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**Author**

Jackson, Thomas L

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# Amending Models of Trans-Sierran Obsidian Tool Production and Exchange

THOMAS L. JACKSON, Archaeological Research Facility, Univ. of California, Berkeley, CA 94720.

**SEVERAL** very large modified and unmodified pieces of obsidian have been recovered separately from and near archaeological sites on the Pineridge Ranger District, Sierra National Forest, Fresno County, California (Fig. 1). The discovery of these specimens, weighing up to 7 kg., on the west slope of the Sierra Nevada suggests that bulky, minimally reduced obsidian raw material and cores were a regular part of the prehistoric obsidian exchange inventory. Current lithic technology models incorporating a paradigm that emphasizes efficiency in resource and artifact procurement, production, distribution, and exchange may not adequately characterize trans-Sierran prehistoric lithic production systems. This paper describes the subject artifacts and their dating, and discusses the finds vis-a-vis models of obsidian artifact production and exchange in the western Great Basin and southern Sierra Nevada.

## PROVENIENCE AND DESCRIPTION

Some years ago, an unmodified piece of obsidian measuring approximately 10 by 10 by 15 cm. was observed by the author in the private artifact collection of a late Mr. Robinson, Big Creek, Fresno County, California. The actual weight was not determined but it is estimated at approximately 1.5 kg. Physical characteristics suggest the obsidian is from the Casa Diablo geological source.

Mr. Robinson, a long-time resident of the area and avid artifact collector who maintained some documentation of his finds, recounted that he found the piece on Stump

Springs Road, Sierra National Forest, but not on an "Indian site" (Fig. 1). Six or seven archaeological sites (Forest Service records are unclear) are within 1 km. of the reported discovery location, and the Stump Springs roadway corresponds in part with an ethnographically documented Mono Indian trail. However, the skeptical author originally surmised it possible that the obsidian chunk had fallen from the cargo box of a pickup truck. Unfortunately, the specimen is no longer available for study.

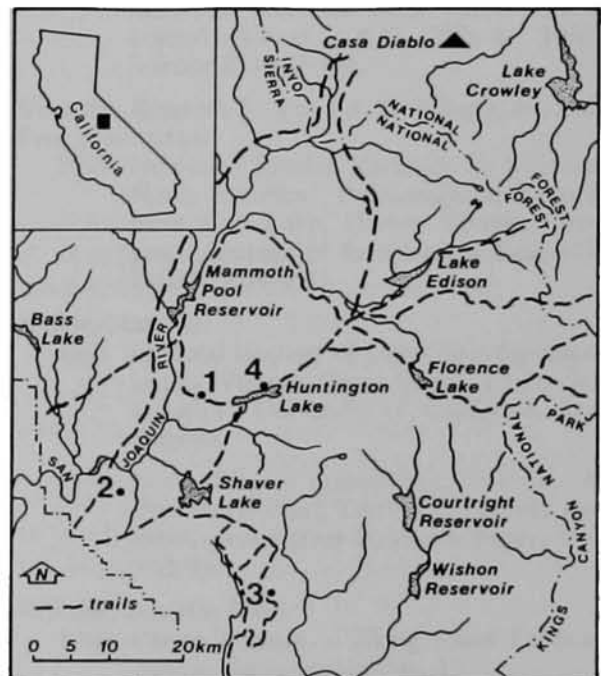


Fig. 1. Locations of large obsidian pieces and selected historic trails, Pine Ridge Ranger District, Sierra National Forest. 1, Stump Springs Road (Robinson Find); 2, Jose Basin; 3, FRE-1984; 4, FRE-291. Trail locations after Gayton (1948), Hinds (1959), and Theodoratus et al. (1982).

Two other large pieces of obsidian from the Pineridge Ranger District were brought to the author's attention by Sierra National Forest archaeologists Dolly Stangl and Larry Swan. The obsidian pieces are stored at the Pineridge Ranger District office, Shaver Lake, California, and are illustrated as Figures 2 and 3.

