# CHAPTER 10

## New Perspectives on the Stockhoff Quarry: Toolstone Procurement at a Quarry Complex in the Blue Mountains of Northeastern Oregon

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### Introduction

The term “Stockhoff basalt” is familiar to many archaeologists who work in the Pacific Northwest. One of the largest recorded archaeological sites in Oregon, the Stockhoff Quarry site (35UN52) encompasses over 3,400 acres of land on the western flank of Craig Mountain, located about 16 km southeast of La Grande in Union County (Figures 10-1 and 10-2). The Stockhoff Quarry is named for Gene Stockhoff, who owned the land in 1955 when Alan Bryan and Donald Tuohy initiated the first archaeological investigations at the site. Working in advance of construction of a natural gas pipeline, Bryan and Tuohy (1960:489-490) conducted limited testing within the pipeline right-of-way, where they found stone tools and hundreds of flakes of “fine-grained glassy basalt.” The dark gray to black, fine-grained volcanic (FGV) toolstone local to the Craig Mountain vicinity has since been known colloquially as “Stockhoff basalt” for ease of reference, even as our knowledge of the compositional variability of FGV materials in archaeological contexts has increased over the last two decades (e.g., Bakewell 1993, 1996, 2005; Bakewell and Irving 1994). Accordingly, terms such as “FGV” and “vitrophyre,” which have been proposed as alternatives to the catchall term “basalt,” will be used here for the sake of accuracy.

In 2009 and 2010, archaeologists employed by Archaeological Investigations Northwest, Inc.

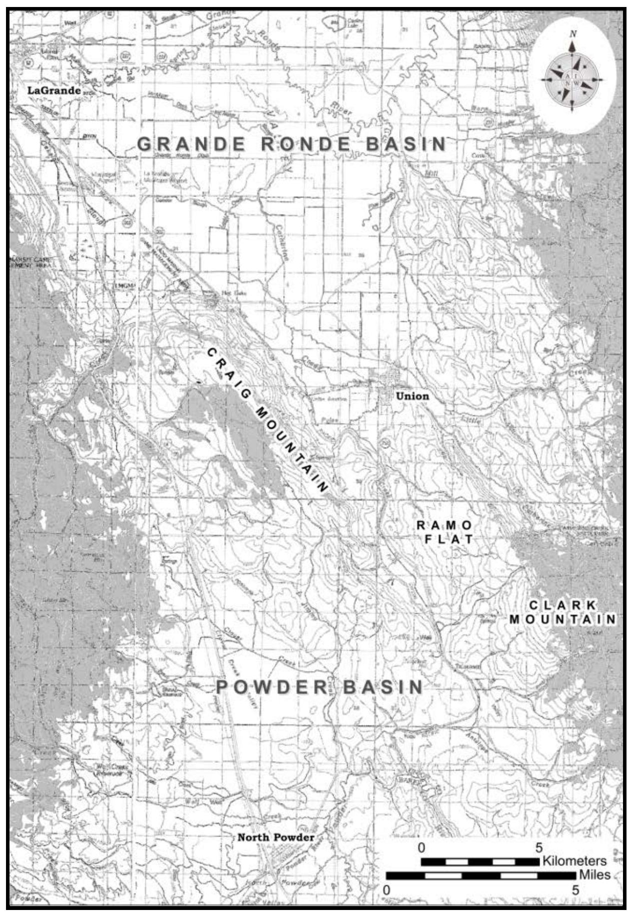


**Figure 10-1. General study area showing Craig Mountain in relation to prominent features of the surrounding landscape.**

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(AINW), assisted by members of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Cultural Resources Protection Program (CRPP), surveyed over 11,000 acres of private land on Craig Mountain and nearby landforms, including over 530 acres within the recorded boundary of site 35UN52. In this unique geological setting, outcrops of igneous rock range in composition from basalt to andesite to dacite and variations in between, and among them are vitrophyric toolstone sources that attracted native people for millennia (Figures 10-1 and 10-2). Excluding the Stockhoff Quarry site itself, more than 218 pre-contact archaeological resources were identified during the survey, including 28 quarry sites, 81 lithic scatters, and 109 isolated finds, as well as numerous stacked rock feature sites (Davis et al. 2010; Smits et al. 2009). Based on the survey results, it is clear that the Stockhoff Quarry site represents only part of a much larger quarry complex consisting of dozens if not hundreds of individual quarry "sites" and lithic reduction workshops across Craig Mountain and surrounding landforms.

Cultural materials were not collected during AINW's survey work, and therefore geochemical and petrographic analyses of FGV artifacts and source samples was not possible for this study. Although much of the toolstone at these sites appears similar to the naked eye, some variability in color, glassiness, and vesticularity is apparent. Fine-grained volcanic materials of various compositions are locally abundant and associated with lava flows of both the Columbia River Basalt Group (CRBG) and the Powder River Volcanic Field (PRVF), which overlap in this area. Recent geologic mapping and geochemical data indicate that Craig Mountain proper is composed primarily of dacitic materials emplaced during middle Miocene flows of the PRVF (Ferns et al. 2010). Pre-contact toolstone procurement on Craig Mountain appears to have been focused on specific sources of dark, glassy FGV material associated with dacitic and andesitic flows of the PRVF (Ferns et al. 2010:14). The chemical diversity inherent in the extrusive PRVF flows, which are more geographically restricted than the extensive and more chemically uniform CRBG flows, suggests that the FGV materials once known as "Stockhoff basalt" may represent toolstone from multiple sources that differ in chemical composition. Limited trace element data from source reference samples collected by previous researchers indicate that some of these toolstone sources on Craig Mountain may be distinguishable from each other.

Technological data based on field observations of lithic tools and debitage are generally consistent with those reported by previous archaeologists at the Stockhoff Quarry (McPherson, Coe, Day, Hall, and McGlone 1981; McPherson, Hall, McGlone, and Nachtwey1981; Womack 1977). Given an abundance of toolstone sources, pre-contact flintknappers appear to have been extremely selective. Quarrying was focused on localized sources of high-quality, glassy FGV toolstone available on Craig Mountain at elevations generally ranging from 985 to 1,460 m above sea level. Tools, debitage, and raw material sources at quarry sites indicate a focus on the removal of large flakes from cobbles and boulders for the purpose of producing bifacial cores and blanks for export. As reported for the Stockhoff Quarry (Womack 1977:7), the abundance of toolstone allowed flintknappers to be both selective and non-conservative, discarding pieces during the reduction process rather than correcting mistakes or working with flaws encountered in the material. The lithic scatter sites located away from quarries represent workshops for creating blanks for export and the occasional production and maintenance of other finished tools.

