CHAPTER 6
THROUGH A GLASS, DARKLY: PATTERNS OF OBSIDIAN AND FINE GRAINED VOLCANIC TOOLSTONE ACQUISITION ON THE SOUTHERN PLATEAU

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ABSTRACT
Early 19th century explorers, fur traders, and missionaries sometimes made passing reference to the toolstones used by Southern Plateau natives. Although some travelers compiled lexicons of native words, their own English and French vocabularies for the rich diversity of regional lithics ranged from impoverished to eccentric. As a result, many native terms for lithic categories have been simultaneously recorded and lost: we know how to say them but we don’t know what they mean. Nevertheless, to cite one example, a slowly-dawning awareness of the place of regional obsidians in native industries can be traced from a neglected William Clark map of 1806 to the first appearance of the word itself in Irving’s The Adventures of Captain Bonneville in 1837. This paper reviews how the “flints,” black Bottle Glass,” “crystalised carbonated Bitunem,” and cailloux of early 19th century journal entries, word lists, and maps became recognized as obsidians in the 1870s and andesites and dacites by the 1980s. Some potential social boundary implications for late prehistoric western Idaho and eastern Oregon that emerge from these data are mentioned in conclusion.

INTRODUCTION
Our understanding of the distribution and identity of igneous toolstones along the boundary zone between the Columbia Plateau and Great Basin culture areas has increased markedly in recent years. Contract reports, theses, and journal articles routinely report the sources and the distances represented by obsidian artifacts. The fine-grained volcanic suite of basaltic andesites, andesites, and dacites is beginning to receive comparable attention using x-ray fluorescence and petrographic analyses. However, less effort has been devoted to the outcrops, quarries, source areas, and workshops where these toolstones began their journeys. This paper highlights what we’ve learned – and still haven’t learned – about these places after two centuries of intermittent inquiry. Toolstone data gaps noted for the Great Basin more than a decade ago still need to be addressed on the Southern Plateau: source area distributions, comparative ease of extraction, workability, and package size (Jones and Beck 1999:91-92).

No attempt will be made here to separate toolstones identified in the literature as obsidians (Hughes 2007), vitrophyres (Sappington 1981a), vitreous tuffs (Bailey 1992), and ignimbrites (Jaehnig 1992). For present purposes, all are grouped as “obsidian.” Similarly, cherts, chalcedonies, flints, agates, jaspers, petrified woods, silicified argillites, and other microcrystalline silicates will be lumped under “chert.” Finally, the umbrella term “fine-grained volcanic” (FGV) includes rocks informally known as “basalts” (Bryan and Tuohy 1960), “fine grained basalts” (Jaehnig 1991; Womack 1977), and “glassy basalts” (Nisbet and Drake 1982) in the regional literature. When these are geochemically and petrographically analyzed, depending largely on their silica content, they group as basaltic andesites, andesites, dacites, and trachydacites (Bakewell 1991). Nevertheless, it is still a good practice to distinguish these toolstones from basalt proper. For example, among middle Holocene industries reported along the lower Snake River it can be difficult for the reader to tell whether “basalt” means locally available subconchoidally-fracturing basalt river or talus cobbles, or conchoidally-fracturing, siliceous, fine-grained volcanic toolstones imported from a distant upland source, or some combination of the two (Muto 1976).
HISTORY OF INVESTIGATIONS

Early 19th century explorers, fur traders, and missionaries sometimes made passing reference to the toolstones used by Southern Plateau natives, including the Shoshone (Tyrrell 1916:329) and Nez Perce (Baird 2000). Although a few visitors compiled lexicons of native words, their own English and French vocabularies for the rich diversity of regional raw materials ranged from impoverished to eccentric. As a result, native discriminations among lithic categories have been simultaneously recorded and lost: we sometimes know how to say them but we don’t always know what they mean. Nevertheless, a dawning awareness of the distinctive qualities and limited distribution of obsidian flickers through the early literature. Sorting out the basalt problem got off to a much later start (Bakewell 1991, 1993, Bakewell and Irving 1994, Reid et al. 1993, Reid 1997).

The word obsidian does not appear in the journals or correspondence of the Lewis and Clark expedition, the Astorians, or the North West or Hudson’s Bay Company clerks who left the first written records of the region, although they sometimes noted the distinctive properties of volcanic glass and sometimes attempted to describe it. For example, Samuel Black’s response to a Hudson’s Bay Company questionnaire in 1829 says that the Nez Perce

“...point their arrows with Flint & a kind of crystal stone near resembling the color of Black Bottle looks like crystallised carbonated Bitumen, its found in the mountains but I believe a Secondary production Rock Crystals may be found but do not know whether in the primative or Secondary productions.—I have seen the carbonated Bitunem like crystal hanging about them as ornaments it appears to brake in Thin bits like Flint Pebbles &c This is all the minerals I have seen among the Indians” (Baird 2000:50).

Unknown to the undictionaried Black, obsidian had long been recognized as a “stone reckoned among glass, sometimes green, sometimes black and clear and bright” (Simpson and Weiner 1989:665). However, at least for this study area, the term languished in obscurity until Washington Irving resurrected it in 1837, where arrows “tipped with obsidian” are mentioned for the first time among natives in the Browns Bench area south of Twin Falls (Irving 1961:221).

Irving’s widely read books seem to have popularized the term, for it appears with increasing frequency after 1837. The following year a missionary mentioned obsidian outcrops in the upper Henry’s Fork (Parker 1990:99), and in 1839 an itinerant naturalist recalled his thirsty companions sucking on “bullets, pebbles of chalcedony, and pieces of smooth obsidian” near Lost River (Townsend 1999:80). These may be the first references to the nearby Big Table Mountain and Big Southern Butte sources. Russell’s memoir of trapping the same area covers the years 1834-1843, although it was not readied for publication until 1848. His mention of Snake arrows “pointed with quartz or obsideon” (sic) probably postdates a reading of Irving’s Bonneville (Russell 1965:144).