Specimen #53-1984-39 (Fig. 2) was collected from the east edge of Sugarloaf Road in Jose Basin (No. 2 on Fig. 1). The find spot is equidistant from two recorded archaeological sites adjacent to the roadway and it is possible the obsidian was removed from one of the sites during road grading. The piece is 14.8 cm. wide, 18.2 cm. long, 7.5 cm. thick, and weighs 1.66 kg. The obsidian apparently is from the Casa Diablo source, judging by physical attributes. The specimen is the distal portion of a truncated flake with approximately 90% of the exterior (dorsal) surface retaining the natural cortex.

An obsidian core (Fig. 3) was collected from the logged-over surface of site CA-FRE-1984 (No. 3 on Fig. 1). Maximum dimensions are approximately 25.5 cm. long, 17 cm. wide, and 15 cm. thick; weight is approximately 7.0 kg. The geological source of the obsidian is Casa Diablo, determined by X-ray fluorescence (XRF) trace-element analysis. An estimated 70% of the surface area of the block is covered by cortex. Unlike the two previously described pieces, this artifact shows clear evidence of flake removal from one face of the core.

Two additional large pieces of obsidian were discovered during test excavations at FRE-291, located on the north shore of Huntington Lake at Bear Cove. The two pieces were found *in situ*, placed one atop the other, between 20 and 46 cm. below present ground surface. Bedrock was encountered in the excavation unit at 50 cm. below surface. The artifacts presumably were cached. Although no pit outline was



Fig. 2. Obsidian piece from Jose Basin (USFS #53-1984-39).



Fig. 3. Obsidian core weighing 7 kg. from FRE-1984.

visible, they obviously had been emplaced into a culturally sterile stratum of glacial cobbles and pebbles.

The larger of the two specimens (catalog number 291-119) weighs 5.2 kg. and measures 26 by 23 by 8.5 cm. (Fig. 4, left). This piece was derived from a tabular slab of obsidian, shows numerous flake scars on both surfaces, and retains cortex on both the upper and lower surfaces. The smaller piece

