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## Flaked Stone Basalt Technology in the Northern Sierra Nevada of California

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*A replicative experimental study was carried out with the intention of elucidating the best technological strategies for producing Middle Archaic basalt projectile points and bifaces. This work led to an appreciation of the difficulties of working with Sierran basalts, as well as an admiration for the skills of Middle Archaic knappers. The study shows that, despite the technical challenges, expediency was not the sine qua non of Middle Archaic technology in the northern Sierra Nevada, and provides insight into regional archaeological assemblages.*

**DURING** the Middle Archaic in the northern Sierra Nevada, basalt<sup>1</sup> was heavily favored as the raw material for flaked stone artifacts. Basalt is abundantly available in bedrock outcrops at many locations, and quarry sites of considerable extent occur at some of them. The period of maximum use of basalt seems to have ended at around A.D. 500, probably coincident with the introduction of the bow and arrow. After this time, assemblages are dominated by chert, and obsidian is in greater evidence as well. Heizer and Elsasser (1953) first gave the name Martis to the major basalt-based assemblages in the northern Sierra Nevada. Since then, numerous additional assemblages have been assigned to the so-called Martis Complex, mostly at moderate to high elevations from the Lake Tahoe region to the Feather River country of Plumas County (Johnson 1980). A few lower elevation sites are known, such as CA-NEV-15 near North San Juan in Nevada County (Elsasser 1960). Basalt assemblages classified as Martis occur on both sides of the Sierran crest and into west-central Nevada (Elston 1986a). Elston (1986b) presented a summary of tentative

Martis stages and chronology, portraying Martis as a unique contrast to earlier and later assemblages by its abundant, large basalt bifaces. Martis is also characterized by a variety of projectile points, assumed by their relatively large size to be dart points.

In recent years, considerable discussion has emerged regarding characterization of Martis as a complex or a tradition (see Neuenschwander [1994] and Ataman et al. [1999] for a history of the discussion). Recent interpretations (e.g., Elston 1986a; Kowta 1988) tend to depict Martis as merely a name referring to possibly unrelated assemblages, unified only by their use of basalt and a Middle Archaic technology.

It is not the purpose of this report to review characterizations of the Martis Complex, but rather to elucidate basalt flaked stone technology, with special reference to the Middle Archaic of the northern Sierra Nevada. The bulk of such basalt-based assemblages in this region have, at one time or another, been assigned to Martis, although basalt was also employed, albeit to a lesser degree, both earlier and later (Ritter 1970; Elston et al. 1977; Jackson 1999). The northern Sierra Nevada Middle Archaic assumes special significance because convincing evidence exists that the people responsible for the creation of such assemblages were also responsible for most or all of the complex petroglyph arrays that frequently occur in the same region (Elsasser and Gortner 1991; Foster et al. 1999). Hereinafter, for simplicity's sake, northern Sierra Nevada Middle Archaic basalt assemblages will be referred to as Martis.

To understand basalt technology, replicative experimentation is necessary. Previous replicative studies (e.g., Noble 1983; Duke 1998a) made progress in the elucidation of technostrategies implied by Martis assemblages, and many archaeologists working in the northern Sierra Nevada have experimented with knapping basalts (e.g., Rondeau 1980; Bloomer et al. 1997; D. Stevens, personal communication 2000). How-

ever, the relative intractability of basalt for biface manufacture has discouraged experimentation that would be extensive enough to test a diversity of knapping strategies. Knappers accustomed to obsidian or chert find their skills tested to the limits by basalt. Perhaps the most serious obstacle is the cumulative damage to joints (fingers, hands, wrists, elbows, shoulders, and neck) caused by a sustained program of percussion and pressure of this demanding material (cf. Callahan and Titmus 1999). Despite such limitations, and even though further experimentation is needed, replicative studies reported here shed light on assemblage variability and typology.

Originally introduced to the art by Glynn Isaac, eminent African prehistorian then teaching at the University of California, Berkeley, the author has been a knapper since 1976. Initial interest was in the African Lower Paleolithic and the analysis of large bifaces (Edwards 2001). Authentic replication entailed experimentation with many raw materials, but especially basalt, one of the two most widely used materials in Africa (the other being quartzite). More recently, the author turned his attention to Martis technology, and over a period of four years, a number of Martis replicas were attempted. The hope was to learn as much as possible about the technological skills and strategies reflected in Martis flaked stone assemblages.

### APPROACH AND DEFINITIONS

From 1997 to 2000, extensive replicative experiments were conducted using basalt collected at Alder Hill/Prosser Lake in Nevada County, California, and at several sites in the Lakes Basin/Gold Lake area of Sierra County (Fig. 1). Using a variety of techniques, crude and refined bifaces were replicated, as well as expedient and refined projectile points, in both fine- and coarse-grained basalts. Four different kinds of percussors were used, including antler baton, wood baton, hard hammerstone, and soft hammerstone. The time required for each replication was re-

corded, along with notes on strategy and results. This work was combined with a literature review, a study of collections housed at Tahoe National Forest, and an examination of artifacts in known surface scatters, especially at Alder Hill/Prosser Lake and at four sites in the Lakes Basin area.

"Refined" refers to a projectile point or biface with relatively straight edges in edge view, symmetrical plan form, fairly symmetrical cross section ("camber"), near absence of steps, and an organized flake scar pattern. It may be thick or thin but, all else held equal, thinner is more refined. "Crude" bifaces or points tend to have the opposite of all these attributes. An "expedient" projectile point is a crude one. Expedient points with a minimum of flake scars—most of them noninvasive so that the desired functional shape is achieved with a minimum of effort—should theoretically prove more common in areas where raw materials are more coarse.

