological unit. Similarly well controlled diagonal parallel pressure flaking is exhibited on one specimen from the Pilcher Creek site recovered in pre-Mazama ash deposits (Brauner, Satler, and Havervcroft 1983:Fig. 7c). In the Northern Great Basin, Fagan (1974:27) reports lanceolate points which appear to be similar in morphology, thickness and pressure flaking. Similarly, these points exhibit "evenly spaced flake scars" which often meet on the medial axis or carry past it. Basal grinding is evident on several specimens (Fagan 1974:26-29). These artifacts are associated with Fagan's Period IV dating between 7000 and 11,000 BP (Fagan 1974:105).

Five of the six items in this group were correlated at acceptable probabilities; four to Indian Creek and one to Shumway Ranch.

Large Square Shouldered Projectile Points

This category consists of six large, square shouldered projectile point fragments (Fig. 12). The shoulders on these points are small and square, though two specimens (Fig. 12b) have slight "tangs" on the shoulders.

The first specimen (Fig. 12e) appears roughly similar to some of the large side-notched points from both the Great Basin and the Columbia Plateau. Similar points have been found at the Nightfire Island site in contexts dating between 5000 and 3350 BP (Hughes 1983:Fig. 5-11k) and at the Ksunku site at Kettle Falls on the Columbia River in contexts dated between 6500 and 6000 BP (Chance and Chance 1972:Fig. 59g, 151). Low P(X/G) values for this specimen indicate that it belongs to a source outside of the sampling universe.

The remaining points in this group exhibit squared shoulders with straight to slighlty contracting stems. Their inferred large finished size suggest a relationship with the Gatecliff Series found in the Great Basin dating between ca. 5000 and 3300 BP (Thomas 1981:22). Two of these specimens were acceptably correlated with the Indian Creek source area, one (Fig. 12c) with the Seneca-Glass Mountain, and one with the Owyhee A source.

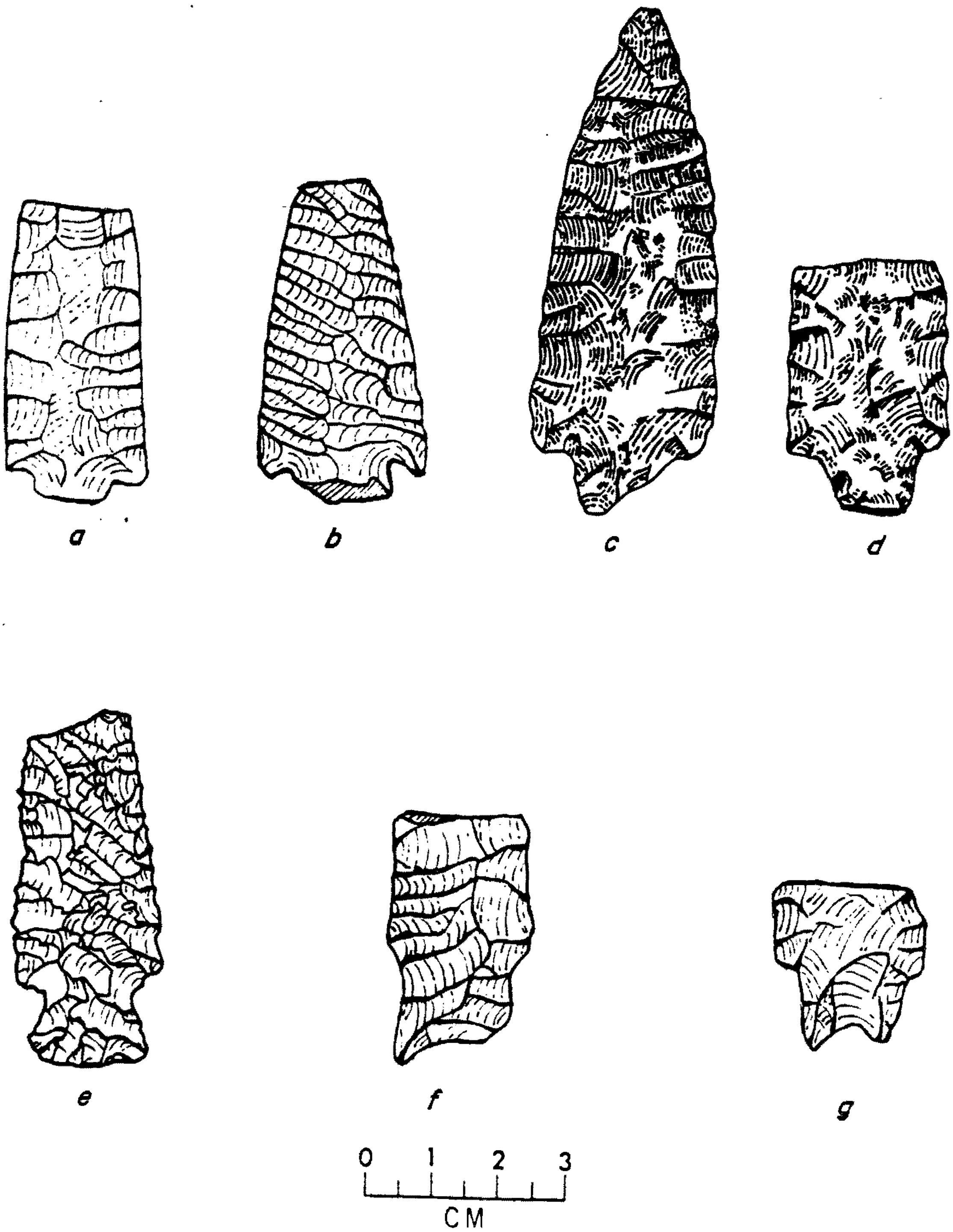

Fig. 12. Large square shouldered projectile points (a-e) and shouldered lanceolate projectile points with concave bases (f,g).

Shouldered Lanceolate Points with Concave Bases

This category consists of two basal fragments of shouldered lanceolate projectile points with concave bases (Fig. 12f, g). These have small well defined shoulders with straight to expanding stems. Grinding of the stem edges or bases was not observed. Stylistically, these projectile points are similar to Windust phase points and fall well within the measured ranges for artifact width, stem width and stem length of Windust points found in the lower Snake River canyon. Many of the Windust specimens also lacked pronounced stem grinding (Rice 1972:42). Morphologically similar projectile points were recovered below Mazama Ash at Fort Rock Cave in stratigraphic units believed to date between 8000 and 11,000 BP (Bedwell 1973:82,141). Both of these specimens were acceptably correlated with the Indian Creek source.

Lanceolate Projectile Points with Concave Bases

This group consists of three lanceolate point fragments with concave bases. Stylistically, these specimens (Fig. 13a-c) are similar to Humboldt Concave Base projectile points found in the Great Basin. As a series, the Humboldt points span a relatively long period of prehistory from ca. 5000 to 1300 BP (Heizer and Hester 1978:155-157). Closer to the study area, Sappington (1978:96, Figs.25, 28) recorded Humboldt projectile points in both the upper and lower components of the Lydle

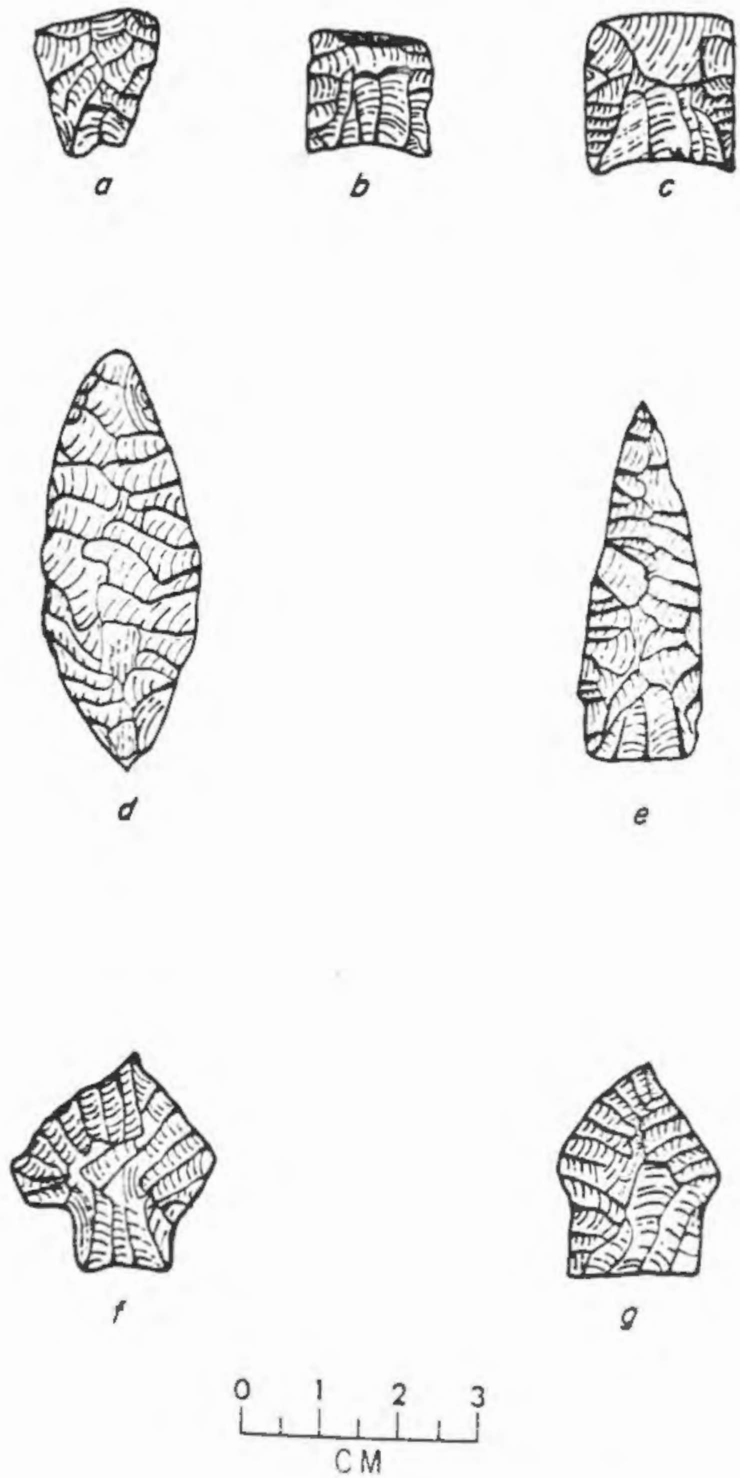

Fig. 13. Lanceolate points with concave bases (a-c); small lanceolate points (d,e); and small broad-stemmed points (f,g).

Gulch site dating their use in the Boise, Idaho area between 3800 and 800 BP. Similar obsidian Humboldt points were recovered from the Stockhoff site in components dating between 3800 and 1700 BP (McPherson and others 1981:240, Fig.76). One specimen (Fig. 13b) was correlated with the Seneca-Glass Mountain source area while the Indian Creek source was indicated to be the raw material source for the other item (Fig. 13c). A correlation for one item (Fig. 13a) to the Owyhee A source was rejected.

Small Lanceolate Projectile points

This category consists of two small lanceolate projectile points and one small lanceolate projectile point fragment. The first specimen (Fig. 13d) has been manufactured from a thick flake and has been pressure flaked on one surface only. This artifact, correlated with the Shumway Ranch source, falls well within the range of the Cascade point type dated between 8000 and 5000 BP (Leonhardy and Rice 1970). Morphologically similar artifacts were found in stratum 3 (ca. 6100 BP) at the Marshmeadow site and at the Stockhoff Basalt Quarry (Womack 1977) in contexts dating to approximately 6700 BP.

The second specimen (Fig. 13e) has been manufactured from a thin flake and shows no evidence of grinding on its squared base. Based on morphology, length, width and thickness, this projectile point is very similar to Windust phase projectile points found at Windust Cave in southeast Washington where the component has been radiometrically dated between 10,000 and 8000 BP (Leonhardy and Rice 1970; Rice 1972:Fig. 13a-c). An acceptable correlation with the Indian Creek source was made for this specimen.

Small Broad-Stemmed Projectile Points

This group consists of two projectile points with broad triangular blades and short, broad stems (Fig. 13f, g).

The first specimen (Fig. 13f) has a slightly concave base and exhibits no stem or basal grinding. This specimen is roughly comparable to Gatecliff points found in the Great Basin dating between 5000 and 3300 BP (Thomas 1981:22). This item was correlated with the Indian Creek source. The second point (Fig. 13g) is similar to projectile points from Windust phase components on the lower Snake River (Rice 1972: 66) and to specimens from a postulated early component (ca. 11,000 to 7000 BP) at a spring site in southeast Oregon (Fagan 1974:97, Fig. 15, Table 18). This artifact could not be acceptably correlated to one of the sources used in the analysis.

Side-Notched Projectile Points

This group of artifacts consists of fifteen side-notched projectile points (Fig. 14).

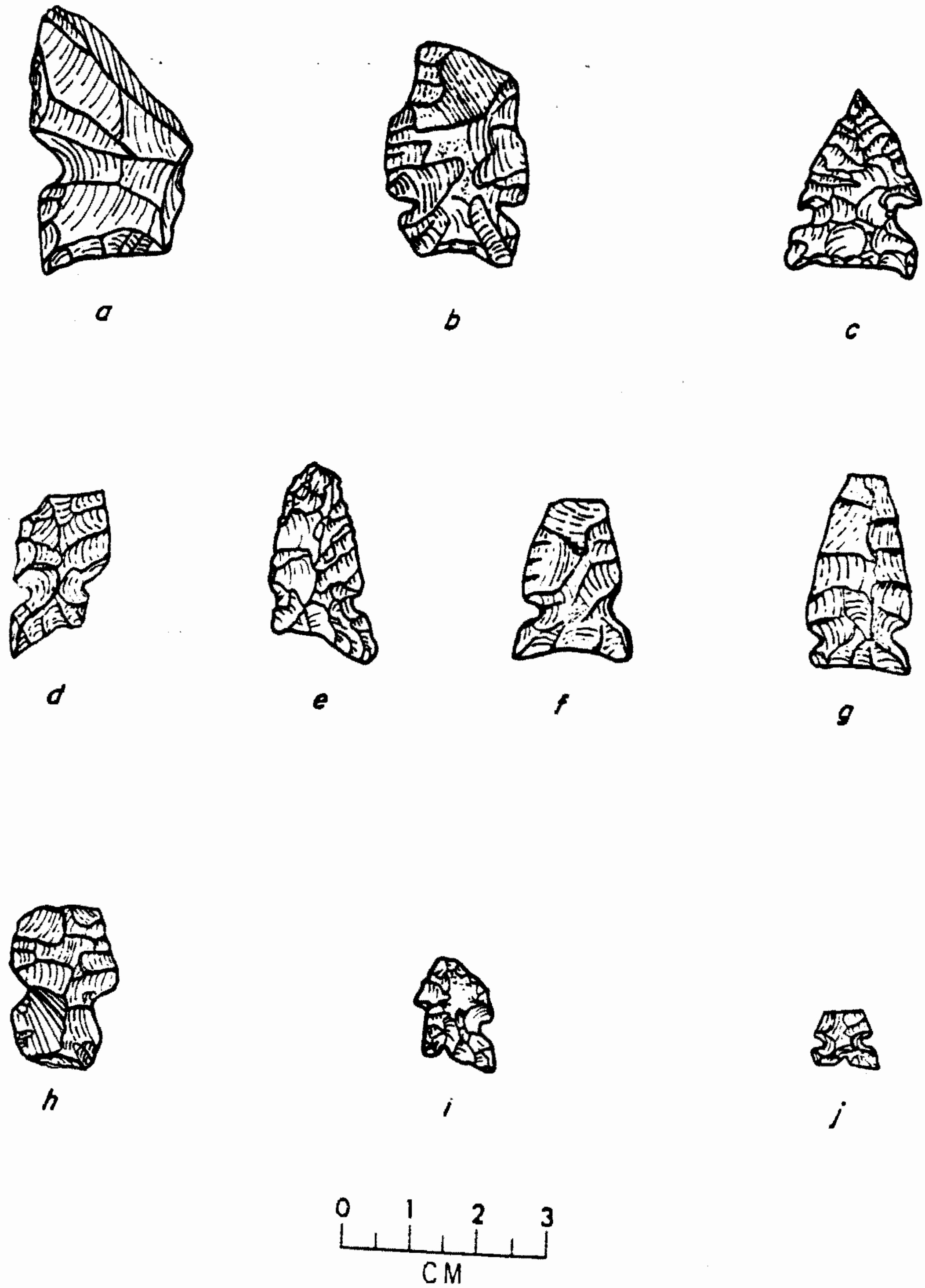

Fig. 14. Side-notched projectile points.

The first two items (Fig. 14a, b) are significantly larger than the remaining projectile points and are similar to the Cold Springs and Northern Side-Notched projectile point types.

On the southern Columbia Plateau, these large side-notched points have been used to distinguish the late Cascade from the early Cascade phase. While the large lanceolate and bi-pointed forms are found in the early part of the phase, the large side-notched projectile points have been almost exclusively limited to the latter portion of the phase dating between 6700 and 5000 BP (Leonhardy and Rice 1970:11). The Northern side-notched projectile point type dates to as late as 2250 BP (Gruhn 1961) and has been found with pit houses at Givens Hot Springs dating between 4000 and 2400 BP (Green 1982). It thus appears that the large side-notched points found in northeast Oregon may have a relatively long period of use dating to as early as 6000 BP and lasting until possibly 2400 BP. One artifact was correlated with the Indian Creek source while Shumway Ranch was indicated as the source of raw material for the other point.

Side-notched points smaller than the first two specimens are generally correlated to later assemblages in both the southern Plateau and Great Basin. Stylistically similar points generally occur after about AD 1300 along the lower Snake River (Leonhardy and Rice 1970:20). One specimen (Fig. 14c) is nearly identical to an obsidian specimen found at the Marshmeadow site and dating sometime after 690 BP (McPherson and others 1981:622, Fig. 173b).

