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THE EXPERIMENTAL REDUCTION OF ROCK IN A CAMAS OVEN: TOWARDS AN UNDERSTANDING OF THE BEHAVIORAL SIGNIFICANCE OF FIRE-CRACKED ROCK

Douglas C. Wilson and David V. DeLyria

Abstract

The selection and management of rock for roasting ovens, hearths, and sweat lodges were not trivial concerns for prehistoric households. The results of replicating a camas roasting oven are used to address the use-life and use-stages of fire-cracked rock. We conclude that the industry associated with the procurement and management of fire-cracked rock in the Pacific Northwest required significant quantities of labor and expertise to manage the raw materials and camas roasting byproducts. Recording the technological performance characteristics of fire-cracked rocks, including composition, size, and durability, is a necessary step to interpret and compare fire-cracked rock features at archaeological sites.

Fire-cracked rock is the most abundant artifact identified at many prehistoric sites in the Pacific Northwest. Even a cursory review of the archaeological and ethnographic literature shows that it had many uses: drying and processing facilities often employed "hot" or "thermal" rocks as heat radiators; sweat lodges used heated rocks as a source for steam; and boiling stones were used in the cooking of foods (e.g., Thoms 1986, 1989; Schalk and Meatte 1988). Large hearths filled with fire-cracked rock usually formed the central core of houses. Roasting ovens associated with the processing of roots, especially camas (*Camassia quamash*), employed large quantities of rocks as heating elements (e.g., Thoms 1986, 1989; Schalk and Meatte 1988). In spite of its central role in prehistoric household activities, fire-cracked rock remains an understudied and undervalued analytical resource compared with its more attractive and traditional counterparts: flaked and ground stone tools, bone implements, faunal and floral remains, and even lithic debitage. A review of the ethnographic literature reveals that few researchers have described the technology of hot rocks (e.g., Downing and Furniss 1968). Likewise, the archaeological literature has few good discussions of variability in fire-cracked rock features found at archaeological sites (e.g., Cree and Cochran 1991; White 1975, 1980), and only a few studies have addressed the interpretive potential of fire-cracked rock through distinguishing the general principles of rock fracturing and methods to identify and analyze it in archaeological contexts (e.g., Kritzer 1995; McDowell-Loudan 1983; Lovick 1982; Schalk and Meatte 1988; Thoms 1986, 1989).

The goal of our replication experiments was to document the forms and rate of decomposition of fire-cracked rock in a replicated camas roasting

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oven. Recording the stages of use and the successive degradation of fire-cracked rock in a commonly-used traditional facility was designed to establish a baseline to better compare and evaluate fire-cracked rock from archaeological sites in the Pacific Northwest.

REPLICATION METHODS

We based our experiments on ethnographic descriptions of camas roasting ovens, the experiences of other researchers who had observed or experimented with camas roasting (including Randall Schalk, Nancy Stenholm, and Alston Thoms), and on information gleaned from excavated archaeological features from the Willamette Valley and lower Columbia River. For our oven, we collected 266 cobbles (135 kg) from a new subdivision that had exposed Bretz flood cobble deposits in Orchards, Washington, a few miles north of the Columbia River in Clark County. The cobbles were subrounded to rounded and were of mixed lithology, most of andesite/basalt composition with notable quantities of quartzite. The average rock weighed 508 g (calculated from the maximum weight of the sample) with the largest rock three times as much at 3,800 g, and measuring 19 cm in maximum dimension. The smallest rock weighed 150 g and measured 6.5 cm in maximum dimension. A sub-sample of 30 rocks was individually weighed, and the distribution of weight for this subsample, with a mean of 850 g, suggests that the distribution of rock size for the entire 266 rock sample might be skewed toward larger-sized rocks. We collected skunk cabbage leaves from a wetland near Ridgefield, Washington, to use in our oven. In the Pacific Northwest, ethnographers have documented use of skunk cabbage (*Lysichiton americanum*) as a material used to protect and contain camas bulbs during roasting (see Thoms [1989]).