## Geology and Environment

Located in the Blue Mountains of northeastern Oregon, Craig Mountain is a northwest-trending spur that separates the Grande Ronde River Basin to the north from the Powder River Basin to the south (Figures 10-1 and 10-2). Reaching 1,497 m above sea level at its summit, Craig Mountain towers over the Grande Ronde Valley, its steep northern and eastern faces shaped by faulting and landslides (Ferns et al. 2010:36). The Grande Ronde River drains the valley below as it winds its way northeast toward the border between Washington and Idaho, where it meets the Snake River some 120 km away. Elevations within the Grande Ronde basin vary between 835 and 915 m. The south- and southwest-facing slopes of Craig Mountain are more gentle, composed of undulating terrain that leads gradually down toward the Clover Creek and North Powder valleys, which are drained by tributaries of the Powder River, itself another

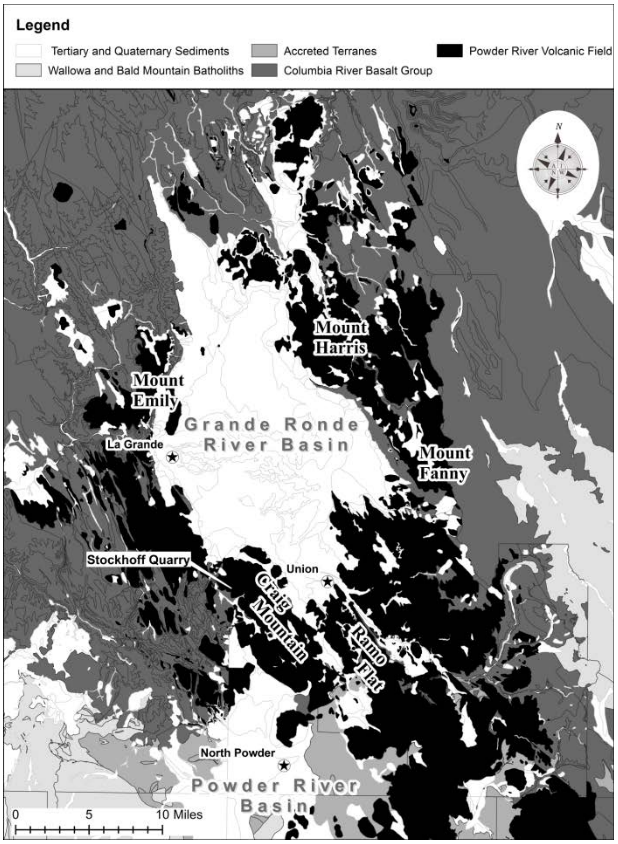


**Figure 10-2. Relief map showing lithology of the Grande Ronde and Powder River basins (after DOGAMI 2009 and Ferns et al. 2010).**

tributary of the Snake River. To the east of Craig Mountain, separated by Pyles Canyon, are the rolling hills of Ramo Flat and the lower slopes of Clark Mountain at the foothills of the Wallowas. To the west and southwest, across Interstate 84, are Glass Hill and Tamarack Mountain, and farther to the south and west are the Elkhorn Mountains, all part of the Blue Mountains.

The Blue Mountains are not a cohesive mountain range but instead comprise a number of smaller ranges that reflect a complex geological history. The basement rocks consist of exotic terranes accreted onto the North American continent as a result of tectonic activity during the Mesozoic era (Orr and Orr 1996:169; Orr et al. 1992:21-27). Portions of two of these terranes, the Wallowa and Baker terranes, are exposed in places within the Grande Ronde and Powder River valleys (Ferns et al. 2010:40). The Clover Creek Greenstone formation, which is Permian or Triassic in age and associated with the Wallowa Terrane, is exposed in road cuts and stream beds, particularly in the Clover Creek Valley south of Craig Mountain (Baldwin 1964:108; Ferns et al. 2010:29,41; Gilluly 1937). During the early Cretaceous, the terranes were cemented together by intrusions of the granitic Wallowa and Bald Mountain batholiths (Ferns et al. 2010:26-27; Orr et al. 1992:28).

In the middle Miocene epoch, starting approximately 17.5 million years ago, a series of vast lava flows known as the Columbia River Basalts erupted from fissures and vents in the earth, covering over 164,000 square km of what is now Oregon, Washington, and western Idaho (Hooper 1982:1464; Tolan et al. 1989:1). The Columbia River Basalt Group (CRBG), as it is known, comprises several formations representing over 300 separate flows distinguished by subtle differences in chemical and mineralogical composition (Barrash et al. 1980; Orr and Orr 1996:292-293). Of these, the most extensive formation is Grande Ronde Basalt, made up of over 120 separate flows that constitute an estimated 90 percent of the overall volume of the CRBG. Andesites and basaltic andesites of the Grande Ronde Basalt formation are exposed on the eastern edge of Craig Mountain and along Ladd Canyon on its western margin (Ferns et al. 2010). The most recent of the CRBG formations are the Wanapum and Saddle Mountain basalts, which are more silica-rich than the earlier formations (Orr and Orr 1996:295). Wanapum Basalt is exposed along the northern margin of the Powder River valley near the southern end of Craig Mountain. In general, the flood basalts of the CRBG are primarily tholeiitic (i.e., iron rich, silica-saturated) basalts, though they range in composition from basalt to basaltic andesite and andesite within the Craig Mountain vicinity (Ferns et al. 2010:17-21; Tolan et al. 2009).

Beginning approximately 14.5 million years ago, as eruptions of the CRBG waned, eruptions of the Powder River Volcanic Field began (Bailey 1990; Ferns et al. 2002:5; Ferns et al. 2010:44). Over the next 12 million years, extrusive PRVF lavas erupted intermittently from small composite and shield volcanoes, burying the older CRBG vents. Ranging in composition from olivine-rich basalt to andesite and dacite to basanite and trachyandesite, PRVF lava flows were more viscous and chemically diverse than CRBG flows (Ferns et al. 2002:5). Flows of PRVF lavas were also more siliceous and were calc-alkaline to alkaline in composition as opposed to tholeiitic basalt flows of the CRBG (Ferns et al. 2010:17, 44-46).

Approximately 13.4 million years ago, dacitic flows of the PRVF began with the eruption of Mount Emily flows along the western margin of the Grande Ronde Valley (Ferns et al. 2010:44). Dacitic and andesitic flows erupted from Mount Harris and Mount Fanny along the eastern margin of the Grande Ronde Valley, and small basaltic andesite cinder cones formed at Ramo Flat. The orientation of the vents at Ramo Flat suggests that fault zones in this vicinity may also have become active as the PRVF volcanism began (Ferns et al. 2010:44-46).

Recent geochemical data and geologic mapping indicate that most of Craig Mountain is composed of dacitic flows of the PRVF (map unit Tpd), described as “light bluish-gray to light pinkish gray, aphyric to sparsely porphyritic lava flows and domes” that outcrop as rounded, bouldery cliffs and platy flows (Ferns et al. 2010:14). In certain places, flows of black, vesicular, glassy, aphyric dacite occur between thicker flows of dacitic material. Also found on Craig Mountain are PRVF flows of andesite and basaltic andesite that “vary from dark gray, very fine to medium grained, porphyritic, vesicular lava flows, to gray, platy jointed, aphyric to light- to medium-gray fine-grained lava flows” (Ferns et al. 2010:13).

As defined by Ferns et al. (2010:13), the andesite and basaltic andesite map unit (Tpa) of the PRVF is primarily andesite but ranges in composition from basaltic andesite to low-silica dacite, and it includes what Barrash et al. (1980:17) described as “glassy basalt” of the Glass Hill sequence. This “Glass Hill basalt” was the material identified by previous researchers as the focus of past quarrying activity at the Stockhoff Quarry (Cochran and Leonhardy 1981:8). To the west of the Stockhoff Quarry, at Glass Hill, are exposures of basanite and trachybasalt (Tpbo), which are dark bluish gray to very dark gray in color, aphanitic to glassy, olivine-phyric rock that Ferns et al. (2010:12) describe as “difficult to break, rings like a bell on impact, and forms conchoidal fractures.” These geochemical data highlight the variety of chemically distinct FGV materials that are present within close proximity to the Stockhoff Quarry site.

Between about 10 and 7 million years ago, regional uplift and warping occurred along the Blue Mountain anticlinorium, accompanied by subsidence of the fault-bounded Grande Ronde Valley (Ferns et al. 2010:40, 46). Folding and faulting continued into the Pleistocene, contributing to the formation of the modern topography (Ferns et al. 2010:30). Craig Mountain itself is surrounded on the west, north, and east by discontinuous fault zones (Ferns et al. 2010:36). The steep northeastern face of Craig Mountain is characterized by massive landslides and steeply tilted, fault-bounded blocks of broken rock.

