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EXPERIMENTS IN REPLICATING HOHOKAM POINTS

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Introduction

This paper is concerned with aiding the typologists by describing pressure flaking techniques. The occasion for doing so was created when Emil W. Haury of the University of Arizona asked me to examine a representative sample of the points found at the Hohokam Site of Snaketown during the excavations of 1964-1965. In order to cover the greatest possible number of techniques in a single paper, the fabrication of the Snaketown points will be described. Hohokam represents no single point type, but a representative collection incorporates a wide variety of form, style, barbing, serrating, and controlled thinning and narrowing of the tips without breakage.

Although students of typology and lithic technology are admirers of the well-controlled pressure-flaked artifacts of this hemisphere, generally they do not understand the manufacturing techniques which produce these varied flake scars. Unfortunately, in the past, typologists over-emphasized "measurements," "shape," and "form," and overlooked, or ignored, the working techniques. But today archaeologists are evaluating the technological aspects of the stone tool industry, thereby prompting an inquiry into the manufacturing techniques. Because of this accelerated interest in technological features, we have begun to respect the subtle differences in flake and flake scar character and to realize that an understanding of the manufacture and design of flaking patterns is an integral part of typology.

The Lithic Technology Conference at Les Eyzies, France, in November 1964, (Jelinek 1965; Smith 1966) did much to stress the need not only for analysis and interpretation of technological traits, but also emphasized the importance of actual experiment. Here the participants tried some flintknapping experiments and found that, given instruction and by actually fracturing the material, they could learn more than by mere observation.

Since we have not been able to actually observe the aboriginal in the act of making his stone tools, we must verify the experiment by trying diverse techniques until we produce a true replica. Therefore, experiment is the end result of hypothesis based on theory, but now supported by fact even though, in this instance, the aboriginal approach may parallel or have slight variations. Without theory we cannot experiment, but we must be capable of dismissing the theory which the experiment proves to be false. Nothing is as potent as verified experiment, and actual practice in the rudiments of stone flaking will soon make one aware of: the physical properties of the material when subjected to force; the human factor involved in developing the obvious muscular motor habits; coordination of hands and mind; conscious control and planning; and the feel and perception of the causes and effects. Experiment also permits one, as it did the aboriginal, to devise and design ways and means of overcoming the ever-changing conditions encountered when reducing rough material to a finished artifact. It might even stress the necessity to reconsider and reappraise points varying in type due to modification and emphasize the difference between preparation and functional scars on scrapers, knives, wedges, and other cutting implements. Type sites often contain aberrant forms which are merely the result of modification due to breakage, manufacturing miscalculation and error, imperfections in material, or due to resharpening.

Constantly questions are asked such as: How does one tell whether an artifact was made by percussion or pressure? How can one distinguish a preform from a blank or a completed tool? How do we determine if this was billet struck or worked with a hammerstone? How is a preform distinguished from a crude biface? and so on and on. The fact that these questions are put to an experimenter attempting to replicate the technological patterns of the aboriginal artifact is its own answer. Unwittingly, the inquirer is aware that he must understand the mechanics of percussion, indirect percussion, and pressure to be able to recognize these differences and that the answer lies in verified experiment. The student should always be discouraged from indiscriminately applying "crude" to artifacts unless the word is qualified and related to the quality of the material and regional variations and differences. What may appear to be a "crude" biface to the novice could, in reality, be the result of a skilled workman overcoming stubborn and inferior material.

The writer would like to carry this interest in technology a step farther and make the inquirer aware that the completed artifact represents only the final stages of manufacture and that it is equally important to reconcile the beginning and intermediate stages of fabrication. These, too, are very important because there are multiple technological traits represented in these initial steps which furnish information for defining the manufacturing techniques. For this reason, the importance of a careful study and analysis of flake debitage should be continually stressed. Gathering and storing flakes may be tiring, bulky, and cumbersome; and cataloging and analyzing them may be tedious, but they can reveal much regarding the techniques and technological traits. For these reasons, my technological papers emphasize detailed descriptions of the manufacturing techniques. It is also important to study the wear patterns on any hammerstones, billets, punches, or pressure tools found at a site for the functional scars on these tools have diagnostic value and can aid in determining the working techniques.