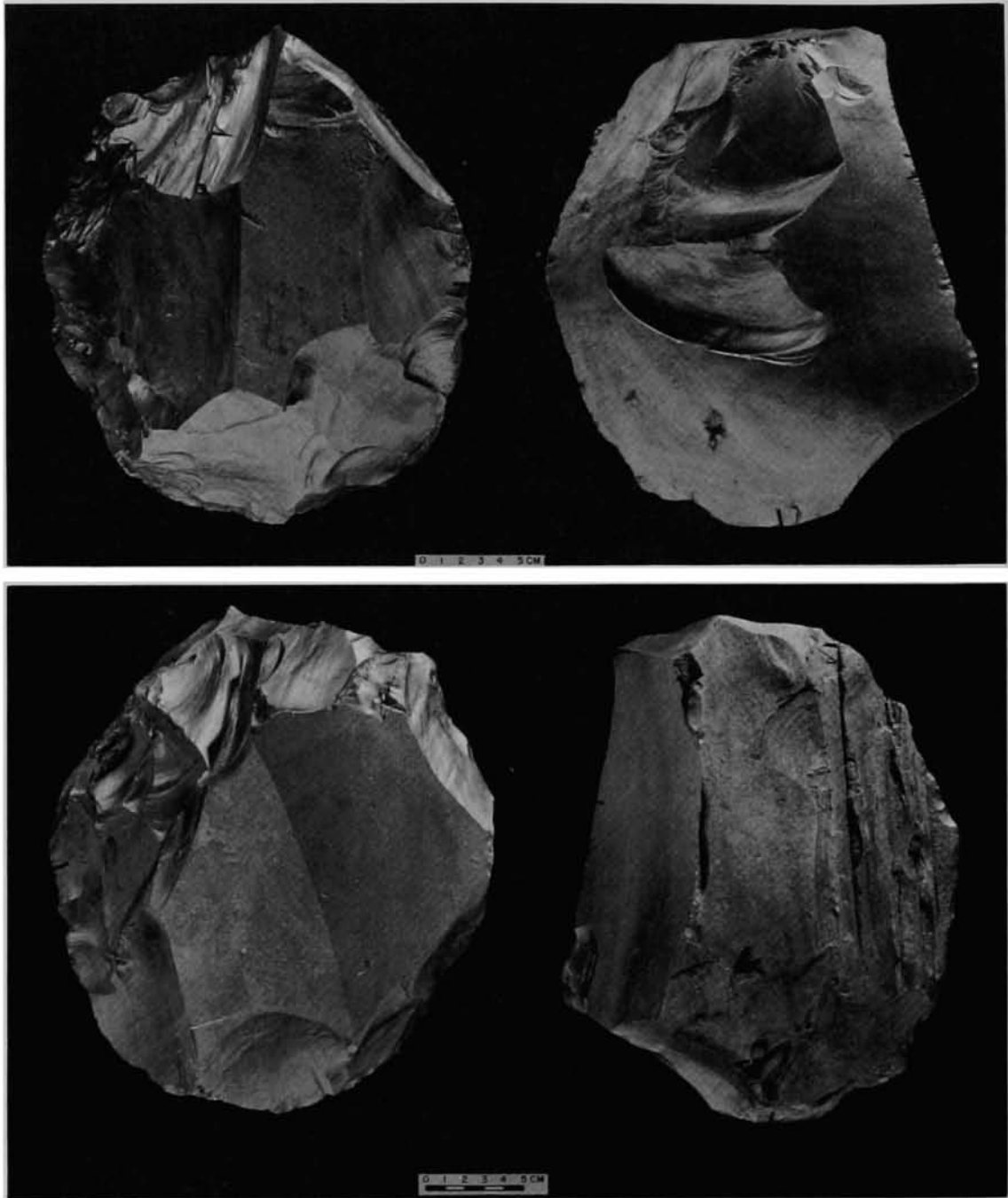


Fig. 4. Obsidian artifact numbers 291-119 (left) and 291-118 (right) from FRE-291. Opposing faces in upper and lower views. Note the cortex-bearing surfaces on both specimens (flat surface on 291-119 and irregular surface on 291-118 in the upper view, and the remnant cortex [flat surface] on 291-119 in the lower view). Specimens are coated with aluminum powder for photographic enhancement.

(catalog number 291-118) measures 26.5 by 22.5 by 8.4 cm. and weighs 3.7 kg. (Fig. 4, right). The dorsal surface of this large flake is completely covered by cortex. This specimen was modified only by the deliberate dulling of one otherwise sharp flake edge. Physical characteristics of the glass suggest that both artifacts are of Casa Diablo obsidian.

Three of the obsidian find locations are near historically reported trails (Fig. 1). The Robinson find and artifacts from FRE-291 are adjacent to a trail reported by Hinds (1959) to have passed through the Huntington Lake basin and paralleled the San Joaquin River along a route corresponding, in part, to the modern Stump Springs Road. FRE-1984 is located near a Holkoma trail reported by Theodoratus et al. (1982). Although the Jose Basin find is not associated with a reported trail through that area, it seems probable that a trail would have existed there.

### ARTIFACT DATING

An understanding of when these large obsidian pieces were imported to the western Sierra is critical to any interpretation of the role they played in obsidian tool production systems. There are two separate issues: (1) when were the pieces actually created at the quarry; and, (2) when were they imported for use in the western Sierra? It should not be assumed that these pieces were incorporated into the technological or exchange systems immediately after they were created. On the contrary, it is possible that these pieces of obsidian could have been collected from the Casa Diablo quarries centuries after their creation.

The two Forest Service specimens and the two artifacts from FRE-291 were submitted to Robert J. Jackson, Lithichron, Inc., to obtain measurements of their hydration rinds. Selecting a surface on which to make the

hydration cut on the Jose Basin piece proved difficult because there is no definitive modification. Because the cortex surface and apparently very recent flake scars obviously were to be avoided, this left the edge at the intersection of the ventral flake surface and the surface formed when the flake was truncated. The hydration rind at this location measures 4.75 microns.

The core from FRE-1984 provided a better opportunity for dating artifact use. The striking platform edge on the core has a hydration rind measuring 4.0 microns.

The two specimens from FRE-291 also were cut for hydration rind measurements. Two separate cuts were made on specimen number 291-118, one on an unmodified flake margin, and the other on the dulled flake edge. The unmodified edge has a variable hydration rind with an average thickness of 2.5 microns (modal value of measurements is 2.69 microns). The modified flake edge has a rind 2.7 microns thick. The hydration rind on specimen number 291-119 is 2.7 microns. Thus the specimens from FRE-291 are assumed to have been created at the same time, lending support to the idea they were transported and cached as (part of?) a single cargo.