Quaternary surficial deposits cover the Miocene flows of the CRBG and PRVF throughout much of the study area. To the north of Craig Mountain, the Grande Ronde basin is filled with as much as 600 m of late-Miocene, Pliocene, and Pleistocene sediment (Ferns et al. 2010:2). Across Craig Mountain, Clark Mountain, and Ramo Flat, soils are generally shallow and formed from a mixture of loess, colluvium and residuum derived from basalt and volcanic tuff (Dyksterhuis and High 1985). Lithosols are common, particularly at higher elevations. Deeper soils that formed in a mixture of loess and Pleistocene/Holocene fluvial and lacustrine deposits are present on upland valley floors. At site 35UN52, stratigraphic profiles of excavations conducted near Ladd Creek showed evidence of five major alluvial cycles (aggradation, surface stability, and erosion) since the early Holocene, the last depositional episode occurring around 100 BP (Cochran and Leonhardy 1981:3).

The current semiarid climate of the study area supports steppe vegetation characteristic of the grassland/forest ecotone. Lower elevations are inhabited by sagebrush communities that include perennial bunchgrasses such as bluebunch wheatgrass, Idaho fescue, and sandberg bluegrass (Franklin and Dyrness 1973:219). Higher elevations support Ponderosa pine communities that contain stands of western larch and black hawthorn and an understory of common snowberry, rose, arrowleaf balsamroot, buckwheat, and bitterbrush (Franklin and Dyrness 1973:168-173). Blooms of camas and “death camas” occur in the upland meadows, and riparian vegetation is present along perennial and ephemeral streams. Today, most of Craig Mountain is privately owned; land at higher elevations is used as rangeland for livestock grazing, and lower elevations are cultivated for agricultural crops.

The native vegetation of Craig Mountain would have sustained a variety of small and large mammals, many of which were hunted by native people. Historically, the lower elevations were inhabited by rabbits, squirrels, mice, rats, and gophers, and were common winter ranges for antelope, mountain sheep, and mule deer (Bailey 1936:14-15). The uplands continue to be inhabited by mule deer, elk, chipmunks, and squirrels, as well as a variety of birds including grouse, sparrow, and thrasher (Bailey 1936:23-28). Bison were also present in the past (Csuti et al. 1997:443; Francy n.d.).

## Ethnography and oral history

Craig Mountain is within the ceded lands of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), in an area historically occupied by the Cayuse (*Weyíiletpuu*). The Cayuse occupied the middle and upper courses of the Umatilla, Walla Walla, Powder, and Grande Ronde river basins, while their neighbors to the north were focused on the Columbia River and lower courses of its major tributaries. The Cayuse, who traditionally spoke a distinct language, had close ties and a large degree of social interaction with neighboring groups such as the Nez Perce (*Ni Míi Puu*), Umatilla (*Imatalamláma*), and Walla Walla (*Walúulapam*), who spoke Sahaptin dialects (Kinkade et al. 1998:61-62; Rigsby 1969:73-75; Stern 1998:395; Suphan 1974:101, Walker 1998:420). These groups all used the mountainous upper reaches of major rivers-including the Grande Ronde River valley-during the summer months, often using the same resource locations at the same time (Stern 1998:396-397; Suphan 1974:101; Walker 1998:420). In the historic period, southern Plateau groups including the Cayuse and Nez Perce traveled together by horse across the Rocky Mountains to join communal buffalo hunts and interact with people of the Great Plains (Stern 1998:396).

The Cayuse fished, gathered vegetable resources such as roots, berries, and medicinal plants, and hunted on a seasonal round basis. Fish (both anadromous and local) made up approximately 50 percent of their diet, plants another 25 to 40 percent, and game the remaining 10 to 25 percent (Steinmetz 2003:8). Winter months were spent along the major rivers at lower elevations. Subsistence during the winter was focused on stored roots and bulbs, dried fish and game, and some fresh meat. In April, the first plant roots of the season, cous (biscuit root) followed by camas, became available at lower elevations. These roots were supplemented by spring chinook salmon caught in nearby rivers. Roots at lower elevations were available until roughly mid-July (Stern 1998:396-400, Suphan 1974:100, 112).

As vegetable resources became available at higher elevations, smaller (often family) groups moved to the uplands where the summer was spent fishing, hunting, and gathering plants (Stern 1998:397,400; Suphan 1974:113). Foodstuffs were dried and cached, to be collected on the return trip to winter villages. The Cayuse typically moved to the Grande Ronde Valley in late June. In mid-August, groups in the Grande Ronde Valley moved higher into the Blue Mountains for more intensive hunting, often using fire to drive game in communal hunts. Plants such as bitterroot, cous, chokecherry, wild onion, celery, and balsamroot, along with a number of species of fish and game, continue to be culturally significant “first foods” for members of the CTUIR (Anastasio 1972:119; Quaempts et al. 2007).

Oral histories on file with the CTUIR indicate that permanent villages were located in the nearby Grande Ronde Valley (Steinmetz 2002:4). Early non-Indian visitors to the area reported villages of a dozen lodges or drying sheds near fisheries on the Grande Ronde River (Stern 1998). These settlements were likely smaller than those on the major rivers during the winter, and possibly reflecting this, Suphan (1974) reports no villages in the Grande Ronde Valley, only resource locations. Ethnographic information regarding the wide variety and abundance of plant and animal resources available on Craig Mountain and in the adjacent valleys indicates that procurement of toolstone, although important, was one of many reasons for native people to visit these uplands as part of their seasonal round.

## Previous archaeology

The Blue Mountains are considered part of the southern Plateau, for which numerous cultural chronologies have been developed (e.g., Ames et al. 1998; Chatters 1989; Chatters and Pokotylo 1998; Leonhardy and Rice 1970). The Blue Mountains are also at the periphery of the northern Great Basin and have been characterized as a frontier zone where pre-contact cultural interactions occurred between Plateau and Great Basin groups (Brauner 1976; McPherson, Hall, McGlone, and Nachtwey 1981:713-720). In his study of linguistic relations on the southern Plateau, Rigsby (1965) argues that the Cayuse moved into this upland area within the last 2,500 years in response to migrations of Chinookan-speaking and Sahaptin-speaking populations along the Columbia and Snake Rivers.

A summary of previous archaeological investigations at the Stockhoff Quarry is presented below. The boundary of site 35UN52 encompasses over 3,400 acres across the western slopes of Craig Mountain, and it includes areas where raw material was procured for toolstone as well as workshop areas where the stone was further reduced and made into tools, among other activities. For the most part, previous archaeological investigations at site 35UN52 have focused on a relatively narrow corridor adjacent to Ladd Canyon and Interstate 84, where pipelines and transmission lines have been constructed through the area.

Although not part of this study, other FGV toolstone quarry sites are known to exist nearby. The closest recorded example is the Union Golf Course Basalt Quarry Site (35UN250), located at the north end of Ramo Flat near the city of Union (Jaehnig 1997). Major workshops in the vicinity include Marshmeadow and Ladd Canyon (Jaehnig et al. 1996; Reed and Reed 1980; McPherson, Hall, McGlone, and Nachtwey 1981), Ladd Marsh (Ogle et al. 2006; Steinmetz 2002), and Pilcher Creek (Brauner 1985). Also nearby are stratified archaeological deposits and pictographs at Pagliarulo Rockshelter (Mead 1975) and a late pre-contact bison kill site known locally as “the Buffalo Jump” (Francy n.d.), both located outside of the city of Union. “Basalt” tools and debitage were reported at all of these nearby sites.