The last two specimens (Fig. 14i, j) fall well within the range of the Desert side-notched series. The Desert side-notched series are well dated in the Great Basin where they span the period from about 900 BP to historic times (Heizer and Hester 1978:163-165, Fig. 6, 7). Support for their late occurence is documented by by their association with domestic cow bones at Hanging Rock Shelter in northwestern Nevada (Heizer and Hester 1978:163-165).

The analysis indicates that of the thirteen smaller side-notched points, six were manufactured from Indian Creek obsidian. Two items were correlated with the Gregory Creek source, two to Timber Butte, and one artifact was correlated with the Shumway Ranch source. Unacceptable probability estimates resulted in rejecting assignments of two items to the Coyote-Buckboard source and one item to the Seneca-Glass Mountain source.

Corner-Notched Points with Notched Bases

This class consists of six corner-notched points with notched bases (Fig. 15e-h). One item (Fig. 15b) has been manufactured from a flake. Pressure flaking is random on all but one specimen. Stylistically these projectile points are similar to artifacts referred to as Pinto points by Heizer and Hester (1978:157-159, Fig. 6.3) and as Gatecliff Split Stem points by Thomas (1981:22). The Gatecliff Series dates between approximately 5000 and 3300 BP (Thomas 1981:22). Two of these

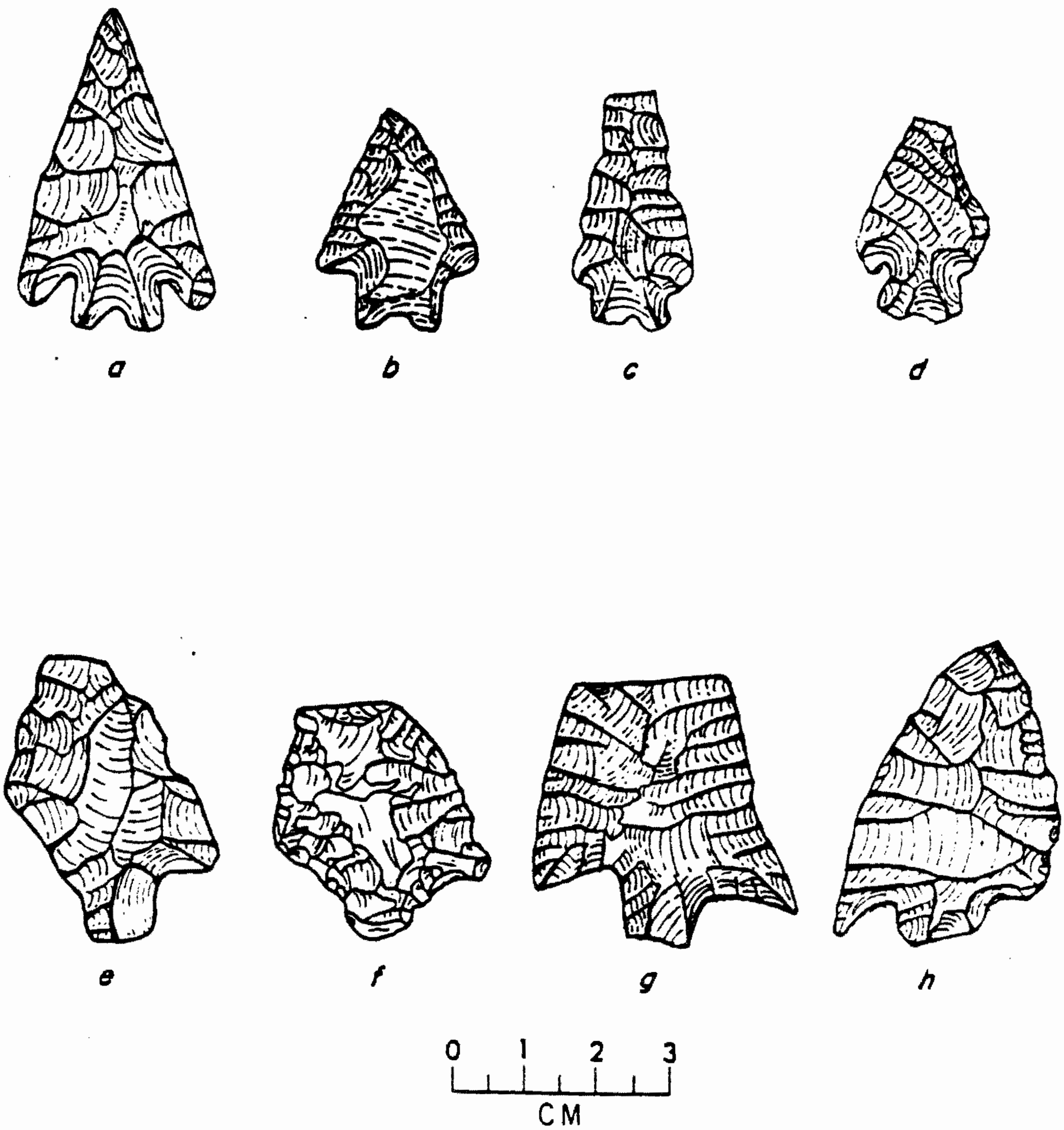

Fig. 15. Corner-notched points with notched bases, (a-d); large triangular and stemmed points (e-h).

items found in surface contexts at the Indian Creek source were acceptably correlated to that source. One point from the northern end of the Forest was also correlated to Indian Creek. Acceptable correlations with the Gregory Creek and Shumway Ranch sources were made for two items from the Burnt River Basin while one item (Fig. 15b) was indicated as having nearly equal probabilities for either the Drewsey or Seneca-Glass Mountain sources. In the last case, the slightly higher probability obtained for the Drewsey source was rejected. The geologic source for this artifact is unknown at this time.

Large Triangular and Stemmed Projectile Points

This category consists of five large triangular and stemmed projectile points and point fragments (Fig. 15e-h). Though three of the five are incomplete, they appear to have had finished lengths ranging between approximately 38 and 45 mm. Generally having quite broad artifacts widths (< 25mm), the margins of these artifacts are characteristically slightly convex. The shoulders are quite prominent and range from straight to more basally notched specimens with basal tangs (Fig. 15g, h). Technologically, most specimens appear to have been manufactured from large flakes. Very little effort appears to have been extended in pressure flaking of these points. Flake scars are quite broad and short suggesting that many of these were finished by direct percussion with a soft hammer.

Stylistically similar points have been recovered in Harder phase components on the Lower Snake River and date between 2500 and 700 BP (Leonhardy and Rice 1970:17).

Acceptable correlations were made for the Indian Creek (two specimens), Shumway Ranch (one specimen), and Owyhee A (one specimen) sources. One item from the Imnaha River Basin had near equal probabilities as being derived from the Indian Creek or Coyote-Buckboard sources. Its geologic source remains unknown.

Corner-Notched Projectile Points

Of all temporally diagnostic artifacts used in this study, this sample is the best represented and consists of 33 specimens (Fig. 16, 17a-d). Generally there are two sub-groups in this category; those with straight bases and those with concave bases. Typologically, these specimens are similar to the Elko Series. In general, the Elko Series is morphologically divided into two types: the Elko Corner-notched and the Elko Eared varieties. Elko Eared points differ from the Elko Corner-notched points in that the eared points have markedly concave bases and display prominent basal "tangs." For purposes of dating, both the Elko Corner-notched and the Elko Eared specimens are essentially contemporaneous (Heizer and Hester 1978:159; Thomas 1981)

It appears the Elko points appeared earlier in the eastern Great Basin than in the central or western Basin (Thomas

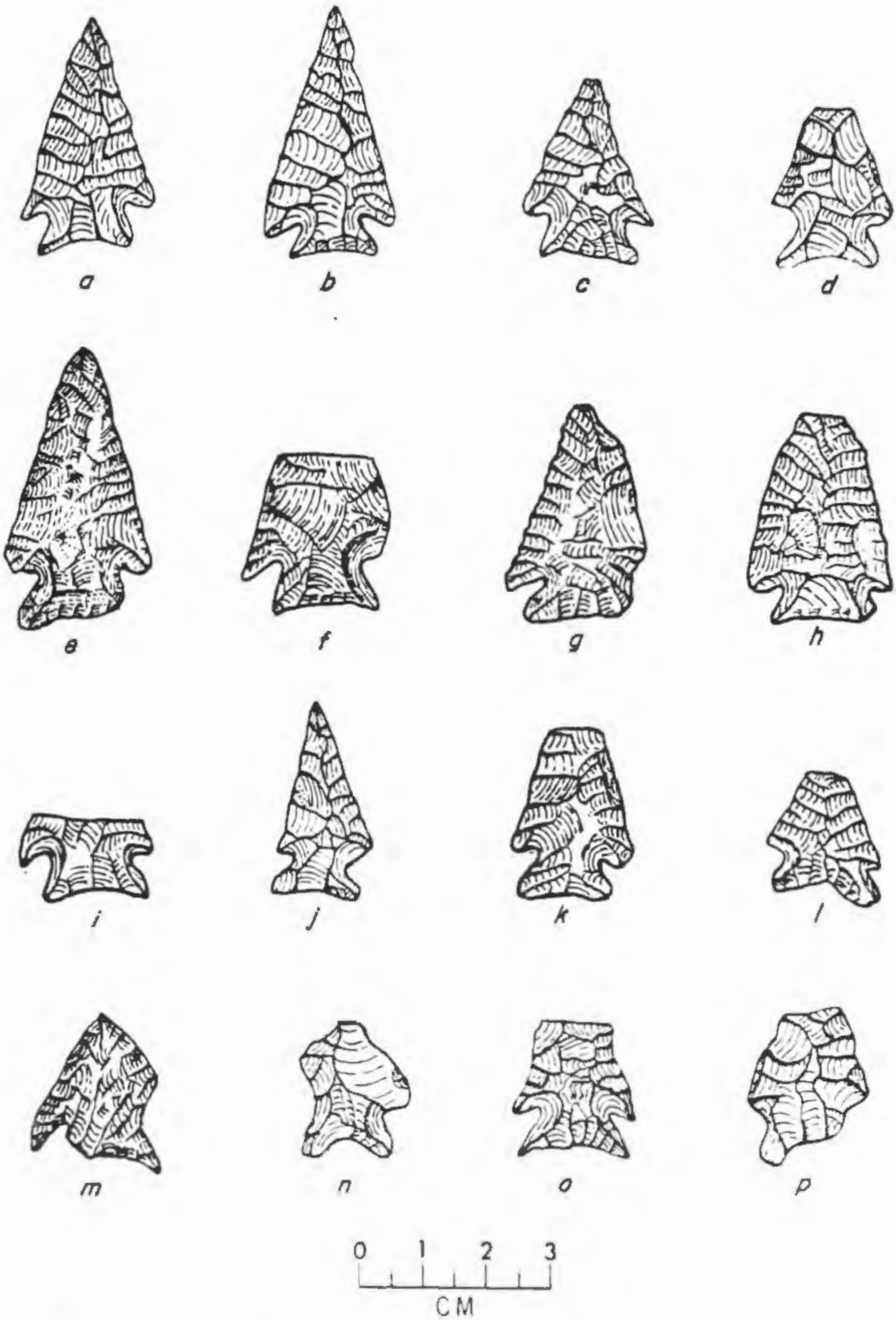

Fig. 16. Corner-notched projectile points.

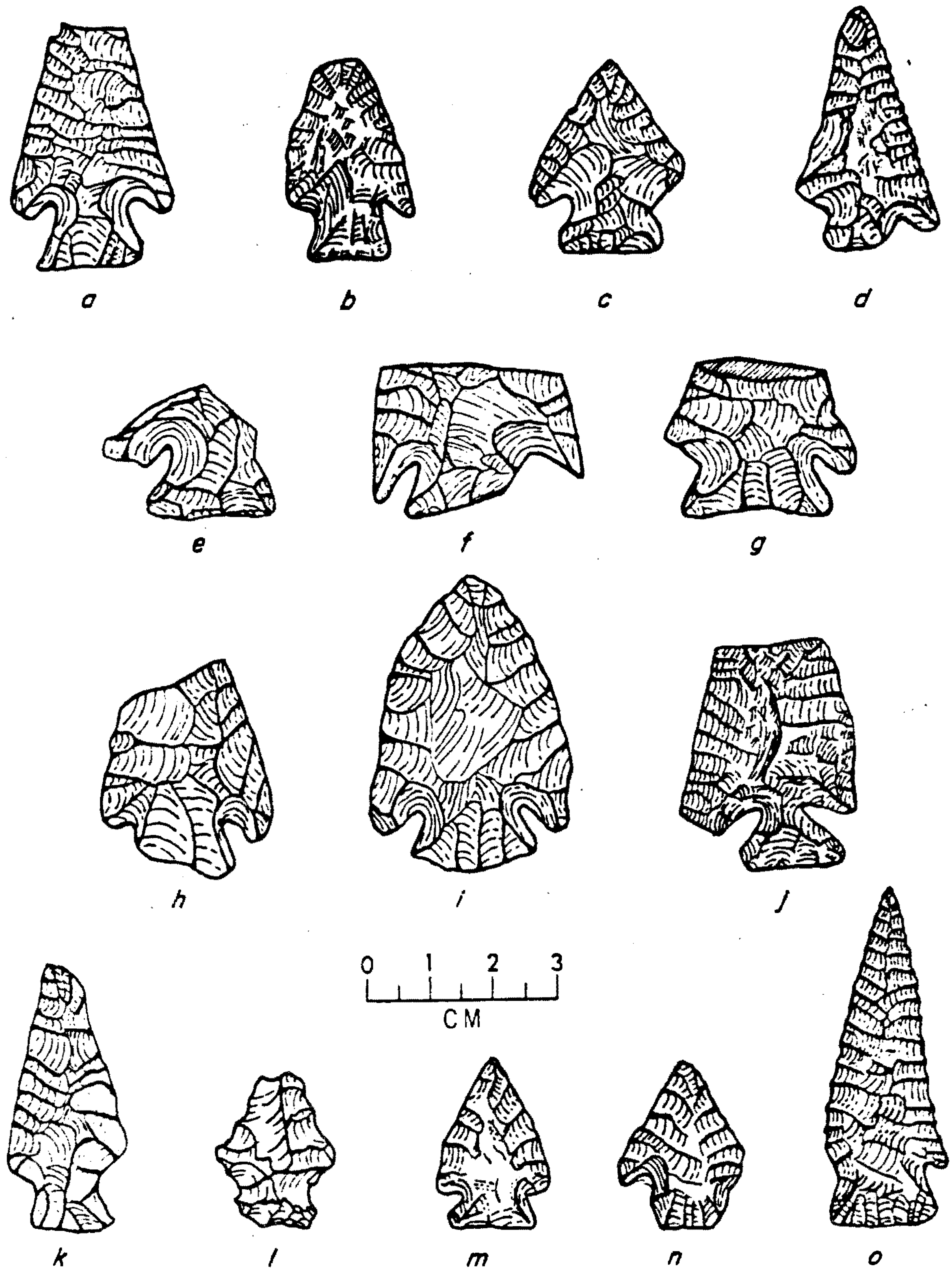

Fig. 17. Corner-notched (a-d); large corner-notched (e-j); and side to corner notched (k-o) projectile points.

1981:32-33; Aikens 1970:51). Early dates (ca. 7000 BP) have also been reported for the occurence of Elko points in the Fort Rock Basin of Oregon (Bedwell 1970).

Corner-notched points appear only rarely in the lower component of the Lydle Gulch site (4000-2000 BP), whereas in the upper component (2000-800 BP) they comprise over 60% of the projectile point assemblage (Sappington 1981:86-92). Here, the Elko series may have developed into the Rosegate series. At Givens Hot Springs in southwest Idaho, the Elko Series is dated by association with pithouses between 2400 and 1100 BP (Green 1982). Similar projectile points recovered at the Marshmeadow site date between 3400 and 690 BP (McPherson and others 1981:622).

The Elko Series is important because it is believed to represent the transition from the atlatl to the bow and arrow (Heizer and Hester 1978:163). Thomas (1981:32) suggests that while some Elko points may have continued in use after AD 500, such use was limited to curation of older artifacts. By this time they had largely been replaced by the Rosegate Series. Based on the available evidence, it seems reasonable to infer that the Elko Series sample here dates between roughly 3400 and 800 BP.

Acceptable correlations for 29 of the 33 projectile points in this category were made. Of these 29 artifacts, acceptable correlations include Indian Creek (N=14, 48%), Timber Butte (N=5, 17%), Owyhee B (N=3, 10%), Owyhee A (N=1, 3%), Seneca-Glass Mountain (N=1, 3%), Gregory Creek (N=1, 3%), Coyote-Buckboard (N=2, 7%), and Shumway Ranch (N=1, 3%).

Large Corner Notched Projectile Points

This group of artifacts consists of five partial specimens and one complete specimen (Fig. 17e-j). In comparison with the previously described corner-notched points, these have been subdivided into a second category on the basis of their much larger size. The three partial specimens are fractured transversally near the mid-section and would appear to have had completed lengths ranging between 40 and 50 mm. Blade margins are straight to slightly excurvate, while the bases vary from slightly concave to slightly convex.

Typologically, these points fall well within the range of the Elko Corner-notched projectile points found in the Great Basin (Heizer and Hester 1978; Holmer 1978).

Acceptable probability estimates indicated the use of Indian Creek (N=2), Gregory Creek (N=1), and Owyhee A (N=1) obsidian for the manufacture of these points.

Side to Corner-notched Projectile Points

This category consists of twelve projectile points and point fragments (Fig. 17k-o). These points are, in general, roughly similar to some of the side-notched and some of the corner-notched points. The major criterion for placing them in a separate category is the positioning of the notching; artifacts in this group tend to be notched lower than the side-notched points and slightly higher than the corner-notched specimens.

Within the Lower Snake River region, similar specimens have been recovered in Tucannon phase contexts. While a terminal date of ca. 2500 BP has been established for the phase, its inception is estimated at ca. 4500 BP (Brauner 1976:295-311). Additionaly, the observation that the lithic technology of the Tucannon phase "seems crude and impoverished" (Leonhardy and Rice 1970:11-14) is one that fits many of the specimens in this group. Several exhibit very thick cross-sections and 33% have stacked step fractures. Whether or not this indicates an unfamiliarity with raw material or their possible use as expediency tools as suggested by Binford (1979) is not known.