The artifacts from the three dated finds were produced at different times over a period spanning perhaps 1,500 years. An approximation of hydration rind measurements as absolute dates is achieved using a rate formula for Casa Diablo obsidian proposed by Hall (1984). Applying Hall's rate, 4.8 microns of hydration translates to ca. 2,273 years B.P., 4.0 microns to ca. 1,630 years B.P., and 2.7 microns to ca. 795 years before present. Hall's formula is used without modification because all dated artifacts are believed to be of Casa Diablo obsidian, were found in comparable environmental settings, and effective temperatures in these settings do not vary significantly

from effective hydration temperatures used by Hall to compute his rate. The ages given are considered "rough-and-ready" estimates (to use Meighan's term) and represent maximum age of deposition at the find localities.

At sites near the obsidian find locations, projectile points with hydration rind values comparable to that on the specimen from FRE-1984 (i.e., between 4.6 and 5.2 microns, allowing for measurement error) are typed as "Pinto," and others informally described as "wide-stemmed," "large corner-notched," and "large side-notched" from CA-FRE-805 (Jackson and Dietz 1984:135), and "medium lanceolate" from CA-FRE-812 (Goldberg and Moratto 1984:147, Table 4.8). These projectile points co-occur stratigraphically with Humboldt and Elko series projectile points in the southern Sierra Nevada (Jackson and Dietz 1984:77, 135). In the eastern Sierra Nevada comparable Casa Diablo obsidian hydration values are associated with Elko, Humboldt Concave-base, and Little Lake series projectile points (Hall 1983; Jackson 1985:86, Table 4).

Projectile point types of Casa Diablo obsidian with hydration rinds corresponding to the Jose Basin specimen (3.8 to 4.2 microns) include all of the foregoing plus Elko series points at FRE-798 and FRE-805 and Sierra Concave Base points at FRE 812 (Jackson and Dietz 1984:77, 135; Goldberg and Moratto 1984:Table 4.8). In the eastern Sierra Nevada, Rosegate, Elko, and Little Lake series projectile points exhibit hydration rinds in this thickness range (Hall 1983; Jackson 1985:86, Table 4).

In the Eastern Sierra Nevada projectile points with hydration rinds ranging from 2.5 to 2.9 microns (similar to those of the FRE-291 pieces) are, for the most part, restricted to the Rosegate and Desert series (Hall 1983; Jackson 1985:86, Table 4). These hydration rinds generally exceed the thicknesses found on Desert and Rosegate series projectile

points at FRE-798, FRE-805, and FRE-812. Projectile points with hydration rinds in this range at these sites include Pinto, Elko, Humboldt forms, "large side-notched," "large corner-notched," "small side-notched," "wide-stemmed," and "orange" types (Goldberg and Moratto 1984:Table 4.8; Jackson and Dietz 1984:77, 135).

#### THE FRE-291 SPECIMENS IN CONTEXT

The two specimens recovered from FRE-291 are the only such artifacts found *in situ* in an archaeological deposit in the region. Extensive obsidian hydration dating, stratigraphic, and contextual analyses allow a more comprehensive evaluation of the temporal and cultural contexts of these items. It is deduced that the artifacts were placed in a pit excavated from a surface superior to the level of the uppermost artifact, that is, less than 20 cm. below present ground surface.

Table 1 lists the obsidian hydration measurements on obsidian debitage from the excavation unit in which the cached obsidian was found. Obsidian hydration measurements were made by Thomas M. Origer, Sonoma State University. All samples are believed to be of Casa Diablo obsidian as determined by visual sourcing by the author.

The obsidian hydration measurements show an increase of mean hydration rind thickness with depth that reflects the cultural stratigraphy in the unit. Mixing in the deposit indicated by variation in intra-level hydration rind measurements is attributable to rodent activity and disturbance by tree roots. The difference in mean hydration rind thickness between the 10-20-cm. and 20-30-cm. levels may suggest a hiatus in occupation or deposition of cultural remains, either in the area of the excavation unit, or for the site as a whole.