The new word spread quickly. Within ten years, obsidian had been recognized in an archaeological context in Hopewell mounds in Ohio (Squier and Davis 1848). By 1876, the term was familiar enough for Powell to elicit different Numa terms for “arrowhead,” Wu-nap’, and “black obsidian arrowhead” Ta-sip’ (Fowler and Fowler 1971:131, 251). Two years later the pioneering lithic technologist William Henry Holmes visited the Obsidian Cliff source area at Yellowstone National Park and published a detailed description (Holmes 1879).

Ethnographers soon took note of the stone as well. Robert H. Lowie discovered obsidian (du’p’) was widely available and used for knives and arrowpoints among the Northern Shoshone at the Lemhi Agency (1909:173). By the following year, when Herbert J. Spinden summered among the Nez Perce gathering thesis data, the word appeared regularly in scholarly monographs. He identified obsidian as the preferred stone for chipped implements among the Nez Perce, with pieces collected in the John Day valley to the west and from Yellowstone to the east (Spinden 1908:184).
Spinden was unfamiliar with the earlier work of Alice Fletcher in the Nez Perce country. Had he reviewed her notes, he might have assigned shorter distance-to-source estimates for Nez Perce obsidians. Fifteen years earlier, Fletcher had reported that

“In southern Idaho, in the Snake country, were two buttes, and parties went there for flint at the risk of their lives. They would quarry the stone and put the rough pieces of flint in a deerskin bag, and start home. In safe places they would stop and rest, and while resting would work out arrowheads. (I have found many workshops at resting places on the trail leading from the Nez Perce land to the southern country)” (Sappington and Carley 1995:22).

While it is arguable whether “Snake country” refers to the land of the Snakes (Numa) or the Snake River Plain, I suspect the two southern buttes were sources of obsidian rather than flint. The term appears nowhere in Fletcher’s notes on the Nez Perce, but she described a “black stone (ops) from which arrow points were chipped” and that sometimes figured in men’s names (Sappington and Carley 1995:25). The Nez Perce Dictionary gives two terms, ?aps and sxus, for flint or obsidian (Aoki 1994:1158). Presumably ops and ?aps are the same stone. The black color and use for arrow points suggests the material is obsidian, while use of the term in male names is confirmed by Apash Wyakaikt, “Flint Necklace,” the Nez Perce chief who hosted Lewis and Clark in 1806 (Moulton 1991:204). Again, ops, ?aps, and apash, all seem to be the same term.

Fletcher’s notes bring us back to the records and maps of Lewis and Clark. Although the word does not appear in any of the expedition’s journals, a few entries describe a toolstone that is certainly obsidian, though always called “flint.” Thus, in camp with the Shoshones on the Lemhi River, Lewis recorded “…some of this flint was as transparent as the common black glass and much of the same color easily broken, and flaked off much like glass leaving a very sharp edge” (Moulton 1988:143).

Less widely appreciated is the probability that William Clark, the expedition’s cartographer, pinpointed the location of the most important obsidian source in western Idaho. He labeled a Nez Perce map with translated place names, including a “Flint Rock” in the lower reach of a stream now known as the Payette River (Moulton 1983:100). “Flint Rock” matches the location of the obsidian source at Timber Butte (Figure 6.1).

The early conflation of obsidian and flint may not have ended there. Eight years later, the first published version of Clark’s map of the Snake River country shows the modern Burnt River as "Flint River" (Moulton 1983:126), with the name placed in the lower valley at the approximate location of the Dooley Mountain obsidian sources. If Clark’s Nez Perce informants used the same name for the rock and the river, it was probably ops, and Fletcher’s two buttes probably correspond to the first two obsidian sources met by south-bound Nez Perce: Timber Butte and Dooley Mountain. As noted by Fletcher, both might have been risky places for Nez Perce knappers early in the 19th century. However, in the more distant past Timber Butte and Dooley Mountain fell within, rather than at the contested edge, of the ancestral Nez Perce territory.

If Clark unknowingly recorded the location of Timber Butte, and Fletcher unknowingly described direct procurement of Timber Butte obsidian by Nez Perce knappers, the source did not become known to archaeologists and geologists until 1963. While searching for an historic Shoshone grave, Idaho’s state historian stumbled onto an obsidian outcrop "more than 20 feet wide, and extending at least 60 feet along a fracture" near the crest of Timber Butte (Wells 1980:3). The source area had been overlooked by geologists, and was not professionally mapped and recorded until a decade later (Clemens 1990:8).
Figure 6.1. Nez Perce map of 1806 showing the location of Timber Butte ("Flint Rock"). Redrawn and relabeled from Moulton (1983: Map 100).
Following Wells’s brief report of the Timber Butte source, and excepting a single early attempt to chemically source samples from Veratic Rockshelter in southeastern Idaho (Wright et al. 1969; Hughes 2007) obsidian studies in the Snake River basin blossomed (Sappington 1981a, b, c, 1984; McDonald 1985, 1986; Reed 1985; Bailey 1992, 2006; Willingham 1995; Holmer 1997; Plager 2001; Thompson 2004; Corn 2006; McAlister and Henrikson 2007; Willson 2007; Holmer 1997; Plager 2001; Thompson 2004; Corn 2006; McAlister and Henrikson 2007; Willson 2007; Armstrong 2009; Lee and Metcalf 2011). However, with the exception of McDonald’s work at Dooley Mountain, these studies focused on the identification and sourcing of artifacts using x-ray fluorescence analysis of their geochemistry. Studies of trade and travel trumped any pursuit of procurement, processing, and production, and little effort went into characterizing source areas as workshop or quarry sites.