Six of the ten items in this group were acceptably correlated with one of the groups used in the analysis. Of these six, four were correlated to Indian Creek Creek, one to Ebell Creek, and one to Gregory Creek source. Matches to Indian Creek (N=1), Owyhee A (N-1), and Coyote-Buckboard (N=1) were rejected on the basis of the obtained probability estimates. In three of the four rejected cases, low values of P(G/X) indicated that these items may be from source groups other than those considered here.

Small Stemmed and Basal-Notched Projectile Points

This group consists of eighteen small, stemmed and basal-notched points (Fig. 18). Most specimens are triangular shaped with straight to slightly convex margins. The stems of these points are generally quite narrow and straight though in some of the larger specimens the stems are somewhat broader and slightly contracting.

Stylistically similar points are placed within the Rosegate Series in the Great Basin. As a series, the Rosegate specimens date between AD 700 and AD 1300 (Thomas 1981:19-20). Heizer and Hester (1978:162, Table 6.4) suggest that these specimens experienced a fluorescence of use between AD 600 and AD 1000 with a continued use into historic times. In the lower Snake River region, these points are generally found in late prehistoric contexts dating between 2000 BP to historic times (Leonhardy and Rice 1970:14-20). Dates for similar points in late prehistoric contexts has also been reported from southwest Idaho where Rosegate specimens date to ca. 1100 BP (Boaz 1984:24; Sappington 1981:74, Fig. 27n).

These dates are supported by data from the Marshmeadow and Ladd Canyon sites which place their occurence in northeast Oregon sometime after 1000 BP (McPherson and others 1981:622, Figs. 174, 196, 203, Table 24).

Thirteen (72%) of the eighteen artifacts in this category were adequately correlated with source groups included in the analysis. Indicated source groups used for the manufacture of

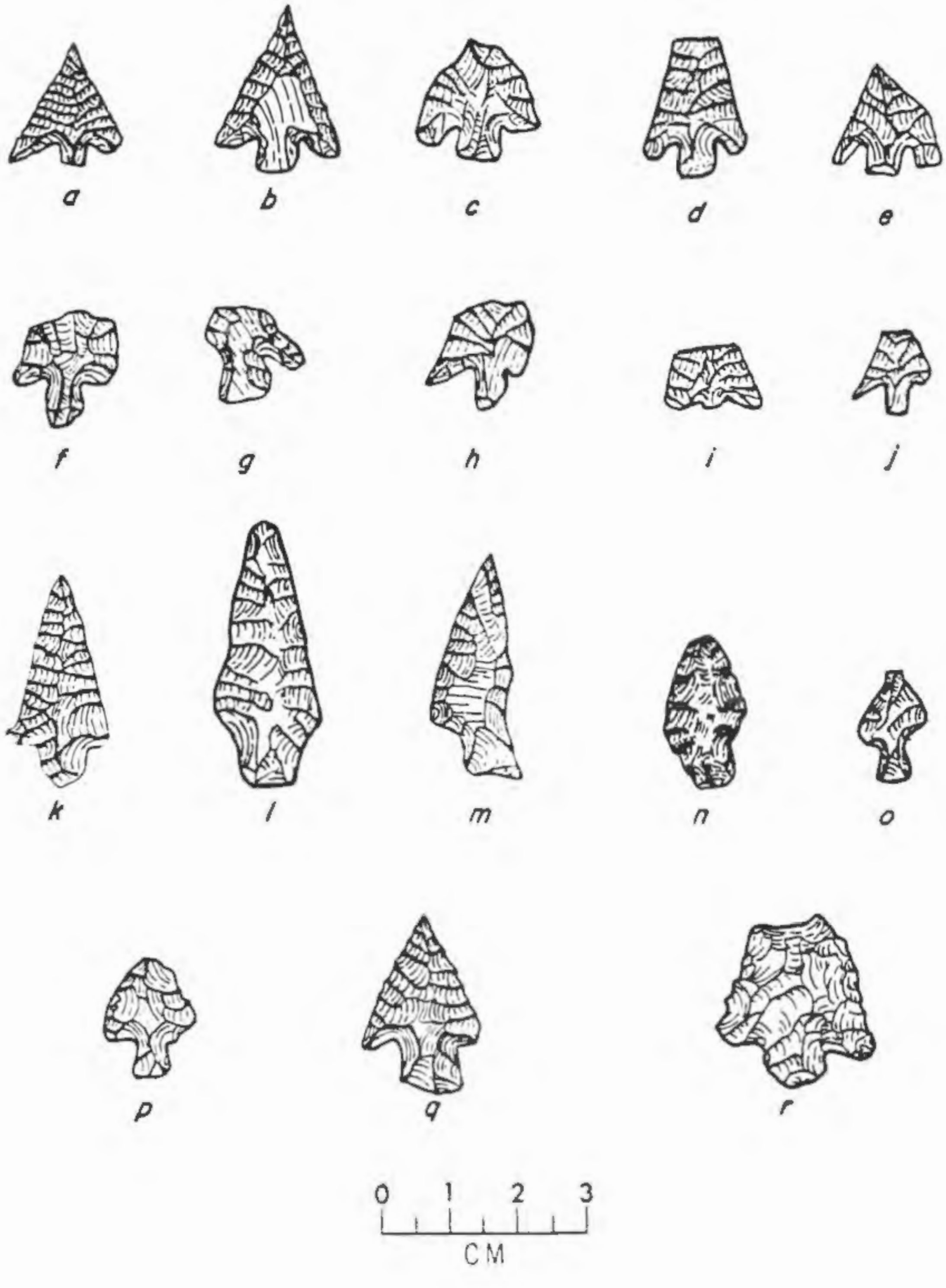

Fig. 18. Small basal-notched and small stemmed projectile points.

Rosegate points include Indian Creek (N=8, 62%), Timber Butte (N=2, 15%), Coyote-Buckboard (N=1, 8%), and Seneca-Glass Mountain (N=1, 8%). Rejected correlations include those made to Indian Creek (N=1), Drewsey (N=2), Seneca-Glass Mountain (N=1), and Coyote-Buckboard (N=1).

Other Flaked Obsidian Artifacts

Several other flaked obsidian artifacts are included in the analyzed sample and the classification results will be briefly summarized. This sample includes 8 non-diagnostic projectile point fragments, 1 flake awl, 4 end scrapers, 2 unifaces, and 7 biface fragments (Table 7).

Seven of the eight analyzed projectile point fragments were acceptably correlated to one of the sources used in the analysis. Four were correlated to Indian Creek, and one each to Gregory Creek, Shumway Ranch, and Timber Butte.

Five of the seven bifaces were acceptably correlated to one of the sources used in the analysis. Somewhat surprisingly, none of the bifaces were assigned to one of the local sources. However, none of the bifaces come from sites within the study area. As the Indian Creek and Ebell Creek sources are generally located over 30 km from the sites in which the bifaces were recovered, it may be the bifaces represent "curated" tools (Binford 1979) that were transported from their original sources from the south and southeast. The indicated sources for the manufacture of the bifaces are

TABLE 7

Flaked obsidian artifacts from the Wallowa Whitman National Forest

Wallowa Whitman Forest Site No.	Smithsonian Site No.	Artifact Registration No.	Morpho-use category	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Source Assignment [a]
-	-	4-44-36	Projectile point fragment	13	14	5	1.4	-
4-48-12-1	-	4-48-12-1	" "	31	50	6	4.0	813-
9-35½-27-1	-	9-35½-27-1.1	" "	20	15	4	1.0	802+
9-36-35-1		9-36-35-1.2	" "	17	13	3	.7	812+
10-39-7-3	-	10-39-7-3	" "	31	27	6	4.9	805+
11-40-27-2	-	11-40-27-2.1	" "	33	25	6	5.9	812+
-	-	15-37-5	" "	35	20	6	4.0	812+
Sheep 4	35BA281	Sheep 4-ArD	" "	33	22	5	3.3	812+
Sheep 7	35BA284	Sheep 7	" "	31	20	5	3.0	809+
4-48-28-1	-	4-48-28-1	Uniface	23	10	2	.7	803+
10-37-29-8	-	10-37-29-8	"	17	13	4	1.5	812-
9-35½-34-1	-	9-35½-34-1	Biface fragment	-	-	-	-	805+
10-35½-26-1	-	10-35½-26-1	"	59	30	6	8.0	806+
10-35½-28-2	-	10-35½-28-2	"	28	28	8	7.8	813-
10-35-34-1	35BA186	10-35-34-1	"	23	21	5	2.7	803+
10-35-36-2	35BA190	10-35-36-2	"	22	23	7	5.0	804+
Amelia 1	35BA286	Amelia 1, It.a	"	31	25	7	6.7	803-
Amelia 11	35BA294	Amelia 11	"	34	40	12	18.9	801+
10-35½-26-1	-	10-35½-26-1.2	End scraper	30	25	4	4.3	812+
10-35½-28-2	-	10-35½-28-2.1	"	38	34	7	10.2	806+
-	35WA8	35WA8.1	"	27	26	5	4.9	805-
Sheep 3	35BA280	Sheep 3 It.1	"	30	27	6	5.3	812+
Sheep 5	35BA282	Sheep 5	Flake awl	27	18	4	2.4	812-

[a] Source Assignment:

801 Drewsey
802 Shumway Ranch
803 Coyote-Buckboard
804 Petroglyphs
805 Gregory Creek
806 Seneca-Glass Mountain
807 Owynee A
808 Owynee B
809 Timber Butte
810 Reynolds Creek
812 Indian Creek
813 Ebell Creek

\+ indicates accepted source assignment
\- indicates rejected source assignment

Coyote-Buckboard (N=1), Gregory Creek (N=1), Seneca-Glass Mountain (N=1), Petroglyphs (N=1), and Drewsey (N=1).

Of the four obsidian end scrapers included in the analysis, two were correlated to Indian Creek and one each to the Gregory Creek and Seneca-Glass Mountain sources. One uniface was correlated to the Coyote-Buckboard source, while the other assignment to Indian Creek was rejected. The flake awl could not be correlated to one of the sources at an acceptable probability.

Summary

Of the 149 artifacts included in the Wallowa Whitman sample, 115 (77%) are acceptably correlated to one of the sources included in the analysis. Of the acceptably correlated items, the following sources and their frequency of use are as follows: Indian Creek (54%), Gregory Creek (10%), Seneca-Glass Mountain (9%), Timber Butte (8%), Shumway Ranch (5%), Coyote-Buckboard (5%), Owyhee A (3%), Owyhee B (3%), Ebell Creek (1%), Petroglyphs (1%), and Drewsey (1%).

Viewed from a geographic perspective, the Wallowa Whitman data are suggestive of a relationship between distance from source and frequency of use. Projectile points from sites located within the study area are overwhelmingly manufactured from the local Indian Creek material. Eleven of the 17 projectile points from sites located within nine miles (15 km) of a source of Indian Creek obsidian are manufactured of raw material from that source.

On the other hand, analysis of 24 projectile points from over 30 miles (50 km) to the north and northeast indicate a slightly different source-use pattern. While Indian Creek still is the most frequently used (N=10, 41%), five (21%) are assigned to Timber Butte, three (13%) to Shumway Ranch, two (8%) to Owyhee B, and one (4%) each to Ebell Creek, Coyote-Buckboard, and Owyhee A. Although the results from the sample located near Indian Creek and the sample from over 30 miles (50 km) to the north are not dramatically different, they do indicate a trend toward more diversified use of obsidian sources as distance increases. Importantly, the northern sample contains more items assigned to Timber Butte. Trade or travel routes through Hells Canyon may at least partially account for the apparent increase in Timber Butte obsidian in the northern sample.

Marshmeadow (35UN95)

Introduction

The Marshmeadow site is located within the Blue Mountains of northeast Oregon approximately ten miles (16 km) south of LaGrande, Oregon (Fig. 19). Physiographically, the site is situated on an upland spur of Columbia River Basalt which divides two graben valleys, the Grande Ronde Valley to the

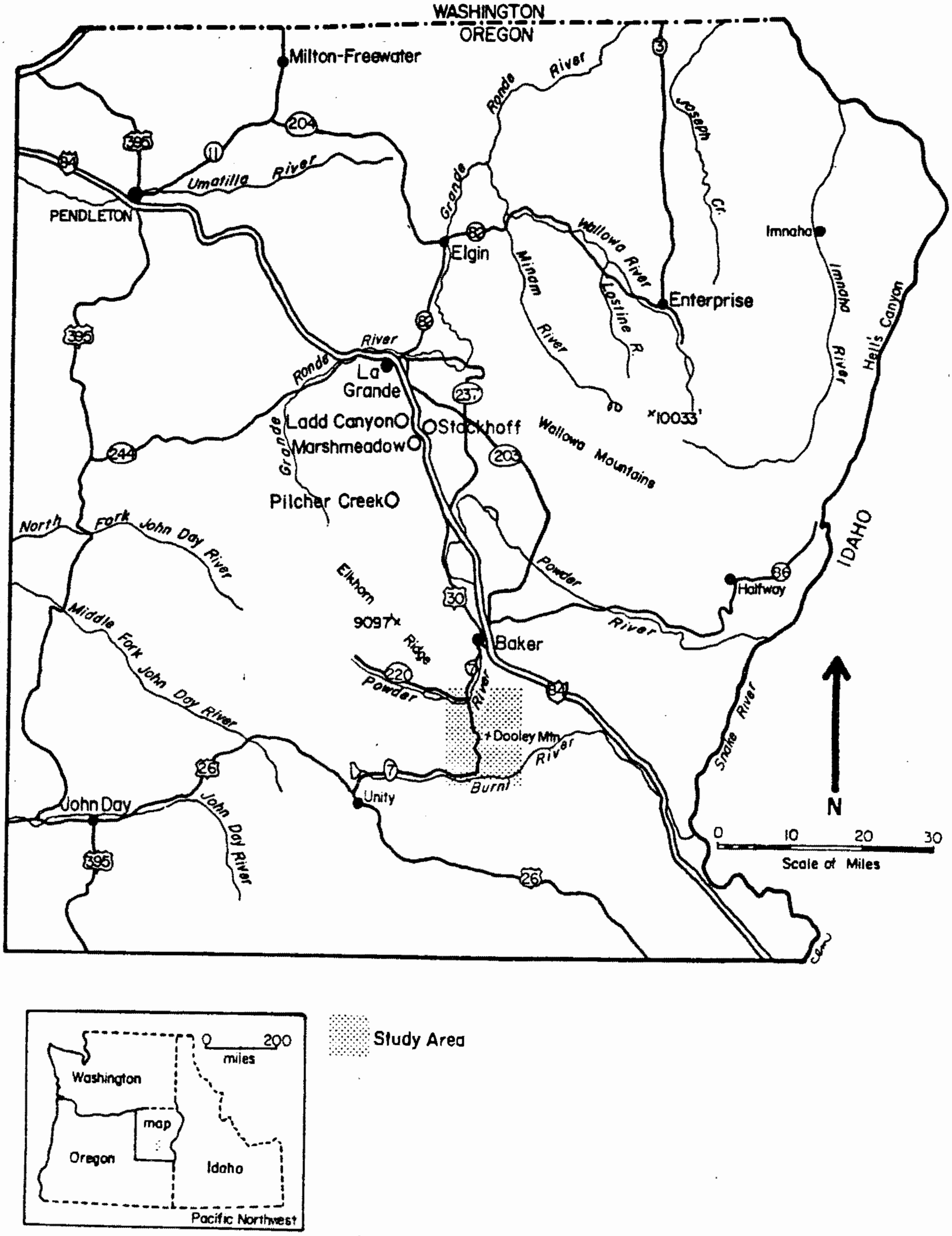

Fig. 19. Marshmeadow, Stockhoff, Ladd Canyon, and Pilcher Creek site locations.

north drained by the Grande Ronde River and the Baker Valley to the south drained by the Powder River. Both rivers are tributaries of the Snake River. The Marshmeadow site lies at the base of a northeast sloping hillside overlooking a large camas meadow (McPherson and others 1981: 350). Less than a mile (1.6 km) northwest of the site is the Stockhoff Basalt Quarry (35UN52) well known for its association with the the Cascade phase (Womack 1977). It is not surprising then, that most of the toolstone used by the occupants of the Marshmeadow site originated at the Stockhoff Quarry.

Excavation at the Marshmeadow site was concentrated near the base of the northeast sloping hillside in a zone extending from a small ephemeral stream to a point where basal colluvial rocks contact the surface of the marshy camas meadow. While 30 2 x 2 meter units were excavated within three zones at the site, 27 of these were located in the area just mentioned. Eight culture bearing strata were encountered in this zone (McPherson and others 1981: 355).

Based on the presence of Mazama Ash, radiocarbon-dated charcoal, and typological comparisons of artifacts, seven occupation zones representing three occupation periods were recognized. Occupation zones were correlated with natural stratigraphy, while the occupation periods were defined by "observed similarities in the total artifact assemblage, with major emphasis placed upon the concurrent occurrence of projectile point styles as well as similar lithic technologies" (McPherson and others 1981:622).

The earliest occupation period (Occupation Period I) began immediately after the deposition of Mazama Ash ca. 6700 BP and lasted until sometime after 6100 BP. During this period the site was occupied on a seasonal basis by peoples culturally affiliated with the Columbia Plateau. Based on the types of tools recovered and lithic use-wear studies, it appears that the Period I occupants of the site depended to a significant degree upon large game animals. The lithic technology at the site during this initial period of occupation contains "indications of a Levallois-like reduction technology" (McPherson and others 1981:623) and is centered on the use of the local Stockhoff Basalt. Like its occurrence throughout the site's occupational history, obsidian debitage constitutes less than 1% of the raw material types. Obsidian tools were found even less frequently.

After this initial occupation of the site, there is an apparent occupational hiatus which may have lasted as long as two thousand years. Sometime after 4000 BP and before 3400 BP, the site was re-occupied by people with an entirely new tool kit and affected to a significant degree by Great Basin influences. Many of these tools appear to have been rapidly produced, used only for a short period, and then discarded. Unique to Occupation Period II are the occurrence of elaborately incised stones indicative of Great Basin influence (McPherson and others 1981:555-556).