### TECHNOLOGICAL OBSERVATIONS

Martis knappers were highly skilled at working with basalt, as illustrated in Elsasser (1960: Plate I), Neuenschwander (1994:Figs. 3 and 5), and here in Figure 2. Any knapping session in basalt is always problematical at the outset, given the difficulty of the stone. Nevertheless, Martis knappers achieved complete control of attributes sufficiently often that it is clear they equaled in skill the best modern knappers.

Raw material quality differs dramatically between Martis quarries. The basalt of Oakland Pond in Plumas County, California (Bloomer and Hall 1998), is the finest of all; the various grades distributed around Gold Lake/Lakes Basin/Church Meadows (including Oakland Pond) are generally finer grained and glassier than sources near Truckee, Squaw Valley, and Lake Tahoe in Nevada County and Placer County (Davis 1958; Duke 1998b; Ataman et al. 1999). Some archaeologists employ the whimsical term "basidian" for the former sources.

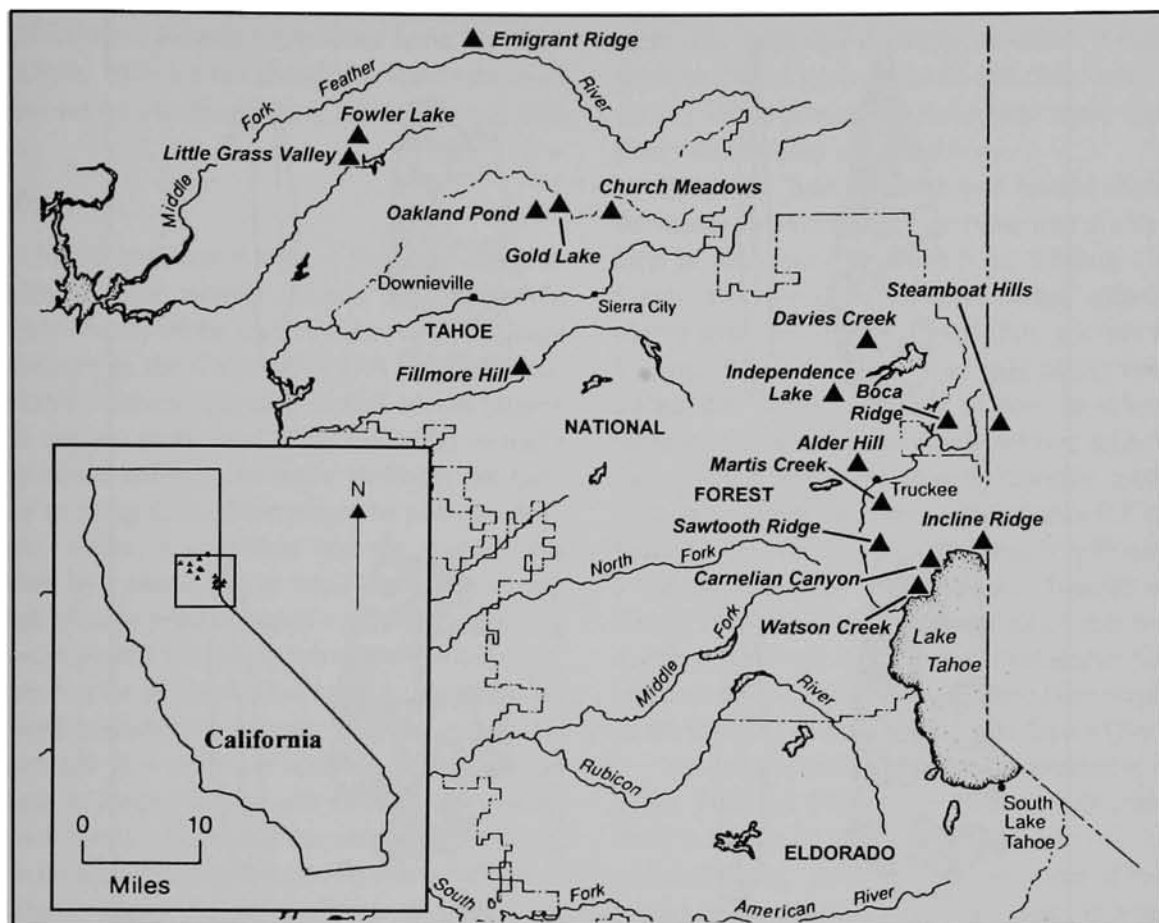


Fig. 1. Selected geologic sources of basalt in the northern Sierra Nevada, including sites mentioned in the text. Map courtesy of Craig Skinner.

Workability is drastically different between the basalts in these areas. Lakes Basin basalts are far more controllable; outcomes of percussion are more predictable and pressure flaking is far easier. Consequently, bifaces/projectile points manufactured from Lakes Basin basalts tend to have more regular flake scar patterns, both in replicated and aboriginal samples. Nevertheless, even with relatively coarse, step-prone Alder Creek basalt, Martis knappers frequently attained thorough control of attributes, including pervasively regular flake scar patterns and perfected cambers and planforms. The superior knappability of Gold Lake basalt partially explains why Ataman et al. (1999) discovered that about 35% of the projectile points from Martis Valley sites

were of material from distant sources, although Alder Hill, Watson Creek, and Sawtooth Ridge sources were much closer (see Fig. 1).

Some of the raw materials that look like basalt at Martis sites may not be basalt at all. Material from presumed Martis surface sites along Bowman Lake Road in Nevada County was submitted to Steven Shackley at the Archaeological X-Ray Fluorescence Spectrometry Laboratory at the University of California, Berkeley. On the basis of trace elements, this black, aphanitic, basalt-like rock appears to be rhyodacitic (S. Shackley, personal communication 1999). However, assignment to rock type on the basis of trace element XRF is problematic (C. Skinner and S. Shackley, personal communication 1999).