Desert Side-notched and Cottonwood Triangular projectile points from the site are

Table 1  
OBSIDIAN HYDRATION MEASUREMENTS ON DEBITAGE FROM UNIT 4-EXTENSION

Level	Measurements										Mean	S.D.	Corrected Mean <sup>a</sup>
0-10 cm.	1.1	1.9	1.0	1.0	2.0	1.2	2.7	3.3	1.0	nvb	1.69	0.80	1.49
10-20 cm.	1.1	dh	3.0	1.1	1.2	1.8	1.1	dh	2.3	2.0	1.70	0.66	1.51
20-30 cm.	3.2	1.2	1.8	3.1	3.0	1.2	3.1	nvb	3.1	1.3	2.33	0.87	2.33
30-40 cm.	2.8	dh	2.4	3.6	2.4	2.4	2.4	1.9	1.2	nvb	2.26	0.63	2.26
			2.3	3.0	1.9	1.5	1.6						
40-50 cm.	2.3	2.5	2.6	3.0	3.0	3.0	3.1	2.8	2.2	2.3	2.68	0.32	2.86

<sup>a</sup> Corrected mean calculated using Chauvenet Criteria; nvb = no visible hydration; dh = diffuse hydration. Specimens with diffuse hydration or no visible hydration band are not included in the calculation of the mean hydration values for levels.

confined to the upper 20 cm. of the deposit. Dated Desert Side-notched points from the site ( $n = 5$ ) have hydration rind measurements ranging from 1.7 to 2.0 microns. One of these projectile points has a second hydration rind measuring 3.6 microns, indicating manufacture on an older flake blank.

Rosegate series projectile points and preforms and Elko series projectile point fragments occur throughout the 50-cm. deep deposit. Dated Rosegate series points at the site ( $n = 5$ ) have hydration rinds ranging from 1.5 to 2.6 microns, with two specimens having second rinds measuring 2.3 and 5.4 microns, indicating reworking or manufacture from older flakes. One Rosegate point has a hydration rind 5.2 microns thick but is uniaxially thinned on a flake blank and the hydration measurement presumably relates to the original flake surface.

Projectile point preforms from FRE-291 have hydration rinds ranging from 1.2 to 1.8 microns thick. Two of the five dated preforms show no visible hydration rinds. The preform with a hydration rind of 1.8 microns shows initial notching to create a stemmed, corner-notched form, presumably a Rosegate series projectile point. The other two dated preforms are not sufficiently developed to indicate an end product, but with hydration rinds of 1.2 and 1.5 microns they likely would have been finished as either Desert or Rosegate series points.

One other projectile point was dated by hydration analysis. This is a medium-sized (2.7 g.) side-notched form, typologically undefined (possibly reworked from an Elko series point), with a hydration rind thickness of 3.1 microns. All of the dated projectile points and preforms are made from Casa Diablo obsidian, based on XRF analysis.

The excavation unit from which the obsidian cores were recovered and contiguous units produced disproportionately large amounts of obsidian debitage, projectile point preforms, and projectile points as compared with units excavated in other parts of the site. An antler tine, presumably a flaking tool fragment, also was found near the cache. This suggests that the cores were buried in a tool manufacturing area.

The only ground stone tools observed at the site include bedrock mortars, situated in three separate granite outcrops, and a single hand stone (mano), which was recovered at a depth of 40-50 cm. in the unit in which the cache was found. A single steatite vessel sherd was found in the 10-20-cm. level of the unit in which the cache was found. Hand stones typically are associated with assemblages containing obsidian artifacts with hydration rinds measuring 3.0 microns or more (on Casa Diablo obsidian) in this part of the Sierra Nevada, while bedrock mortars are linked with assemblages containing obsidian artifacts with hydration rinds of less

than 3.0 microns (Jackson and Dietz 1984).

### Discussion

At least two interpretive possibilities arise from the available data from FRE-291. The first is that the obsidian cache is associated with the latest occupation phase, the cache pit having been initiated from a cultural surface above the 20-cm. excavation level. The alternative is that the cache is associated with the earlier Rosegate/Elko assemblage.