Our first firing (Experiment 1) occurred on May 20, 1995. The replicated oven measured about one m in diameter and about 40 cm deep in a basin-shaped pit that we excavated into sandy silt loam (Hillsboro loam). Several rocks were placed across the bottom of the pit. We also placed some self-supporting pyrometric witness cones in the base of the oven to measure the maximum temperature of the fire at its center. A pyrometer measured temperature on the edges and top of the oven. We logged temperature to document the maximum heat achieved during the firing and the rate of cooling. This was done partly to correlate with the rock fracturing traces and partly to address effects on obsidian hydration for artifacts deposited within the oven, an element of the experiments not addressed in this article.

For the lower heating element, a pile of wood measuring approximately .1 m^3 and consisting of hazelnut (*Corylus cornuta*), cascara (*Rhamnus purshiana*), some elderberry (*Sambucus racemosa*), and Douglas fir (*Pseudotsuga menziesii*) was burned in the base of the pit with 166 of the cobbles. A total of 100 rocks was retained for the upper heating element. Our pyrometer recorded temperatures of about 350 degrees C at about 5 cm into the pit during the firing of the lower heating element and about 150 degrees C on the pit edge. After placing all of the lower heating element rocks into the fire, the fire was rebuilt with another .1 m^3 of wood (Figure 1). During the firing of the lower element, a few explosions sent fragments of rock flying out of the oven. The fire burned for 1.25 hours and then, after removing the larger embers and smoothing

Figure 1. The lower heating element after firing and prior to covering.

out the rocks and coals, we placed a few centimeters of sediment on top. After covering, the pyrometer measured temperatures of 100 degrees C in the matrix above the heating element and as high as 425 degrees C on the rocks within the element. The pyrometric witness cones confirmed that temperatures of about 425 degrees C were near the maximum achieved during the firing.

After firing the lower element, a layer of fresh skunk cabbage leaves was placed on top of the covering sediments. While our goal was not actually to roast camas, we did have a few bulbs provided by Ms. Bonnie Mills from her garden, and used potatoes to simulate the rest of the volume of the roasting area. These were wrapped in skunk cabbage leaves and placed in the pit. Another layer of skunk cabbage leaves was then placed on top[1]. Another few centimeters of sediment was shoveled on top of the upper layer of skunk cabbage and large pieces of still-burning wood retained from the lower heating element fire were used to help start the fire for the upper heating element (Figure 2). The 100 rocks for the upper heating element were dropped into this fire which burned for another 1.25 hours using similar quantities and types of wood. Temperatures recorded in the upper heating element were about 300 degrees C. Again a few explosive fracturing events propelled fire-cracked rocks out of the oven pit. Most of these ejecta fell within two meters of the pit, a short range, but one explosion sent a rock about 25 meters away, hitting the side of the neighbor's metal shed with a loud "clang." After an hour and a half, the pile of charcoal and rocks was covered with sediments to make a pile 29 cm above the ground surface. One-half hour after the oven was completed, the temperatures recorded on top of the rocks of the upper heating element had fallen to between 100 and 140 degrees C.

Figure 2. Firing of the upper heating element with pyrometer in background.

Nearly 21 hours after completing the oven, the temperatures on top of the upper heating element rocks continued to be about 50 degrees C. At this time, we disassembled the oven (see Figure 3), sieving all the sediments through 1/4" mesh hardware cloth to retrieve all fire-cracked rocks. While the potatoes had turned into unpalatable mush, the few camas bulbs were perfectly cooked: sticky and sweet and not unlike the flavor of sweet potatoes.

The rocks collected from each heating element were counted and weighed separately and several other measurements were taken of a subsample. The oven was fired again on August 12, 1995 (Experiment 2), using identical procedures and using all of the same rocks from each heating element again, regardless of size. All the rocks used in the lower heating element for Experiment 1 were also used in the lower heating element for Experiment 2 and all the rocks used in the upper heating element for Experiment 1 were also used in the upper heating element for Experiment 2. Unfortunately, we did not have any camas this time and we used Walla Walla sweet onions instead of potatoes to simulate the volume of the oven center, again blanketed by skunk cabbage. Similar temperatures were achieved in the firing, and the oven retained temperatures of about 50 degrees C by the next day. Notably less explosive fracturing occurred and only a few pieces of fire-cracked rock escaped from the oven pit. After the

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[1] Approximately 5 kg of skunk cabbage was used in the first experiment with similar amounts used in the succeeding two experiments.

second experiment, the rocks were again counted and weighed and a more detailed analysis of each piece of fire-cracked rock was conducted.