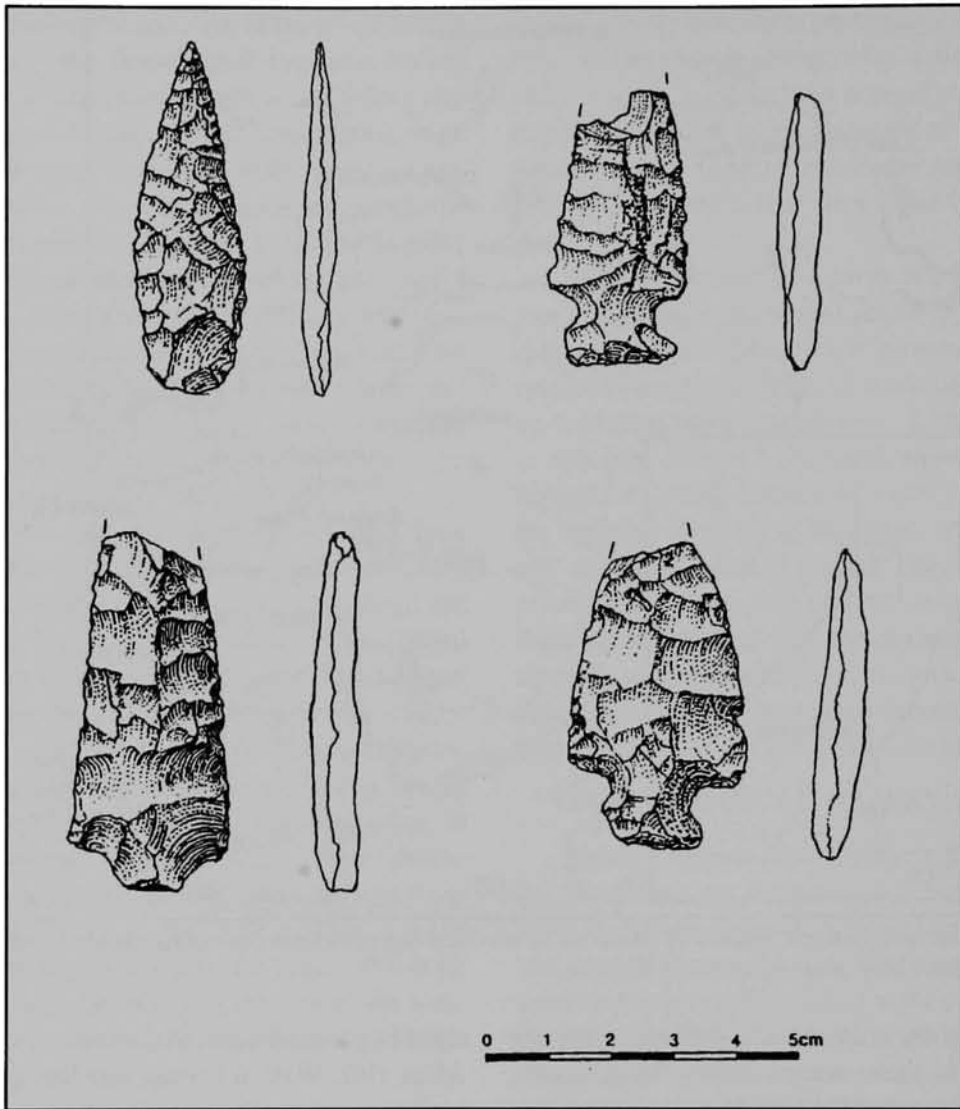


Fig. 2. Examples of refined dart points from an excavated assemblage at Lakes Basin Campground, Plumas National Forest. From Neuenschwander (1994), published with permission of Peak and Associates, Sacramento, California.

The definition of boundaries between igneous rocks is actually based on the percentage of silica. Measuring silica content might be more than merely a pedantic exercise, as that number could add a dimension to assist in discriminating sources.

Knappable bedrock basalt occurs in many parts of California, as well as in western Nevada. Although Martis research has focused on Sierran

sources, it is not out of the question that some Martis or Martis-like artifacts found at lower elevations or in the Central Valley of California were derived from Coast Range sources. The latter include excellent basalts in Lake, Napa, Contra Costa, and probably San Benito counties. In the author's experimental replications, rocks from all of these counties have been tested, and samples of all have been given to Craig Skinner

at Northwest Research Obsidian Labs for XRF analysis. Skinner has added characterizations of these sources to his growing XRF reference data base.

### Bifaces

Martis artifacts that have been described as "bifaces" are usually larger than projectile points. Many of the thicker ones resemble Stage 2 bifaces in the Callahan (1979) classification. In lithic scatters, it is easy to find Martis bifaces that are too small (and often too thick) to make functional knives, and were probably on their way to being thinned for projectile point production. Often, it is evident that the process was halted by a major step or stack (a stack is a steep bank of steps piled on top of each other, resulting from repeated failures to remove an initial step), such that the piece was too small to allow the required percussion cleanup. Larger, thinner bifaces are also common and are almost always found as fragments that are virtually never conjoinable with other major fragments. These large, thin bifaces would have made excellent functional knives. Many are far too large to have been made directly into projectile points without tremendous waste. A good example of a complete thin bifacial knife is on display at the United States Forest Service (USFS) North Yuba Ranger Station (Tahoe National Forest Accession Number 3394). This specimen is nine centimeters long and amygdaloidal in planform, similar to a miniature version of a late Acheulean or Mousterian handaxe.