*Bryan and Tuohy (1960)*

The “Stockhoff Basalt Quarry” was identified in the mid-1950s by Bryan and Tuohy (1960), who excavated eight 1-x-1-m test units within the right-of-way for a natural gas pipeline. In total, Bryan and Tuohy (1960:489) found 165 tools and “hundreds” of flakes on the ground surface and in shallow, widely dispersed archaeological deposits. The tools were described as projectile points, cores, blanks, bifaces, scrapers, and choppers, and all of the artifacts were “fine-grained glassy basalt” with the exception of a few obsidian flakes and one flake of jasper. A sample of charcoal from one of excavation units yielded a radiocarbon date of 2600±200 years BP. Bryan and Tuohy (1960:489-490) also identified a possible “habitation mound” within the site on the west side of what is now Interstate 84, which runs through Ladd Canyon.

Bryan and Tuohy (1960:487,490) noted that quarrying activity was focused on rounded nodules and tabular slabs of the fine-grained glassy material, which they described as occurring “in a layer of elongated oval to flat cobbles.” The vesicular texture of the quarry material indicated to them that it was from the surface of a flow, and it was visually distinct in comparison to adjacent basalt flows, which were of different textures and contained macroscopic minerals. Petrographic analysis by Andrei Isotoff, then a geology professor at Idaho State University, indicated that “the glassy groundmass is composed of microlites of sodic labradorite showing trachytoid texture, and a few phenocrysts of augite are seen in the section” (Bryan and Tuohy 1960:490).

All of the tools (n=165) in Byran and Tuohy’s (1960:490-500) assemblage were percussion flaked. No evidence of pressure flaking was observed on the debitage or tools of FGV material, although evidence of pressure flaking was observed on the few obsidian artifacts at the site. Artifacts of FGV material from Bryan and Tuohy’s (1960:490-500) excavations were classified primarily by form and secondarily by bifacial or unifacial reduction technology. Large bifaces, which they called “blades” and “blade blanks,” were large ovate or leaf-shaped specimens that made up over 44 percent (n=73) of the assemblage. Only two of these were categorized as finished “blades,” the rest were unfinished “blade blanks.” Also of note was a lack of hammerstones at the site.

Photographs of the artifacts described by Bryan and Tuohy (1960:Figures 3 and 4) suggest that the tools classified as projectile points were likely bifacially and unifacially reduced blanks in a later stage of reduction than the larger “blade blanks” they identified. The projectile points also appear to be quite thick, with large flakes removed by percussion and little evidence of the finish-work to complete this type of tool. This is not to say that a projectile point must be finished using pressure flaking (Bucy 1971:14), rather that the artifact photographs presented by Bryan and Tuohy (1960) do not exhibit the expected attributes of finished points. Bryan and Tuohy (160:491) do caution that some of the unifacially reduced projectile points may represent unfinished forms.

A comparison of their data from the Stockhoff Quarry with those from other quarry sites on the Columbia Plateau, Great Basin, and elsewhere in North America led Bryan and Tuohy (1960:506) to conclude that the primary activity at this site was the initial reduction of stone material and the manufacture of expedient tools to be used on site. Importantly, Bryan and Tuohy (1960:506) argued that pre-contact flintknappers at the Stockhoff Quarry were not producing bifacial blades and blanks primarily for export, but were instead utilizing flakes from the initial reduction of raw material for the production of a wide variety of expedient tools. They acknowledged the possibility, however, that "at least some of the large bifaces were exported in their 'unfinished' state for use as heavy-duty multi-purpose tools," and that the large numbers of "unfinished specimens" at the Stockhoff Quarry could be interpreted as "blanks" and "rejects" (Byran and Tuohy 1960:506,509 citing Holmes 1919).

*Womack (1977)*

In 1975, Eastern Oregon State College began excavations at the "habitation mound" at site 35UN52, which turned out to be a 20th century refuse deposit (Womack 1977:3). Controlled surface collections and test excavations were then conducted at the site on the east side of Interstate 84, yielding over 670 tools and 3,900 flakes of FGV material (Womack 1977:v). Ten 3-x-3-m units were excavated on an ancestral floodplain of Ladd Creek, where relatively deep archaeological deposits were encountered. Stone tool types attributed to the Cascade Phase (8000 to 4500 BP) were found above and below a deposit of Mazama tephra. Based on a lack of tool types post-dating the Cold Springs Phase (6000 to 4000 BP), Womack (1977:145) argued that the quarry site was used as a source of toolstone by 8000 BP and no later than 4000 BP.

According to Peter Hooper, then chair of the Geology Department at Washington State University, the FGV material at the Stockhoff Quarry was "probably an andesite" emplaced during a localized eruption of "andesitic lavas occurring at the same time that the more common Columbia River basalts were extruded" (Womack 1977:15). Womack (1977:15) noted that the fine-grained material used as toolstone occurred as "cobbles from both colluvial and lag deposits [that] are generally tabular and only moderately rounded." Acknowledging that the material was probably not basalt in composition, Womack (1977:16) used the term "basalt" for the sake of continuity with earlier researchers.

Based on technological analysis of artifacts and replication experiments, Womack (1977:27) defined the stages of a biface reduction system for the Stockhoff Quarry site. Womack's sequential stages of biface manufacture consist of 1) removing the cortex from a flake or cobble, 2) thinning the artifact, 3) forming the final outline of the artifact, and 4) finishing the edge and hafting element (if present). Womack (1977:59) also defined five categories of debitage associated with biface manufacture, consisting of decortication flakes, thinning flakes, biface thinning flakes, multiple removal flakes, and non-diagnostic shatter.

Of the 671 tools analyzed by Womack, 77 percent (n=520) were bifaces or biface fragments, and variation among these bifaces was interpreted to represent the sequential stages of biface manufacture (Womack 1977:5, 28). Analysis of the debitage supported Womack's conclusion that the primary function of the quarry site was the production of bifaces for export. Womack (1977:146) also noted that in the vicinity of raw material sources, biface blanks and debitage were indicative of initial reduction and earlier stages of biface manufacture, whereas the terraces located a short distance from toolstone sources were used as workshop areas for further reduction and/or manufacture of formed tools. Many of the artifacts observed by Womack (1977:7) were considered to be "rejects," meaning they were broken during manufacture or had a flaw and were discarded.

Womack observed very little evidence of core preparation and thought this could be explained by the overwhelming abundance of raw material at the Stockhoff Quarry. If a pre-contact flintknapper found a flaw in the stone or made a mistake, little effort would have been spent trying to correct it. Instead, the piece would have been discarded in favor of a new one. Many of the boulders also exhibited flake scars and evidence of battering consistent with the “block on block” technique, whereby large flakes are produced by striking the platform of a cobble or boulder against an anvil. Womack (1977:32) concluded that the main function of the Stockhoff Quarry was the production of bifaces from large, relatively thick flakes taken off of source materials, and that later stages of reduction to complete formed tools would have been done at workshops away from the quarry locations.

*Western Cultural Resource Management, Inc. (1980)*

In 1980, Western Cultural Resource Management, Inc. (WCRM), conducted surveys, testing, and data recovery excavations for the Pan Alberta Natural Gas Pipeline project, focusing on proposed impacts to the Stockhoff Quarry (35UN52), Ladd Canyon (35UN74), and Marshmeadow (35UN95) sites (McPherson 1980; McPherson, Coe, Day, Hall, and McGlone 1981; McPherson, Hall, McGlone, and Nachtwey 1981; Reed 1980; Reed and Reed 1980). An extensive survey was conducted to determine the areal extent of site 35UN52, and the resulting boundary was defined based on the distribution of surface artifacts as well as topographic extrapolation (Johnson et al. 1980:2; Reed 1980). This larger site boundary encompasses over 3,400 acres and includes nine defined artifact concentrations, the largest of which completely encompasses the area where Womack (1977) conducted his earlier fieldwork. The site was also found to contain an historic component that included two extant buildings, three collapsed structures, two corrals, and a segment of the Oregon Trail (Reed 1980).