It is not my intention to make a flintknapper of every student and anthropologist, but it is hoped that these manufacturing steps will be read and studied in detail and even tried, to some extent, by those concerned with lithic technology. Just observing the final series of flake scars and the form of the artifact, or reading the description of manufacturing techniques is not enough for complete understanding because an integral part of fabrication is by "feel." There is no substitute for actual experiment. Contrary to popular belief, the act of removing a flake by percussion or pressure is not too difficult and the amount of force exerted is only relative to the width of the flake and the isolation of the platform area. The enigma and difficulty of both pressure and percussion flaking is learning to control the width, length, thickness, form, and termination of the flake. This text will attempt to explain how this control is attained. One need not become proficient at stoneworking, but even an attempt will familiarize the student with regulating the fracture and behavior of lithics, help him to understand the many diagnostic features of flakes representing the various stages of fabrication, and to distinguish the intentional from the unintentional.

Some of the Hohokam points are common, utilitarian, everyday hunting points derived from assorted flakes and materials (Fig. 1). These points appear to be made from a flake by pressure alone. First the flake is straightened, then retouched and notched, completing each point individually. The flake is hand-held and straightened by pressure flaking: (1) The bulbar part at the proximal end is removed on the ventral side of the flake. This is done by applying inward pressure from the outer margin of the flake diagonally toward the center of the flake. As the flake being detached nears its termination point, outward pressure is applied to dissipate the inward force and to step or hinge fracture the flake at the median line. (2) Then a flake is detached from the opposite margin to meet this step or hinge fracture, thereby thinning the proposed artifact. If the flakes are not terminated in this step or hinge fracture, then the bulbar part will not be thinned. (3) Finally, the dorsal side is made regular by pressure retouch and then the base is notched, completing each point individually. Often points made from straightened flakes still retain a part of the original flake surface and will be plano convex in transverse section. These smaller points lack standardization of form—that is, the point conforms to the flake rather than the flake conforming to the point.

Other point styles are more elaborate which show form and technological differences and may be separated into categories of characteristics and attributes. For example: the long barbed styles (Fig. 2a-c) indicate a specialized industry, a material preference, and technological refinements not demonstrated in the common hunting point. These points appear to be derived from a blank, then a possible thermal alteration of the material, then preformed by direct percussion, and further refined by pressure flaking. After the final pressure flaking the point is notched, barbed, and finally, the distal end is reduced in width and made pointed. Each of these stages would demand an interchange of flaking tools and the use of different muscular motor habits.

The long, straight, serrated Snaketown points appear to have been made by the core technique from large percussioned flakes and blanks or nodules, rather than from blades. Blades conserve material, but those large enough to serve as preforms would generally be too curved to result in this type of point which is bi-convex in transverse section. Because of the technique required to remove a blade from a core, blades lack the strength of a large flake or core tool. When a blade is detached from the core, it compresses and flexes almost to its elastic limit and, thereby, induces hidden stresses, causing the blade material to be fatigued and subject to breakage. Points made from blades are generally plano convex, whereas the long, barbed Hohokam points are biconvex in transverse section, indicating that they were derived from blanks other than blades. For these reasons, in my experiments, I used core preforms or large preformed flakes rather than blades (Fig. 5a). However, the small points (Fig. 1, 2d-h) represented in this collection were derived from simple flakes detached rhythmically from the core, for they still retain the ventral surface of the detached flake.

