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Boulders to Bifaces: Initial Reduction of Obsidian at Newberry Crater, Oregon

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THE archaeological remains in Newberry Crater, Oregon are associated with a large prehistoric obsidian quarry complex. The main attraction to Newberry Crater obsidian throughout prehistory appears to have been the availability of boulder-size blocks (greater than 256 mm. diameter, Wentworth scale). These large-sized obsidian blocks were used to make extremely large cores, bifaces, and projectile points. Although manufacture of large tools may have been the norm at quarry areas throughout western North America, it is infrequently reflected in lithic assemblages from sites across the landscape because of use-life reduction prior to discard.

Experimental and archaeological data are used here to determine aspects of prehistoric lithic technology represented at three sites within the obsidian quarry complex in Newberry Crater. These data indicate that several different sets of technological activities occurred at sites within the crater; however, all involved reduction of obsidian into large-sized bifacial artifacts.

SETTING

Newberry Volcano, a quaternary shield volcano, covers an area of approximately twelve hundred square kilometers on the western High Lava Plain (Fig. 1). The caldera is 6-8 km. in diameter and contains two lakes (Paulina Lake and East Lake), numerous cinder cones, and at least nine obsidian flows (including two separate East Lake flows) (Fig. 2).

The quaternary geology of Newberry Volcano is extremely complex. Approximately 700,000 years ago, basalt flow eruptions from the Newberry vent began, creating the volcano (MacLeod et al. 1981:87; MacLeod 1982:125). Between about 500,000 and 100,000 years ago, the caldera formed as the result of a series of collapses following enormous tephra eruptions, some more than 40 $km.^3$ in volume (Higgins 1973; MacLeod et al. 1981; MacLeod 1982: 125). Mount Mazama (Crater Lake), located some 100 km. to the southwest (Fig. 1), erupted approximately 6,800 years ago (Bacon 1983) depositing a blanket of tephra nearly one meter thick over the entire volcano. Approximately 1,550 years ago, a pyroclastic eruption from a vent at the southern edge of the caldera (Fig. 2) deposited a narrow plume of pumice several meters thick in the southeastern quadrant of the crater and east across the High Lava Plain. Ash from the same vent flowed toward Paulina Lake approximately 1,350 years ago followed immediately by extrusion of the Big Obsidian Flow (Macleod et al. 1981:91; MacLeod 1982:125).

Of the nine exposed obsidian flows (Fig. 2), five stratigraphically overlie Mazama tephra and, therefore, must be less than 6,800 years old. The other four are older than 6,800 years. Archaeological quarry/workshops are associated with several of these obsidian sources and other prehistoric sites are located in many areas of the crater. Three of these sites have been test excavated and analyzed (Flenniken and Ozbun 1988). Data obtained from investigation of these three sites are used to examine one aspect of prehistoric lithic technology: large initial artifact size as a planned design concept to maximize the use-life of obsidian tools across the