Studies of the fine-grained volcanic (FGV) toolstones in the region had an earlier start with Bryan and Tuohy’s (1960) Stockhoff monograph, and gained momentum when obsidian sourcing accelerated. However, in contrast with the obsidian studies, the FGV focus remained on quarries, workshops, and reduction technologies, rather than on tracing artifacts to outcrops within regional frameworks of mobility and exchange (Warren et al. 1971; Ruebelmann 1973; Bucy 1971, 1974; Womack 1977; McPherson et al. 1981; Nisbet and Drake 1982; Jaehnig 1991, 1992; Dickerson 1998; Reid and Root 1998). Recent success with FGV sourcing using x-ray fluorescence and petrographic thin sections (Bakewell 1991, 1993, 2002, 2005; Dickerson 1998) promises that establishing artifact-to-outcrop distances and directions will soon become routine. However, the continuing tendency to characterize outcrops and workshops as “quarries” still leaves the earlier phases of production dynamics largely unexamined.

WORKSHOP ECONOMICS

The appraisal of toolstone quality by archaeologists has taken several directions, ranging from symbolic to kinetic to mechanical. Apart from package size, accessibility, and workability, the emic role of such qualities as color, luminosity, radiance, brilliance, and “strength” are appropriate to acknowledge in some contexts. For example, a term for “powerful or strong” among the Lemhi Shoshone distinguished obsidian from iron (Lowie 1909:173). As noted earlier, Samuel Black’s reference to the ornamental use of obsidian may be echoed in the name of Flint Necklace for a Nez Perce chief (Baird 2000:50; Moulton 1991:204). The power of obsidian may also have been related to its use for war points in recent times (Tyrrell 1916:329). While there is surely more to toolstone selection than geographic proximity and mechanical properties, here we shall only acknowledge the semiotics while we focus on the economics.

Economic geologists distinguish between the place value and the unit value of rocks and minerals. High place value characterizes a rock when it is used at or near the place where it occurs naturally. High unit value characterizes a rock with properties that make it unique or valuable within a certain context, and worth transporting over long distances (Bates 1960:7-8). The distinction may have more general applicability. But what are the time and labor costs involved in finding, testing, trimming, and transporting stone-age lithics?

Cost/utility indices offer a more quantitative approach to measuring the place and unit values of toolstones. Cost/utility indices gauge search and processing time, as well as the workability, size and form, and durability of the material (Elston 1990:154-159). Search time includes extraction and assaying pieces of toolstone. Processing time includes primary and secondary reduction, and the production staging sequence for bifaces. In the Snake River basin, all of these activities unfold in a context partly determined by elevation, snow cover, and vertical exposure.

The size and form of desired tools constrain decisions about the appropriate clast or nodule shape and weight. Size varies widely among different raw materials and obviously constrains the initial dimensions of cores and flake blanks. Small nodules or clasts can only make small stone tools, and may require distinctive reduction methods such as block-on-block or bipolar flaking to do so (Andrefsky 1994:384-386). Raw materials that allow
large cores, blanks, or early-stage production bifaces to be made at the source for transport elsewhere may be favored over smaller pebble or cobble sources. For example, the dacite at Craig Mountain outcrops in blocks more than 1 m in diameter near the summit (Womack 1977: Fig. 3) and as tabular and subrounded boulders strewn down the southern slope (Figure 6.2). At the other extreme, regular exploitation of small cobble source areas may be masked by the export of cobbles

![Figure 6.2. Dacite boulder at the Stockhoff workshop (author photograph).](image)

and their subsequent reduction at camps distant from the source (McDonald 1985).

Workability is a measure that combines toughness and soundness. Knapping experiments show that highly variable soundness or resistance to freeze-thaw cycles typifies the basaltic andesites from Elk Mountain and Starvation Spring (Nisbet and Drake 1882:18-20; Jaehnig 1991:41). This factor must have compromised any advantage promised by the large size of toolstone clasts at Starvation Spring. The soundness of surficial obsidian deposits is also often problematic. Bailey’s (1992) inspection of more than seventy surface exposures around the Snake River Plain noted how little of the material was suited for controlled flaking because of devitrification. Presumably, smaller clasts dry out more quickly and completely than larger ones. Other factors affecting obsidian soundness include spherulitic inclusions and phenocrystic impurities (Bailey 1992).

Toolstone toughness refers to the effort required to sustain a controlled fracture, and corresponds to what Elston (1990:156) terms plasticity. Toughness has often been appraised kinetically through replicative knapping. Numb-wristed veterans of these experiments agree that fine-grained volcanic toolstones are hard to work (Bucy 1971:98-101; Jaehnig 1991:40-45; Root 1998:7.1-7.13). FGV toolstones in the Great Basin are similarly intractable, with higher fracture toughness than cherts (Jones and Beck 1999:90). However, not much has been done to actually measure the differences, or explore varying workability within individual toolstones.