Having only a small representative collection of these points and no flaking debris as a guide to replication, the primary stages of the manufacturing technique must, of necessity, be inferred, for the actual technological traits remain with the manufacturing debitage flakes. The collection I have replicated serves only as a guide for the final stages of pressure flaking and notching techniques. However, my replications are based on actual experiments—rejecting and accepting various stages of manufacture until simulation of the aboriginal artifact is acquired. Replica results of the Snaketown points appear to be much the same but, in reality, an accurate duplication can be made only of the last stages of pressure work. The numerous stages of developing the rough material from the first to the final phases of pressure flaking and notching will be described according to my experiments, but the primary stages are not necessarily aboriginal. However, if the finished product is a true replica, then it is safe to assume that the primary and intermediate stages are parallel to those of the aboriginal. For, if the experimenter allows extreme deviations in the initial stages, then the finished product will be aberrant in form and techniaue and, therefore, not a true replica.

Material

Through the courtesy of Dr. Raymond Thompson and Dr. Emil W. Haury, University of Arizona, a representative collection of sixty Hohokam points was loaned for replication by experiment. Points in this collection were of assorted material, ranging from a pure translucent chalcedony to a diversity of impure, colored and opaque varieties of siliceous stone such as jaspers, cherts, silicified sedimentary rock, and obsidian.

Eighteen of the aboriginal points were made of varieties of obsidian—translucent, opaque, and silver sheen. Two points (Fig. 1f, g) very similar in form and technology were of obsidian which reflected an amber color when held against a strong light, reminiscent of obsidian found in Mexico. One point was of quartz crystal, one of basalt, and a single specimen of white pegmatite quartz.

When the specimens were arranged according to form and technological patterns, there was an automatic sorting of stone; and it appeared that the worker preferred a precise material for a definite point style. This may have been because he required definite qualities in a given material for a particular point style, or simply because he had become accustomed to the behavior of certain materials for a definite technique. The long, barbed points were consistently made of a grey siliceous sedimentary stone; the larger serrated points were of cream-colored chert-like material; the smaller serrated triangulate points were of obsidian and quartz crystal; and the very thin side-notched points were made of the cream-colored chert-like material. Other point types fell into pairs and each pair was made of identical material. The ordinary random-flaked side-notched hunting points were of assorted materials. Obviously, these people had diverse sources of raw material, or possibly, there was an interchange of goods and materials from distant sources. Having no flakes and manufacturing debitage to examine, the source of the raw material is unresolved. However, the exterior, or primary, debitage flakes of the aboriginal points should retain surface characteristics which could provide a clue to the material's origin—whether it be alluvial deposits, quarry, etc. (Crabtree 1967a).

Some of the artifacts in the representative collection were made of siliceous material which was quite vitreous, fine-textured, and generally of high quality. This might suggest that the Hohokam people altered the raw stone prior to pressure flaking, for generally this type of material is course-textured and has a sugary appearance. When this type of stone is heated to 450°F to 500°F a molecular change occurs and the raw material has a vitreous, glassy texture (Crabtree and Butler 1964). Vitreous material, whether natural or altered, responds better to pressure flaking than coarse-textured stone. However, examination of the debitage is essential for positive proof of thermal treatment. Lacking the Hohokam debris, there was no conclusive evidence regarding the pros and cons of thermal alteration. A flake detached from a core retaining the natural surface on the dorsal side can give more positive proof of alteration. This is because the natural surface will not alter but the ventral side of the altered flake will be vitreous. When one has only the completed artifact for analysis, all the original surface has been removed by pressure flaking and it is impossible to determine if the stone were treated, but it would be essential for the toolmaker to use either altered or superior material to form and pressure flake elaborately serrated points such as those recovered at Snaketown.