Figure 3. The lower heating element exposed during recovery of the rocks.

The third experiment on March 16, 1996 (Experiment 3), again used the same rocks and identical procedures. No explosive fracturing was observed this time, though similar temperatures were achieved in both elements. Rocks were again counted and weighed following the firing.

RESULTS

Igneous rocks of andesite or basalt composition comprised the bulk of the cobbles used in the experiments, about 78% by weight, with the remainder primarily composed of quartzite. The first, most obvious finding of our experiments is that the igneous rocks fractured differently from the quartzite rocks. In both the upper and lower heating elements, most of the unbroken rocks remaining after two firings were igneous (between 85% and 96%). A low percentage of the quartzite rocks by weight remained whole--1% in the upper element and 13% in the lower. In contrast, between 21% and 28% of the andesite/basalt rocks remained unbroken after Experiment 2. The finding that igneous rocks are more durable than quartzite suggests that identification of the composition of fire-cracked rock may be important in inferring prehistoric selection criteria for thermal rock facilities. Different rocks break differently, have different rates of degradation, and consequently have different performance characteristics (in the sense of Schiffer and Skibo 1992). These translate into different technological advantages and disadvantages that may have been known to prehistoric peoples.

Fracture Types

Two types of fractures were evident--spalling fractures that created thin, flat potlids, and fractures that broke the core of the rock into blocky fragments. The first type is the result of thermal gradient associated with differential heating rates from the outside portions of the rock to the inside portions (Schalk and Meatte 1988). Blocky fracturing may be a result of thermal mismatch stress, where variability in expansion of the crystalline matrix of the rock breaks bonds between crystals within the rock. While the results of thermal mismatch stress in more grainy rocks, such as granite, appear to lead to crumbling (Schalk and Meatte 1988), the results for both the basalt/andesite and quartzite rocks used in our experiment suggest that exploitation of incipient weaknesses or remnant bedding planes, pores, and incipient cracks within the rocks lead to larger, angular fracturing. The heating and cooling of water trapped in intergranular pores and cracks might also lead to the formation of blocky, cracked rocks. As a quantitative reference, blocky cracked rocks tended to have a low maximum dimension to weight ratio (below 1 mm/g) while spalls tended to have a much higher maximum dimension to weight ratio (generally above 10 mm/g).

About 30% of the broken andesite/basalt rocks were assigned to the blocky/core category while nearly 40% of the quartzite rocks from the lower heating element and 62% of the quartzite rocks from the upper heating element were assigned to this category. More than 50% of the blocky-cracked quartzite rocks were broken along cleavage or relict bedding planes that may have provided a weakness within the rock that could be exploited by thermal mismatch stress. For the basalt/andesite rocks, spalls comprised 50% of the rocks by count, including unbroken rocks, for the lower heating element, and 57% for the upper heating element. For the quartzite rock, spalls comprised between 52% (lower) and 37% (upper) of the rocks by count.

It was clear from the results of Experiment 2 that many rocks contained cracks, suggesting that they would soon break into blocky chunks. Interestingly, for the basalt/andesite rocks, variability was noted in the presence of cracks on whole rocks between the two heating elements. About 18% of the 82 unbroken rocks remaining from the lower heating element after Experiment 2 contained cracks while 62% of the 50 unbroken rocks remaining from the upper element contained cracks. For the quartzite cobbles, about half the 11 unbroken cobbles remaining from the lower heating element contained cracks while both of the unbroken quartzite cobbles remaining from the upper heating element contained cracks. The broken, blocky fragments also contained cracks, comprising between 37% and 52% of the blocky fragments, regardless of material. The spalls contained few cracks, generally less than 10%, probably because they tended to be small and homogeneous in composition (see Schalk and Meatte 1988:8-8 to 8-9).

Attention to the inferred mechanisms of rock fracturing in archaeological features may provide insights into the function of thermal rock concentrations. For example, seven concentrations of fire-cracked rock were identified during excavations at the Covington site (45CL422), near Orchards, Washington, in Clark County (Wilson and Roulette 1998). Nearly 90% of the rocks recovered in these features were of basalt/andesite composition, suggesting that rocks exhibiting roughly similar performance characteristics were selected for use. Of these, Feature 6 contained the lowest percentage of spalls (16.7%, n=7), while Feature 7, found only two meters north of Feature 6, contained the highest percentage of spalls (67.1%, n=51). Feature 6 also contained significantly larger blocky fragments by maximum length. The two features, therefore, were found to contain very different types of thermal rock, reflecting different stages of degradation. Feature 6 appears to represent a stockpile of still-useable rocks, while Feature 7 appears to be a concentration of rocks rejected for further use. That these features are so close to one another suggests prehistoric sorting behavior, possibly associated with a single hearth or oven facility.