Taking a page from the fracture mechanics literature, MacDonald (1995:348) used a textbook abrasion test as a toolstone quality index to rank toughness for andesites, cherts, opalites, and obsidians recovered from a seasonal camp near Starvation Spring. Andesites ranked almost twice as tough as chert and opalite, and obsidians, as expected, were the easiest material to biface. However, the referenced toughness values include the caution that they “do not represent the range of variability that occurs within these groupings” (Cottrell and Kamminga 1990:129).
The Pataha Canyon lithic analysis used a controlled mechanical fracture toughness test to evaluate workability of the local basaltic andesite (Domanski and Webb 1998). Testing followed procedures described in Domanski et al. (1994:186-188) and Whittaker et al. (1992:262-267). Cylinders approximately 22 mm in length and 15 mm in diameter were mechanically impacted by forces ranging between 21-56 lbs, yielding fracture toughness values expressed as megapascals (MPa.mm\(^{0.5}\)). Although the sample sizes may be too small to be more than suggestive, they show the difference between two cobbles of Pataha Canyon basaltic andesite is as great as the difference between unheated and successfully heated chert (Table 6.1). The good workability knappers report for Stockhoff dacite (Womack 1977:76-83; Root 1998:7.3) is reflected in its low fracture toughness.

As expected, the data indicate that obsidians have the lowest fracture toughness and are the easiest toolstone to biface. However, given the notoriety that fine-grained volcanics have for relative intractability, it is surprising to find that at least three of the FGV toolstones are comparable to unheated cherts, flints, agates, and jaspers in their fracture toughness. Significant differences among them do not appear until the cherts are heat treated to 400°C. The siliceous dacite from Stockhoff is actually easier to work than the unheated chert, jasper, agate, and one of the flint controls, and not much more difficult than the successfully heated jasper.

### TOOLSTONE TERRANES OF THE BASIN-PLATEAU BOUNDARY

With these considerations on package size and workability in hand, we can turn to the toolstone geography of the study area.

The southern Snake River basin alternately divides and integrates the Basin and Plateau culture areas. It includes two partially overlapping toolstone provinces or “terranes” (Elston 1990:155) where igneous lithologies rival cherts in abundance, distribution, size, and workability. The middle and upper Snake River and lower reaches of several tributaries are rimmed by more than 70 reported obsidian sources. Nearly half have been chemically fingerprinted through continually refined x-ray fluorescence studies.

Unlike the garland of obsidian sources draped around the Snake River Plain, FGV toolstones cluster within the Columbia River Basalt Group (CRBG) of northeastern Oregon, southeastern Washington, and adjacent western Idaho. Three bedrock peninsulas of this CRBG Terrane jut eastward into Idaho (Figure 6.3): from south to north, the Weiser, Clearwater, and St. Maries (or Benewah) embayments (Camp et al. 1982).

The Weiser and Clearwater embayments host extensive toolstone exposures and workshops, including the Midvale Hill and Mesa Hill sites in the Weiser basin, and High Breaks Ridge on the Joseph Plain (Fig. 5). Similar sources may outcrop on the St. Maries embayment, but have not yet been documented.

### Table 6.1. Comparative Fracture Toughness Values\(^1\) for Regional Fine Grained Volcanics compared to Obsidians and Unheated and Heated Chert, Flint, Agate, and Jasper (data from Domanski and Webb 1992, 1998).

<table>
<thead>
<tr>
<th></th>
<th>Obsidians</th>
<th>FGV</th>
<th>“Chert” -</th>
<th>“Chert” - 300°C</th>
<th>“Chert” - 400°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.01(^a)</td>
<td>73.50(^a)</td>
<td>48.54 (chert)</td>
<td>49.13</td>
<td>36.75</td>
<td></td>
</tr>
<tr>
<td>26.30(^a)</td>
<td>70.86(^a)</td>
<td>65.85 (flint)</td>
<td>38.84</td>
<td>37.12</td>
<td></td>
</tr>
<tr>
<td>27.42(^a)</td>
<td>55.67(^a)</td>
<td>51.52 (flint)</td>
<td>37.31</td>
<td>34.88</td>
<td></td>
</tr>
<tr>
<td>25.82(^b)</td>
<td>77.16(^b)</td>
<td>81.96 (agate)</td>
<td>64.92</td>
<td>31.72</td>
<td></td>
</tr>
<tr>
<td>89.51(^b)</td>
<td>72.41 (jasper)</td>
<td>56.04</td>
<td>47.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Papua New Guinea; \(^b\) Glass Butte, Oregon; \(^1\) Midvale Hill basaltic andesite; \(^2\) Stockhoff dacite; \(^3\) Pataha Canyon basaltic andesite
Snake River Plain Terrane

The locations, identities, and synonymies of Snake River Plain (SNP) Terrane sources have been summarized by Holmer (1997). Working with a database of 1,200 sourced specimens from southeastern Idaho, he offered several distributional generalizations for the eastern Snake River Plain: obsidian seemed to move in directions parallel rather than perpendicular to the Snake River; greater distances between artifacts and sources were noted among late Paleoindian and late prehistoric assemblages than during the middle and late Holocene; projectile points were found on average 43 km further from the source than debitage; sources had a catchment radius of about 250-300 km; and five of the sources accounted for 82% of the sample. He did not attempt to distinguish source areas, workshops, or quarries from one another, and based his findings exclusively on artifact-to-source distances and bearings.

Building on Holmer’s start, Plager (2001) developed a database for all of southern Idaho, and calculated distance algorithms for each obsidian source. She found that prehistoric hunter-gatherers hiked along procurement paths 20% longer than Holmer’s Euclidian distances (Plager 2001:57). Her data confirmed east-west traffic patterns along the Snake River Plain, and found a regular distance-decay relationship for the six most represented obsidians: Big Table Mountain (Bear Gulch), Big Southern Butte, Browns Bench, Malad, Owyhee, and Timber Butte.