Through the courtesy of Dr. Earl H. Swanson and a National Science Foundation grant (#GS-1659), a large quantity of obsidian from Glass

Butte, Oregon, was acquired for the experiments and a small amount of Harrison County, Indiana, flint donated by Dr. Raymond Baby and Dr. James Kellar. Both materials were used to replicate the Snaketown points. The obsidian was in the form of water worn cobbles and the flint was spheroid with a chalky cortex. Much of my ultimate success in replicating the Hohokam points is due to the encouragement of Dr. Earl H. Swanson, Idaho State University, who urged me to persist in replication and to record the detailed description of these pressure techniques.

To make the core preform, an obsidian cobble slightly larger than the proposed artifact was selected. When material other than cobbles was used, an attempt was made to select elongated and somewhat flat shapes rather than spheroid or round. Before any work was begun, the raw material was carefully examined to determine if it contained any imperfections or deeply bruised parts. If it appeared to be relatively free of flaws or imperfections, then it was tapped with a hard hammerstone to calculate its resonance. A dull thud, or hollow sound, indicates previously undetected planes of weakness, cracks, fissures, and general imperfections. When this happened, the stone was abandoned and a new piece selected and tested. Good lithic material should respond to the hammerstone's tap with a ringing sound, indicating that the vibrations of the hammerstone's contact are evenly transmitted throughout the raw material. Various forms and textures vibrate differently, and only practice will enable the experimenter to differentiate between suitable and unsuitable material.

The nature and quality of the raw material will not only determine to a degree the techniques required, but also the type of percussion tools needed to reduce the material to a usable form. If the raw material occurs in large blocks, boulders, or other massive forms, it can be made portable by trimming pieces into blanks, preforming, or making cores for detaching flakes. This is done by using a hammerstone and direct percussion to remove and discard the poor quality non-homogenous and irregular parts of the material. These trimming flakes are easily identifiable because of their irregularities, particularly on the dorsal surface of the flakes. They are random and lack uniformity due to the general unconformity of the raw material. However, it is well to examine the contact area (platform) and bulbs of force to determine the technique involved and the kind of percussion tool used.

Percussion Tools

The first step in making a Hohokam point, or any other artifact, is to secure materials which lend themselves to a particular artifact style. If the material is a surface find, then it is no problem to simply gather the necessary quantity. But, if the material is *in situ* or massive, then a large hammerstone of material resistant to shock must be used to quarry a piece of adequate size. The nature of the raw material and its geological occurrence will determine the type and size of the percussion implement used to quarry and reduce massive rock to a suitable size (Crabtree 1967b).

After the material has been gathered or quarried, it must be reduced to a usable form. This form is known as a blank. There are several primary and intermediate stages of blanking and preforming which require a series of hammerstones graduated in size. Large hammerstones are used for the initial fractures and to remove non-homogenous parts and cortex. Hammerstones become progressively smaller as the objective piece is reduced in size and nears the preform stage. The size, weight, and texture of the hammerstone (or billet) must conform to the size, weight, and texture of the material being flaked. That is, highly vitreous materials require a relatively soft hammerstone while less vitreous materials will respond well to the harder hammerstone. Obsidian, because of its vitreous and brittle nature, is vulnerable to the induction of undue fatigue, platform collapse, and shattering by the percussor and, therefore, the hammerstone must be of a relatively soft yielding material such as sandstone, limestone, vesicular basalt, reconstituted tuff, or materials of similar texture. But materials like flint and chert are more resistant and, therefore, the hammerstone can be granite, quartzite, or other hard stone.

The form of the hammerstone can be a diagnostic trait, indicating the technique and preference of the worker. Personal preference is for an ovoid or discoidal hammerstone for, when one part becomes flattened by use, it can be rotated and a new striking area exposed. This is one of the reasons why a well used hammerstone is often spherical.