As part of the testing regime, WCRM excavated ten backhoe trenches adjacent to the pipeline corridor and in areas of alluvial and colluvial deposition between the pipeline and Interstate 84 (McPherson 1980:Map 3). The areas where trenching occurred were divided into three topographic zones consisting of the hilltop, hillside, and valley bottom zones (McPherson 1980:11). Subsequent data recovery excavations at site 35UN52 consisted of 32 excavation units (measuring 2x2-meters each) located within and near the pipeline corridor (McPherson, Coe, Day, Hall, and McGlone 1981). The results of testing and data recovery fieldwork indicated that the site was repeatedly occupied between 7660 BP (perhaps as early as 10,700 BP) and the historic period, and that the most intense occupation occurred between 6700 BP and 5800 BP (McPherson, Hall, McGlone, and Nachtwey 1981:713-716). These dates of occupation were based on site stratigraphy, radiocarbon dates from charcoal samples, Mazama tephra deposits, and projectile point typology (Cochran and Leonhardy 1981; McPherson, Coe, Day, Hall, and McGlone 1981; McPherson, Hall, McGlone, and Nachtwey 1981).

According to McPherson, Hall, McGlone, and Nachtwey (1981:713-720), pre- and post-Mazama occupation at site 35UN52 was focused on procurement of toolstone and the production of bifaces for export. They interpreted the presence of flake tools as evidence of limited meat processing at the site prior to the eruption of Mount Mazama ca. 6700 BP. Between 6700 and 5800 BP, an abundance of other tool forms (projectile points, bifaces, cores, scrapers, edge-ground cobbles, flake tools, groundstone, and possible net weights) provided evidence for an array of other activities, including hunting, gathering, and processing of plant and animal foods on a seasonal basis. The site appears to have been occupied to a diminished extent between 5750 and 4000 BP, when activities were more narrowly focused on toolstone procurement, lithic reduction, and animal processing, with no direct evidence of plant processing. Between 4000 and 650 BP, the site continued to be occupied for the purpose of toolstone procurement and biface production with a secondary emphasis on animal butchering and hide processing. During the same period, evidence of plant processing increased at nearby Marshmeadow, where camas processing tools became increasingly specialized after 2200 BP. Based on projectile point types, McPherson, Hall, McGlone, and Nachtwey (1981:718) suggest a temporary shift from southern Plateau to Great Basin cultural affiliation or influence during this period. Between about 650 and 100 BP, toolstone continued to be procured from the Stockhoff Quarry, with little evidence of other activities, which appear to have been shifted to other nearby sites.

An analysis of flaked stone tools and debitage led McPherson, Hall, McGlone, and Nachtwey (1981:713-720) to conclude that lithic procurement and reduction activities at site 35UN52 were focused on the production of bifacial blanks for export, and that the technology used to produce these tools was relatively unchanged over time, although the bifaces produced between about 4000 and 650 BP tended to be smaller in size than the ones produced before 4000 BP. The lack of technological change reflected that "the reduction of basalt in a technomorphologically constant manner through time was the most efficient means of reducing the toolstone…though populations on the site were not necessarily homogenous" (McPherson, Coe, Day, Hall, and McGlone 1981:346). McPherson, Coe, Day, Hall, and McGlone (1981:118-147) also revised Womack's (1977) biface reduction scheme, as they regarded Womack's four stages to be too subjective. Instead, they proposed a quantitative classification system whereby four stages of bifacial reduction were defined based on a measureable "sinuosity index" combined with the method of percussion ("hard hammer," "soft hammer," and "pressure flaking"). In general, McPherson, Hall, McGlone, and Nachtwey (1981:716) found that the Stockhoff Quarry site was primarily a quarrying and tool manufacturing locale that was utilized for at least 10,000 years.

*Other Studies*

Since the early 1980s, site 35UN52 has been revisited by archaeologists for several cultural resource compliance projects (Jaehnig et al. 1996:62; James 2009; Ozbun 1999; Ozbun et al. 2000; Peak and Associates 1989). Most of these projects were narrow, linear corridors for cable, fiber optic, or pipeline alignments that parallel the interstate. None of these projects involved archaeological excavations or analysis of substantial numbers of artifacts.

## Survey methods and results

In 2009 and 2010, archaeologists employed by AINW, assisted by members of the CTUIR CRPP, conducted an archaeological survey of over 11,000 acres of Craig Mountain and surrounding landforms for a proposed wind farm development. The surveyed area was not a single, contiguous study area but rather multiple areas of various sizes connected by linear corridors and access roads. The pedestrian survey was performed by three crews of archaeologists using parallel transects spaced 30 m apart. More closely spaced transects ranging from 5 to 15 m apart were used when artifacts or features were encountered and in areas where archaeological resources were considered likely to be present based on topography or proximity to certain natural resources (e.g., permanent water sources, natural outcrops of FGV material, camas meadows). The pedestrian survey was supplemented by shovel testing in areas of alluvial and colluvial deposition.

The Oregon State Historic Preservation Office defines archaeological sites as "ten or more artifacts (including debitage) likely to have been generated by patterned cultural activity within a surface area reasonable to that activity" (SHPO 2007:9). Archaeological features—with or without associated artifacts—are also considered archaeological sites. In Oregon, archaeological isolates comprise nine or fewer artifacts. Not including the Stockhoff Quarry (35UN52), more than 218 pre-contact archaeological resources were identified during the survey for this project, including 28 quarry sites, 81 lithic scatters, and 109 isolated finds (Davis et al. 2010; Smits et al. 2009). Although some of these sites also contained stack rock features, sites composed solely of individual or multiple rock features are not included in this total.

In the field, the survey crews counted the number of artifacts present at isolates and smaller sites and estimated the numbers of artifacts present at larger sites. Field crews also noted the probable function(s) for each resource and documented the range of tools types and lithic materials represented at each resource based on the attributes of artifacts observed. No cultural materials were collected during the fieldwork, and therefore petrographic and chemical analysis was not possible for this paper. The survey-level data are presented here at a necessarily basic level, and despite their limitations have much information to impart.

Included in the pedestrian survey were over 530 acres within the recorded boundary of site 35UN52. The methods used for surveying land within the Stockhoff Quarry site were the same as the methods

**Figure 10-3. Overview of a quarry site on Craig Mountain. The view is toward the southeast along the main ridgeline of Craig Mountain.**

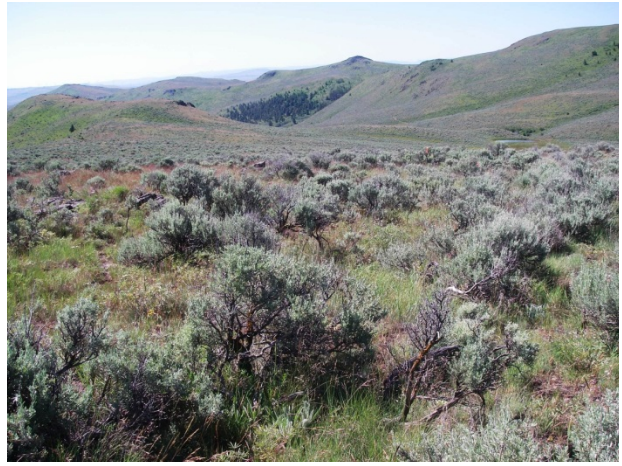

**Figure 10-4. Overview of another quarry site on Craig Mountain. The view is toward the south.**

used for the rest of the project, with the exception that shovel testing was not done within the site boundary per Oregon SHPO guidelines. The survey results indicate that site 35UN52 contains discrete concentrations of surface artifacts or single items separated by large areas of land where no artifacts are present on the surface, similar to the distribution of archaeological sites and isolates across the rest of Craig Mountain.