It is the author's assessment that regions where Martis artifacts occur are literally strewn with broken knives. It also appears that the fragments found in collections or in surface scatters are more commonly proximal (butt) ends (e.g., see Jensen 1979; Fig. 3). This fits the modern knapper's typical procedure very well: save the broken-off tips of knives or large bifaces for later reduction into projectile points. Although it is not possible to be certain whether a given frag-

ment was originally proximal or distal, it makes sense as a working hypothesis that distal ends are usually more pointed, thinner, and more intensively flaked than proximal ones.

Elegantly flaked leaf-shaped knives about a decimeter in length, such as those that are common in prehistoric interments in lowland California, are rare in Martis collections, although pieces approaching this description are not unknown. While the author has only begun to examine the USFS collection at Nevada City, a variety of moderately to highly refined large bifaces was noted. Particularly notable among these is a contracting-stem biface that is 9.2 cm. long (Tahoe National Forest Accession Number 17-3683), collected in the Truckee District and clearly made from the coarse basalt of that area. A very impressive approximately decimeter-long and broadly triangular tanged biface is on display in the Kentucky Mine Museum in Sierra City.

In a private collection recently donated to the Tahoe National Forest (the Corbett collection), there is a class of elegantly flaked, narrow, lanceolate bifaces. Although broken, some of these appear to have been about a decimeter in length when intact. There is also a biface of this type on display at the North Yuba Ranger Station (Tahoe National Forest Accession Number 2883). A basalt biface approximately 14.5 cm. long from Kings Beach (CA-Pla-9) was illustrated in Heizer and Elsasser (1953:22), and interpreted by them as possibly Martis.

Broken and complete bifaces, including those that are large and thin as well as those that are thick and crude, litter the Martis landscape. Thin bifaces make excellent, precambered preforms for projectile points. Thus, finding pieces that refit to these broken, thin bifaces will probably always remain highly unlikely. Since distal ends of the bifaces make the best projectile point preforms, it is predicted that proximal ends will be more commonly encountered in debitage scatters.

Another possible explanation for the rarity of elegantly flaked, complete, large knives is that

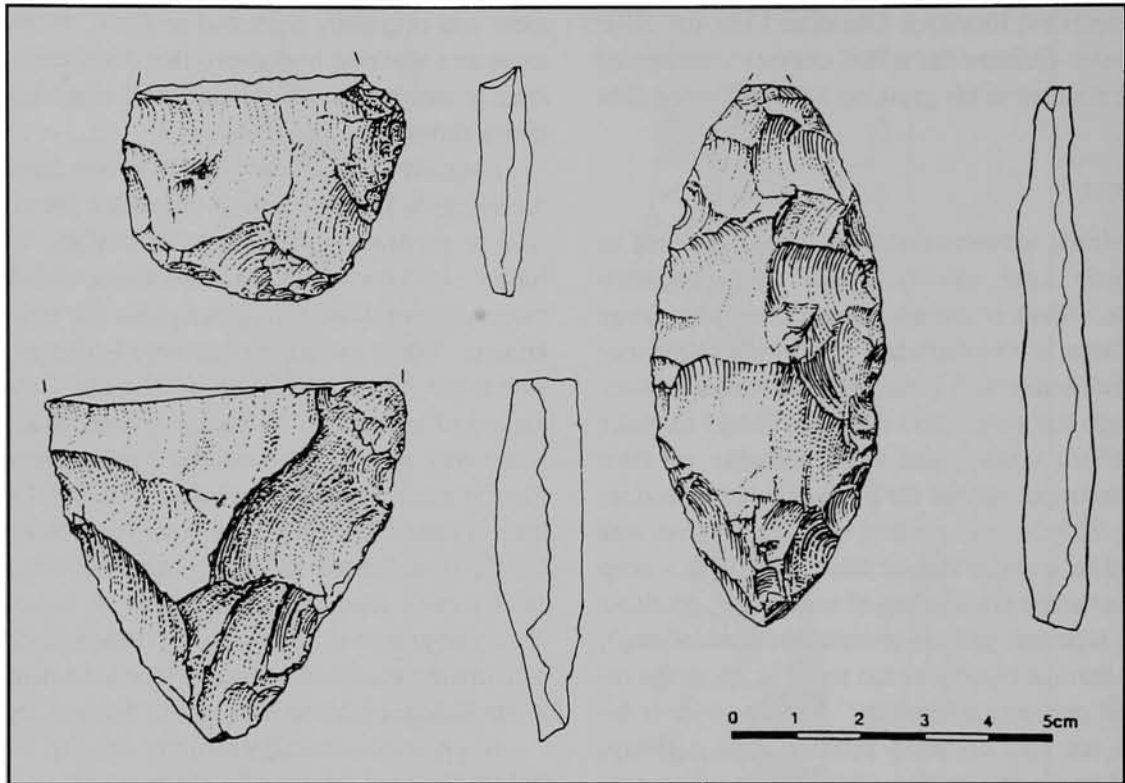


Fig. 3. A moderately refined Stage 3-4 biface, nearly complete, and two biface fragments, both probably proximal ends, from an excavated assemblage at Lakes Basin Campground, Plumas National Forest. From Neuenschwander (1994), published with permission of Peak and Associates, Sacramento, California.

crude ones are themselves highly functional (e.g., see Jones 1981). Other possible explanations are that Sierran basalt knappers had limited interest in refined bifaces/knives, or that some percentage of such artifacts was placed in interments, although no Martis interments or interment associations have yet been identified in the Sierra Nevada.

As opposed to projectile points, bifaces rarely snap in half during use. They certainly can break, as when they are used for chopping wood (E. Callahan, personal communication 1999). The vast majority of substantial biface breaks occurs during percussion thinning. Most fatal breaks come during thinning from Stage 2 to Stage 3 or from Stage 3 to Stage 4, when thinning is rapid and achieved by powerful percussions. Of course, that is the view of a modern

knapper who produces bifaces but does not use them for subsistence and survival. Nevertheless, it is likely that most Martis bifaces were broken because they were in the process of being thinned, for whatever reason. This view may be tested by examining the distribution of broken versus complete bifaces in the archaeological record. If snapped biface fragments are dominant at sites judged to be quarries, or at near-quarry lithic reduction sites, while complete or nearly complete bifaces are relatively more frequent at greater distances from quarries, this scenario of most major breaks occurring during percussion reduction might be corroborated.