Holmer and Plager limited themselves to distributional studies of chemically fingerprinted obsidian artifacts. Neither examined source areas or workshops in any detail. Although 31 chemically distinguishable outcrops have been mapped and sampled, only a handful account for most of the sourcing data reported in Holmer (1997), Plager (2001), and Willson (2007). Five sources made up 80% of the 1,200 artifacts in Holmer’s (1997) data base: Malad, Timber Butte, Big Southern Butte, Browns Bench, and Big Table Mountain (Bear Gulch).

Working with an enlarged data base of 2,607 artifacts, Plager (2001:35-36) found that 85% of the southern Idaho specimens came from the same five sources, plus Owyhee. Willson (2007:22) summarized findings for 2,033 obsidian artifacts from 96 sites. Again, five sources accounted for 85% of the sample, except that here the Owyhee source outranked Big Table Mountain.

The distribution of the most represented sources is shown in Figure 6.4. The prominence of the subsample summarized in Table 6.2 is reinforced by individual site studies. For example, at deeply stratified Wilson Butte Cave, the Browns Bench and Big Southern Butte sources accounted for two thirds of the 17 SNP obsidians identified (Bailey 2006:126).

Bailey (1992:31-32) visited 76 ignimbrite/obsidian exposures around the Snake River plain and found none exposed in bedrock. All sources comprised cobbles exposures on hillslopes or stream gravels. At most localities, much of the exposed material was too weathered for successful knapping. The average lower elevation of the most widely trafficked obsidians is about 500 m higher than the same contour for the FGV workshops, a potential constraint on seasonal accessibility.
Figure 6.4. Source areas for the most widely distributed obsidians of the Southern Plateau.
Clast sizes for the obsidians are comparable to the basaltic andesites, but considerably smaller than the dacites (Table 6.3). Obsidian nodules in the study area typically range between 15-30 cm in their long axis. Measurements from nearby biface caches sourced to these exposures are consistently less than 20 cm (Kohntopp 2006; Lohse et al. 2010; Pavesic 1966; Hughes and Pavesic 2005).

By comparison, the package size of regolithic or interflow outcrops of microcrystalline toolstone in the region is poorly documented. However, alluvial cherts in the Snake River basin typically occur as small cobbles or pebbles. Chert gravels exceeding 13 cm in diameter are mentioned in geological sources (Reid 1997:75), but siliceous cobbles on gravel bars examined below Hells Canyon Dam are smaller. Size ranges have not been reported for the chert component of the Crowsnest Gravel, exposed along the Snake River for 160 km below Kanaka Rapids. Chert clasts make up a “sizeable proportion” of the unit and presumably decrease in caliber in a downstream direction (Malde and Powers 1962:1215).

Among the six highest ranked obsidian sources reviewed here, quarry pits have been identified only at 10CL627 (Table 6.2), one of eight recorded workshops that make up the Big Table Mountain (Bear Gulch) complex in the Centennial Mountains. Information available for the other sources in Table 6.2 supports the general applicability of Sappington’s (1984) “procurement without quarry production” hypothesis.

These exposures were probably visited by individuals or families during the seasonal round, with cobble harvests embedded in other activities. Grubbing with stone or antler picks or digging sticks for shallowly buried unweathered nodules would have been no more difficult than harvesting potatoes for today’s gardener. On-site testing for cobble soundness would involve little effort. Procurement costs included seasonally-timed uphill hikes, harvesting and assaying of nodules, and downhill treks with suitable pieces of toolstone or early-stage production bifaces.

The vast area reported for the Browns Bench exposure (Table 6.2) is probably underestimated and certainly includes many unrecorded workshops of variable size. Similarly, the Timber Butte source area is based on the Timber Butte Rhyolite Formation, which presumably includes several unrecorded workings. The property is on private land and has not yet been systematically surveyed. The figure for the Dooley Mountain sources includes 12 sampled and mapped areas on the summit and north and south slopes of Dooley Mountain (McDonald 1985:66). Among the eight sites at Big Table Mountain, 10CL267 is the largest, at .51 km², and the only one with quarry pits. The others range in size from 114 m² up to >2 ha. Halford (2008:49) suggests that the bedrock quarrying of Bodie Hills obsidian in California between about 3500 1350 B.P. was
stimulated by the continuous depletion of larger surface cobbles beginning in the early Holocene. A similar dynamic may account for the shift from surface collection to excavation apparent at Big Table Mountain.

However, the obsidian sources as a group do not display the intensive nearby workshop activity reported for the FGV sources. This picture stands in still sharper contrast with procurement evidence recently reported for the Obsidian Cliffs source area on the Yellowstone Plateau. Here recent post-fire surveys have identified scores of quarry/workshop clusters, each comprising groups of depressions, pits, and trenches associated with abundant workshop debris: blocks of obsidian, cores, production bifaces, anddebitage. Clast sizes are not reported, but it appears that pieces collected at or near the surface were smaller than mined or quarried pieces. The depressions and pits ranged up to 2.5 m in depth, and the trenches up to 35 m in length (Johnson et al. 1995; Davis et al. 1995: Appendix A). Hundreds of these quarry features clustered in 59 discernible loci, a pattern arguably consistent with direct procurement by task groups moving large amounts of material in single episodes.

Columbia River Basalt Group (CRBG) Terrane

An array of fine-grained volcanic sources mapped as the Powder River Volcanic Field (Bailey 1990) in eastern Oregon includes the high-silica dacite at Craig Mountain, where the Stockhoff, Marshmeadow, Ladd Canyon and nearby Pilcher Creek workshops cluster. The dacite originates in the Saddle Mountain Basalt Flow. Another cluster of basaltic andesite workshops occurs on the Joseph Upland, where the Grand Ronde Basalt Flow laps around the Wallowas on the north and east, and juts eastward across the Snake River in three Idaho embayments. The Grande Ronde is the most widely distributed flow in this toolstone province.