*Quarry Sites*

The 29 archaeological sites classified as quarries (including site 35UN52) exhibited evidence of lithic procurement focused on geological deposits of FGV material that occur mainly as tabular, sub-rounded to sub-angular cobbles and boulders, and in some locations as bedrock outcrops. Toolstone was procured from primary geological deposits consisting of boulders and cobbles eroded from weathering lava flows as well as bedrock outcrops, and from secondary deposits including colluvial and fluvial deposits. No evidence of mining or subsurface extraction was observed, as boulders and cobbles of high-quality FGV material were exposed on the ground surface (Figure 10-5). Culturally modified and unmodified boulders and cobbles of this raw material were abundant within the quarry sites. These sources of toolstone would have been attractive because of their excellent conchoidal fracture characteristics, sharp and durable edges, and large size. Large-sized lithic raw materials facilitate long use-lives of stone tools by allowing production of oversized tools that could be resharpened and reworked many times. Large initial size as a planned design concept has been identified as a component of pre-contact technological strategies at other toolstone sources in Oregon (Ozbun 1991).

Archaeological quarry sites were identified across Craig Mountain and were concentrated along the northwest-trending spine of the mountain's main ridgeline at elevations greater than 985 m above sea level (Figures 10-3 and 10-4). Less extensive evidence of quarrying was also observed at the northwestern foot of Clark Mountain, just above Ramo Flat. The quarry sites recorded during the survey ranged in size from less than 0.5 acre to over 100 acres, with an average size of about 11 acres. Field estimates of the numbers of artifacts at each site ranged from 22 to over 7,000 artifacts per site, the vast majority of which consisted of FGV debitage. The artifacts were generally sparsely distributed across the ground surface. High-density artifact concentrations were observed near the source material at some but not all of the quarry sites.

Within the recorded boundary of site 35UN52, the distribution of cultural materials observed on the ground surface was similar to the distribution of sites and isolates observed throughout the rest of the 11,000-acre survey area. That is to say that the recorded boundary of the 3,400-acre Stockhoff Quarry includes large areas between artifact concentrations and isolated artifacts where no cultural materials are present on the ground surface. The 530 acres of the Stockhoff Quarry surveyed by

**Figure 10-5. Negative flake scars on boulder of raw material at a quarry site on Craig Mountain.**

AINW, mainly on ridges and slopes where sediments are shallow, stand in contrast to the more well-known portion of the site where dense, stratified archaeological deposits have been the focus of previous research (Cochran and Leonhardy 1981; Womack 1977; McPherson, Hall, McGlone, and Nachtwey 1981). These observations also reflect the way in which the 3,400-acre site boundary was originally recorded using topographic extrapolation (Johnson et al. 1980:2; Reed 1980). Based on the distribution of quarry "sites" identified across Craig Mountain and nearby landforms, it is suggested that the Stockhoff Quarry be considered part of a larger quarry complex.

The quarry "sites" represent locations where FGV materials were procured, assayed for quality,


**Figure 10-7. Negative flake scars on large cobble of raw material at a quarry site on Craig Mountain.**

and systematically reduced to create cores and blanks suitable for export (Figure 10-6). Many of the cobbles are tabular in form and were reduced directly into large bifaces by beveling the angular or square margins. Immovable boulders of raw material frequently displayed large negative flake scars and signs of battering (Figure 10-7). Often, the edges of the boulders did not appear to support the correct angles for removal of flakes with a hammerstone. Step fractures were common in the debitage and on the negative flake scars visible on raw material. These observations are best explained by use of the "block on block" technique described by Womack (1977), whereby large boulders served as either cores or as anvils to strike cores against, or both (Figure 10-8). The large flakes removed from boulders were used to produce large bifaces, which then served as bifacial cores or blanks. Very few finished tool types were observed at the quarry sites—these consisted of a total of two scrapers, one pressure-flaked biface midsection, and some possible flake tools (edge-modified or edge-damaged flakes).

Tools classified as bifaces and bifacial blanks had flakes removed from two opposing sides, typically around the margin of the piece, by percussion flaking (as opposed to pressure-flaking). Incomplete reduction of "rejected" bifaces or blanks appeared to have been the result of breakage or other manufacturing errors; however, many bifaces recorded during the fieldwork appeared complete. Bifaces observed within the quarry sites tended to be large (between 10 and 20 cm in length)

**Figure 10-8. Negative flake scars on boulder of raw material showing evidence of “block on block” technique.**

with long flake scars extending towards the center of the artifact (Figures 10-9 and 10-10). The large bifaces appear to be similar to the bifacial blanks described by Womack (1977) and might have been more easily transported than multidirectional cores or other core forms. Primary geologic cortex was present on many of the bifaces and cores at both quarry sites and lithic scatter sites.

Unidirectional, multidirectional, and bifacial core reduction strategies were all represented in the assemblage of cores, from which flake blanks and flake tools were made using direct freehand percussion on cobbles and boulders. Cores were common at quarry sites and tended to range in size from 10 to 30 cm in diameter. In the field, tools that displayed more than one negative flake scar were classified as cores, while materials exhibiting a


**Figure 10-9. Biface at a quarry site on Craig Mountain.**


**Figure 10-10. Biface at a quarry site on Craig Mountain.**

single flake scar were classified as tested raw material. (One of the “quarry” sites included here was composed of tested raw material and relatively few flakes and may represent a “prospect” locale rather than a quarry [see Wilke and Schroth 1989].) Very few cores were found that were exhausted or were small in size.

Debitage present on the ground surface at the quarry sites included waste flakes from the testing and initial reduction of raw material. The majority of debitage at the quarry sites represented early-stage core and biface percussion reduction. The flakes tended to be large in size with large cortical platforms and few dorsal flake scars. Only one obvious hammerstone (an imported quartzite cobble) was recorded at a quarry site, suggesting that perhaps local FGV materials were used as expedient hammerstones.

*Lithic Scatters*

The 81 lithic scatter sites were accumulations of flakes and flaked stone tools that, unlike quarry sites, were not located in areas where lithic raw material was directly procured. Instead, the focus of these “workshops” was on the reduction of FGV material and the early stages of production of bifacial blanks and cores for export, and to a lesser extent the later stages of tool production and maintenance. Some of the lithic scatters were found in association with stacked rock features, generally located on ridgetops and along ridgelines. Some of the lithic scatters were found in association with historic-period artifacts. Small numbers of obsidian and cryptocrystalline silicate (CCS) artifacts were observed at a handful of sites. When present, artifacts of imported obsidian and CCS tended to represent late-stage tool production and maintenance.

Although the survey-level data are not sufficient for tallying early and late-stage flakes of specific reduction technologies, generalizations can be made regarding the presence of core reduction flakes, bifacial thinning flakes, and pressure flakes. The early stages of tool production were well represented by core reduction flakes and early stage percussion bifacial thinning flakes. Primary geologic cortex was present on debitage at most of the lithic scatter sites, reflecting close proximity to the sources of raw material. Debitage representing late stages of stone tool production was less common than other flake types at lithic scatter sites and included late stage biface percussion flakes and pressure flakes.

Finished tools observed at the lithic scatter sites included projectile points, worked flakes, and an occasional scraper. Of the 27 projectile points identified at lithic scatters, 25 were of FGV material and 2 were obsidian. The projectile points were typically isolated finds and included a single lanceolate or "Cascade" point, 11 corner-notched points, 2 side-notched points, and 13 points which were either midsections or tips where no type could be identified. Metric data from the projectile points were collected in the field and used to attempt to distinguish darts from arrows. Numerous researchers have addressed this question, and three formulas were attempted using the projectile point data from this study (Bradbury 1997; Hildebrandt and King 2012; Shott 1997). These formulas variously use shoulder width, maximum width, neck width, and maximum thickness attributes, not all of which could be measured on each artifact depending on how it had broken. Seventeen of the points had a consistent measurement (shoulder width) that could be used to compare them. According to Shott's (1997) formula, 10 were dart-sized points and 7 were arrow-sized points. Hildebrandt and King's (2012) Dart-Arrow Index could be applied to seven of the projectile points, and in each of these instances the results were the same as those obtained using Shott's (1997) formula.