### Flakers

Baton or cylinder hammer percussion is evident by the presence of controlled, invasive per-

cussion scars on Martis tools. For both Lakes Basin and Alder Creek replications, antler was the baton of choice. However, a wood baton (*Comarostaphylis* [Ericaceae], very similar to manzanita, and *Cercocarpus* [Rosaceae], mountain mahogany) worked well for percussion flaking projectile points and small bifaces/knives, just as long as really thick places, such as knots or stacks, were avoided. Batons made of wood native to the northern Sierra Nevada are not dense enough for working very large (hand ax-sized) bifaces, nor for flaking difficult or thicker edges of smaller bifaces/projectile points. For that, an antler or a hammerstone is required (antler is far superior to stone as a hammer, although a soft hammerstone can produce good results).

In addition, the lightness of a wood baton forces the knapper to swing harder than would be the case with antler, and harder swings mean less control and less finesse. Compounding the problem is the fact that with wood, more percussions per flake removal are required than with antler; one begins swinging lightly to maintain control, and ends swinging harder with less control. Statistically, the more percussions, the more mistakes that result from bad aim. Finally, there is a tendency for a wood baton to increase the edge angle, since the flakes tend to be less invasive than with antler, probably because less force is applied with wood. Thus, in fashioning projectile points from basalt flake blanks, it is a viable strategy to rough out a biface to Stage 2 using a hammerstone, then to switch to a wood baton for more refined thinning, finishing with pressure flaking using an antler tine.

For basalt knapping, as with other raw materials, it is necessary to smooth the working end of the baton—whether of antler or wood—from time to time. Chatter marks flaked and gouged into the baton hamper its ability to do refined flaking. This is particularly true with basalt, which erodes antler rapidly. It is even more true of elk or deer antler (or hardwood), which would have been available to Martis people, than of the

moose antler favored by modern knappers, because the former are much less dense. However, deer antler is denser than elk antler, and before the era of modern trophy hunting, large deer antler was probably more available.

Although roughout of bifaces with a hammerstone is a far cruder enterprise than working with a baton, it is nevertheless possible to make a fairly thin basalt preform using a relatively soft hammerstone. One may then proceed directly to pressure flaking. Based on degree of control and narrowness of flake scars, thinner, sometimes narrower, and more finished Martis bifaces typically look like baton work; thicker, sometimes broader, and cruder ones look like hammerstone work.

### Pressure Flaking

As projectile points are reduced in size, they become too difficult to hold firmly enough to take the hard blows required for percussion in basalt. The vast majority of Martis projectile points has been pressure flaked. This is evident also from the fact that many display more or less uniformly sized and spaced narrow flake scars, indicating control and delicacy practically unattainable in basalt by percussion. An experienced modern knapper will normally recognize, with a high level of confidence, a point that has been intensively pressure flaked. Many knappers speak of the “rhythm” that often helps them regularize flake scars all along the length of a point. The most highly organized pressure flake scar patterns simply attain greater regularization than is the case even with controlled percussion. Pressure flaking in basalt is demanding. Different flows vary in their susceptibility to pressure control. The Alder Hill material can be pressure flaked, even elegantly; but it is far more difficult to control than the Lakes Basin material.

With obsidian or chert, platforms for pressure flaking are generally standard; that is, made by grinding or microchipping tiny flakes off the face opposite the face of the intended flake release. With basalt, such standard platforms work



well, but it is often effective to thicken the edge by flaking or pressing off tiny flakes on the same side as the intended flake release. I call this reverse platform preparation. In both percussion flaking and pressure flaking in basalt, this approach is frequently useful. It is this technique that yields flakes with the "platform" on the dorsum of the flake—something that could be puzzling to investigators accustomed to working with obsidian, in which standard platform preparation is the rule. Platform preparation in basalt is best done with the antler baton or antler tine pressure flaker. Grinding with a hammerstone, a procedure that works very well for obsidian, is normally ineffective with basalt.

Pressure flaking of basalt can be accomplished with a short antler tine. This can be hard on the wrists, fingers, and shoulders. For more power and less strain on the wrists and shoulders, one can use a long, more or less straight antler tine, the butt end of which can be braced against the abdomen or side. The antler may also be mounted in a wooden handle or brace. Although pressure flaking works well in northern Sierra Nevada basalts, it cannot be relied upon for removing steps or for substantial thinning. To finish a projectile point with well-ordered pressure flake scars, free of steps, it is necessary to begin pressure on a thin blank or on a preform that is well cambered and free of steps.

Just as there is a lower size limit for hand-held basalt bifaces or points during percussion flaking, there is an analogous, smaller limit for handholding during pressure flaking. This will depend on hand size and finger strength, of course, but there are ways to lower the minimum size limit. Some pressure flaking can continue if you lay the point on a pad, on the ground, or on some other support. This works well for minor edge trimming/straightening or minor shaping, but it is unlikely that much invasive flaking can be accomplished in this manner. The technique does not allow generation of enough force for invasive flaking, particularly in basalt. An exceed-

ingly thin, nicely pressure flaked, small preform can be generated as the tip of a larger biface, which allows for a strong grip on the piece while knapping. Subsequent to being broken off, whether purposefully or accidentally, that biface tip requires minimal further work to make a refined projectile point.