During the second occupation period (Occupation Period II), and continuing well into the historic period, the site was utilized as a hunting base camp and lithic manufacturing station. Charred camas bulbs in association with stone features interpreted as camas ovens indicates that root crops may have become an important food item toward the end of this period ca. 650 BP. This increasing reliance upon plant foods continued until about 100 BP when the site was abandoned (McPherson and others 1981:627-628). Obsidian debitage during this period never exceeds 2% of the raw material types utilized at the site.

During the first two occupation periods, projectile points were manufactured "primarily from basalt obtained at the Stockhoff Quarry" (McPherson and others 1981:627). However, in the succeeding Occupation Period III, projectile points are manufactured primarily from obsidian. After 690 BP, small notched and stemmed points were introduced to the site (McPherson and others 1981:627).

Sample Selection, Temporal Considerations, and Results of Analysis

A total of 128 pieces of obsidian debitage and 35 obsidian tools were selected for x-ray fluorescence analysis. I had originally selected and planned to analyze a larger sample, but because a correlation of stratigraphic units to excavation levels was unavailable, I selected only those items from excavation levels which could reasonably be correlated with a particular stratum or strata. In this approach, the goal was to obtain a large enough sample from temporally discrete units which would allow the aboriginal use of obsidian sources at Marshmeadow to be studied from a diachronic perspective.

Obsidian debitage and tools from all temporal units were analyzed. Overall though, the sample is more heavily derived from Occupation Period II (Table 11). The obsidian projectile points recovered during this period include lanceolate, side-notched, corner-notched, and small stemmed forms (Table 8, Fig. 20).

Occupation Period I (6700-4000 BP)

A total of 121 pieces of obsidian debitage and a re-worked obsidian lanceolate projectile point were recovered from Occupation Period I. From this sample, 18 flakes (15%) and the lanceolate projectile point were selected for analysis (Tables 9,10). Of these, six flakes (33%) and the projectile point were correlated to one of the sources at acceptable probabilities.

Only one flake from the early portion of Occupation Period I (6700-6100 BP) was acceptably correlated to one of the sources used in the analysis. This item was correlated to the Indian Creek source. Even though the values of P(G/X) were sufficiently high for acceptance (.77 and .94), low values of P(X/G) suggested that the other two flakes might more properly be classified to groups outside of the sampling population.

TABLE 8

Projectile points from Stockhoff, Ladd Canyon and Marshmeadow

Site No.	Stratum	Artifact Registration No.	General Morphology	Cortex	Original Object	Condition	Transverse Section	Bifacial Flaking	Unifacial Flaking	Breakage	Pressure Flaking	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base	Margins	Neck Width (mm)	Stem	Serration	Source Assignment #	Illustration No.
35UN52	8	38-5-16	Lanceolate, concave base	2	3	2	1	2	3	3	9	12	22	6	1.4	2	2	-	5	0	805+	21b
"	8	49-5-10	" "	2	3	2	1	2	3	3	2	16	21	5	2.0	2	2	-	5	0	812+	21a
"	7	45-7-12	Basal/corner-notched	2	3	2	2	2	3	3	6	15	13	3	.9	7	4	-	5	0	801-	-
35UN74	III*	100-3-50	Small stemmed	2	3	1	2	2	3	8	6	22	11	3	.9	1	3	7	3	0	812+	21c
"	"	109-6-29	" "	2	3	1	1	2	3	8	6	23	11	3	.7	1	1	5	3	0	812+	21d
35UN95	3	211-9-30	Small lanceolate	2	3	1	3	2	3	8	6	38	22	7	6.0	9	2	-	5	0	807+	20a
"	5	208-7-46	Lanceolate, concave base	2	3	2	1	2	3	1	2	15	15	5	5.0	2	4	-	5	0	801-	20b
"	"	229-5-8	Corner-notched	2	3	2	1	2	3	3	6	14	14	4	.9	7	4	-	1	0	807+	-
"	6	209-7-30	Projectile point tip	2	1	2	2	4	2	7	9	27	15	3	.7	7	3	-	4	0	809+	20e
"	"	220-7-36	Small stemmed	2	1	1	2	1	1	8	6	16	10	2	.4	1	1	4	3	0	812+	20i
"	"	214-6-23	" "	2	3	1	1	2	3	8	1	33	12	2	1.0	1	3	5	1	0	808+	20h
"	"	225-7-10	Side-notched	2	3	1	3	2	3	8	6	26	17	5	1.8	2	3	13	1	0	807-	20g
"	7	227-5-15	" "	2	3	1	1	2	3	8	2	44	20	4	2.2	2	1	12	1	0	812+	20j
"	"	208-5-13	Corner-notched	2	3	2	1	2	3	3	6	11	13	3	.4	7	4	-	4	0	801+	20p
"	"	207-5-6	" "	2	3	2	2	2	3	3	6	12	13	2	.3	7	4	-	4	0	813-	20o
"	"	227-4-9	" "	2	1	2	2	2	3	3	6	19	13	2	.3	7	3	-	4	0	803-	20n
"	"	217-4-49	" "	2	3	2	1	2	3	3	2	16	17	3	.6	7	3	5	4	0	813+	20m
"	"	208-5-14	" "	2	3	2	1	2	3	3	6	23	16	4	.9	7	3	6	4	0	807-	20l
"	"	213-3-8	Indeterminate base fragment	2	3	2	1	2	3	3	1	13	10	3	.5	7	3	-	4	0	807+	-
"	8	202-4-6	Corner-notched	2	3	2	1	2	3	3	6	17	14	3	.9	3	4	-	4	0	807+	20v
"	"	208-4-7a	" "	2	3	2	1	2	3	3	6	12	12	2	.3	1	1	4	1	0	805+	20t
"	"	227-3-6	" "	2	3	2	2	1	4	3	6	12	10	2	.3	7	3	-	4	0	807+	20s
"	"	219-4-8	" "	2	3	2	1	2	3	3	2	16	12	2	.4	7	3	-	4	0	812+	20r
"	"	208-4-9	" "	2	1	2	2	2	3	7	2	19	19	2	.7	1	3	5	1	0	812-	20q
"	7	216-5-41	Side-notched	2	3	1	2	2	3	8	6	30	21	4	2.4	1	3	12	3	0	808+	20k
"	"	226-5-8	" "	2	3	2	4	3	4	3	9	10	13	3	.4	2	4	-	1	0	812+	-
"	5	225-8-17	Corner-notched	2	3	2	1	2	3	3	6	12	12	2	.4	1	3	5	1	0	802+	20c
"	6	227-7-45	Lanceolate	2	3	2	1	2	3	5	9	12	18	5	1.3	2	3	-	5	0	807+	20d
"	"	222-7-51	Corner-notched	2	3	2	3	2	3	3	2	37	20	5	2.7	7	3	8	5	0	807-	20f

Refer to Table 6 for explanation to coding. * Zone III
in this table corresponds to # in Table 6

TABLE 9

Marshmeadow obsidian debitage: attributes and source assignments

Site No.	Registration No.	Stratum	Flake Type[a]	Weight (grams)	Source Assignment[b]
35UN95	208-5.1	6,7	2	9.0	803$^-$
35UN95	208-5.2	6,7	3	.5	807$^+$
35UN95	208-5.3	6,7	3	.6	812$^-$
35UN95	208-11.1	2,3	3	1.4	812$^-$
35UN95	208-12.1	2	3	1.1	804$^-$
35UN95	209-5.1	6,7	3	.9	813$^-$
35UN95	209-5.2	6,7	2	.6	803$^-$
35UN95	209-6.1	6,7	2	1.5	803$^-$
35UN95	209-6.2	6,7	2	1.2	803$^-$
35UN95	209-6.3	6,7	3	.9	803$^-$
35UN95	209-6.4	6,7	2	.8	807$^-$
35UN95	209-7.1	5,6	2	1.0	807$^+$
35UN95	209-7.2	5,6	3	.8	803$^+$
35UN95	209-7.3	5,6	3	.7	-
35UN95	211-5.1	6,7	4	.6	808$^+$
35UN95	211-6.1	5,6,7	3	1.0	812$^-$
35UN95	211-7.1	4,5	1	.9	812$^-$
35UN95	212-7.1	5,6	3	1.2	807$^-$
35UN95	212-8.1	4,5	3	.4	812$^+$
35UN95	212-8.2	4,5	3	.4	812$^+$
35UN95	212-10.1	3,4	3	1.2	807$^-$
35UN95	212-10.2	3,4	3	1.7	812$^+$
35UN95	212-12.1	2,3	3	1.0	803$^+$
35UN95	212-13.1	2	3	.5	812$^+$
35UN95	213-5.1	7	-	-	807$^-$
35UN95	214-5.1	6,7	3	3.0	807$^-$
35UN95	214-5.2	6,7	2	1.3	812-
35UN95	214-5.3	6,7	2	1.0	808$^+$
35UN95	214-5.4	6,7	5	.8	806-
35UN95	214-5.5	6,7	3	.5	808$^+$
35UN95	214-5.6	6,7	3	.5	808$^+$
35UN95	214-9.1	3,4	2	5.0	807$^+$
35UN95	214-9.2	3,4	2	.9	803-
35UN95	214-9.3	3,4	3	2.1	807-
35UN95	214-9.4	3,4	3	.8	803-
35UN95	214-10.1	2,3	3	.9	807-
35UN95	214-10.2	2,3	3	.5	803+
35UN95	214-11.1	2,3	3	2.2	803+
35UN95	216-5.1	7	2	1.6	807-
35UN95	216-5.2	7	2	.7	803-
35UN95	216-4.1	7,8	1	8.0	807-
35UN95	216-3.1	7,8	5	9.4	803-
35UN95	216-3.2	7,8	1	2.5	-
35UN95	216-6.1	6,7	3	.6	807-
35UN95	216-6.2	6,7	5	.5	812+
35UN95	216-7.1	5,6	3	.4	812$^+$

TABLE 9 (continued)

Site No.	Registration No.	Stratum	Flake Type[a]	Weight (grams)	Source Assignment[b]
35UN95	216-10.1	3,4	3	.5	812+
35UN95	217-4.1	6,7	-	-	812-
35UN95	217-5.1	6,7	2	1.1	804-
35UN95	217-5.2	6,7	3	1.0	803+
35UN95	217-5.3	6,7	3	.7	805+
35UN95	217-6.1	5,6	2	2.6	812+
35UN95	217-6.2	5,6	3	1.3	807-
35UN95	217-6.3	5,6	1	.9	804-
35UN95	217-6.4	5,6	2	2.0	803+
35UN95	217-10.1	2,3	3	.6	807-
35UN95	218-8.1	5,6	5	.5	812+
35UN95	218-8.2	5,6	3	.6	812+
35UN95	218-9.1	5	3	1.5	812-
35UN95	218-9.2	5	3	2.1	807-
35UN95	218-12.1	2,3	3	.9	807-
35UN95	218-13.1	-	5	.4	804-
35UN95	219-5.1	6,7	3	.8	807+
35UN95	219-5.2	6,7	3	1.4	807-
35UN95	219-6.1	6	2	1.2	803+
35UN95	219-6.2	6	2	1.0	808+
35UN95	219-6.3	6	5	.5	807+
35UN95	219-7.1	5,6	2	.7	807+
35UN95	219-7.2	5,6	5	.8	807-
35UN95	219-7.3	5,6	3	1.0	803-
35UN95	219-7.4	5,6	5	1.5	804-
35UN95	219-8.1	5	1	2.2	804-
35UN95	219-812	5	5	1.6	804-
35UN95	219-8.3	5	5	2.0	803+
35UN95	219-10.1	3,4	2	1.3	812+
35UN95	219-10.2	3,4	5	.8	810-
35UN95	219-11.1	2,3	2	.8	807+
35UN95	219-11.2	2,3	2	.5	808-
35UN95	220-5.1	6,7	5	.7	812-
35UN95	220-5.2	6,7	5	.5	804-
35UN95	220-5.3	6,7	3	.5	807-
35UN95	220-6.1	6	3	.7	803+
35UN95	220-6.2	6	2	.4	812-
35UN95	220-6.3	6	5	.7	812+
35UN95	220-8.1	4,5	3	1.3	804-
35UN95	220-8.2	4,5	3	1.5	804-
35UN95	220-8.3	4,5	5	.6	803+
35UN95	220-9.1	4,5	3	.5	807-
35UN95	220-12.1	2,3	3	.5	807-
35UN95	220-13.1	2	4	.4	804-
35UN95	221-10.1	2,3	5	1.3	803-
35UN95	222-8.1	4,5	3	1.4	807-

TABLE 9 (continued)

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]	Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN95	222-8.2	4,5	2	1.0	803-	35UN95	224-7.8	5,6	5	1.6	803+
35UN95	222-8.3	4,5	2	.8	807-	35UN95	224-7.9	5,6	3	1.0	807-
35UN95	223-6.1	-	-	-	807-	35UN95	224-7.10	5,6	3	.8	803-
35UN95	223-7.1	6,7	2	.6	803-	35UN95	224-8.1	4,5	2	.9	807-
35UN95	223-10.1	3,4	2	.8	812+	35UN95	224-8.2	4,5	2	.9	807+
35UN95	224-6.1	6,7	1	1.3	812+	35UN95	224-8.3	4,5	5	1.0	807-
35UN95	224-6.2	6,7	5	1.4	807-	35UN95	224-8.4	4,5	3	.7	807-
35UN95	224-6.3	6,7	5	.5	803-	35UN95	224-9.2	3,4	3	.9	807-
35UN95	224-6.4	6,7	3	.8	803-	35UN95	224-9.3	3,4	5	.6	807+
35UN95	224-6.5	6,7	2	12.4	807-	35UN95	224-9.4	3,4	3	1.3	808-
35UN95	224-6.7	6,7	1	1.2	812+	35UN95	224-9.5	3,4	2	1.5	807+
35UN95	224-6.8	6,7	2	.5	803-	35UN95	226-6.1	6,7	5	.6	807-
35UN95	224-6.9	6,7	3	.8	803+	35UN95	226-8.1	5,6	3	1.2	807+
35UN95	224-6.10	6,7	5	2.0	807-	35UN95	226-12.1	2,3	5	1.4	804-
35UN95	224-6.11	6,7	2	2.1	807-	35UN95	227-8.1	4,5	2	.6	808-
35UN95	224-7.1	5,6	6	14.0	807-	35UN95	227-11.1	4,5	3	.7	807-
35UN95	224-7.2	5,6	5	4.5	803-	35UN95	228-5.1	6,7	2	1.8	808+
35UN95	224-7.3	5,6	5	2.5	804-	35UN95	228-7.1	5	5	.7	807+
35UN95	224-7.4	5,6	1	1.5	807-	35UN95	228-8.1	4,5	5	.9	812-
35UN95	224-7.5	5,6	2	1.0	812-	35UN95	228-11.1	2,3	3	2.0	807-
35UN95	224-7.6	5,6	2	.9	807-	35UN95	229-7.1	5,6	5	2.1	812-
35UN95	224-7.7	5,6	2	.9	803-	35UN95	229-7.2	5,6	3	1.2	803-

TABLE 9 (continued)

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]	Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN95	229-7.3	5,6	2	3.4	812+						
35UN95	229-7.4	5,6	5	.9	807-						
35UN95	229-7.5	5,6	3	.7	807-						
35UN95	229-7.6	5,6	3	.6	808+						
35UN95	229-7.7	5,6	5	.8	808+						
35UN95	229-10.1	2,3	5	1.6	807-						
35UN95	229-11.1	2,3	3	8.0	812-						

[a] Flake Type:

1. Primary decortication flake. Defined as a flake with the entire dorsal surface covered with cortex.
2. Secondary decortication flake. Defined as a flake with cortex on part of the platform or dorsal surface of the flake.
3. Thinning or tertiary flake. Defined as a flake exhibiting no cortex on the platform or dorsal surface.
4. Pressure flake. Defined as a small, thin flake being generally twice as long as it is wide and exhibiting no cortex. In practice, these are very difficult to distinguish from many thinning flakes.

[b] Refer to *n*, Table 6 for explanation of source assignment coding.

TABLE 10

Flaked obsidian artifacts: Marshmeadow and Ladd Canyon

Site No.	Stratum	Artifact Registration No.	Morpho-use category	Condition *a*	Cortex *b*	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Source Assignment *c*	Illustration No.
35UN74	III*	100-4-65	Perforator	1	2	22	11	3	.9	812+	21e
"	"	111-8-19b	Core	1	-	32	24	11	-	808+	-
35UN95	6	202-5-18	Biface	2	2	23	19	8	3.8	808-	-
"	"	222-6-28	"	2	2	14	24	4	1.1	812+	-
"	7	201-3-7	"	2	2	22	10	6	2.2	804-	-
"	"	223-5-9	"	1	2	38	29	5	5.7	803+	-

Refer to Table 6 for coding explanation. *a, b, c* correspond to *c, a, n* of Table 6 respectively.

Fifteen flakes could not be assigned exclusively to either strata 2 or 3. I therefore asigned them to strata 2 and 3 which conservatively places their temporal occurrence somewhere between 6700 and ca. 4000 BP (McPherson and others 1981: Table 21). Accepted probability estimates indicate use of the Indian Creek (N=2), Coyote-Buckboard (N=3), and Owyhee A (N=1) sources during this period. Items assigned to the Petroglyphs (N=4) and Owyhee B (N=1) sources were rejected. One lanceolate projectile point (Fig. 20a), typologically associated with the Cascade Phase (Leonhardy and Rice 1970) was acceptably correlated to the Owyhee A source.

Strata 3 and 4 (6100-3400 BP)

Fifteen flakes from strata 3 and/or 4 were analyzed and 40% of these were correlated at acceptable probabilities to one of the sources used in the analysis (Table 10). Because these items could not be correlated exclusively to either stratum 3 or 4, they must be viewed as belonging to a relatively long period lasting from 6100 to 3410 BP (Table 11).