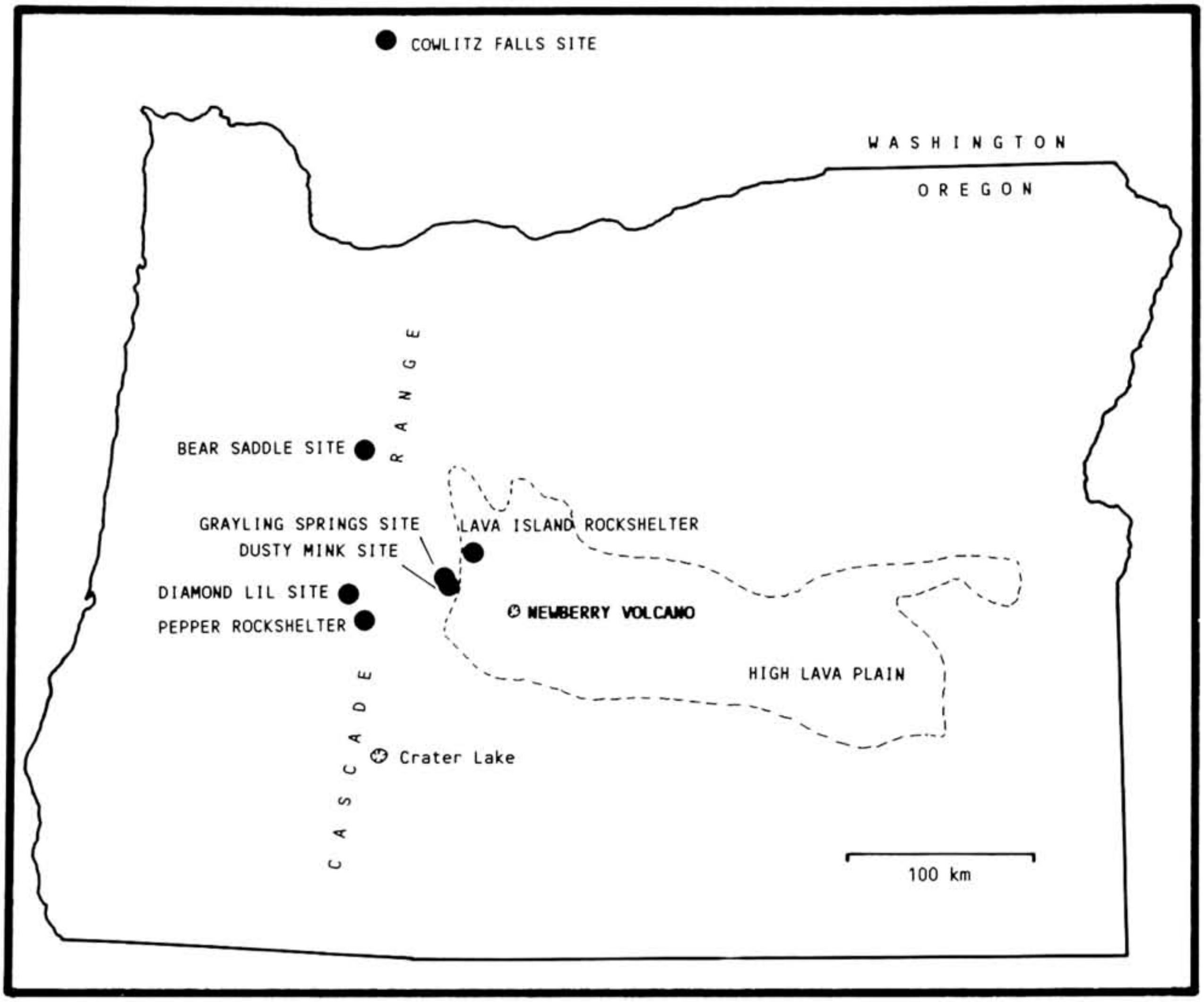

Fig. 1. Location of Newberry Volcano and archaeological sites with Newberry obsidian artifacts.

landscape away from lithic resources.

Results of test excavations at three sites within Newberry Crater and the lithic analyses of the recovered artifacts form the basis for this study. Raw data, concerning topography, stratigraphy, and lithic assemblages, and interpretations of those data are presented in detail elsewhere (see Flenniken and Ozbun 1988) and, therefore, will not be reproduced here. Further test excavations within the crater have recently been completed (Connolly 1991).

BIG OBSIDIAN FLOW SITE

The Big Obsidian Flow site (35DS212) is one of several quarry/workshop sites located within the crater. The site consists of a continuous scatter of artifacts around the entire periphery of the Big Obsidian Flow (9 km. in circumference) and extends from the edge of the flow only about 15 m. (Fig. 2). Artifacts were not found on top of the flow, probably because of the treacherous and jagged topography. Pre-