To accept the first interpretation we would have to explain why the cores do not have hydration rind measurements comparable to the mean or modal values that characterize the later lithic assemblage. One possibility is that the obsidian was imported at this time but not reduced at the site before being cached. The lack of modification on the smaller piece from the FRE-291 cache supports this possibility. It should be recalled that the Robinson find and the artifact from Jose Basin also lack evidence of deliberate efforts to derive flakes or otherwise reduce those pieces.

The second assessment, to attribute the cache to the Rosegate/Elko assemblage, seems more compatible with the hydration rind measurements. Hydration values for the lower levels in the excavation unit are more comparable to the rind values for the cached pieces. Also, the most conspicuous evidence of lithic tool production at the site seems to be associated with the manufacture of Rosegate projectile points. The stratigraphic position of the cache would make sense in this scenario if we interpret an occupational hiatus between the deposition of the earlier and later assemblages and some erosion of deposits covering the cache.

In either event the cached obsidian can be regarded as concurrent with some occupation period at the site. This is significant for the interpretation of the other dated

large obsidian pieces that lack critical provenience. If we posit that these other pieces were created in the period of intended use, then we can also argue for a long history of trans-Sierran distribution of largely unreduced obsidian.

### IMPLICATIONS FOR MODELS OF EXCHANGE AND TECHNOLOGY

Prehistoric trans-Sierran obsidian exchange is of obvious archaeological importance, and researchers have modeled the nature of such exchange systems (e.g., Singer and Ericson 1977; Ericson 1981, 1982; Bouey and Basgall 1984; Jackson 1984). Additionally, several significant technological studies have described obsidian tool manufacture from procurement of raw material through finished artifact in the eastern and southern Sierra Nevada (e.g., Jackson et al. 1983; Jackson 1985; Skinner 1986). These are necessary correlates of exchange studies.

Technologists have concluded that much of the obsidian was imported to the western Sierra Nevada as "roughouts," "plates," "preforms," "blades," and "bifaces," principally the latter. This supposedly is indicated archaeologically by the quantities of biface thinning flakes, broken pieces of unfinished bifaces, and occasional discoveries of intact individual bifaces or caches of bifaces. Fragments of obsidian characterized as "cores," large pieces of "shatter," or debitage with cortex occur in much smaller quantities, leading to an interpretation that very early reduction stages were rarely undertaken beyond the quarry or other procurement locality (e.g., Ericson 1982; Jackson et al. 1983; Jackson 1985; Skinner 1986:587; for similar reasoning see Scott et al. 1986). Both exchange and technology models have tended to incorporate the assumption that native people were striving to achieve maximum efficiency (energy conservation) in the procurement, production, distribution, and



exchange of lithic raw material and tools. Consequently, they discounted the notion of long-distance transport of lithic raw material.

As Flenniken (1984:192) has indicated, technological models of lithic reduction processes are only descriptive models. By analyzing both finished artifacts and the debris from their manufacture, and through replicative experiments, the lithic technologist provides an approximation of the procedures by which an artifact was created. From studies of debitage from an archaeological assemblage the technologist presumably can ascertain what stages of manufacture (reduction) were carried out at a given site. The utility of such models is directly related to their descriptive accuracy and is limited according to the weight of inherent unproved assumptions.

Could we have employed contemporary lithic technology models to predict the discovery of the large obsidian pieces on the west slope of the Sierra Nevada? I think not, for the simple reasons that the models describe only data from archaeological collections available to analysts, and that the models cannot incorporate data of which the analysts are unaware. More critically, however, technological models seldom are purely descriptive of technological systems within a specific cultural framework. Rather, they are composite representations of what the lithic technologist has learned about lithic artifact production, incorporating what the analyst has been taught to observe and interpret as meaningful and appropriate.

It is noteworthy that four of these large pieces bear cortex. The relative paucity of obsidian with cortex in the western Sierra is one clue (among others) used by lithic reduction specialists to imply primary reduction at or near quarries. But this begs the question of how much cortex actually remains on obsidian removed from the quarry

area. The percentage of cortex-bearing material relative to the total volume of any given piece of obsidian raw material will vary substantially depending upon obsidian formation and subsequent erosion processes at each source. As these specimens illustrate, there may be relatively little cortex on some very large pieces of obsidian raw material from Casa Diablo. Once this cortical veneer is dispersed among hundreds or thousands of pieces of debitage in a complex cultural deposit, an effective interpretation of the implication of cortex-bearing flakes is extremely difficult.