Three of the seven flakes correlated with the Owyhee A source were statistically acceptable as were three of four flakes correlated to the Indian Creek source area. Of the acceptably correlated debitage in stratums 3 and 4, all but one were secondary reduction flakes or thinning flakes. The one primary reduction flake recovered was correlated to the Indian Creek area suggesting that Indian Creek obsidian was being transported to Marshmeadow during this time period in raw material form or in very minimally reduced form. Other debitage correlated to the Coyote-Buckboard (N=2), Owyhee B (N=1), and Reynolds Creek (N=1) was considered statistically unacceptable.

Occupation Period II (4000-690 BP)

A total of 61 flakes from Occupation Period II were selected for analysis. This constituted a 5% sample of recovered obsidian debitage from this period. Only 23 of these (38%) were correlated to one of the sources at an acceptable probability estimate. The acceptably correlated debitage therefore constitutes only 2% of all obsidian debitage recovered from Occupation Period II (Tables 10,11). Expectedly, the local Indian Creek source accounts for the majority of correlated obsidian debitage (35%) and is followed in frequency by the Owyhee A (26%), Coyote-Buckboard (26%), and Owyhee B (13%) sources during this period.

In contrast to the low percentage (38%) of acceptably correlated debitage from Occupation Period II, 67% of the projectile points from this period were acceptably correlated to one of the sources. Two corner-notched points from stratum 5 (3410-2260 BP) were acceptably assigned to the Shumway Ranch (Fig. 20c) and Owyhee B sources. The Humboldt Concave-Base projectile point from this period could not be correlated to any of the sources used in the analysis.

The latter half of this occupation period is represented by Stratum 6 (2260-690 BP) which contains evidence for "the most intensive occupation of the site" (McPherson and others 1981:483). Five of six flakes from this period were acceptably correlated to one of the sources used in the analysis. Of these, debitage was acceptably correlated to the Coyote-Buckboard (N=2), Owyhee A (N=1), Owyhee B (N=1), and Indian Creek (N=1) sources (Table 11). Acceptably assigned projectile points during this period include a Humboldt Concave Base (Fig. 20d) point correlated to the Owyhee A source, two small stemmed points assigned to the Indian Creek (Fig. 20i) and Owyhee B (Fig. 20h) sources, and a basal-notched point fragment manufactured from a flake assigned to Timber Butte (Fig. 20e). Two obsidian bifaces were recovered from Stratum 6, but only one, assigned to the Indian Creek source is deemed to be acceptable (Table 10).

Strata 6 and 7 (2260-100 BP)

The boundary between Strata 6 and 7 marks the end of Occupation Period II and the beginning of Occupation III. Debitage acceptably correlated during this period indicates continued use of the Coyote-Buckboard, Owyhee A and B, and Indian Creek sources (Table 9,11). Other assignments indicate the use of Gregory Creek and Ebell Creek sources. With the exception of the Indian Creek source all of the debitage consists of secondary reduction and thinning flakes along with a few pieces of non-diagnostic shatter and one pressure flake. Of the four flakes correlated to the Indian Creek source, two were primary reduction flakes suggesting that obsidian from Indian Creek was being brought to the Marshmeadow locale either in raw material form or it was only partially reduced at the source and then transported to the site.

Stratum 7 (690-100 BP)

Stratum 7 is believed to represent the continuation of the economic patterns established during Occupation II with a persistent influence from the Great Basin. While projectile points during the preceding periods are manufactured from basalt, the points characteristic of this final occupation of Marshmeadow from 690-100 BP are made from obsidian (McPherson and others 1981:627). Sources used for the manufacture of these projectile points include Indian Creek (N=2) (Fig. 20j), Owyhee B (N=1) (Fig. 20k), Drewsey (N=1) (Fig. 20p), and Ebell Creek (N=1) (Fig. 20m).

Stratum 8

Stratum 8 is entirely disturbed and thus of little archaeological value (McPherson and others 1981:609). Five corner-notched points points were recovered from stratum 8 (Fig. 20q-u). Four were acceptably assigned to the Gregory Creek (N=1), Owyhee A (N=2), and Indian Creek (N=1) sources.

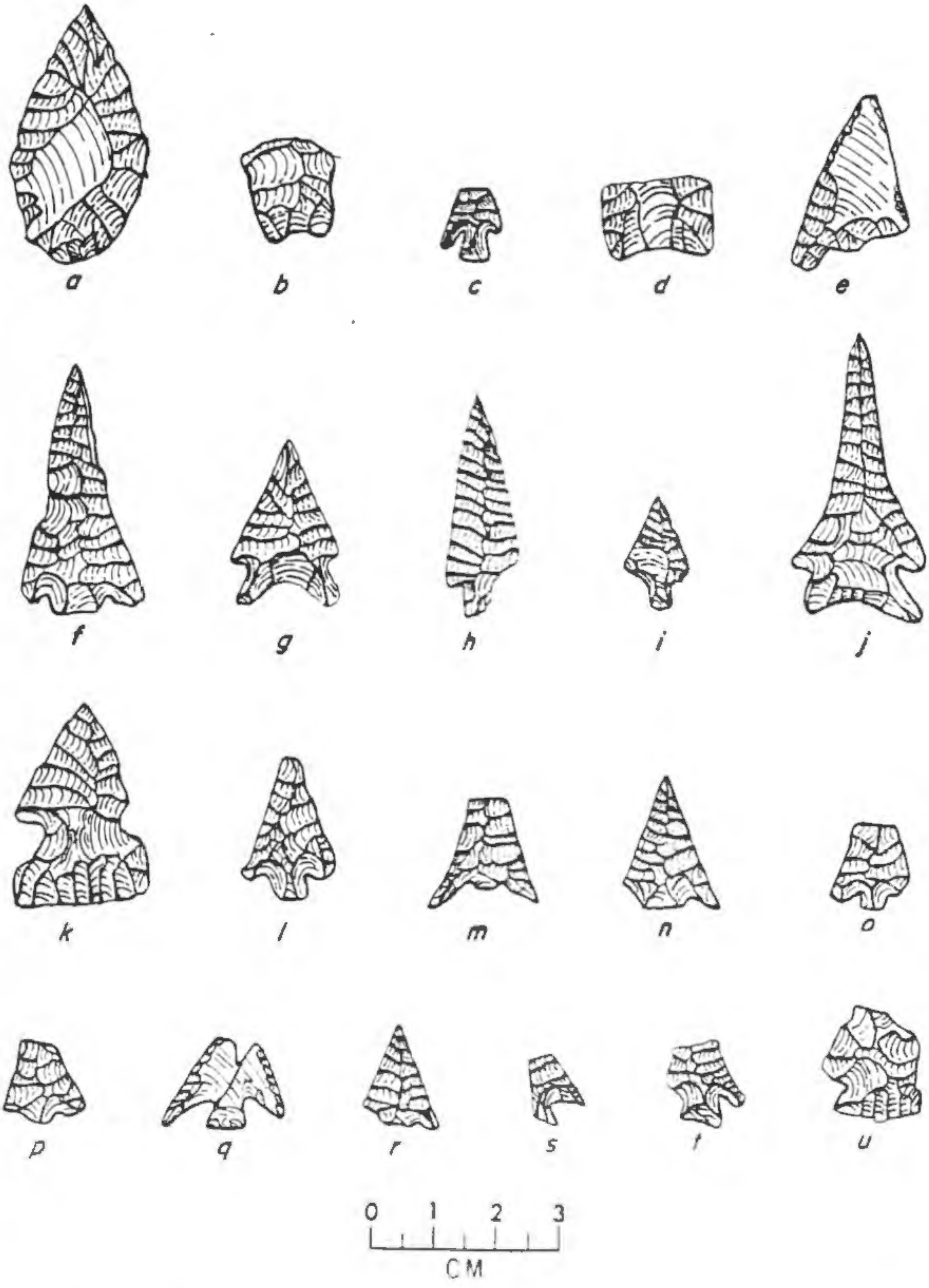

Fig. 20. Projectile points from Marshmeadow (35UN95). a, Stratum 3; b-c, Stratum 5; d-j, Stratum 6; k-p, Stratum 7; q-u, Stratum 8.

Table 11

Marshmeadow Debitage: Source Assignments by Strata/Occupation Period

SOURCE	CATEGORY	OCCUPATION PERIOD I			OCCUPATION PERIODS I AND II	OCCUPATION PERIOD II					OCCUPATION PERIODS II AND III		OCCUPATION PERIOD III	TOTAL
		STRATUM 2 6700-6100 B.P.	STRATA 2, 3 6100-4000 B.P.	TOTAL	STRATA 3, 4 6100-3400 B.P.	STRATA 4, 5 4000-2260 B.P.	STRATUM 5 3410-2260 B.P.	STRATA 5, 6 3410-690 B.P.	STRATUM 6 2260-690 B.P.	TOTAL	STRATA 5, 6, 7 3410-100 B.P.	STRATA 6, 7 2260-100 B.P.	STRATUM 7 690-100 B.P.	
COYOTE-BUCKBOARD 803	TOTAL ASSIGNED		4	4	2	1	1	9	2	13		9	1	29
	(N,%) ACCEPTED		(3, 75)	(3, 75)		(1,100)	(1,100)	(3, 33)	(2,100)	(6, [illegible])		(3, 33)		(12, 41)
	(N,%) REJECTED		(1, 25)	(1, 25)	(2,100)			(6, 67)		(7, 54)		(6, 67)	(1,100)	(17, 59)
	(N,%) CORRELATED ITEMS			(3,50)						(6, 26)				(12, 24)
PETROGLYPHS 804	TOTAL ASSIGNED	2	2	4		2	2	3		7		2		11
	(N,%) ACCEPTED													
	(N,%) REJECTED	(2,100)	(2,100)	(4,100)		(2,100)	(2,100)	(3,100)		(7,100)		(2,100)		(11,100)
	(N,%) CORRELATED ITEMS													
GREGORY CREEK 805	TOTAL ASSIGNED											1		1
	(N,%) ACCEPTED											(1,100)		(1,100)
	(N,%) REJECTED													
	(N,%) CORRELATED ITEMS													(1, 02)
SENECA-GLASS MT. 806	TOTAL ASSIGNED											1		1
	(N,%) ACCEPTED													
	(N,%) REJECTED											(1,100)		(1,100)
	(N,%) CORRELATED ITEMS													
OWYHEE A 807	TOTAL ASSIGNED		6	6	7	8	2	12	1	23		12	2	50
	(N,%) ACCEPTED		(1, 17)	(1, 17)	(3, 43)	(2, 25)	(1, 50)	(2, 17)	(1,100)	(6, 25)		(2, 17)		(12, 24)
	(N,%) REJECTED		(5, 83)	(5, 83)	(4, 57)	(6, 75)	(1, 50)	(10, 83)	(	(18, 75)		(10, 83)	(2,100)	(38, 76)
	(N,%) CORRELATED ITEMS			(1, 17)						(6, 26)				(12, 24)
OWYHEE B 808	TOTAL ASSIGNED		1	1	1	1		2	1	4		5		11
	(N,%) ACCEPTED							(2,100)	(1,100)	(3, 75)		(4, 80)		(7, 64)
	(N,%) REJECTED		(1,100)	(1,100)	(1,100)	(1,100)				(1, 25)		(1, 20)		(4, 36)
	(N,%) CORRELATED ITEMS									(3, 13)				(7, 14)
REYNOLDS CREEK 810	TOTAL ASSIGNED				1									1
	(N,%) ACCEPTED													
	(N,%) REJECTED				(1,100)									(1,100)
	(N,%) CORRELATED ITEMS													
INDIAN CREEK 812	TOTAL ASSIGNED	1	2	3	4	4	1	7	2	14	2	7		30
	(N,%) ACCEPTED	(1,100)	(1, 50)	(2, 67)	(3, 75)	(2, 50)		(5, 71)	(1, 50)	(8, 57)	(1, 50)	(3, 43)		(17, 57)
	(N,%) REJECTED		(1, 50)	(1, 33)	(1, 25)	(2, 50)	(1,100)	(2, 29)	(1, 50)	(6, 43)	(1, 50)	(4, 57)		(34, 43)
	(N,%) CORRELATED ITEMS			(2, 33)						([illegible], 35)				(17, 35)
EBELL CREEK 813	TOTAL ASSIGNED											1		1
	(N,%) ACCEPTED													
	(N,%) REJECTED											(1,100)		(1,100)
	(N,%) CORRELATED ITEMS													(1, 02)
TOTAL BY STRATA/ OCC. PERIOD	TOTAL ASSIGNED	3	15	18	15	16	5	33	6	61	2	38		137
	(N,%) ACCEPTED	(1, 33)	(5, 33)	(6, 33)	(6, 40)	(5, 31)	(2, 40)	(12, 36)	(5, 83)	(23, 38)	(1, 50)	(13, 34)		(49, 36)
	(N,%) REJECTED	(2, 67)	(10, 67)	(12, 67)	(9, 60)	(11, 69)	(3, 60)	(21, 64)	(1, 17)	(38, 62)	(1, 50)	(25, 66)		(88, 64)

Summary

The acceptably correlated items in the debitage and artifact sample suggests a rather consistent pattern of obsidian source-use through time at the Marshmeadow site. Overall, Indian Creek accounts for 35% of the debitage sample and is followed in frequency by Coyote-Buckboard (24%), Owyhee A (24%), Owyhee B (14%), Petroglyphs (2%), and Ebell Creek (2%). The correlation of one biface and primary decortication flakes from the Indian Creek source suggests the transport of material from that source in raw or partially reduced form. Material from more distant sources appears to have arrived in more reduced form.

These conclusions are rendered with some caution because over 60% of the debitage sample could not be correlated to one of the sources in the analysis. In contrast, over 70% of the Marshmeadow artifacts were acceptably correlated. This anomaly is discussed below.

While the acceptably correlated sample from Marshmeadow is not large, it does suggest use of diversified sources during all periods. This diversified source-use may be representative of either a highly mobile settlement system or increased trade contacts with groups to the south.

Ladd Canyon (35UN74)

Introduction

The Ladd Canyon site is located along Ladd Creek near the base of Craig Mountain and Glass Hill at the extreme southern end of the Grande Ronde Valley (Fig. 19). Because of the "large size of the site and diverse topographies," the Ladd Canyon site was divided into four geomorphological zones. All of these zones were traversed by the Pan Alberta Pipeline (McPherson and others 1981:630). The sample of obsidian debitage and artifacts used in this study were recovered almost exclusively from one of these zones; Zone III, the modern floodplain of Ladd Creek.

> The floodplain is composed of a complex series of unconnected, interbedded lenses of silt, sand and gravel believed to be of very late Holocene alluvial deposits. Their recent deposition is indicated by the presence of bedding planes not yet masked by pedogenesis. Due to the lack of soil development in any of the sediment within the zone, it is likely no particular surface was exposed for an extended length of time. It is believed the different lenses of alluvium are essentially contemporaneous and it is probable they resulted from the same event (flood) or some series of events associated with the last aggradation period (1500-150 BP) [McPherson and others 1981:649].

A radiocarbon date of 2950 BP was obtained on charcoal from these sediments, but the date was rejected as being too old as a lower limiting date for the sediments. The charcoal is believed to have been redeposited from its original older context upstream into the more recently deposited silt lens (McPherson and others 1981:649). The association of diagnostic artifacts similar to those recovered at Marshmeadow which date after 650 BP led McPherson and others (1981:650) to conclude that the culture bearing floodplain sediments to be younger than 1000 years old.

Four 2 x 2m units were excavated in Zone III. In comparison to the other zones, Zone III contained the greatest amount of cultural material including temporally diagnostic projectile points, bifaces, scrapers, utilized flakes, and groundstone tools. Based on the high concentration of artifacts recovered from Zone III, it is believed that this portion of the site served as a major habitation area. While evidence of living structures was not detected, it is believed that the Ladd Canyon site may have served as a base camp for the peoples using the Marshmeadow site sometime after 690 BP (McPherson and others 1981:657).

Sample Selection and Results of Analysis

Thirty-four pieces of obsidian debitage (Table 12), two projectile points, several used used flakes, and a perforator were selected for analysis (Table 13; Fig. 21). Fifteen flakes or 44% of the debitage were acceptably assigned to one of the sources used in the analysis.