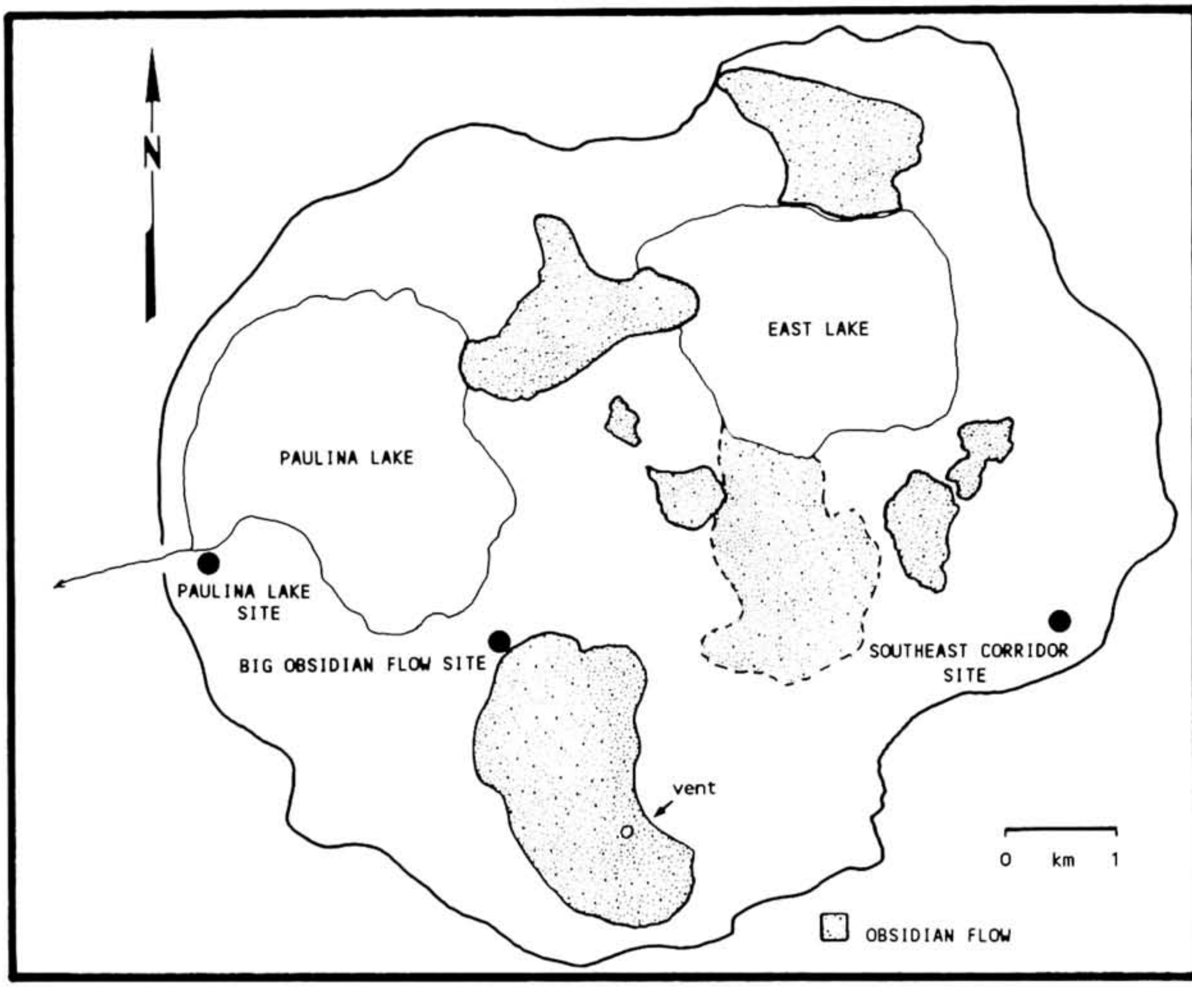

Fig. 2. Newberry Crater interior and investigated archaeological sites.

historic use of the Big Obsidian Flow site must be less than 1,350 years old since the material quarried did not exist before that time.

Large blocks (i.e., boulder-sized and much greater) of flakeable obsidian are easily accessible at edge of the flow. Archaeological evidence that large flakes were removed directly from the blocks is indicated by negative flake scars evident on many of the obsidian blocks. Also, the huge (greater than 40 cm. diameter) hammerstones associated with the site and the presence of large detachment scars on large discarded bifacial cores and bifacial core fragments suggest that direct flaking of immovable obsidian blocks occurred. Analysis of debitage and formed artifacts from the Big Obsidian Flow site have allowed reconstruction of the obsidian reduction sequence employed by prehistoric knappers at the site (Fig. 3). The analysis indicates that bifacial cores and bifacial blanks were manufactured at the source and exported from the site. Bifacial cores, bifacial core fragments, and debitage from their manufacture, recovered from the excavations, suggest that the cores frequently exceeded 20 cm. in length (Fig. 4). The size of the bifacial blanks produced was approximately 12 cm. in length, estimated both from blanks broken (Figs. 5 and