After quarrying from blocks or reducing irregular cores, the most frequent starting point in Martis projectile point percussion/pressure replication, at least for the author, is a flake about 10 mm. thick. Callahan's (1979) basic reduction sequence is nearly always involved: Stage 1, unretouched blank; Stage 2, roughout by edging; Stage 3, first round of invasive thinning flakes; Stage 4, second round of invasive thinning flakes; and Stage 5, careful finishing of platform and straightening of edges. The stages often flow together with no break, and it is rare that a stage can be skipped. The latter is particularly true if the knapper starts on a relatively thin blank (six mm. or less thick) that possesses excellent camber, already foreshadowing knife or projectile point cross-sectional geometry. Only very rarely is a blank thin enough, and cleanly precambered enough, to allow final main flake scars to be created on the first rapid pass of thinning flakes, thus bypassing one (at most two) of Callahan's (1979) stages, and moving directly from Stage 2 to Stage 4 (or early Stage 5).

Unfortunately, even small, thin blanks nearly always have irregularities that require much work, such as thick edges, cortex, ridges, flaws, inclusions, and curvature. To these problems are added the myriad knapping errors that must be cleaned up, and to which even the best knappers are particularly prone when working with basalt. It should also be noted that a thin flake blank with a high width/thickness ratio will obtain a lower ratio during initial edging, so that substantial work is sometimes required to get the flake back to the very high ratio of Stage 4 bifaces. With a Martis projectile point that seems incredibly thin and pervasively well-flaked with an or-

ganized flake scar pattern, it can be assumed that a very substantial amount of concentrated work went into it.

On the basis of analysis of extensive recent collections from Martis Valley, Ataman et al. (1999) suggested that Middle Archaic projectile points there were produced through pure pressure flaking on very thin flake blanks (with no percussion) about 25% of the time. This technique is possible; indeed, "wafer thin" dart points are common in archaeological assemblages, and often exhibit large remnants of the original flake-release surface, appearing as if percussion might have been bypassed. However, in the production of basalt flake blanks from cores, flakes with thinly tapered edges all the way around and about the right size for projectile point generation are rare; the fact is that nearly all come off with at least one thick edge, which usually requires percussion reduction.

Furthermore, practice shows that even small, thin flake blanks start wider (usually much wider) than the conceived point and need to be narrowed. Such a procedure is far quicker and easier with a percussor than with a pressure flaker, and thus easier on the hands and wrists, so it does not make sense to start with the pressure flaker too early. Finally, the projectile point that is finished with pressure flaking may not show any detectable trace of the initial percussion edging. In the author's opinion, all-pressure strategies in basalt are and were rare.

Serrated Martis projectile points are not uncommon. Serration usually consists of closely spaced, small denticulations that are best made with a specially modified pressure flaker. This procedure requires patience and skill. Usually it is the terminal stage in the knapping process. Most basalt pressure flakes shatter during detachment.

### **Missing Transitional Forms**

For their respective field areas near Truckee and in Lakes Basin, Neuenschwander (1994) and

Duke (1998) pointed out that transitional forms between percussion flaked bifaces and pressure flaked projectile points are rare. Complete, "finished" preforms ready for commencement of pressure flaking are not commonly found, nor are broken bifaces upon which pressure flaking had been commenced. Duke (1998a) believed that crude percussion flaked bifaces were often ends in themselves; in other words, they were intended to be tools, not simply preforms (also see Ritter 1970). Moreover, most projectile points would have been knapped directly from small, thin flakes requiring a minimum of percussion preparation.

Neuenschwander (1994) suggested that percussion flaked preforms were exported from his study site at Lakes Basin Campground for finishing elsewhere. In line with Duke's (1998a) model, in presumed Martis lithic scatters, one can find small, thin flakes not much larger than most Martis projectile points that have percussion flake scars or even pressure flake scars well under way. Furthermore, many Martis points have a remnant flake-blank release surface, suggesting that the initial blanks were thin and required minimal or no invasive thinning. But small, thick bifaces, too small and thick to be effective as functional knives (probably meant as preforms) are also commonly encountered at Martis sites. Halves of thin, well-worked larger bifaces are also common. The missing halves, already prepared by careful reduction, probably went into projectile point production. The remaining halves may then be regarded as possible records of the missing transitional forms.

It is important to recognize that during manufacture of bifaces, most fatal breaks occur during percussion thinning from Stage 2 to Stage 3 or 4; once pressure flaking is commenced, such breaks are far less common. Perhaps they were even more rare in Martis days than they are for modern knappers. After all, we are experimenting; Martis knappers were using their lithics for survival and were expert knappers of basalt as well.

This would account for the rarity of percussion flaked preforms upon which pressure flaking had been commenced.

### BASALT KNAPPING CHALLENGES AND STRATEGIES

Alder Creek and Lakes Basin basalts (but probably more the former than the latter) have weak internal flow-lamination that facilitates the splitting off of large, flat flakes during quarrying or reduction of large blocks or cores. These blanks naturally tend to have thick, nearly vertical margins around most of their perimeters. The subtle internal lamination can often be used to advantage when steps occur during biface reduction. Indirect percussion with a beveled antler tine placed against the step can extend the aborted flake release well across the piece, following the lamination. A thick knot or stack on the edge of any biface shorter than about five cm. is usually fatal; in basalt, the hand is not strong enough to hold a piece this small against the forceful blows required to remove the problem.

Stacks or thick knots on small basalt bifaces can sometimes be removed using a modified bipolar technique, which involves setting the stack onto a hammerstone or anvil, then striking the opposite face of the biface, directly over the stack, with an antler baton.