TABLE 12

Ladd Canyon obsidian debitage:
attributes and source assignments

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]	Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN74	100-3-9	III*	2	1.2	812-	35UN74	110-4-10.2	III*	-	-	812-
35UN74	100-2-7	"	3	1.5	803-	35UN74	110-4-4.1	"	-	-	807-
35UN74	100-4-17.1	"	5	1.0	803+	35UN74	110-5-15.1	"	-	-	812-
35UN74	100-4-17.2	"	5	1.4	803+	35UN74	110-5-15.2	"	-	-	807-
35UN74	100-5-25.1	"	2	1.6	808-	35UN74	110-5-15.3	"	-	-	807-
35UN74	100-5-25.2	"	3	1.4	803+	35UN74	110-5-15.4	"	-	-	807+
35UN74	100-6-39B	"	3	1.2	807-	35UN74	110-5-15.5	"	-	-	803-
35UN74	109-1-3.1	"	2	5.4	807-	35UN74	110-5-15.6	"	-	-	812+
35UN74	109-1-3.2	"	2	1.2	807-	35UN74	110-6-20.1	"	-	-	803-
35UN74	109-1-3.3	"	5	.4	804-	35UN74	110-6-20.2	"	-	-	803-
35UN74	109-3-20	"	5	.3	804-	35UN74	110-6-20.3	"	-	-	812+
35UN74	109-3-21	"	3	.4	807-	35UN74	110-6-24.1	"	-	-	807-
35UN74	109-8-34	"	2	.4	812+	35UN74	110-6-24.2	"	-	-	803+
35UN74	109-10-37.1	"	3	.3	807-	35UN74	110-8-37.1	"	-	-	804-
35UN74	109-10-37.2	"	5	.4	803+	35UN74	110-7-26.2	"	-	-	812+
35UN74	109-10-37.3	"	5	.5	807-	35UN74	110-8-36.1	"	-	-	808+
35UN74	109-10-37.4	"	5	.2	807-	35UN74	111-2-3.1	"	-	-	812+
35UN74	110-1-1	"	-	-	804-	35UN74	111-6-12.1	"	-	-	803+
35UN74	110-2-2.1	"	-	-	808-	35UN74	111-7-14.1	"	-	-	803-
35UN74	110-3-5	"	-	-	807+	35UN74	111-9-20.1	"	-	-	804-
35UN74	110-3-7	"	-	-	803+	35UN74	111-11-28.1	"	-	-	807+
35UN74	110-4-10.1	"	-	-	813+						

Refer to Table 9 for coding explanation

Table 13

Ladd Canyon and Stockhoff used obsidian flakes: attributes and source assignments

Site No.	Stratum	Registration No.	Cortex [a]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Gross shape [b]	Angle of used edge	Source Assignment [c]	Illustration No.
35UM74	III*	100-1-4	2	25	20	4	2.2	6	55	803+	21f
"	"	100-3-12	1	30	17	6	3.5	2	40	803+	-
"	"	109-7-32	2	18	12	3	.6	5	70	803+	-
"	"	110-2-2a	2	38	17	5	4.2	4	65	-	21g
"	"	110-13-7b	2	30	9	4	1.4	6	35	812+	-
35UN52	9	15-11-38a	2	37	25	5	4.0	7	40	812+	-

[a] Cortex:
1. Present
2. Absent

[b] Gross Shape
1. Round
2. Oval
3. Bi-pointed
4. Leaf-shaped
5. Triangular
6. Rectangular
7. Amorphous
8. Indeterminate because of breakage

[c] Source Assignment:
801 Drewsey
802 Shumway Ranch
803 Coyote-Buckboard
804 Petroglyphs
805 Gregory Creek
806 Seneca-Glass Mountain
807 Owyhee A
808 Owyhee B
809 Timber Butte
810 Reynolds Creek
812 Indian Creek
813 Ebell Creek

\+ indicates accepted source assignment
\- indicates rejected source assignment

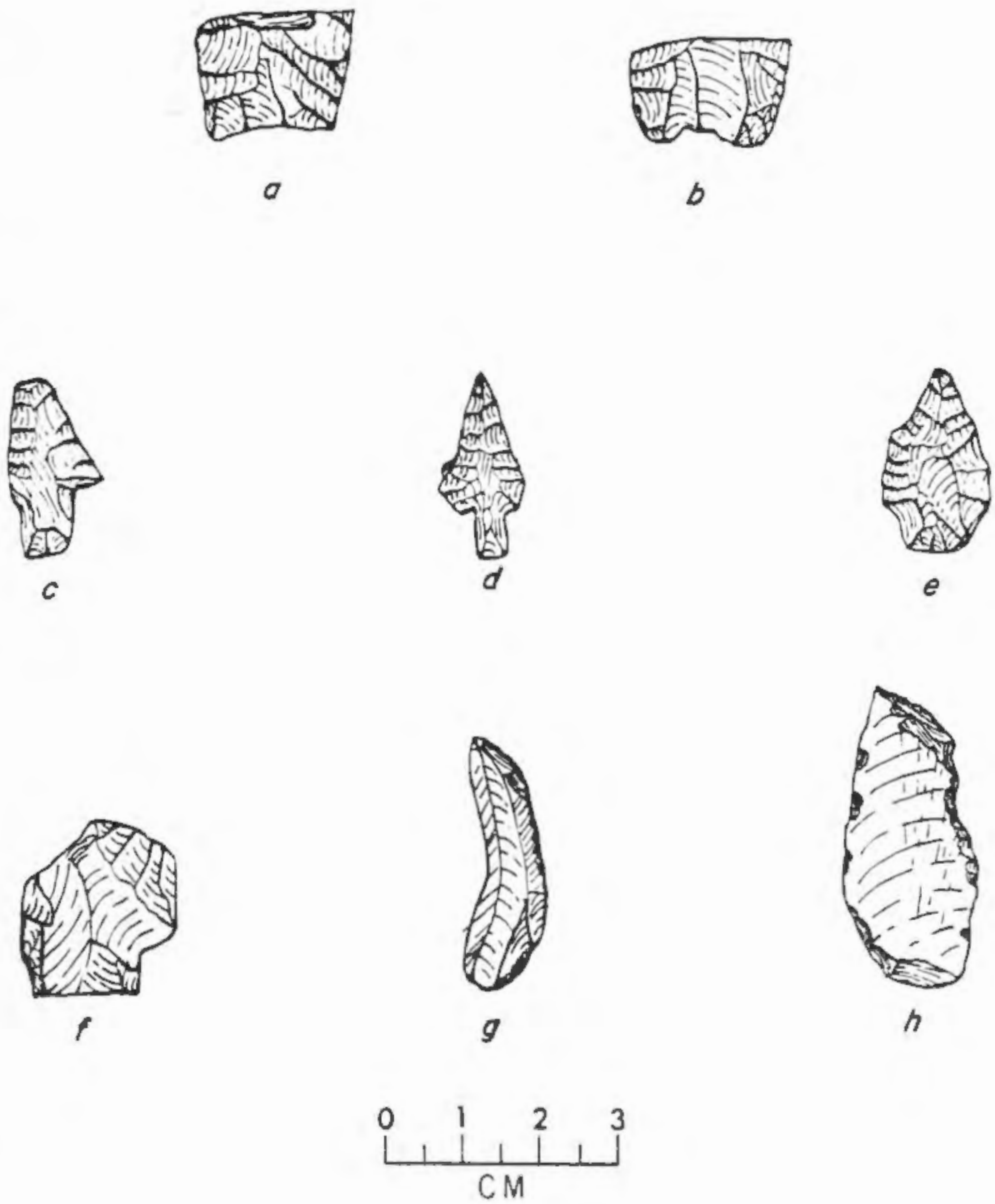

Fig. 21. Flaked obsidian artifacts and used flakes from Stockhoff and Ladd Canyon. a-d, projectile points; e, perforator; f-h, used flakes.

Debitage analysis indicated use of the Coyote-Buckboard (N=6, 40%), Indian Creek (N=5, 33%), Owyhee A (N=2, 13%), Owyhee B (N=1, 7%), and Ebell Creek (N=1, 7%) sources. Two small stemmed projectile points, a bifacially flaked perforator (Fig. 21c, d, e), and a utilized flake were acceptably correlated to the Indian Creek source area. One small core and a used flake were acceptably assigned to the Owyhee B source and three used flakes (Fig. 21f, g) were acceptably correlated with the Coyote-Buckboard source.

Stockhoff Basalt Quarry (35UN52)

A few artifacts from the Stockhoff Basalt Quarry (Fig. 19) were also included in the analysis. Since these constitute only a very small portion of the analyzed sample used in this study, Womack (1977) and McPherson and others (1981) should be consulted for background information on the Stockhoff site.

A Humboldt Concave Base projectile point fragment (Fig. 21a) and a used flake from stratum 8 (3800-1700 BP) and stratum 9 (1550-100 BP) respectively, (McPherson and others 1981:Table 13) were assigned to the Indian Creek source. Another Humboldt Concave Base point fragment from Stratum 8 was acceptably correlated to the Gregory Creek source.

Pilcher Creek (35UN147)

Introduction

The Pilcher Creek site is located at the northern end of the Baker Valley (Fig. 19) about 27 miles (43 km) north of the Dooley Mountain vicinity. The site is situated adjacent to Pilcher Creek, a tributary to the Powder River at 4000 feet (1210 meters) elevation near the base of the glacially carved Elkhorn Mountains.

Three stratigraphic units have been identified at the site. Subdivided into two substrata (1A and 1B), the first stratigraphic unit extends to a depth of 140 cm. Mount Mazama Ash is a major constituent of the lower part of this unit (1B). Only low frequencies of cultural material were recovered in this first stratigrpahic unit (Brauner, Satler, and Havercroft 1983:17).

Stratum 2 is a buried soil representing a surface which had remained stable for sometime prior to the eruption of Mount Mazama. The majority of cultural material from the Pilcher Creek site was recovered from this stratum. While some ash was deposited into stratum 2, all of this was believed to be intrusive from rodent burrowing. All cultural material from stratum 2 predates the eruption of Mount Mazama (Brauner, Satler, and Havercroft 1983:20).

Pilcher Creek represents an upland base camp which "was most intensively occupied prior to the eruption of Mount Mazama" (Brauner, Satler, and Havercroft 1983:42). Diagnostic artifacts from stratum 2, while rare, are stylistically similar to artifacts found associated with the Windust Phase (10,000 to 8000 BP) in the Lower Snake River canyon (Leonhardy and Rice 1970; Rice 1972). The flaked lithic assemblage, like the Marshmeadow, Ladd Canyon, and Stockhoff assemblages, consists primarily of locally available basalt. Obsidian debitage constitutes about 4% of the lithic detritus recovered from the site (Brauner, Satler, and Havercroft 1983: Fig. 12).

Sample Selection

The analyzed obsidian sample includes 57 artifacts and 125 waste flakes (Tables 14-17). Correlation results indicate a striking disparity between the two samples. Whereas 90% of the artifact sample was acceptably correlated to one of the sources used in the analysis, only 15% of the debitage sample was so correlated. Results of the artifact and debitage analyses are discussed below.

Debitage

Only 19 (15%) of the 125 waste flakes are considered to be acceptably correlated. Sources accounting for this debitage include Coyote-Buckboard (N=8, 42%), Indian Creek (N=5, 26%), Owyhee A (N=4, 21%), and Shumway Ranch (N=2, 10%). All of the correlated debitage consists of interior or thinning flakes, and non-diagnostic shatter. Thirty flakes (24%) are from

TABLE 14

Projectile points/point fragments from Pilcher Creek

Site No.	Strata	Artifact Registration No.	General Morphology	Cortex[a]	Original Object[b]	Condition[c]	Transverse Section[d]	Bifacial Flaking[e]	Unifacial Flaking[f]	Breakage[g]	Pressure Flaking[h]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Base[i]	Margins[j]	Neck Width (mm)	Stem[k]	Serration[l]	Source Assignment[m]	Illustration No.
35UN147	2	G-306	Projectile point base	2	3	2	3	2	3	5	2	26	19	8	4.4	2	2	-	5	0	812+	22c
"	2	G-484	" "	2	3	2	1	2	3	5	2	15	17	5	1.3	1	2	-	5	0	812+	22d
"	-	J-3	" "	2	3	2	1	2	3	5	1	37	20	5	4.6	3	2	-	5	0	812+	22a
"	1	L-14	" "	2	3	2	2	2	3	5	6	31	21	5	3.6	2	2	-	5	0	808+	22b
"	1	L-10	" "	2	3	2	1	2	3	6	9	14	16	5	1.4	1	2	-	5	0	812+	-
35UN147	2	104	Projectile point medial fragment	2	1	2	2	1	1	2	-	23	14	4	1.6	-	3	-	5	0	808+	-
"	2	G-53	" "	2	3	2	2	2	3	7	6	40	16	6	4.0	-	2	-	5	0	812+	-
"	1	G-269	" "	2	3	2	1	2	3	3	2	18	17	5	2.2	-	2	-	5	0	808+	-
"	2	G-383	" "	2	3	2	3	1	1	3	6	36	19	9	6.2	-	2	-	5	0	812+	-
"	2	G-449	" "	2	3	2	1	2	3	1	3	21	18	7	3.3	-	2	-	5	0	812+	-
35UN147	2	G-371	Projectile point tip	2	3	2	1	2	3	3	2	34	19	8	4.5	-	2	-	5	0	812+	-
"	-	L-607	" "	2	1	2	2	1	1	1	3	35	21	5	3.4	-	2	-	5	0	812+	-
35UN147	2	122	Stemmed Lanceolate point (complete)	2	1	2	1	2	3	8	3	76	23	6	12.0	2	2	17	3	0	812+	22h

a-m Refer to Table 6 for coding explanation

Table 15

Pilcher Creek obsidian debitage:
attributes and source assignments

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN147	F-5/1	1A	5	.3	804-
35UN147	F8/1	1A	5	.3	812-
35UN147	F9/1	1A	3	.3	812-
35UN147	F9/2	1A	3	.3	807+
35UN147	F11/6	1A	3	.4	804-
35UN147	F14/1	1A	5	.4	804-
35UN147	F15/1	1A	3	1.0	804-
35UN147	F15/2	1A	3	.4	804-
35UN147	F11/8	1A	3	.7	804-
35UN147	F-16/2	1A	3	.5	803-
35UN147	F-16/1	1A	3	.3	807-
35UN147	F-17/1	1A	5	.3	804-
35UN147	F-17/2	1A	3	.4	803+
35UN147	F-17/3	1A	3	.9	812+
35UN147	F-17/4	1A	3	.9	807-
35UN147	F-27/1	1A	3	1.6	804-
35UN147	F-26/10	1A	3	1.0	812+
35UN147	F-26/1	1A	3	.3	807-
35UN147	F-29/1	1A	2	.9	804-
35UN147	F-29/2	1A	3	.5	807-
35UN147	F-29/14	1A	3	3.2	803+
35UN147	F-36/1	1A	3	.4	807-
35UN147	F-36/2	1A	3	.4	804-
35UN147	F-36/3	1A	5	.3	804-
35UN147	F-37/1	1A	3	.7	809-
35UN147	F-38/1	1B	3	.7	807-
35UN147	F-39/1	1B	3	.3	804-
35UN147	F-39/2	1B	3	.3	803-
35UN147	F-40/1	1B	3	.3	804-
35UN147	F-40/2	1B	3	.3	812+
35UN147	F-42/1	1B	3	1.0	804-
35UN147	F-42/2	1B	3	1.0	804-
35UN147	F-45/1	1B	3	.6	807+
35UN147	F-48/1	1B	3	1.6	804-
35UN147	F-48/2	1B	5	.3	807-
35UN147	F-50	1B	4	.2	807-
35UN147	F-51/1	2	3	1.3	807-
35UN147	F-51/2	2	3	.4	804-
35UN147	F-51/3	2	5	.4	807+
35UN147	F-51/4	2	3	.4	804-
35UN147	F-52/1	2	5	.4	807-
35UN147	F-52/2	2	3	.4	812+
35UN147	F-53/1	2	3	1.7	803-
35UN147	F-53/3	s	4	.4	807-

Table 15 (continued)

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN147	F-53/4	2	3	.5	812-
35UN147	F-56/28	2	3	4.0	803-
35UN147	F-56/32A	2	5	.8	807-
35UN147	F-56/32B	2	5	.5	804-
35UN147	F-57/1	2	3	1.2	812-
35UN147	F-57/2	2	3	1.4	807-
35UN147	F-57/3	2	3	.4	807-
35UN147	F-57/4	2	3	.4	802+
35UN147	F-57/5	2	3	.4	804-
35UN147	F-57/6	2	5	.4	812-
35UN147	F-59/1	2	3	.7	804-
35UN147	F-59/2	2	5	.4	803+
35UN147	F-59/3	2	5	.4	807-
35UN147	F-59/40	2	3	.8	804-
35UN147	F-59/54	2	5	.4	804-
35UN147	F-60/1	2	3	1.1	804-
35UN147	F-60/2	2	5	.5	804-
35UN147	F-60/32	2	5	.4	804-
35UN147	F-62/1	2	3	.4	812+
35UN147	F-62/3	2	3	.4	807-
35UN147	F-62/4	2	3	.4	803+
35UN147	F-62/5	2	3	.4	-
35UN147	F-63/1	2	5	1.0	807-
35UN147	F63/2	2	5	.4	807-
35UN147	F-63/3	2	3	.4	807-
35UN147	F-63/40	2	3	1.0	803-
35UN147	F-63/41	2	3	.6	812-
35UN147	F-65/1	2	5	.6	804-
35UN147	F-65/2	2	5	.4	804-
35UN147	F-65/3	2	3	.6	804-
35UN147	F-65/4	2	3	.6	805-
35UN147	F-65/5	2	5	.4	804-
35UN147	F-65/6	2	3	.4	803+
35UN147	F-65/7	2	3	.4	803-
35UN147	F-65/8	2	2	.6	807-
35UN147	F-65/9	2	5	.4	803-
35UN147	F-65/29	2	5	.8	804-
35UN147	F-66/1	2	2	.5	807-
35UN147	F-66/2	2	5	.4	804-
35UN147	F-66/3	2	3	.4	803+
35UN147	F-66/5	2	5	.3	804-
35UN147	F-66/6	2	5	.3	804-

Table 15 (continued)

Site No.	Registration No.	Stratum	Flake Type [a]	Weight (grams)	Source Assignment [b]
35UN147	F-66/7	2	5	.3	803-
35UN147	F-67/1	2	5	5.4	803-
35UN147	F-67/2	2	3	.3	804-
35UN147	F-67/3	2	5	.3	804-
35UN147	F-67/4	2	5	.3	810-
35UN147	F-67/5	2	4	.4	812-
35UN147	F-67/6	2	3	.2	803-
35UN147	F-67/7	2	5	.5	803-
35UN147	F-67/8	2	5	.2	-
35UN147	F-67/9	2	4	.3	804-
35UN147	F-67/23A	2	5	2.0	804-
35UN147	F-67/23B	2	5	.9	807-
35UN147	F-67/23C	2	5	.5	804-
35UN147	F-68/1	2	3	.5	807-
35UN147	F-68/2	2	4	.3	807-
35UN147	F-70/1	2	3	.6	804-
35UN147	F-70/2	2	5	.3	803-
35UN147	F-71/1	2	3	.7	807+
35UN147	F-71/2	2	3	.6	807-
35UN147	F-72/1	2	3	.3	804-
35UN147	F-72/2	2	3	1.6	804-
35UN147	F-75/1	2	3	2.3	807-
35UN147	F-75/2	2	5	1.0	804-
35UN147	F-75/3	2	3	.3	807-
35UN147	F-75/4	2	3	.4	803-
35UN147	F-75/5	2	3	.5	804-
35UN147	F-75/6	2	3	.2	803-
35UN147	F-79/1	2	5	.9	804-
35UN147	F-85/1	2	5	1.7	803-
35UN147	F-85/2	2	3	.4	804-
35UN147	F-85/3	2	3	.8	804-
35UN147	F-85/5	2	3	.3	803-
35UN147	F-85/6	2	3	.5	804-
35UN147	F-85/8	2	3	.4	804-
35UN147	F-85/9	2	3	.3	804-
35UN147	F-85/10	2	3	.6	803-
35UN147	F-85/11	2	4	.3	804-