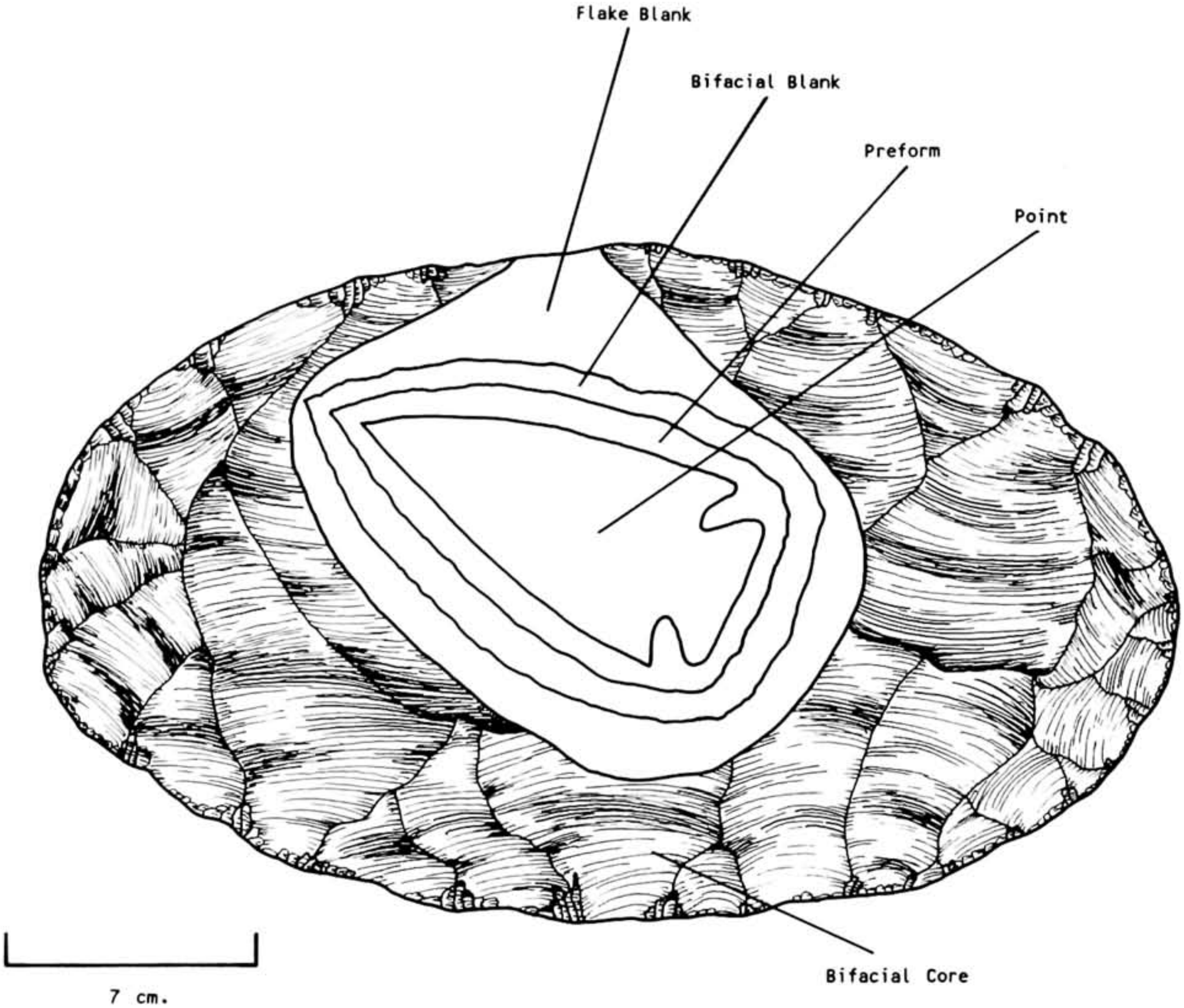

Fig. 3. Reconstructed obsidian reduction sequence for Newberry Crater archaeological sites.

6) and rejected (Fig. 7) in manufacture, and from debitage corresponding to that stage of reduction (Flenniken and Ozbun 1988).

PAULINA LAKE SITE

The Paulina Lake site (35DS34) is located on the southern shore of Paulina Lake (Fig. 2) and exhibits two distinct components. The upper component (above Mazama ash) contains evidence for an emphasis on tool finishing at the site. The reduction sequence is represented by arrow point blanks, arrow point preforms, and broken arrow points.

Artifacts from the lower component are concentrated at the surface of a paleosol directly beneath Mazama ash. Charcoal associated with the artifacts in the paleosol has been dated to 8,210 $\pm$ 60 B.P. (Flenniken and Ozbun 1988) and 7,080 $\pm$ 80 B.P. (Connolly 1991). The lithic assemblage of the lower component exhibits emphasis on production of dart points (Fig. 8). Measurements from stage-diagnostic formed artifact fragments and late-stage bifacial thinning flakes were used to estimate the size of the dart points produced at the site. Estimates from the debitage are based on measurement of the

Fig. 4. Bifacial core from the Big Obsidian Flow site (length is 24 cm.).

lengths of late-stage percussion bifacial thinning flakes only. This debitage category most accurately reflects intended formed artifact size because complete flakes of this category extend from the margin to the midline of the biface in most cases and, therefore, their lengths are representative of approximately one-half the width of the biface from which they are removed. Unbroken late-stage percussion bifacial thinning flakes recovered from the lower component of the Paulina Lake site average 29 mm. in length, suggesting a width of 58 mm. for the finished blanks. A proportionate length calculated on the basis of recovered formed artifacts from the site and experimental data indicates a length of 10-12 cm. This estimate corresponds with the estimated size of blanks leaving the Big Obsidian Flow site (Fig. 3), although the two sites are temporally unrelated.