Rock Size

Our second firing experiment also recorded important information on the distribution of rock sizes. Our results suggest a trimodal distribution of individual rock weights. The modes were at 1.5 grams, 15 grams, and 115 grams. This distribution suggests that when recording fire-cracked rock, simply counting and weighing all rocks in a feature or level could be very misleading. Some attention should be paid in the field to getting the range of variability present in features and in separating out variability in central tendencies of the fire-cracked rock distribution.

Rate of Fracturing and Maintenance

The analysis of the data from the three experiments together (Figure 4) suggests that much of the fracturing of the rocks in the upper heating element occurred during the first firing. Over half the cobbles in the upper heating element broke during Experiment 1 while the remaining unbroken cobbles did not break during the second and third firings. As noted before, much of the explosive fracturing associated with the oven experiments was associated with the initial experiment, especially the upper heating element. The rocks in the lower heating element continued to crack throughout the three experiments. Eighty percent of the original 159 rocks in the lower

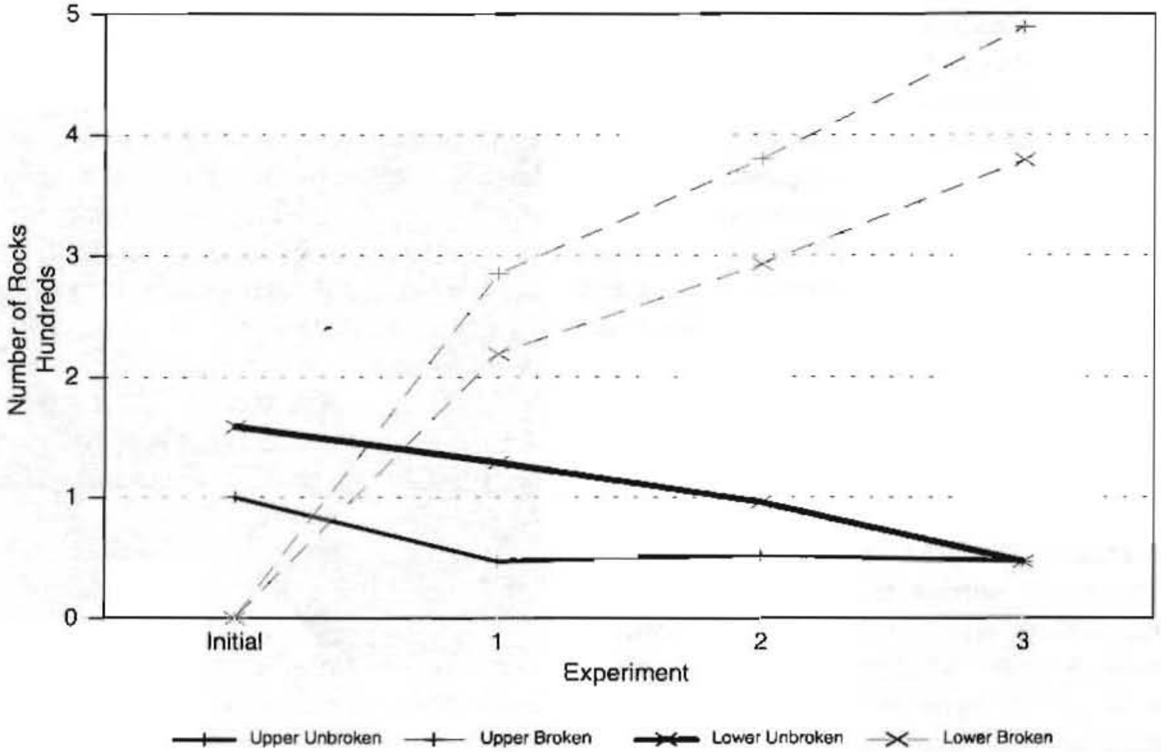

Figure 4. Number of whole and broken rocks for three camas oven replication experiments.

element remained unbroken after the first experiment, while only 50% of the 96 unbroken rocks from the second experiment remained unbroken after the third experiment. In the lower heating element, subsequent firings may have led to increased weakness of the rock, including lessened shock resistance. Increased numbers of broken rocks were associated with each experiment, and included were both newly broken cobbles and broken rocks that continued to degrade.