Initial blanking and preforming is by direct percussion with a hammerstone but it is better to change to an antler billet for the thinning of the preform. The antler billet permits the worker to increase the velocity of the blow with greater control; it imparts less shock to the material and lessens the risk of breakage. The billet can be a section of elk, caribou, reindeer, moose, or deer antler, or even a piece of very hard wood. But, generally, one resorts to using a wood billet only when antler is not available. Deer antler billets are the least desirable because they are curved and lack sufficient weight. However, deer tines are excellent for pressure tools. A section of moose antler, beginning at the part affixed to the skull and terminated just before the spread, is highly prized and does a better job because it is straight, solid, and devoid of the spongy center. However, what is available, individual preference, and the material being worked will determine whether the worker uses a hammerstone or a billet of antler, horn, bone, or hard wood.

Cones

Before one can comprehensively explain the detachment of a flake from the parent mass—whether by percussion or pressure—he must consider the behavior of lithic material when subjected to stress by force. Flakes struck, or pressed, from the margins of an artifact are positive cone parts and their scars are the negative cone parts. A complete understanding of the formation and behavior of cones is a real aid when interpreting the wide range of techniques and tools used to induce a particular type and style of fracture.

When a vertical blow is delivered to a flat surface well in from the margin, a complete cone is formed. When a rectangular piece is struck vertically at right angles on the margin, a half-cone is formed. If the vertical blow is delivered to the corner of a rectangular piece, a quarter cone is formed. These cones, or parts of cones, are very evident when a hard hammerstone is used and the force delivered by direct percussion. They are not as obvious on pressure flaked artifacts. The platform or contact area receiving the force is the truncated top of the cone and the percussors—depending on whether they are hard, soft, curved, or flat—cause dissimilar truncations. The angle at which the force is directed will be manifest on both the negative and positive fracture plane of the cone when the force is percussion. Since the fracture plane of the cone is fairly constant, it is relatively simple to interpret the direction in which the blow was delivered.

Pressure flakes are cone parts, but the compressor can be manipulated to change the fracture angle of the cone. This is accomplished by directing the force at an angle contrary to the angle at which the pressure tool is held and first pressing inward into the body of the objective piece and then away in the direction which controls and determines each particular technique. The coordination of the two forces causes the cone to change position within the artifact. For example: the tip of the pressure tool is seated on a platform previously prepared on the margin of an artifact and sufficient inward pressure is applied to cause fracture at a predetermined area. But fracture will not occur until outward force is applied. As the outward, or downward, force is increased, the cone is shifted and its angle changed from a right to an oblique, prohibiting the cone from being driven into the body of the artifact. The ratio of inward and outward pressures changes the angle of the cone until it is parallel to the face of the artifact, causing the material to exceed its elastic limit and detach a flake. This pressure flake, or cone part, has a bulb of pressure at the truncated end of the flake. The ratio of inward and outward forces control, in part, the flake character.

Core Technique Using a Cobble as Raw Material

(1) A large hammerstone, relative in size to the dimensions of the raw material is used as the percussor to make the first break, establish a working surface, and reduce the raw material to a usable form. (2) The worker then changes to a smaller hammerstone to remove, by percussion, the exterior surface. When the worker wants to remove all the exterior surface of a nodule, he detaches large thick curved flakes for they conform to the shape of the nodule and remove, in one operation, a greater area of cortex. (3) To complete the percussion preforming, a still smaller hammerstone is used; or, as previously mentioned, one can also use a billet (Fig. 5e-g).

Blanks Derived From Flakes, Blades and Cores

A blank is a usable piece of lithic material of adequate size and form suitable for making a stone artifact. Blanks can be a piece of stone or unmodified flakes and blades bearing little or no waste material, but they must be of a size larger than the proposed artifact and suitable for assorted artifact styles. Blanks may show some modification but are not yet to the preform stage. If the size and weight of the material are correct, then the worker uses the material "as is" to serve as the blank, and can start the preform stage. But, if the material is too large or irregular, the irregularities are removed and the piece reduced in size and weight by direct percussion to an embryonic tool shape. It may be difficult for the novice to separate and distinguish between blanks and preforms for he cannot know the worker's intended finished design of the proposed artifact. The blank differs from the preform in that the margins are highly irregular, further percussion thinning is necessary, and it is considerably larger than either the preform or the proposed artifact.