SOUTHEAST CORRIDOR SITE

The Southeast Corridor site is situated near the rim of the crater along a natural access route (Fig. 2). Materials recovered from the site overlie a thick deposit of 1,550 year-old pumice derived from a Newberry Volcano eruption. Two small concentrations of debitage and formed artifacts comprised the entire site assemblage. These concentrations were determined to be segregated reduction locations (SRLs) representing single individual flintknapping events (Flenniken and Stanfill 1980; Flenniken and Ozbun 1988). SRLs are relatively rare in the archaeological record since most lithic scatter sites contain accumulated debitage from repeated flintknapping events at the same location over a period of time. Analysis of debitage from an SRL results in a more

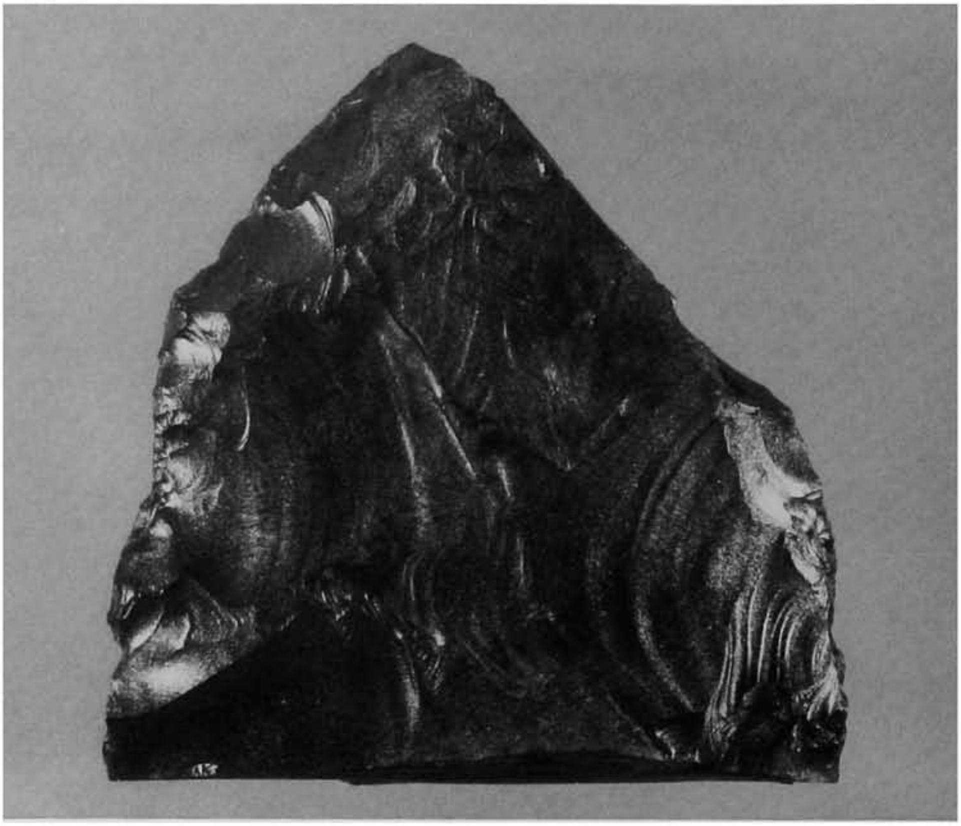

Fig. 5. Bifacial blank fragment from the Big Obsidian Flow site (length is 5.4 cm.).

precise definition of reduction technology since residues from different events are not mixed together.

The obsidian reduced at the Southeast Corridor site was likely obtained from the East Lake Flows quarry located less than one kilometer from the site. One SRL was produced as the result of reduction of flake blanks to bifacial blanks by percussion. The other SRL involved reduction of a flake blank to a pressure-flaked biface. The length (greater than 2 cm.) of the pressure flakes recovered suggest that a large biface was produced and exported from the site. Although the site dates to a period traditionally associated with bow and arrow technology, the assemblage does not appear to be related to arrow point production. The bifaces exported from the Southeast Corridor site may have functioned as dart point preforms, lanceolate points (cf. Connolly and Baxter 1986; Daugherty et al. 1987), or trade bifaces (cf. Scott et al. 1986).

COMPARISON OF REDUCTION TRAJECTORIES AND SITE FUNCTION

All three of the sites described above are located in close proximity to expansive obsidian sources and were likely situated wholly or partly to take advantage of the abundant lithic resources in the crater. Although each analyzed assemblage represents different stages of reduction and potentially different end products, all are related to the same or similar reduction technologies (Fig. 3). The lithic technological activities that occurred indicate a pattern of locationally staged manufacture of bifacial artifacts within, and outside of, the crater.