A rough maintenance rate can be extracted from the data collected from the second experiment. If we can assume that the small rocks (<= 70 g) were being removed from the oven along with the ash, charcoal, overcooked camas bulbs and skunk cabbage remains, then the amount of basalt/andesite rocks being removed from the lower heating element after the second experiment would be about 50% of the rocks by count and about 2% by weight. The quartzite from the upper heating element had a much higher rate of attrition, with nearly 80% of the rocks by count and almost 26% by weight being removed. The basalt/andesite from the upper heating element had an attrition rate of about 65% by count and 4% by weight.

Assuming an oven composed only of basalt/andesite rocks and a steady rate of attrition due to maintenance of about 2% by weight per firing, it follows that after 10 firings of the oven, the 87.54 kg of rock in the lower heating element would be reduced to about 71.5 kg, or about 18% of the rock. About 43 new rocks at an average size of 370 g would be necessary to replenish the amount of removed rock. After 20 firings, about 29 kg, or 33%, of the rock would be gone, requiring 78 new rocks to replenish those removed through maintenance.

Since attrition documented on the rocks of the upper heating element was even greater after the second experiment, it is possible that these rates for the lower heating element are conservative.

Further, the incipient cracking on some rocks may have significantly affected their heat retention capabilities, a possibility we have not addressed.

Using Thom's (1989:234) estimates for the length of the camas season and intensity of use of camas ovens, it is likely that a family or supra-family group using camas as a staple resource would fire an oven between 10 and 20 times a year. Clearly, there was a continuing need to replace and replenish rocks and to discard the large quantities of small, broken, and less useful pieces. For both heating elements of an oven similar to the size we replicated, featuring only basalt/andesite rocks, a rough estimate of 75 new rocks (27.75 kg) would be required after 10 firings to replace those that were no longer useful. For larger camas ovens, the rocks lost to attrition would be even greater.

Also related to maintenance processes, we found that large quantities of ash, charcoal, and waste skunk-cabbage were generated at each firing. While we went to extraordinary lengths to retain all of the rocks from the camas oven for each experiment, in an aboriginal situation most of the smaller rocks would probably have been left on the side of the oven or discarded elsewhere. For example, the contrast in rock fracture types and sizes between Features 6 and 7 at the Covington site (45CL422), noted above, suggest that aboriginal rock sorting, and therefore maintenance behavior was present. Given the probable intensive use of camas roasting ovens, materials would build up quite rapidly if left next to them, which would have hindered further activities. It is likely, then, that formal refuse sorting and disposal was an integral part of the camas roasting process, especially in cases where many large ovens were in use simultaneously. We can expect subsidiary features at such sites, like stockpiles of still-useable rocks and refuse disposal areas.

CONCLUSIONS

The procurement and management of fire-cracked rock, as a prehistoric industry in the Pacific Northwest, required significant quantities of raw materials, labor to transport and handle them, and managerial expertise. Our experiments suggest that differences in the fracturing characteristics of rocks affect their reusability. This suggests that prehistoric oven-builders possibly selected materials based on their knowledge of the technological performance characteristics of the rocks, especially thermal shock resistance.

The quantities of materials used and the need for replacement of rocks documented by these experiments suggests that resource intensification will be correlated with greatly increased rock waste and possibly the formation of distinctive formal locations for waste materials. The labor associated with the procurement and disposal of rocks and the quantities of wastes produced suggest that camp layouts associated with intensive camas processing would have become more formalized as the site was used through time. Also, there would be incentive to use sites where rocks could be reused, had previously been stockpiled, or were abundant nearby.