Table 6.3 summarizes extant data on nine FGV workshops of the CRBG Terrane. Their locations are shown in Figure 6.5. The level of investigation varies across the sample. A gridded surface collection of 5,860 m² at 10WN10 on Midvale Hill recovered 320 nodules, 165 cores, and 37 bifacial and unifacial blanks (Bucy 1974:16-17), while at nearby Mesa Hill, also within the Weiser embayment, a 68 m² block excavation of a shallowly sealed single-component workshop floor piece-plotted a much higher density of bifaces, unifaces, cores, hammerstones, anvils, and finished tools (Ruebelmann 1973), revealing gaps and clusters that may mark working positions of individual knappers (Figure 6.6).

Block excavations at Pilcher Creek sampled superimposed Archaic (Cascade phase) and Paleoarchaic (Windust phase) components, but revealed no changes in production biface output over time (Brauner 1985). Smaller samples from blocks and test units at the other six workshops focused on working out the reduction sequences.

At Starvation Spring, workshop debris extended to bedrock at depths ranging to 140 cm. Lithics were concentrated on an eroded paleosol capped by redeposited Mazama tephra. A temporal trend was identified, with the initial occupants generating a complete biface reduction sequence, while the later knappers shifted to testing, trimming, and transporting the toolstone off-site for further reduction elsewhere. Projectile points from the seven test units indicated a Tucannon-early Harder phase temporal sequence between about 4000-2000 years ago (Jaehnig 1992:37).

A pattern of nearby off-site reduction was postulated at Midvale Hill (Dort 1964:19; Bucy 1974:16-17) and demonstrated at High Breaks Ridge (Dickerson 1998). At the latter workshop cluster a nearby upland camp relied almost entirely on the same chemically identified basaltic andesite, and displayed core and biface reduction stages successional to those represented at the workshops. The campsite dated to between 3500-3100 RCYBP and appears to date the workshop cluster as well.

Temporal control at most FGV workshops continues to rely on diagnostic projectile points. Paleoarchaic stemmed Windust and Haskett points were recovered in the Stockhoff (Womack 1977:Fig. 20j; McPherson et al. 1981:296-297), Marshmeadow (McPherson et al. 1981:359, Fig. 109), Ladd Canyon (McPherson et al. 1981:651-652, Fig. 204h), and Pilcher Creek (Brauner 1985:51-54) workshops. Paleoarchaic FGV points have been recovered in campsite settings elsewhere in the
region at Evans Creek (Nisbet 1983:Fig. 5d,e), Gould Gulch (Gallison and Reid 1995:56), and Hetrick (Rudolph 1995:Tables 6-40, 6-41). To date, although Paleoindian knappers made wide use of the obsidians, no fluted Clovis or Folsom points made from FGV toolstones have been reported in the region.

Exploitation of the tough basaltic andesites seems to intensify in the later Holocene. The emergent pattern hints that Paleoarchaic knappers favored more tractable but also more localized dacites over tougher, but more widely distributed, basaltic andesites. Thus, while middle and late Holocene knappers continued to exploit the Craig Mountain dacite source, they also brought into production several basaltic andesite outcrops of the widespread Grande Ronde Basalt Flow. These include Midvale Hill, Mesa Hill, Elk Mountain, High Breaks Ridge, and Pataha Canyon.

In common with the obsidian sources, the variability in FGV workshop area apparent in Table 3 reflects in part how (and when) the sites were recorded. For example, the site record for Stockhoff (35UN52) includes nine separate concentrations ranging in area from 4 to 121 ha. Similarly, the heavily forested condition of Starvation Spring obscures any internal variability at this large site. The scale challenge typical of source-area sprawl suggests that these workshops would profit from a noninvasive remote sensing approach such as LiDar light ranging and mapping. Subtle traces of pits and other features now obscured by vegetation and field conditions might be captured in comprehensive site overviews linking surface debris to underlying rock structure.

Table 6.3. Summary Data for Fine Grained Volcanic Workshops of the CRBG Terrane.

<table>
<thead>
<tr>
<th>Source</th>
<th>Elevation</th>
<th>Site Area</th>
<th>Toolstone</th>
<th>Clast Size</th>
<th>Fracture Toughness</th>
<th>Production Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockhoff</td>
<td>1103-1335 m</td>
<td>186</td>
<td>dacite</td>
<td>&gt;1 m</td>
<td>55.67</td>
<td>~6845-5800</td>
</tr>
<tr>
<td>Marshmeadow</td>
<td>1122-1140 m</td>
<td>5.5</td>
<td>dacite</td>
<td>&lt;1 m</td>
<td>--</td>
<td>~4000-700</td>
</tr>
<tr>
<td>Plcher Creek</td>
<td>1219 m</td>
<td>.75</td>
<td>dacite</td>
<td>20 cm</td>
<td>--</td>
<td>~10,000</td>
</tr>
<tr>
<td>Midvale Hill</td>
<td>1012 m</td>
<td>8.3</td>
<td>basaltic andesite</td>
<td>20 cm</td>
<td>70.86/73.50</td>
<td>~4500-2000</td>
</tr>
<tr>
<td>Mesa Hill</td>
<td>890-902 m</td>
<td>--</td>
<td>andesite</td>
<td>--</td>
<td>--</td>
<td>~7000-5000</td>
</tr>
<tr>
<td>Elk Mountain</td>
<td>1561 m</td>
<td>1.2</td>
<td>basaltic andesite</td>
<td>10 cm</td>
<td>--</td>
<td>~3000</td>
</tr>
<tr>
<td>Starvation Spring</td>
<td>1310-1402 m</td>
<td>77</td>
<td>basaltic andesite</td>
<td>35 cm</td>
<td>--</td>
<td>~4000-2000</td>
</tr>
<tr>
<td>High Breaks Ridge</td>
<td>1426-1487 m</td>
<td>1.1</td>
<td>basaltic andesite</td>
<td>14 cm</td>
<td>--</td>
<td>~3500-3000</td>
</tr>
<tr>
<td>Pataha Canyon</td>
<td>1155 m</td>
<td>4.2</td>
<td>basaltic andesite</td>
<td>10 cm</td>
<td>77.16/89.51</td>
<td>~2500</td>
</tr>
</tbody>
</table>