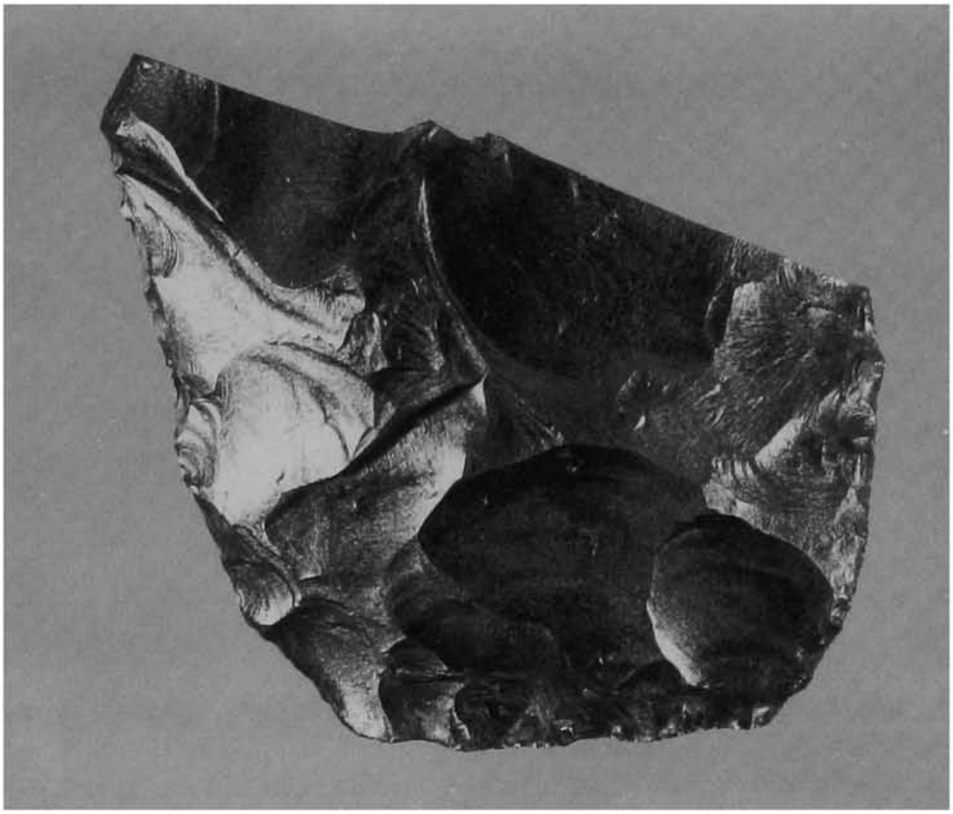

Fig. 6. Bifacial blank fragment from the Big Obsidian Flow site (length is 6.3 cm.).

Quarry sites at source locations in the crater, such as the Big Obsidian Flow site, were used for obsidian procurement and reduction to bifacial cores and blanks. At places such as the Paulina Lake site and other lake shore sites (cf. Flenniken 1987), flake blanks and bifacial blanks manufactured at the quarries were thinned and pressure flaked into projectile points. Sites in the crater located on lake shores appear to have been repeatedly occupied because of the available permanent water supply and possibly other lacustrine resources. The duration of these occupations may have been longer than at other sites without water. Duration of occupation probably correlates well with completion of reduction trajectories and accumulation of the corresponding debitage and broken or rejected formed artifacts. Other locations, such as the Southeast Corridor site and sites in the crater's western access corridor along Paulina Creek (Ritchie 1987), were used as temporary stopping places for intermediate or final reduction stages while in transit from quarries to locations outside the crater.

All sites investigated were remarkable in the large scale of items manufactured. Cores and blanks produced at the quarries are large and correspond proportionally with the sizes of preforms and points produced at other sites located within the source area. Assemblages analyzed range in age from at least 7,000 years to less than 1,350 years old. Although smaller arrow points were manufactured at some of the younger sites, large bifaces were also produced. Large-sized artifacts were exported from Newberry Crater for at least 6,000 years.

Fig. 7. Bifacial blank (length is 12.5 cm.) from the Big Obsidian Flow site. This blank was rejected at the quarry because of a flintknapping error.

SIZES OF ARTIFACTS FROM NON-QUARRY RELATED SITES

Materials exported from Newberry Crater were not generally transported long distances (R. Hughes, personal communication 1990) for use or trade although a small number of artifacts from the western Cascade Range (cf. Flenniken et al. 1990) and as far away as Cowlitz Falls, Washington (Fig. 1) have been identified as Newberry Volcano obsidian by x-ray fluorescence (XRF) analysis (Ellis et al. 1991). Intensive prehistoric use of Newberry obsidians was largely restricted to the flanks of the volcano and the Upper Deschutes River basin (C. Skinner, personal communication 1990).

Artifacts from two sites in the Upper Deschutes River basin were found to have Newberry Volcano obsidian as the primary raw material source (XRF analysis; McFarland 1989). The Dusty Mink (35DS502) and Grayling Springs (35DS381) sites are located on Fall River approximately 30 km. west of the Newberry Caldera (Fig. 1). Sixty and eighty-seven percent, respectively, of the materials analyzed were characterized as Newberry Volcano obsidian, although the sample sizes were small (n=15 each). Most of the points recovered from the Dusty Mink site were related to arrow point technology; however, the other lanceolate and dart points and preforms (n=3) average 55 mm. in length. Three complete, or nearly complete, dart points recovered from the Grayling Springs site average 32 mm. in length.