[a,b] Refer to Table 9 for coding explanation

TABLE 16

Flaked obsidian artifacts: Pilcher Creek

Site No.	Stratum	Artifact Registration No.	Morpho-use category		Condition [a]	Cortex [b]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Source Assignment [c]	Illustration No.
35UN147	2	6430	Projectile point preform/blank		1	2	66	22	7	9.2	812+	22i
"	1	G-13	"	"	1	2	49	19	6	4.6	812+	22e
"	2	G-47	"	"	2	2	28	23	4	2.5	806-	-
"	-	G-122	"	"	2	2	20	15	7	2.2	812+	-
"	1	G-362	"	"	2	2	32	32	8	6.5	808+	-
"	2	G-425	"	"	2	2	38	15	7	4.0	812-	-
"	2	G-406	"	"	2	2	31	24	4	5.5	812-	-
"	2	J-127	"	"	2	2	13	18	5	.6	812+	-
"	2	J-104	"	"	2	2	27	14	5	2.1	813+	-
"	2	K-61	"	"	2	2	23	24	9	3.5	812+	-
"	2	K-140	"	"	2	2	12	17	5	.5	812+	-
35UN147	1	K-20	Stage 2 blank		2	2	36	20	9	4.4	812+	-
35UN147	2	J-114	Drill fragment		2	2	31	14	7	2.2	808+	-
35UN147	2	110	Scraper		1	2	52	18	12	10.6	812+	23f
35UN147	2	114	Biface fragment		2	2	40	43	11	21.8	812+	22f
"	1	G-73	"	"	2	2	63	13	8	5.5	808-	-
"	1	J-132	"	"	2	2	30	55	16	24.5	812+	22g
35UN147	1	F-5	Graver		1	2	30	18	2	1.1	807-	-

[a] Condition:
1. Complete
2. Incomplete

[b] Cortex
1. Present
2. Absent

[c] Source Assignment
801 Drewsey
802 Shumway Ranch
803 Coyote-Buckboard
804 Petroglyphs
805 Gregory Creek
806 Seneca-Glass Mountain
807 Owyhee A
808 Owyhee B
809 Timber Butte
810 Reynolds Creek
812 Indian Creek
813 Ebell Creek

\+ indicates accepted source assignment
\- indicates rejected source assignment

TABLE 17

Pilcher Creek used obsidian flakes: attributes and source assignments

Stratum	Registration No.	Cortex [a]	Length (mm)	Width (mm)	Thickness (mm)	Weight (grams)	Gross shape [b]	Angle of used edge	Source Assignment [c]	Illustration No.
1	F-62	2	38	29	5	5.0	6	45	812+	
1	G-488	2	61	39	3	7.0	5	30	812+	
1	G-515	2	38	26	3	2.5	2	30	808-	
-	G-506	2	38	20	4	2.0	6	25	807-	
2	G-522	2	15	10	1	.1	5	35	803-	
2	H-31	2	18	14	3	.3	6	55	812+	
2	H-49	2	21	19	3	.9	5	35	812+	
-	I-48	2	36	26	3	2.7	6	55	813+	
1	J-13	2	54	18	4	3.5	6	15	812+	
-	J-112	2	34	19	3	1.6	6	15	807-	
2	J-123	2	34	31	4	2.8	7	30	812+	
1	L-30	2	51	28	3	3.0	7	45	812+	
1	F-14	2	46	28	7	7.2	4	55	812+	
1	F-30	2	30	28	6	2.4	5	80	812+	
1	F-42	2	34	30	5	2.6	6	105	812+	
1	G-251	2	36	25	3	1.5	4	60	802+	
2	J-100	2	26	16	7	2.9	6	55	812+	
2	K-99	2	47	22	4	3.5	5	65	812-	
2	F-110	2	25	20	2	.3	5	55	807-	
1	G-509	2	29	21	4	1.6	6	50	812+	
2	G-551	2	28	16	4	1.1	6	50	803+	
2	G-291	2	59	30	3	5.4	4	70	812+	
1	G-276	2	32	21	3	1.5	2	40	803-	
1	L-57	2	41	20	4	3.5	6	75	803+	
2	G-517	2	16	14	2	.2	7	65	803+	
1	L-26	2	59	42	5	6.0	7	65	807+	

[a–c] Refer to Table 13 for coding explanation

Stratum 1, while 87 (70%) are from Stratum 2. The stratigraphic proveniences of eight flakes are unknown.

In the analyzed sample pre-dating 6700 BP (Stratum 2), only 12 of the 87 flakes are acceptably assigned to one of the sources included in the analysis. Based on the acceptable assignments, Coyote-Buckboard (50%) was the most frequently used source. Two items each were assigned to Indian Creek, Shumway Ranch, and Owyhee A.

In the analyzed sample post-dating ca. 6700 BP, Indian Creek accounts for 50%, Coyote-Buckboard 33%, and Owyhee A 17% of the acceptably correlated debitage. However, only 6 of the 30 analyzed flakes (30%) could be correlated to one of the sources used in the analysis.

Flaked obsidian artifacts

In contrast to the poorly classified debitage, over 90% of the obsidian artifacts are acceptably matched to one of the sources (Tables 14, 16, 17). Based on the acceptably correlated items, Indian Creek obsidian was most frequently used both before and after 6700 BP for the manufacture of obsidian tools at Pilcher Creek.

Three obsidian bifaces (Fig. 22; Table 16) are included in the analyzed sample; two are correlated to Indian Creek and the source of one is considered unknown at this time because of unacceptable probability estimates. According to these results, Indian Creek obsidian was used both before and after

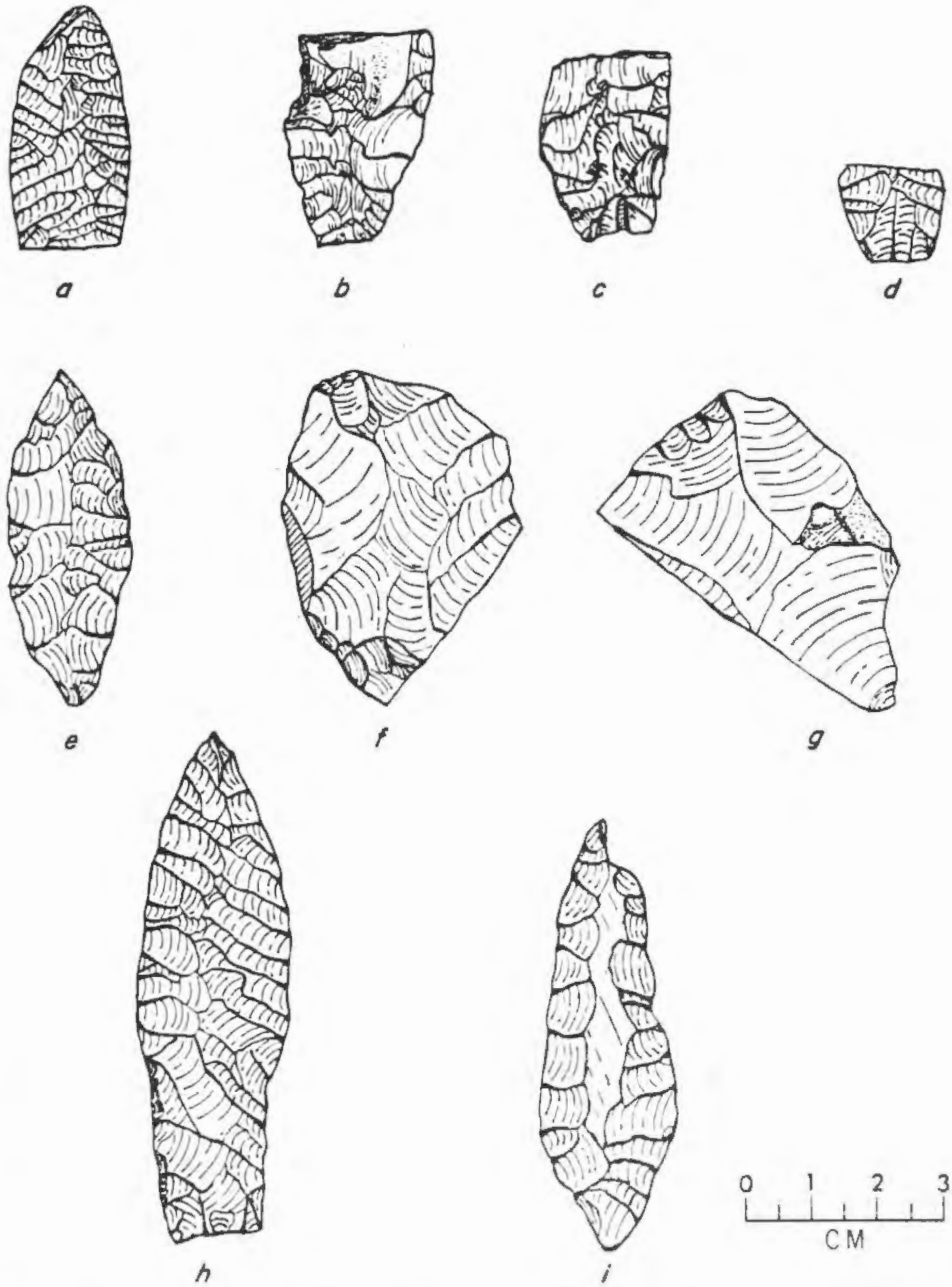

Fig. 22. Flaked obsidian artifacts from Pilcher Creek. a-d, point fragments; e,i, preforms; f,g, bifaces; h, stemmed lanceolate projectile point.

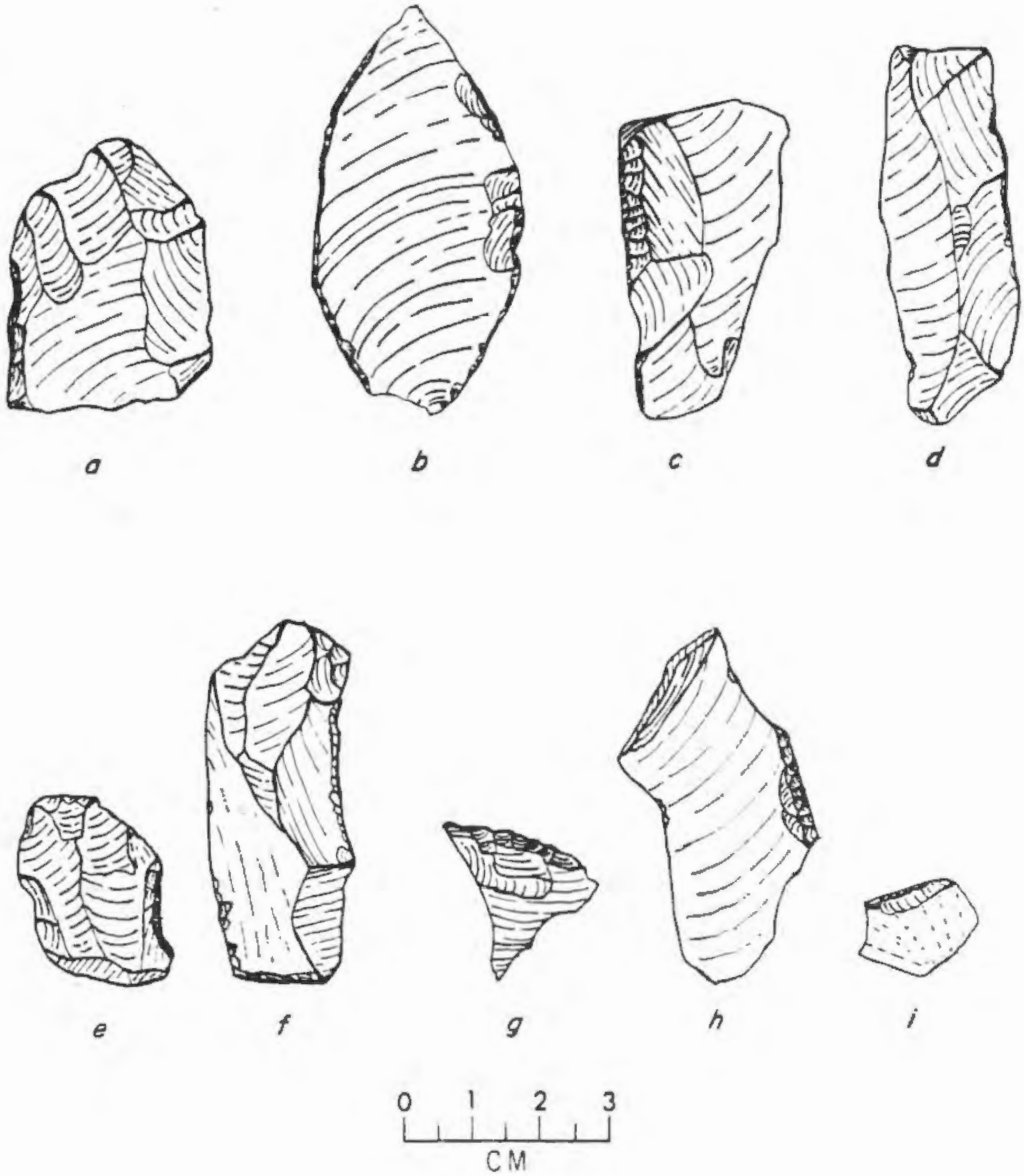

Fig. 23. Used obsidian flakes from Pilcher Creek.

6700 BP for bifaces. Obsidian from Indian Creek was also the most frequently used for projectile point preforms. Of the 13 analyzed preforms, 12 were acceptably assigned to one of the sources. All preforms from Stratum 2 are correlated to the Dooley Mountain vicinity. One was correlated to Ebell Creek and six were correlated to the Indian Creek source. Of the three preforms from Stratum 1, two were assigned to Indian Creek and one was assigned to the Owyhee B source.

Not surprisingly, this apparent pattern of reliance on locally available obsidian for bifaces and projectile point preforms is also exhibited in the analysis of projectile points and point fragments (Table 14).

Correlations of the eight point fragments from stratum 2 to the Indian Creek (87%) and Owyhee B (13%) sources are acceptable. The one complete lanceolate point exhibiting the strong oblique parallel flaking (Fig. 22h) is acceptably assigned to the Indian Creek source.

Used flakes (Table 17; Fig. 23) indicate a slightly more diversified source use, though Indian Creek is still the most frequently used source. Prior to 6700 BP, Indian Creek (N=5,71%) and Coyote-Buckboard are the only sources exploited for useable flakes. After this time, useable flakes were obtained from the Indian Creek (N=8,73%), Shumway Ranch (N=1,9%), Coyote-Buckboard (N=1,9%), and Owyhee A (N=1,9%) sources.

Summary

The results of the artifact analysis strongly suggest that obsidian toolstone procurement at Pilcher Creek both before and after the deposition of Mazama Ash (ca. 6700 BP) was intensely focused on the Indian Creek obsidian source. The probability estimates indicate that Indian Creek accounts for 75% of the bifaces, 73% of the projectile point preforms, 75% of the projectile point fragments, and 72% of the used flakes. Additionally, one large lanceolate projectile point and a flake scraper are assigned to Indian Creek. Assignments to other sources include one projectile point preform to Ebell Creek, and used flakes correlated to Coyote-Buckboard (N=3), Owyhee A (N=1), and Shumway Ranch (N=1).

Discussion: Uncorrelated Debitage

Of the 137 items in the Marshmeadow debitage sample, only 49 (36%) could be adequately correlated to one of the sources in the analysis. Similarly, 44% of the debitage sample from Ladd Canyon and only 15% of the debitage from Pilcher Creek is acceptably correlated. On the other hand, 68% of the Marshmeadow artifacts and 90% of the Pilcher Creek artifacts are acceptably correlated.

The reasons for this striking discrepancy are somewhat puzzling. One of the concerns in analyzing a debitage sample is specimen size. Though I did require that flakes be greater than 1 cm in length or width, individual flake lengths or widths were not recorded. Flake weights though, were recorded and as a gross indicator of flake size, I examined the correlation results by weight.

Prior to examining these data (Tables 11, 15), I suspected that the poorly classified cases might be primarily limited to small or light flakes. However, this is not the case. In fact, the Marshmeadow analysis seems to indicate that as flake weight increased, the number of acceptably correlated items decreased. Of the debitage weighing 0.5 grams or less, 10 of 20 flakes (50%) are acceptably correlated according to the probability estimates. Even fewer (22 of 61, 36%) of the debitage weighing 0.6 - 1.0 grams are acceptably assigned to one of the sources used in the analysis and still fewer (11 of 35, 31%) flakes weighing between 1.1 - 2.0 grams are acceptably correlated. Finally, the heaviest flakes, those with weights in excess of 2.0 grams exhibit the poorest classification results of all debitage (6 of 21, 29%).

With the Pilcher Creek debitage, unacceptable matches occur in all weight categories. The Pilcher Creek sample, however contains more small flakes than does the Marshmeadow sample. Still, only 13 of 79 (16%) flakes weighing less than 0.6 grams are acceptably correlated. Flakes weighing between 0.6 and 1.0 grams are correlated in only 4 of 32 (13%) cases. No correlations for flakes weighing between 1.1 and 2.0 grams are acceptable and only 1 of 4 (25%) cases with weights in excess of 2.1 grams are acceptably correlated. Thus, weight or size does not seem to be a controlling variable with the poorly correlated debitage.

There is one possible source of error existing in the Pilcher Creek debitage sample which is not present in the other samples. Several of the flakes in the debitage sample were encrusted with cemented soil particles which could not be removed through normal washing procedures. Such particles may potentially affect the measured intensity readings through the introduction and subsequent measurement of elements foreign to the stone. Presently, the effects of these foreign substances on the analytic results is unknown. Even by excluding such specimens from the analysis, the Pilcher Creek debitage is still very poorly classified.

If it is assumed that this discrepancy is not due to an analytical or procedural error, it would appear that an unknown or known source not included in the analysis may be the cause of these poorly classified items. While the probability estimates [P(G/X)] for group affiliation in many of the rejected cases were above .90, low probability estimates of P(G/X) suggested that these items might belong to source groups not included in the analysis.