*a Surface area of one or more concentrations in hectares; *b Domanski and Webb 1998; *c Bryan and Tuohy 1960; *d Womack 1977; *e McPherson et al. 1981; *f Reid et al. 1993; *g McPherson et al. 1981; *h Brauner 1985; *i Dort 1964; *j Bucy 1971, 1972; *k Warren et al. 1971; *l Bakewell 2002; *m Ruebelmann 1973; *n Nisbet and Drake 1982; *o Jaehnig 1992; *p Dickerson 1998; *q Reid and Root 1998
Figure 6.5.  Source areas for selected fine-rained volcanics of the Southern Plateau.
Gauging changes in output volume at these workshops has been most seriously pursued at Pataha Canyon (Root 1998). Here four analytic units were defined in a small 15 m² block. Workshop output consisted of flake cores and bifacial preforms in all analytic units, although early-stage bifacial reduction was emphasized in the earlier units. When the occupation span was broken down into three units of 2500 years each, the biface output estimate, derived from replication and size-grading of bifacialdebitage, was about seven bifaces/year for the Harder/Piqunin interval (2500-200 BP). For the Cascade/Tucannon interval (5000-2500 BP), it dropped to 4.5 bifaces/year. During the early-middle Holocene (7500-5000), production achieved about one biface every two years.

By 2500 years ago, a discernible increase in skill level was reflected in fewer bifacial miscarriages. The same notoriously difficult stone seems to have been used throughout the workshop’s time span, but later knappers had learned to make better use of it (Root 1998). This shift may reflect the appearance of craft specialization in the lower Snake basin. It is also accompanied by a much wider range of raw materials among discarded projectile points, perhaps reflecting increased exchange among craft specialists (Cross 1993). These small, unprepossessing workshops of tough and grubby toolstones clearly have the potential to deepen our understanding of social dynamics now known mainly from ethnography (e.g. Thomson 1949:63-81).

Root’s analysis at Pataha Canyon focused on tracking how many bifaces left the workshop over time, while the data in the Stockhoff and Marshmeadow reports tell us only how much debris was left behind at the workshops. Still, a peak in production appears to follow the Mazama
eruption at Stockhoff (Table 6.4), while production at nearby Marshmeadow did not accelerate until after 4000 years ago (Table 6.5).

How this variability patterns over a larger region is far from clear at this point. However, the recently proposed hypotheses that Craig Mountain dacite occurs in significant quantities at sites along the lower Snake River are plausible and geochemically testable. The numerous FGV production bifaces noted at Swift Bar (Andrefsky 1995) and Castle Rock (Morrison 1996) date to the same interval as the production surge at Stockhoff. Qualities that might have made Craig Mountain dacite worth the trip include large package size, low fracture toughness, and workshop proximity to abundant salmon, camas, and game resources. To the extent that the Grand Ronde River served as a dugout canoe transportation corridor feeding into navigable waters below Hells Canyon, biface-ballasted canoes could deliver bulky cargoes to distant downstream destinations. This scenario might also explain the scarcity of the same material at contemporaneous sites in Hells Canyon (Randolph and Dahlstrom 1977; Reid and Gallison 1994; Reid and Chatters 1997), where all FGV toolstone had to have been packed in by pedestrians.

**SUMMARY AND CONCLUSIONS**

After a halting, haphazard start early in the 19th century, the search for igneous toolstones in the Snake River basin flagged for nearly a century and a half before finding direction and scientific footing in geochemical and petrographic analyses and geologic mapping. Steady improvements in fingerprinting through x-ray fluorescence have corrected earlier misidentifications (Hughes 2007; Hughes and Pavesic 2005) and refined the scale of resolution: seed-sized pressure flakes from a Nez Perce lodge floor in Hells Canyon have been traced upstream to Timber Butte and Dooley Mountain (Hughes 2012).

However, much still remains to be learned about

### Table 6.4. Workshop accumulation rates for debitage and bifacial/unifacial blanks at Stockhoff (compiled from McPherson et al. 1981).

<table>
<thead>
<tr>
<th>Stratigraphic Unit(s)</th>
<th>Age (RCYBP)</th>
<th>Debitage</th>
<th>Workshop Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7600 - 6845</td>
<td>11/year</td>
<td>1/20 years</td>
</tr>
<tr>
<td>3, A, B, 6, 7a</td>
<td>6845 – 5800</td>
<td>61/year</td>
<td>1/2.4 years</td>
</tr>
<tr>
<td>7b, c, 8, C</td>
<td>5700 – 1700</td>
<td>11/year</td>
<td>1/24 years</td>
</tr>
<tr>
<td>9, 11</td>
<td>1500 - 150</td>
<td>07/year</td>
<td>1/20 years</td>
</tr>
</tbody>
</table>

1 Age of the Mazama Set O tephra as reported in McPherson et al. (1981) has been adjusted.

### Table 6.5. Workshop accumulation rates for debitage and bifacial/unifacial blanks at Marshmeadow (compiled from McPherson et al. 1981).