Bulk lithic reduction activities could have taken place at localities as much as 30 to 40 km. westward from obsidian sources but remain unrecognized by Sierran archaeologists because of sampling. Most reported technology studies are on assemblages from sites either near quarries or at lower elevations on the western slope of the Sierra Nevada.

None of this discussion is intended to deny the utility of lithic technology studies and the models forthcoming from them. But it is important to appreciate the limitations of models and related research that are not integrated into more broadly drawn studies of cultural systems. Technological studies, combined with more dynamic and integrative studies of prehistoric production and consumption (e.g., exchange) are critical investigative avenues. For example, Ericson (1982:131) pointed out, if one is dealing with a "direct access system," variability in aspects of technology and production in the system make it "very difficult to predict the type of production occurring at any point." The discovery of these five large obsidian pieces implies that prehistoric trans-Sierran obsidian exchange and production systems were based in part on direct access to obsidian sources, either by eastern Sierran populations who then transported the obsidian westward, or by western groups who

obtained obsidian for themselves and for exchange. Thus, production could vary considerably from place to place, not so much as a necessary consequence of distance from the source of raw material, but more specifically in relation to the cultural definition of appropriate behaviors for production and consumption.

It is not necessary to assume that only one "type" of production system was operative in a geographical region at any given time in prehistory. Direct access to the sources clearly was not available to all consumers of Casa Diablo obsidian. Consequently what we have on the western slope of the Sierra Nevada is an interface between "direct access" and "regional" exchange/production systems (to use Ericson's [1982] terminology).

Implications of these finds for exchange studies are relevant to Ericson's (1982:135, 139; cf. Singer and Ericson 1977) modeling of obsidian exchange systems in which he hypothesized a change from biface to flake/blade technologies commensurate with a "shifting away from luxury to utilitarian use of specific resources" (i.e., obsidian). Ericson (1982:142) assigned this transformation in mode of production to the "Late Horizon" in central California, ca. 1,000 B.P., and archaeological evidence for such a shift would include the import of raw materials to production loci removed from the raw material sources.

Like the technological models discussed earlier, Ericson's model assumes that obsidian exchange was dominated by biface distribution prior to the "Late Horizon." The hydration measurements on the large obsidian pieces discussed here could indicate that the import of raw material west of the Sierra summit was a part of exchange systems prior to 1,000 B.P.

The temporal duration for the trans-Sierran distribution of raw material from the

Casa Diablo source remains an open question, one that will not be resolved without the recovery of additional, similar artifacts from datable contexts. One would anticipate from Ericson's hypothesis that such material would be forthcoming from relatively late prehistoric contexts. This may yet prove to be the case. An assessment of the temporal provenience of such finds should not rely exclusively on hydration rind measurements of the artifacts themselves.

It seems curious that examples of large pieces of obsidian have not been reported previously from Sierran sites. My discussions with Forest Service personnel reveal that other large pieces have been spotted at other locations in the Huntington Lake area. It would not be surprising if all such reports involved specimens of Casa Diablo obsidian, and the distribution of large pieces of raw material were confined to areas where Casa Diablo was the predominate source area. Few other quarries provide such large pieces (e.g., Mono Glass Mountain, Mono Craters).

### CONCLUSION

While the discovery of five largely unmodified pieces of obsidian in the western Sierra Nevada is hardly grounds for a radical transformation of current models of lithic technology and exchange in the region, it is cause to suggest amending such models. The discovery also implicates some assumptions inherent in both sets of models regarding cultural concepts of efficiency. While there may be ethnocentrically logical reasons to presuppose that native people did not transport loads of obsidian raw material and cores over mountain passes as high as 3,000 m., they apparently did just that.<sup>1</sup>

### NOTE

1. An example of comparable behavior is found in Goldschmidt's (1951:419) account of three Nomlaki men carrying a total of approxi-

mately 200 pounds of chert "nodules" in fiber cord "hunting pack sacks" from the Yolla Bolly mountains to the western Sacramento Valley foothills.

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