The various lower size limits for holding basalt in the hand during biface reduction are significantly lower for most cherts, and especially so for obsidian, both of which require far less forceful flake removals. Thus, the advent of bow and arrow technology would favor a switch to chert or obsidian. Production of very small, arrowhead-sized points in basalt is an enterprise fraught with difficulties. Even if one starts with a very thin flake or preform, it will probably remain relatively thick as it reduces in length and breadth to arrowhead size. One is then faced with the necessity of pressure flaking a biface that is too small to hold firmly against the force required to do so with basalt. One way to solve

this problem, as detailed above, is to pressure flake the point while it is still the tip of a larger biface. Another technique that has worked for the author is to leave a stem on the preform while pressure flaking, for leverage.

When the pressure flaking is complete, the stem may be removed using bipolar percussion, baton against anvil. If the resulting truncated base is too thick, it may be thinned somewhat using the same technique. It is at this point that there are certain limitations. Once an arrowhead-sized basalt point has been produced by this or any other technique, it is very difficult to notch it unless it is extremely thin. This can be problematic if the knapper (such as the author) has large hands and weak wrists (which are made so by pressure flaking basalt!). Martis knappers were undoubtedly physically better prepared for pressure flaking basalt, and probably could handle thicker preforms. Assemblages in the northern Sacramento Valley do contain significant numbers of arrowhead-sized basalt points (R. Milliken, personal communication 1999; E. Ritter, personal communication 2000).

Most of the author's well-flaked basalt dart points each required about an hour's worth of flaking (see Figs. 4 and 5). In that time interval, two or three comparable obsidian points could be generated. Basalt dart points commenced on irregular blanks with thick margins and/or flaws require still more time. Admittedly, a point might be worked simply and expediently at first, with a minimal number of flake removals to achieve the desired function; later reworking after some period of use might then refine the point. In such a case, the knapping time required to achieve refinement would be spread out over two or more long-separated sessions.

However, it is to be expected that most damage to projectile points would involve fatal snaps or significant tip or stem removals (Flenniken and Wilke 1989), so that reworking would not be a simple case of resharpening. Resharpening *per se* does not normally produce a refined biface or

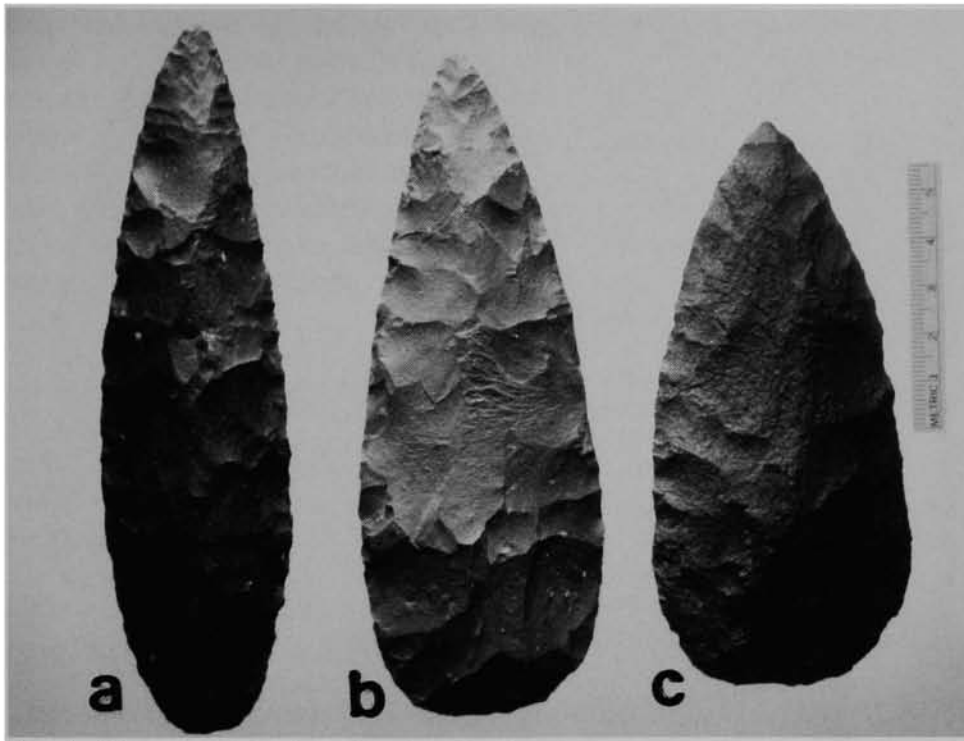


Fig. 4. Bifaces made by the author from basalts of the northern Sierra Nevada. Figures 4a and 4b are from Oakland Pond, Figure 4c is from Alder Creek. The biface in Figure 4a was pervasively pressure flaked; even most of its larger flake scars are pressure scars. The other two bifaces were finished with antler baton percussion.

point; for that, it is necessary to knap strategically, including preserving or creating camber, avoiding or eliminating steps, and making the flake scars invasive (Edwards 2000). A refined basalt biface approximately a decimeter long can be made in about 20 minutes with an antler baton, provided the starting blank is a good one. More complicated blanks can extend the knapping time dramatically. Martis assemblages commonly include very simple, expedient (unrefined) bifaces and/or points. However, fragments of refined bifaces, as well as complete or partial projectile points, are clearly dominant elements in many assemblages.

Noble (1983) noted that the great variability in projectile point typology within the Martis Complex may have resulted in part from the difficulty of working Sierran basalts, and getting a blank to reflect the form initially desired. For

example, it is very difficult to notch a basalt projectile point deeply, unless the point is quite thin. In the author's replications, points that were intended to be notched frequently ended up as contracting stems because the attempt to notch them failed. Deep versus shallow notches probably depended on thin versus thick preforms.

Finally, it is predictable that cores, flakes, and tools should diminish in size in direct proportion to distance of site from raw material source. This should also affect typology to some degree. For example, smaller points might tend on average to be thinner, and thus be more susceptible to notching.