<table>
<thead>
<tr>
<th>Stratigraphic Unit(s)</th>
<th>Age (RCYBP)</th>
<th>Debitage Accumulation</th>
<th>Workshop Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>6700 - 6100</td>
<td>5/year</td>
<td>1/23 years</td>
</tr>
<tr>
<td>4</td>
<td>4000 - 3410</td>
<td>21/year</td>
<td>1/8 years</td>
</tr>
<tr>
<td>5</td>
<td>3410 - 2260</td>
<td>19/year</td>
<td>1/10 years</td>
</tr>
<tr>
<td>6</td>
<td>2260 - 690</td>
<td>21/year</td>
<td>1/5 years</td>
</tr>
</tbody>
</table>
workshop activity at Timber Butte, Dooley Mountain, and the other sources touched upon here. Evidence suggests that no more than six of the scores of obsidian sources in the SNP Terrane contributed the bulk of material that went into regional circulation along the boundary zone between the Basin and Plateau. Regional patterning is consistent with an embedded cobble harvesting pattern and core and biface reduction by individual knappers at off-site workshops (Sappington 1984; McDonald 1985). The labor investment involved uphill climbs and downhill loads rather than regolithic trenching or hammering adits into cirque headwalls (c.f. Choquette 1981).

A cluster of debris-clogged pits littered with quartzite hammerstones at Big Table Mountain is the only true quarry discovered in this review. Its proximity to the Obsidian Cliff quarries on the Yellowstone Plateau, and the fact that both of these obsidians were conveyed to consumers as far east as the Scioto Hopewell (DeBoer 2004) hints at two procurement patterns in the study area: embedded cobble harvesting by tool-depleted resident populations, and direct procurement and surplus production by trade specialists.

Accessibility, portability, and workability gave obsidians a unit value recognized as far away as Ohio during the Middle Woodland period. In contrast, the suite of FGV toolstones outcropping in flows of the CRBG Terrane exhibit more localized distributions suggestive of place value. The durable working edges on these tough toolstones may have anchored activity hubs where other tool materials were bulk processed. Thus, the hardness of FGV toolstones is sometimes cited to support the idea that source areas doubled as industrial loci where tool-quality wooden, bone, and antler raw materials were brought for shaping and scraping into digging sticks and other implements (Bucy 1971:42; Jenkins and Connolly 1990:144-145). Several of the FGV source areas discussed above occur near root meadows, fisheries, and hunting grounds, with seasonal camps clustered in their immediate vicinity. To these potential advantages should be added the generally lower elevations and longer seasonal availability of the FGV sources.

The basaltic andesite workshops reported here cluster along outcrops of the Grande Ronde Basalt Flow. The single confirmed dacite source occurs in the Saddle Mountain Basalt Flow. To date, Grande Ronde toolstones separated by hundreds of kilometers have not been geochemically distinguished from one another. However, they are chemically distinct from the dacite exposed in the Saddle Mountain Basalt Flow at Craig Mountain. The latter toolstone had the added advantages of large package size and low fracture toughness, with local workshops turning out production bifaces longer than 35 cm and standardized unifaces only slightly shorter.

I’ll close with a comment offered from a wider perspective. Thus, nowhere in the study area reviewed here have true quarries been recorded that are comparable to the Obsidian Cliff source on the Yellowstone Plateau (Johnson et al. 1995), the Cashman dacite quarry in southwestern Montana (Baumler et al. 2001), or the more distant Spanish Diggings quartzite quarries in eastern Wyoming (Reher 1990). These are true quarries with numerous pits, ditches, trenches, adits, extensive debris aprons and tailings, and a range of associated features such as caches, cairns, and habitation structures. The absence of such sites has organizational implications at the regional level. For example, the scale of works on the Hartville Uplift has been interpreted to reflect the task-specific, direct-procurement of toolstone, planned and scheduled in concert with communal bison drives and mass processing of kills (Reher 1990:276-279). A similar explanation has not been offered for the extensive quarrying at Cashman, but may be appropriate given the site’s proximity to prime bison habitat.

Whether the apparent absence of these sites in our study area marks a true negative or a sampling or visibility bias should be addressed in future research. Thus, the scale of toolstone quarrying at the Obsidian Cliff National Historic Landmark (Johnson et al. 1995) did not become fully apparent until the catastrophic forest fires of 1988 and a post-fire survey the following year. Similar fires can be expected to increase in frequency in coming years, but it is unlikely that they will be followed by similarly intensive ground surveys. Remote sensing survey and mapping appears to be the logical next step.
to understanding the size and internal complexity of these sites.

ACKNOWLEDGMENTS

I’m grateful to Travis Pitkin and Joshua L. Hood for help with graphics. Conversations and field visits with Bruce Womack, Fred Jaehnig, Bob Nisbet, Jim Gallison, Daryl Ferguson, Matt Root, Ken Dickerson, Tracy Vallier, and especially Ed Bakewell taught me much about fine-grained volcanics. My understanding of Idaho obsidians owes at least as much to Lee Sappington, Rick Holmer, Richard Hughes, Jim Woods, Sharon Plager, Kirk Halford, and Ty Corn. Former Oregon state archaeologist Le Gilsen provided site records for the Craig Mountain area. Forest Archaeologist Ali Abusaidi was similarly helpful in locating obsidian workshops on the Caribou-Targhee National Forest. An earlier version of this chapter was improved by comments from Bonnie Pitblado and an anonymous reviewer. Permission of reproduce a part of the Hohastllpelp map of May 29, 1806 was granted by the Peabody Museum of Natural History, Yale University.

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