Numerous artifacts were recorded in the field as flake tools or worked flakes. Flake tools are defined as exhibiting some type of wear indicative of use, while worked flakes are defined as having been altered to create or resharpen an edge for use as an expedient tool but showing no evidence of wear. Wear or polish as evidence of use is difficult to determine on FGV artifacts, particularly in the field, and no artifacts were collected during the survey.

**Available geochemical data**

Geochemical and petrographic analyses are required to accurately classify and source FGV materials from archaeological contexts. The results of these types of studies conducted elsewhere illustrate the compositional variability among toolstone sources that were once described as "basalt" (Bakewell 1996, 2005; Bakewell and Irving 1994). Igneous rocks are classified by their major element compositions according to total alkalis ($Na_2O$+$K_2O$) versus silica ($SiO_2$) by weight percent (Le Maitre 1989; Le Bas and Streckeisen 1991:830). Variability in trace element composition may then be used to distinguish samples from different geochemical sources. Geochemical analyses are often supplemented with petrographic techniques to identify minerals in thin section. Geochemical variability among FGV materials may not be detectable to the naked eye, however, and thus accurate classification cannot be done using visual attributes alone. It should be reiterated that cultural materials were not collected during the survey fieldwork reported here, which precluded geochemical and petrographic analyses of artifacts and source samples for this study.

Despite its potential, geochemical sourcing of FGV artifacts is not without limitations for the purposes of archaeological inquiry. Chemical compositions of lava flows, particularly the less viscous flows of the CRBG, may be relatively homogeneous over widespread areas. Although lava flows with calc-alkaline affinities tend to be less chemically homogenous than tholeiitic flood basalts, materials from both types of flows may be distributed over fairly extensive areas. Lava flows of the PRVF, which are chemically heterogeneous and geographically restricted, may provide a good opportunity for geochemical sourcing of FGV on a scale suitable for the archaeological study of local and regional patterns of toolstone acquisition, use, and trade.

Recent geologic mapping, based partially on geochemical data, indicates that Craig Mountain proper is composed primarily of dacitic materials of the PRVF (Bailey 1990; Oregon Department of Geology and Mineral Industries [DOGAMI] 2009; Ferns et al. 2010). Andesite and basaltic andesite from PRVF and CRBG flows are also present in the vicinity. Table 10-1 shows the number of acres surveyed by AINW and the archaeological resources identified according to the geologic map units defined by Ferns et al. (2010). Most of the archaeological survey was on Craig Mountain itself, and of the 11,219 total acres surveyed, 69 percent (7,746 acres) is mapped as Mount Emily dacite. Of the 28 newly identified quarry sites, 27 are located in areas mapped as dacite or undifferentiated andesite and dacite, and 1 quarry site is located in an area mapped as a landslide deposit. The majority of lithic workshops, represented by lithic scatters and perhaps isolates, are also located in areas mapped as dacite, but unlike quarry sites they occur in other areas as well. Although the resolution of the geologic mapping data is not appropriate for site-specific analysis, the data do show that quarry sites tend to be focused in areas where dacitic materials are known to occur. Most of the 3,400-acre Stockhoff Quarry site (not included in Table 10-1) is also mapped as dacite of the PRVF, although some areas within the site boundary are mapped as Wanapum and Grande Ronde basalts of the CRBG as well as a variety of quaternary surficial deposits (Ferns et al. 2010).

In their geologic study of the upper Grande Ronde basin, Ferns et al. (2010:63) report the results of X-ray fluorescence (XRF) analysis of over 1,100 source samples. Their database incorporates geochemical data presented by previous researchers (e.g., Bailey 1990), revising and expanding our understanding of the extent of the PRVF (Ferns et al. 2010). Based on their reported geographic coordinates, 52 outcrop samples used by Ferns et al. (2010) were from our general study area, including two whole-rock samples from within the boundary of site 35UN52. No other XRF samples coincide with the locations of the 29 quarry sites; however, several of the reported samples were taken from locations very near the Stockhoff Quarry and other quarry sites on Craig Mountain. All of these XRF samples were classified as dacite of the PRVF, and the samples taken from the Stockhoff Quarry vicinity were assigned to the Glass Hill Volcanic Group formation of the PRVF (Ferns et al. 2010:Appendix). Trace element data are also presented by Ferns et al. (2010); however, it is not known if any of the whole-rock XRF samples collected by geologists would have been suitable for use as toolstone.

For his doctoral dissertation, Bakewell (2005) conducted geochemical and petrographic analyses of artifacts and source samples from vitrophyric toolstone sources across the Pacific Northwest, including four samples from the Stockhoff Quarry and Craig Mountain. Bakewell (2005:53-54) hypothesizes that cultural groups exerted proprietary control over particular sources of toolstone, to the extent that the distribution of artifacts and geochemically distinct sources of toolstone could be assumed to correspond with geopolitical boundaries. In other words, Bakewell's (2005:59) hypothesis was that a given "cultural area" would contain only one type of vitrophyric toolstone, which would originate from a source within that cultural area. Geographic areas occupied by more than one cultural group would be expected to have more than one source of vitrophyric toolstone, and in geographic areas containing multiple toolstone sources but few cultural groups, only a few of the available toolstone sources would have been utilized.

Using petrographic observations and statistical discrimination on geochemical data from 112 samples, Bakewell was able to differentiate among what he calls "Coast Salish toolstone," "Shuswap toolstone," and "Southern Plateau toolstone." Of the 60 cases of Southern Plateau toolstone, 2 were cobbles from the Stockhoff Quarry and 2 were boulders from Craig Mountain (Bakewell 2005:61,115). Using petrography alone, it was impossible to distinguish Stockhoff Quarry/Craig Mountain toolstone from other sources in the "Cayuse area," although these sources could be differentiated from those in other areas of the southern Plateau (Bakewell 2005:74). Geochemically, Bakewell (2005:113) was able to differentiate sources of "Cayuse toolstone" from "Nez Perce toolstone" and "Paiute toolstone." "Cayuse toolstone" (n=31 cases) consisted of dacitic and andesitic materials, also characterized by Bakewell (2005:118) as "Stockhoff-type andesites and dacites." In addition to the previously mentioned samples from Craig Mountain (n=4), identified as siliceous andesite, the Stockhoff-type andesites and dacites included source samples from Mesa Hill (n=1), Alder Springs (n=1) and Anderson Springs (n=1), and artifacts recovered from Beaver Meadows (n=1), Boulder Gorge (n=1), Crane Flats (n=4), Larkspur Springs (n=1), Malheur (n=3), Sanger Mine (n=3), Westwall (n=8), Beech Creek (n=2) and a site in the North Cascades (n=1).

Bakewell (2005) succeeds in discriminating geochemical sources of toolstone from geographically and culturally disparate regions of the Pacific Northwest. His intention was not to distinguish among toolstone sources on a more local scale. Bakewell (2005:53,118-119) acknowledges the presence of a variety of chemically distinct sources of vitrophyric toolstone in the Powder River basin and in the Blue Mountains. He also notes that Powder River dacites are compositionally similar to Powder River andesites and to "Stockhoff materials at Craig Mountain" (Bakewell 2005:118-119). According to Bakewell (2005:119), "Cayuse toolstone" was represented by too few samples to characterize their sources individually, and no assumptions were made regarding temporal span for this perceived pattern.