More than half (52%) of the artifacts sourced by XRF (n=103) from Lava Island Rockshelter (35DS86), 30 km. northwest of the caldera (Fig. 1), have been attributed to Newberry sources (Minor and Toepel 1982). Lanceolate bifaces found in a cache at this site (n=28) were all complete and averaged 76 mm. in length. The technological context of these cached artifacts has been debated in the literature (cf. Scott et al. 1986); however, all agree

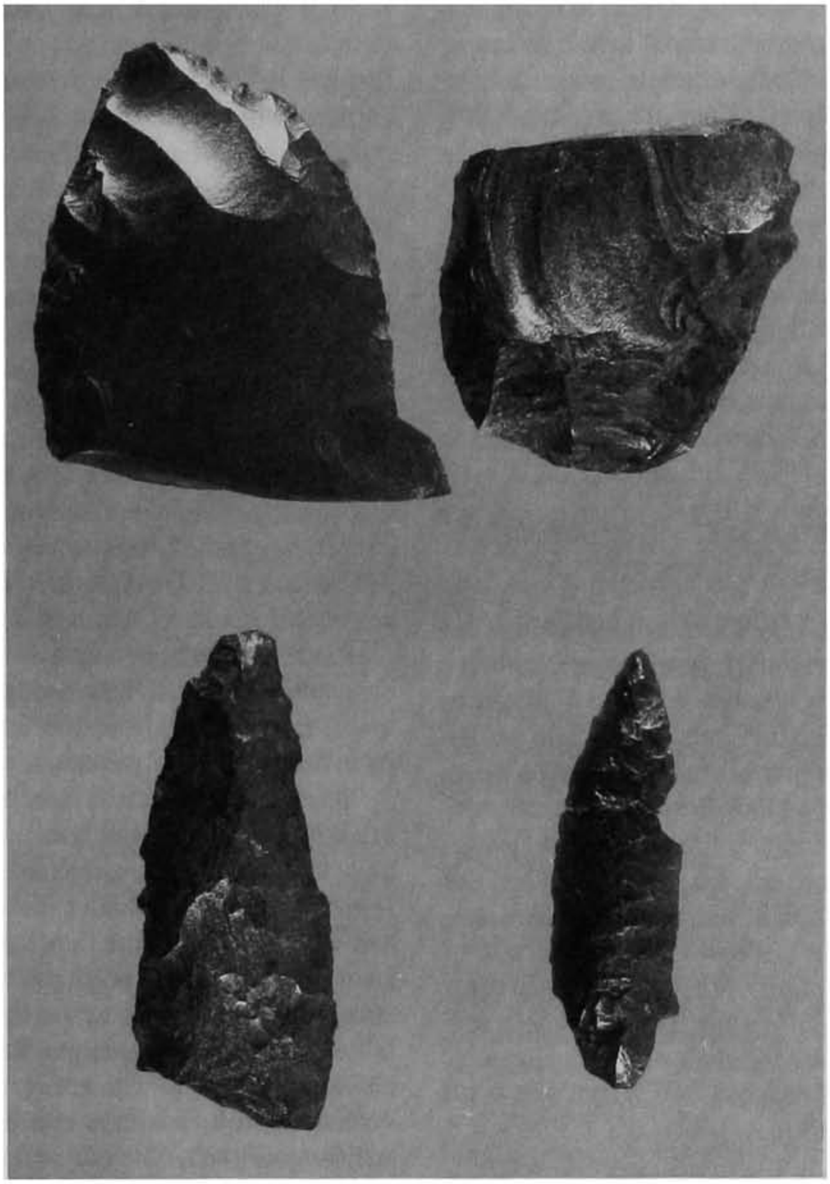

Fig. 8. Stage diagnostic formed artifacts from the Paulina Lake site: preform fragment (upper left); bifacial blank fragment (upper right); dart point fragment (lower left); exhausted dart point (lower right). Length of exhausted dart point is 4 cm.

the artifacts are not projectile points discarded as a result of use-life exhaustion. The cache context probably accounts for the somewhat larger average size of these artifacts in comparison with other artifacts found at more typical sites. Even at the Lava Island Rockshelter itself, lanceolate (n=5) and dart (n=7) points found outside the cache are considerably smaller (46 mm.) in average length.

Lithic assemblages from the western Cascade Range sometimes contain small proportions of Newberry obsidian, usually reworked formed artifacts (Nilsson 1989). Two complete exhausted dart points recovered at the Diamond Lil site (35LA807), for example, were traced to Newberry Volcano (Flenniken et al. 1990). These points measured 19 and 26 mm. in length. Only small, unidentifiable biface fragments were traced to Newberry in assemblages recovered at the Bear Saddle site (35LIN301; Nilsson 1989) and Pepper Rockshelter (35 LA801; Churchill and Jenkins 1989). These small artifacts are probably characteristic of Newberry materials that have been transported over 100 km. across the crest of the Cascade Range.