After further review of geological research in adjacent areas and a recently published obsidian sourcing study, it appears that there are additional obsidian sources within 40 miles (64 km) of the study area which *might* be the source or sources of the uncorrelated debitage.

Lowry (1968:36) notes that "black vitrophyric obsidian with prominent flow structure" occurs at Castle Rock, in the headwaters of Hunter Creek 40 miles (64 km) south of the study area and on the south and southeast slopes of Ironside Mountain about 21 miles (35 km) south of the study area. At Ironside Mountain, obsidian is "not only very abundant, but in places shows columnar jointing." The Ironside Mountain formation begins on the southeast side with rhyolitic flow breccias and thick vitrophyric obsidian flows (Lowry 1968:35-36). Obsidian has also been collected from the west side of Ironside Mountain (Thayer and Brown 1964:493).

Another reported source for which the University of Idaho has no source standards is Sugarloaf Butte (Nelson 1984:53). This source is located approximately 30 miles (50 km) southeast of the Dooley Mountain vicinity. Certainly, additional collection of these souces would be a neccessary step to determine the source affiliation for these uncorrelated debitage specimens. Since these sources are located closer to the sites being investigated than all other sources with the exception of the Dooley Mountain sources, further analysis may help clarify the uncorrelated debitage and amend the results obtained in this study.

An alternative explanation for the uncorrelated debitage is that these cases are in fact members of one of the groups included in the analysis, but the discriminating variables which may be powerful enough to discriminate those cases situated near the group centroids are too weak to classify

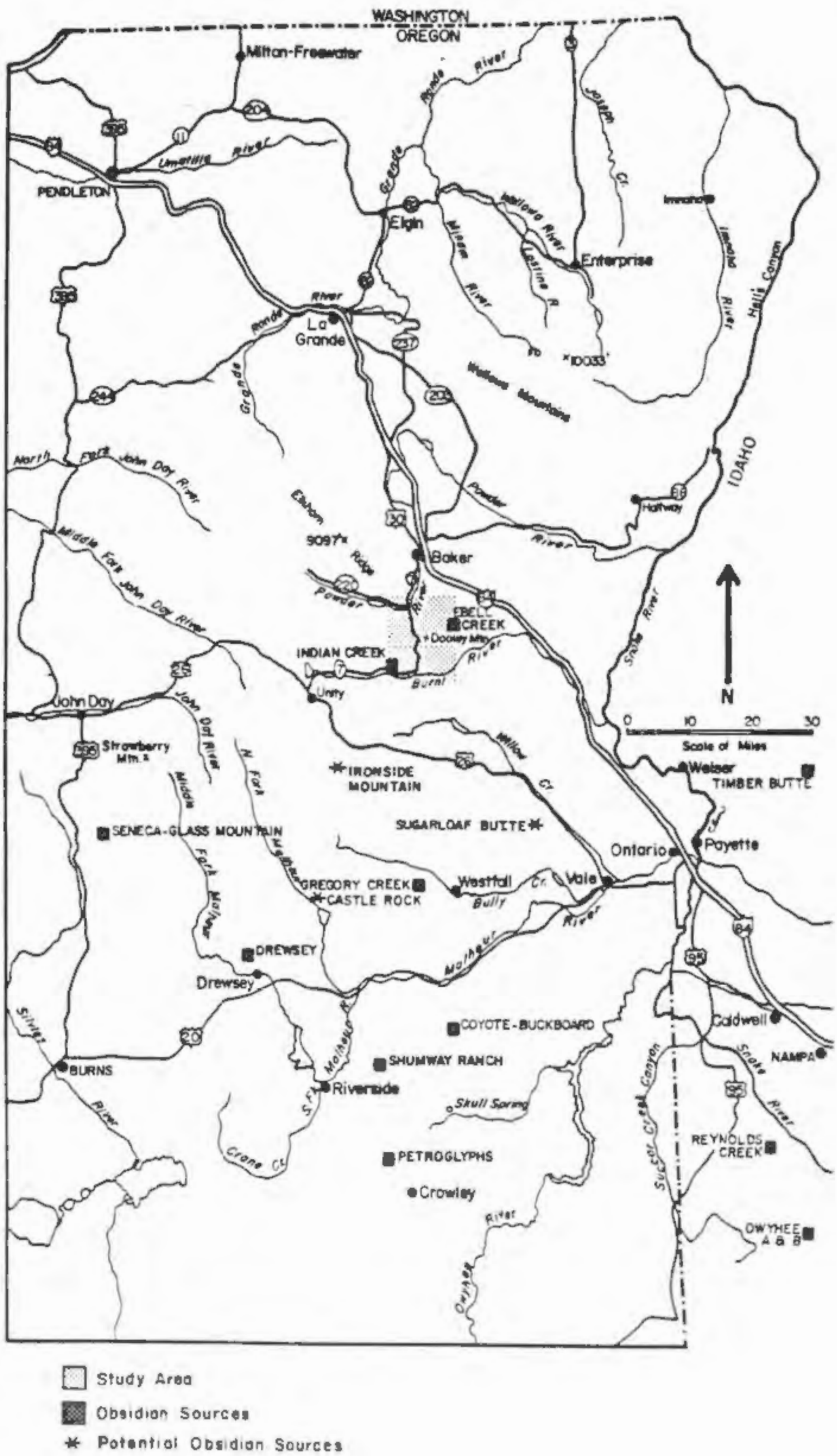

Fig. 24. Map of reported obsidian sources.

cases lying further away from the group centroids. This could potentially account for the large number of P(X/G) probability estimates recorded among the debitage samples.

Another possible explanation is that the acceptance criteria employed in this study is too restrictive, and that some items actually belong to the group to which they were assigned. In the analysis of the included test case, most (80%) of the debitage is correctly classified. However, in the application of the acceptance-rejection criteria applied in this study to the Indian Creek test case, some weakly, but correctly classified items were rejected (Table 5). While this approach allowed cases to be accepted with more confidence, it nevertheless excluded some correct classifications.

Although some possible explanations for the discrepancy have been discussed, the large number of analytic and specimen variables involved in non-destructive X-ray fluorescence analysis makes it extremely difficult to isolate the variable or variables responsible for the rather poorly classified debitage.

IV. CONCLUSIONS

The central objective of this work has been to place aboriginal use of the Dooley Mountain obsidian sources in a chronological framework. I believe this objective has been accomplished.

The analysis of obsidian source specimens by non-destructive x-ray fluorescence analysis indicates that obsidian from two local sources, Ebell Creek and Indian Creek are present in the study area. Though personal reconnaissance and chemical analysis has partially defined the spatial occurrences of obsidian from these two sources, the precise physical limits of these sources are unknown.

Employing economic and anthropological spatial theory, this study assumed that the aboriginal inhabitants of northeast Oregon made rational economic decisions by relying on local obsidian sources to minimize travel and effort. This central assumption provided a working basis for the selection of archaeological data.

Importantly, the Dooley Mountain sources were the closest known obsidian occurrences to all of these sites. Based on stratigraphic horizon markers, age determinations of carbon samples from these sites and through stylistic comparison of projectile points from well dated contexts in both the Great Basin and southern Plateau, the analyzed data encompass a period of prehistory from the first known occupation of the southern Columbia Plateau and northern Great Basin until the historic period. Accordingly, these were judged to be appropriate data for investigating the aboriginal use of the Dooley Mountain sources from a diachronic perspective.

This study also assumed that the methods used to analyze these data would be adequate to discriminate the source groups and classify artifacts of unknown source affiliation. Though the correlations for artifacts of unknown source affiliation can not be determined absolutely, results of the test case and of the classifications of known source groups indicated that approximately 80% of these items are correctly classified.

Chronology

The analysis suggests that Dooley Mountain obsidian, particularly the Indian Creek source, has served a source of toolstone for aboriginal people from as early as 8000-10,000 BP until historic times. To facilitate discussion of the data, the aboriginal use of these sources is divided into five chronologic periods ranging from 10,000-8000 BP; 8000-5000 BP; 5000-3400 BP; 3400 to 1300 BP; and 1300 to 100 BP. These temporal units are used solely as a means of integrating the diverse data used in this study. Consequently, there is some slight overlap between the periods which are based on both stratigraphic correlations from sites in the LaGrande area and on regional projectile point typologies.

10,000-8000 BP

Obsidian artifacts from pre-Mazama Ash sediments at the Pilcher Creek site and projectile points from sites in the Wallowa Whitman Forest which are stylistically similar to projectile points from Windust phase components in the lower Snake River were analyzed and correlated to the Indian Creek source. These artifacts provide evidence for the first documented use of the Indian Creek source and the upper Burnt River region. The results of the discriminant analysis suggest that the people using Pilcher Creek prior to ca. 8000 BP relied on the Indian Creek area as a source of raw material for obsidian bifaces, projectile points and useable flakes.

In conjunction with the few thinning flakes which were correlated to the Indian Creek source, the correlated artifacts indicate that most obsidian from this source was probably reduced into easily transportable forms at or near the source. Once these items arrived at Pilcher Creek, they may have been knapped into preforms and finished artifacts. Alternatively, small nodules may have been transported to Pilcher Creek and then reduced there. Whether produced at the source or at Pilcher Creek, flakes derived from the reduction of obsidian were not discarded, but were put to use in various cutting and scraping tasks.

Windust-like projectile points from upland sites in the Wallowa Whitman National Forest suggest that the flintknappers responsible for their manufacture were also familiar with the Indian Creek area as a source of obsidian for stone tools. Though the sample size is small, over 80% of the projectile points were correlated to the Indian Creek source. Approximately the same percentage of large lanceolate projectile point fragments which also may be associated with this period were assigned to Indian Creek.

In summary, the lithic assemblage from Pilcher Creek and the analysis of Windust-like obsidian projectile points from sites in the Blue Mountains suggest that the flintknappers of this period relied to a significant degree on locally available toolstone. Over 90% of the pre-Mazama Pilcher Creek lithic assemblage consists of local basalt (Brauner, Satler, and Havercroft 1983: Fig.12). The small sample of obsidian artifacts which has been analyzed in this study indicates that the closest source of naturally occurring obsidian was also the most frequently used.

8000-5000 BP

Artifacts from the period between 8000 and 5000 BP are not well represented in the analyzed data. Two large side-notched projectile points from the Wallowa Whitman sample and a few flakes from the Marshmeadow site constitute the only items correlated to Indian Creek.

This period corresponds to the Cascade phase of the lower Snake River canyon. In general, lithic assemblages during the Cascade phase are predominantly of andesite or basalt (Leonhardy and Rice 1970:9). Womack (1977:74) observed that obsidian debitage from the Stockhoff Basalt Quarry exhibited "technomorphological attributes . . . . which were either produced by inexperienced flintknappers or knappers unfamiliar with obsidian." Platform remnants showed signs of repeated battering and pronounced bulbs of force indicated flake detachment was done with excessive force. In short, the basalt oriented technology practiced at the Stockhoff site was probably poorly suited to the more vitreous obsidian (Womack 1977:74). Though the sample size is small, the results indicate some use of the Indian Creek source at this time.

Clearly, the sample from the Marshmeadow site with its easy access to abundant fine-grained basalt is a poor indicator of use of the Dooley Mountain obsidian during this period. But the relatively few artifacts from rather extensive surveys of the Wallowa Whitman Forest has produced only limited evidence for use of the obsidian sources at this time.

5000-3400 BP

Use of the study area after 5000 BP and before 3400 BP is generally well represented by the correlation of large square-shouldered, corner-notched with notched bases, and side to corner notched projectile points from the Wallowa Whitman sample which were correlated to the Dooley Mountain sources, primarily Indian Creek. Projectile points from this period are most similar to projectile points found in Great Basin. This tends to indicate either use of the study area by Great Basin people and/or contact with them.

Archaeological data from Marshmeadow suggest strong Great Basin influences after about 4000 BP (McPherson and others 1981). Though the analyzed obsidian from Marshmeadow during this period is limited, the acceptably correlated items to Indian Creek include secondary, thinning, and primary reduction flakes suggesting both maintenance and manufacture of existing tools and the manufacture of tools from partially reduced forms. Projectile points collected from surface contexts at sites within the study area indicate that the study area was being occupied, possibly on a seasonal basis during this period.

3400-1300 BP

This period is represented by small concave-base lanceolate, corner-notched, large corner-notched, and large triangular and stemmed projectile points in the Wallowa Whitman sample and artifacts and debitage from the Marshmeadow sites from radiocarbon dated strata 5 and 6.

Projectile points from this period are better represented than those from other time periods. The dominant projectile point styles are very similar to those included within the Elko Series in the Great Basin. The source correlations indicate that a fairly broad spectrum of sources were being used at this time, including the first well-indicated use of Timber Butte to the east. Approximately half of the artifacts in this sample including Humboldt Concave Base points and some points similar to those found during the Harder phase on the Columbia Plateau are manufactured from Indian Creek obsidian suggesting fairly frequent use of the source by the knappers occupying the area at this time. In general, projectile points from this time period have been the most frequently collected point type from the study area.

Because there are so few available data for the study area, it is unknown if the larger sample from this period reflects increased human activity. This period corresponds to apparent shifts in aboriginal settlement, especially in the southern Plateau. While semi-sedentary villages occur prior to 4000 BP in both the Great Basin (O'Connell 1975:33) and the southern Plateau (Brauner 1976:318), by 3000 to 2700 BP pit house clusters become quite common in the Plateau (Ames and Marshall 1980:35). One archaeological survey (Womack 1977a) along a small tributary in the study area has noted depressions similar to pit houses found in the southern Plateau, but these have not been excavated.

Ames and Marshall (1980) have hypothesized that an intensification of spatially and temporally restricted root crops may partly account for this change in the Plateau settlement pattern. Archaeological data from the Marshmeadow site indicate that root crops were probably used much more frequently after about 4000 BP. Though the data are very limited, the available evidence from archaeological surveys in the study area suggest that upland spring sites were being used as camps at this time. Isolated finds of corner-notched projectile points also indicate that hunting activities were being carried out in the study area during this period as well.

Speculatively speaking, it is possible that with a return to modern climatic conditions, root crops (camas in the Burnt and Powder river floodplains and lomatiums in the foothills and upper slopes) began to play an increasingly important role in the subsistence patterns of people exploiting the study area. Occupation of the area on a annual basis might have indeed been possible during this period.

1300-100 BP

Continued use of the Dooley Mountain obsidian from 1300 BP to historic times is indicated by the correlation of small side-notched, small basal-notched, and small stemmed projectile points in the Wallowa Whitman sample and debitage and tools in the Marshmeadow and Ladd Canyon samples to the Indian Creek and Ebell Creek sources. As in the preceding periods, obsidian from the Indian Creek source is generally the most frequently used source of those analyzed.

Artifacts recovered from the study area are predominantly manufactured from the local Indian Creek material. Many of the projectile points from this period were collected from spring sites, small tributary streams and as isolated artifacts within the study area. Sites located at springs are suggestive of upland base camps while the isolated artifacts indicate that faunal resources in the study area were also sought by aboriginal hunters during this period.

Synthesis

The data gained through analysis of archaeological artifacts from the Pilcher Creek, Marshmeadow, and Ladd Canyon sites suggest that the aboriginal inhabitants of these sites made rational econommic decisions by relying on the locally available Dooley Mountain obsidian to minimize travel and effort. During the earliest known period of use from approximately 8000 to 10,000 years ago this certainly seems to be the case with over 80% of the correlated artifact sample being correlated to the Indian Creek source.

Data are lacking for the period between 8000 and 5000 years ago and the reasons for this apparent deficiency are unknown at this time. After 5000 BP, use of the Indian Creek source again resumed, but based on the data from the Marshmeadow site and from the sample of temporally diagnostic projectile points from upland sites in the Blue Mountains of northeast Oregon, obsidian source use was more diversified than in the preceding periods. After 5000 BP obsidian was procured from sources in the Malheur and Owyhee river region in southeast Oregon and southwest Idaho. Timber Butte obsidian is recorded only in contexts after approximately 3800 BP. While the Indian Creek source is still the most frequently used source of those analyzed, roughly 50-65% of the analyzed sample from after 5000 BP is from sources other than the local Dooley Mountain obsidian. This may correspond to the development of networks with trading partners to the south or more mobile settlement systems.

One unexpected result of this study was the high percentage of uncorrelated items in the debitage sample. Under a model of least-cost procurement, it was expected that the largest percentage of debitage would be derived from the local source. However, the analysis suggests that these items might belong to unknown or untested sources. Further research into this anomaly revealed the presence of at least three untested sources within less than 40 miles (64 km) of the study area. Although these sources may possibly account for the poorly classified debitage, this hypothesis was not tested.

It is difficult to imagine that aboriginal activities in the study area were solely limited to procurement of obsidian toolstone. The study area is situated in a diverse environmental regime which supports a wide array of animal and plant resources. Mountain sheep, antelope, deer, elk, and rabbits inhabit or have inhabited the study area in the past. It is unlikely that these potential food resources or the anadramous and perennial fish resouces of the Burnt and Powder rivers and their tributaries were overlooked. Root crops such as biscuitroot in the foothills and upper elevations and camas along the floodplains were undoubtedly gathered when they became seasonally available. Furthermore, it is quite likely that these resources provided the primary incentive for aboriginal people to use the upper Burnt and upper Powder rivers. The addition of a highly isotropic toolstone such as obsidian undoubtedly complimented this diverse natural environment by providing a material which could be used to procure and process the animal and plant resources of the area.

Clearly, this study represents only a beginning to archaeological research of the Dooley Mountain obsidian. Analysis was largely limited to artifacts from sites outside of the study area. To date, no systematic excavation of quarries or workshops within the study area has been conducted, nor has any technological analysis of Dooley Mountain obsidian assemblages been attempted.

This work represents a limited study of a lithic resource which until the last decade was archaeologically unknown. The data gained in the analysis of archaeological collections from sites in the adjacent area have allowed the Dooley Mountain obsidian sources to be placed within a chronological framework. Consequently, this research should be a contribution to the essentially unknown prehistory of the region which will serve as an aid to future research in the upper Burnt and upper Powder river areas.

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