Comparing his data with geochemical data reported by Bailey (1990) for the PRVF, Bakewell (2005:157) states that only 1 of the 142 locations reported by Bailey matches the geochemical signature of "Cayuse toolstone." Bakewell (2005:157) concludes that although the PRVF provides a wide range of vitrophyric toolstone sources, "archaeological toolstones used in the region are distinctively different from the Powder River Volcanics." In other words, based on geochemical information available at the time, Bakewell did not consider the PRVF to be a major source of toolstone for pre-contact groups. In support of his "one group-one vitrophyre" hypothesis, Bakewell (2005:118) interprets these results to mean that relatively few sources of geochemically distinct toolstone were used in the Powder River basin. Bakewell's interpretation of "Cayuse toolstone" also contradicts ethnographic information indicating that, at least by the historic period, the Cayuse and their allies often lived and traveled together, and they sometimes used the same resource locations at the same time (Stern 1998:396-397; Suphan 1974:101,147).

Since Bakewell's study, more recent geochemical and archaeological data have become available. Geochemical data and geologic mapping of the Grande Ronde basin has expanded our understanding of the extent and composition of the PRVF (Ferns et al. 2010), which includes the dacitic and andesitic materials at Craig Mountain. In addition, the results of AINW's archaeological survey show that quarrying activity on Craig Mountain was not restricted to one portion of the Stockhoff Quarry or even to the 3,400 acres within site 35UN52. Instead, evidence of pre-contact toolstone procurement extends across most of Craig Mountain and onto nearby landforms like Ramo Flat and Clark Mountain, also within the PRVF. These newly identified archaeological resources represent a significant increase in the sample size of toolstone quarry sites associated with the PRVF, and they suggest that many more quarry sites are likely to be present in other areas of the PRVF that have not yet been visited or surveyed by archaeologists. While not definitive, visual attributes of FGV materials at the quarry locations reported here suggest that there may be some geochemical variability in these local toolstone sources.

Unpublished trace element data from source samples collected by William Lyons indicate that some of these FGV toolstone sources may be distinguishable from each other (William H. Lyons, personal communication 2012; Craig E. Skinner, personal communication 2012). Lyons' source samples were collected along a linear route on the steep, south-facing roadcut above Interstate 84, where the highway enters Ladd Canyon at site 35UN52. Lyons also collected samples from locations between the eastbound and westbound lanes of the interstate. According to Lyons, whole-rock major element compositions were not determined for his samples, which consisted of dark-colored FGV with macroscopic phenocrysts. Craig Skinner of Northwest Research Obsidian Studies Laboratory conducted XRF analysis on 25 of Lyons' source samples. According to Skinner, trace element data indicate that the samples represent three geochemical sources; most of the samples are from a single source (n=22), while fewer samples are attributed to the second (n=2) and third (n=1) sources. Skinner also notes that the visual variability among samples from the main source is greater than the variability between the

Table 10-1. Acres Surveyed and Archaeological Resources by Geologic Map Unit (after Ferns et al. 2010)

| | Geologic Map Unit | | | Acreage | | Archaeological Resources | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | Description | Formation or Member | Acres Surveyed | % | Isolate | Quarry | Lithic Scatter | Total | % |
| Quaternary Surficial Deposits | Qa | Alluvium | | 229 | 2 | 5 | 0 | 5 | 10 | 4.6 |
| | Qcf | Colluvium and Talus Deposits | | 354 | 3 | 2 | 0 | 4 | 6 | 2.8 |
| | Qls | Landslide Deposits | | 427 | 4 | 3 | 1 | 5 | 9 | 4.1 |
| | Qu | Undifferentiated Surficial Deposits | | 58 | 1 | 1 | 0 | 1 | 2 | .9 |
| | Other | Lacustrine, Alluvial and Fluvial Deposits | | 140 | 1 | 0 | 0 | 0 | 0 | 0 |
| Columbia River Basalt Group | Tbf | Basalt | Wanapum Basalt | 39 | 0 | 3 | 0 | 0 | 3 | 1.4 |
| | Tcg | Basalt and Ferro-Andesite | Grande Ronde Basalt | 57 | 1 | 2 | 0 | 1 | 3 | 1.4 |
| | Tms | Sedimentary Rock Interbeds | Between Wanapum and Saddle Mountain Basalt | 93 | 1 | 0 | 0 | 0 | 0 | 0 |
| Powder River Volcanic Field | Tob | Olivine Basalt Sheet Flows | Little Catherine Creek | 399 | 4 | 3 | 0 | 0 | 3 | 1.4 |
| | Tpa | Andesite and Basaltic Andesite | Sawtooth Crater | 628 | 6 | 0 | 0 | 1 | 1 | .5 |
| | Tpb | Basalt of Little Catherine Creek | Little Catherine Creek | 838 | 7 | 3 | 0 | 1 | 4 | 1.8 |
| | Td | Dacite Flows and Domes | Dacite of Mount Emily | 285 | 3 | 11 | 3 | 4 | 18 | 8.3 |
| | Tpd | Dacite | Dacite of Mount Emily | 5605 | 50 | 47 | 18 | 47 | 112 | 51.4 |
| | Tpgd | Undifferentiated Andesite and Dacite | Dacite of Mount Emily | 1856 | 17 | 29 | 6 | 12 | 47 | 21.6 |
| Wallowa Terrane | TRPwc | Clover Creek Greenstone | Clover Creek Greenstone | 210 | 2 | 0 | 0 | 0 | 0 | 0 |
| ***TOTAL*** | | | | **11,219** | **100** | **109** | **28** | **81** | **218** | **100** |

three sources, again demonstrating that visual attributes may not correspond to geochemical variability. These data, although limited, are intriguing. If distinct geochemical signatures are detectable in source samples from a relatively small portion of site 35UN52, then it may be possible to distinguish geochemical sources of toolstone from other parts of Craig Mountain and the PRVF.

## Conclusions

The results of a recent large-scale archaeological survey indicate that the Stockhoff Quarry (site 35UN52) represents part of a much larger quarry complex consisting of numerous toolstone procurement locations and lithic reduction workshops across Craig Mountain and surrounding landforms. Pre-contact toolstone procurement on Craig Mountain appears to have been focused on sources of dark, glassy FGV material associated with dacitic and perhaps andesitic flows of the PRVF. Recent geochemical data suggest that "Stockhoff basalt" may in fact represent multiple geochemical sources of toolstone that can be attributed to the chemical heterogeneity of PRVF lava flows. Limited trace element data from samples collected by previous researchers demonstrate that at least some of these toolstone sources are distinguishable from each other.

Geochemical analyses of FGV artifacts and source materials from quarry sites on Craig Mountain are required to determine if these preliminary conclusions are supported. If so, the results would have implications for the archaeological study of diachronic trends in toolstone procurement and reduction strategies, mobility patterns, exchange networks, and interaction spheres in this part of the southern Plateau. Lithic technological analysis and flintknapping experimentation would also provide information regarding variability in reduction methods and sequences and assist in elucidating these research themes. Stone tools and debitage of visually similar FGV materials have been observed at nearby archaeological sites (e.g., Ladd Canyon, Ladd Marsh, Marshmeadow, Pagliarulo Rockshelter, Pilcher Creek) as well as sites that are farther afield (Andrefsky 1995; Brauner 1985; McPherson, Hall, McGlone, and Nachtwey 1981; Mead 1975; Ogle et al. 2006; Ozbun 1999; Ozbun et al. 2000; Reid 1997; Reed and Reed 1980). It is hoped that as more geochemical and archaeological data become available, they will contribute specific information about the relationships among these sites in the Blue Mountains and perhaps elsewhere on the southern Plateau.

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