Our oven experiments have helped to identify the bounding conditions on rock use in a camas oven and to help in the identification of the stages of use of fire-cracked rock. It should be clear that features with few whole rocks remaining in them reflect abandonment after a number of firings have already occurred or represent discarded materials. We can also roughly determine the number of firings represented by quantities of waste rock. A cubic meter of midden deposits with a density of fire-cracked rock of 10 kg/m^3, for example, would represent rock from about four firings of a camas roasting oven of about our size. Through further integration of experimental research with data collected from archaeological sites, the interpretive potential of fire-cracked rock will be better exploited.

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REFERENCES CITED

Ames, Kenneth M. and Alan G. Marshall
1980-81 Villages, Demography and Subsistence Intensification on the Southern Columbia Plateau. *North American Archaeologist* 2(1):25-52.

Cree, Beth and Don Cochran
1991 *Independence: A Multicomponent Site in the Middle Wabash Drainage, Warren County*. Archaeological Resources Management Service, Ball State University: Muncie, Indiana.

Downing, Glenn R. and Lloyd S. Furniss
1968 Some Observations on Camas Digging and Baking Among Present-day Nez Perce. *Tebiwa*11(1):48-59.

Kritzer, Kelly Norman
1995 *Thermolithofractography: a Comparative Analysis of Cracked Rock from anArchaeological Site and Cracked Rock from a Culturally Sterile Area*. M.S. Thesis, Ball State University: Muncie, Indiana.

Lovick, Steven K.
1982 Fire-Cracked Rock as Tools: Wear-Pattern Analysis. *Plains Anthropologist* 28(99):41-45.

McDowell-Loudan, Ellis E.
1983 Fire-Cracked Rock: Preliminary Experiments To Determine Its Nature and Significance in Archaeological Contexts. *Chesopiean* 21(1):20-29.

Rapp, George (Rip), Jr., Sanda Balescu, and Michel Lamothe
1999 The identification of granitic fire-cracked rocks using luminescence of alkali feldspars. *American Antiquity* 64(1): 71-78.

Schalk, Randall and Daniel Meatte
1988 The Archaeological Features. In *The Archaeology of Chester Morse Lake: The 1986-87 Investigations for the Cedar Falls Improvement Project*. Randall F. Schalk and Richard L. Taylor, eds., pp. 8-1 to 8-9. Report submitted to the Seattle Water Department. Center for Northwest Anthropology, Washington State University: Seattle Research Unit.

Schiffer, Michael B., and James M. Skibo
1992 Theory and experiment in the study of technological change. In *Technological Perspectives on Behavioral Change*. Michael Brian Schiffer (comp.), pp. 44-76. University of Arizona Press, Tucson.

Thoms, Alston V.
1986 Hot Rocks: the Short-Term Storage of Energy in the Calispell Valley. In *Calispell Valley Archaeological Project: Interim Report for 1984 and 1985 Field Seasons* (Draft Interim Report for Review and Comment). Alston V. Thoms and Greg C. Burtchard, eds. pp.447-477. Contributions in Cultural Resource Management No. 10, Center for Northwest Anthropology, Washington State University: Pullman.

1989 *The Northern Roots of Hunter-gatherer Intensification: Camas and the Pacific Northwest*. Ph.D. Dissertation, Washington State University, Department of Anthropology: Pullman.

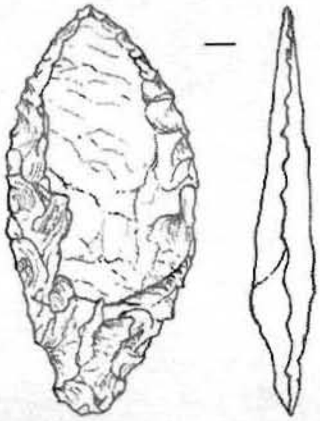
White, John R.

1975 The Hurd Site. In *Archaeological Studies in the Willamette Valley, Oregon*. C. Melvin Aikens, ed., pp. 141-225. University of Oregon Anthropological Papers No. 8.

1980 A Closer Look at Clusters. *American Antiquity* 45(1):66-74.

Wilson, Douglas C., and Bill R. Roulette

1998 *Supplemental Testing and Data Recovery Excavations of a Portion of the Covington Site (45CL422), Clark County, Washington*. Report prepared for Archaeological Services of Clark County and Pacific Wing Fung Enterprises. On file at the Washington Office of Archaeology and Historic Preservation, Olympia.



Basalt Projectile point found at the Covington Site (45CL422) in Clark County, Washington. Illustration by Susan Freiberg