## CONCLUSIONS

Replicative manufacture of a refined basalt projectile point or biface of Martis type takes substantially longer than manufacture of a com-

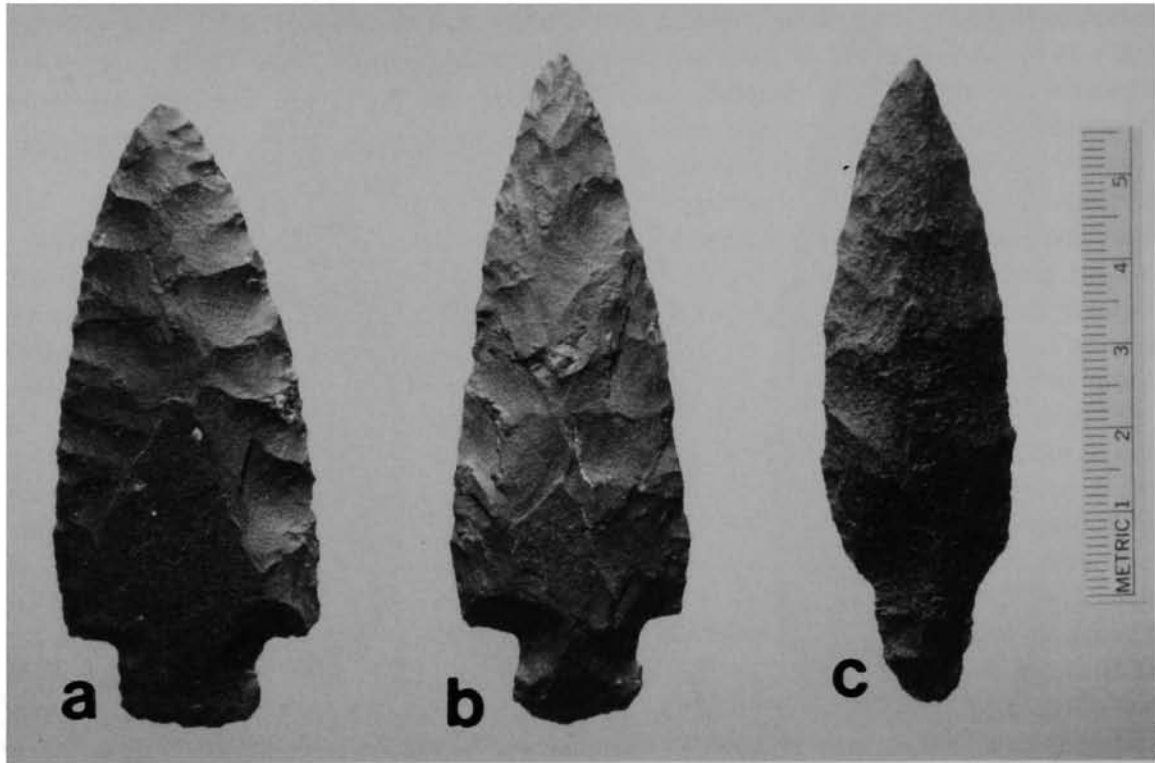


Fig. 5. Projectile points (dart points) made by the author from basalts of the northern Sierra. Figures 5a and 5b are from Oakland Pond, and Figure 5c is from Alder Creek. The point in Figure 5a was commenced on a very thin flake and finished with pressure flaking. Proximally, a significant amount of original flake-blank surface remains. Such remnants are very typical of thin Middle Archaic basalt points. Figure 5b was roughed out with a soft hammerstone, thinned and shaped with a wood baton (*Cercocarpus*), and received final edge adjustments, cleanup of small steps near the tip, and shaping of the stem via antler pressure flaking. Figure 5c was knapped entirely with a wood baton (*Comarostaphylis*), beginning with a thin flake.

parable artifact in obsidian or chert, and it is much more difficult. It is physically demanding and takes concentration, dedication, and energy. A fair percentage of Martis artifacts are, in fact, not merely expedient tools but refined ones.

Despite the challenges of working basalt, pressure flaking was used routinely by Martis knappers. Indeed, the vast majority of Martis projectile points were pressure flaked. However, an approach employing only pressure, bypassing any percussion, would have been exceedingly rare, even if the flaking on some projectile points suggests to archaeologists that such an approach must have been used.

The basic biface reduction model proposed by Callahan (1979) applies to Sierra Nevada basalt and Martis technology. Although wood batons have been used by many modern knappers for making basalt bifaces, Sierran woods are substantially inferior to antler for percussion flaking basalt. There are techniques to facilitate pressure flaking of very small basalt projectile points, involving the initiation of pressure finishing while the preform is still large, which affords a certain amount of leverage.

The conspicuous rarity of elegant, refined "knives" in Martis assemblages probably results from multiple causes, such as the utility of cruder

bifaces and the habitual use of "halves" of broken bifaces to make projectile points. The scarcity of artifacts that are transitional between percussion bifaces and pressure-flaked points has a reasonable technological explanation; most breakage occurs during percussion thinning and skilled Martis knappers probably made few fatal mistakes once pressure was commenced.

#### NOTE

1. "Basalt" has been employed as a broad raw material category in Californian and American archaeology. XRF analyses are beginning to suggest that some important basalt-like raw material sources are not, in fact, basalt; however, other tests, especially assessment of percent silica, should ultimately be brought to bear.

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## Intensified Middle Period Ground Stone Production on San Miguel Island

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*Specialized shell bead manufacture is a defining characteristic of Late Period (A.D. 1300 to 1782) Chumash society. While bead manufacturing has been well studied, other items of economic importance have received less attention by archaeologists. This report is a discussion of a quarry and associated habitation site (CA-SMI-503/504) on San Miguel Island, where mortar and pestle manu-*