LARGE INITIAL SIZE AS A PLANNED DESIGN CONCEPT

Comparisons of lithic assemblages between sites located in a source area such as Newberry Crater and sites located at various distances away from the source indicate that use of that material is conditioned by tool curation practices. Binford (1980) described anticipatory technology as "curated," meaning that elements of it are designed for easy transportation and long-term use. Certain aspects of lithic assemblages have been distinguished as diagnostic of curation. Binford (1979:268) noted that "staging behavior" or the stepped manufacture of tools at various locations on the landscape is characteristic of curation. Bamforth (1986:38) described curated tools as

> effective for a variety of tasks, . . . manufactured in anticipation of use, maintained through a number of uses, transported from locality to locality for these uses, and recycled to other tasks when no longer useful for their primary purposes.

Analyses of the Newberry source area lithic assemblages and assemblages from other sites where Newberry obsidian is found (cf. McFarland 1989; Nilsson 1989; Flenniken et al. 1990) indicate that the staged manufacture was practiced by users of Newberry obsidian. Other aspects of curated technologies, such as tool maintenance through rejuvenation and lateral cycling (Schiffer 1972), are also evident at these sites. Curated technologies, however, cannot be described on the basis of subsistence-settlement strategies without regard for local and regional lithic raw material distributions or tool production and maintenance costs. This contextual aspect of raw material procurement and use has been referred to as the "lithic landscape" (Gould and Saggers 1985; Bamforth 1986). The region that was occupied by the prehistoric people who used Newberry obsidian (mostly to the north and west) is an area where obsidian tool stone is relatively scarce compared to areas south and east of the crater. While other sources were used, evidence from the sites discussed here indicate that tool-kit curation was practiced on Newberry materials. As the Newberry obsidian was transported from the quarry, use of that material decreased and was replaced by a variety of other materials.

Among the sites in the Newberry use-region discussed above, the proportion of the assemblages containing Newberry materials decreases from nearly 100 percent at the quarry, to one half or more at sites within the intensive use area, to only small percentages at distances where other sources dominate the region. This fall-off phenomena has been documented and discussed elsewhere with reference to exchange systems as well as curated technologies (Gould and Saggers 1985).

Individual artifacts within the system also change as they are used and maintained. As a result of attrition, breakage, and rejuvenation, artifacts become smaller through their use-lives until they are laterally cycled to other uses or discarded. Evidence for this process has been demonstrated through analysis of artifact sizes at the various sites. Dart points produced at the Newberry source area were estimated to be approximately 10-12 cm. in length. Similar artifacts found at sites located 30 km. from the source were found to be approximately half of that size, on average. Points found at sites 100 km. away or more were less than one third of the probable original size. This reduction in the size of individual artifacts at various distances from the source area reflects the expected result of artifact use-life reduction. The reduction appears to be very systematic and controlled.

Systematic processing of stone materials through stages of manufacture, use, maintenance, and eventual discard is a well-documented aspect of prehistoric lithic technologies. These technologies are organized to take advantage of the mobility patterns practiced by hunter-gatherers so that tool stone is periodically replenished, and so that the tool kits in use are maintained at levels where replacement and repair of worn or broken parts can be accomplished when necessary (Raymond 1990). This is especially important for subsistence strategies that involve intensive procurement and processing of seasonally available food resources at locations where stone is not available, such as the Diamond Lil site (Flenniken et al. 1990).

The cognitive design aspects of lithic tool manufacture (cf. Hassan 1987) that account for their maintainability (Bleed 1986) are manifest in many attributes of the artifacts themselves, and the assemblages as a whole. These attributes include the use of portable bifacial cores and blanks (Flenniken and Ozbun 1988; Wilke and Flenniken 1988), use of a "specialized repair kit that includes ready-to-use extra components" (Bleed 1986:739), and point notching to facilitate repairable, rather than deleterious, breakage patterns (Flenniken and Wilke 1989). Bleed (1986:739) also noted that maintainable systems are "generally light" to allow for easy transportation. This aspect of the technology is contrary to the apparent emphasis on production of large-sized artifacts at Newberry Crater as described above. It is proposed here that the manufacture of large-sized artifacts is beneficial to use-life longevity in a manner that outweighs additional transportation costs.

Large initial artifact size is proposed as a planned design concept intended to compensate for expected use-life reductions in size through attrition, breakage, and rejuvenation processes. Since long use-life is a desired attribute of the technology, and since the users expect attrition and breakage to occur, it would not be surprising that they also would insure a longer functional utility through manufacture of larger artifacts. Of course, the upper limits of artifact size are conditioned by functional requirements of the systems in which they are used, and the size of the raw materials available. Since the available size of raw materials at Newberry greatly exceeds the estimated size of artifacts produced there, artifacts produced at Newberry may evidence the largest optimal size.

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