When an abundant source of material is available and one wishes to lighten the load for ease in transporting from the quarry, the material is reduced to a convenient weight and form by making blanks. But the worker must always allow enough material in the blank for further preforming. There are several ways of making blanks: by detaching flakes or blades from a core, by designing the core at the source for future flake and blade removal, or by using the core technique to roughly shape the mass by bifacially flaking the material into an ovoid blank of the desired size and weight. Using the latter method simply entails using percussion to detach the cortex and the inferior parts of the material, leaving the waste flakes at the source (Fig. 5a-c). Then these bifacially flaked ovoid blanks can be made into the desired preform at the convenience of the worker. Blanking is usually done at the source of the material, while preforming can be done at the quarry or at a convenient time and place which may be some distance from the material's origin.

The percussion core technique is used to detach blade and flake blanks from a core. Sometimes these freshly struck flakes and blades are used as tools or, as with some Hohokam points, the flakes are detached to serve as blanks for further modification into a point.

When the core technique is used to make usable blades and flakes, detachment is continued until the core is exhausted. Then it is either discarded or can be modified into a usable implement. It is safe to assume that when there was a shortage of material the worker would modify the exhausted core into a wedge, scraper, piece esquillee, or some form of tool. Blademaking is a sophisticated technique and requires special design of the core and a more refined platform preparation than is necessary to detach flakes. There are numerous techniques of detaching flakes and blades from a core, but this paper will only be concerned with the technique applying to Hohokam.

Flake Blanks

Using flakes as blanks is an economical method of utilizing material. A single core may furnish as many as a hundred blanks for small points whereas the core tool method uses a mass of material to produce a single point. Flake blanks are selected for their straightness and form, and the proposed artifact is generally oriented longitudinally but, occasionally, transversely to the flake. Generally, thin flakes can be used for making smaller point by pressure alone, but they must, of necessity, be slightly thicker, longer, and wider than the proposed point.

Large thick flakes can be used as blanks (Fig. 5a) but, if they are too irregular, they are reduced in weight and size to the desired form. Simple direct free-hand percussion is used to remove the large bulbar part and for some preliminary straightening. A medium soft hammerstone, or a 1¼" X 12" antler billet is a satisfactory percussor, for the weight of the blank is sufficient to prohibit its being projected by the blow. To remove the curve from the distal end, blows are struck on the end from the dorsal toward the ventral side of the flake and the force is directed toward the proximal end (bulbar part) (Fig. 5b, c). Flakes are removed from the blank in this manner until the ventral surface is flat from the distal end to midway of the flake.

The flake is then turned end-for-end and the bulbar part on the ventral side is removed. To do this, a platform must be established at the proximal end of the flake blank. This is done by striking on the ventral surface toward the dorsal to remove one corner at the base of the flake blank. This leaves a beveled edge on the corner of the flake blank which is used as the platform to strike off the bulbar swelling on the ventral side at the proximal end. Generally, after one or two flakes have been removed in this manner from the ventral side at the base, and the distal end has been worked as previously described, the flake blank will be sufficiently straight. If the blank (flake) is thick enough, it can be sufficiently straight during the blanking and preforming to result in a completed artifact which will be bi-convex. If the flake is too thin, the artifact will be plano-convex.

Some flakes are intentionally designed by the worker to be larger and wider at the distal end than at the proximal end. These are side-struck flakes. These flakes are more desirable as blanks because of their straightness and the lack of strains normally present in long flakes and blades, due to their flexing during manufacture. Side-struck flakes are removed by direct percussion from the plane surface of a rectangular core. The flake is detached with the right angle edge of the distal end of the core adhering to, and becoming part of, the distal end of the flake. These specialized flakes resemble, in outline, the high button shoe—the bulb of force being at the ankle part.

Another style of flake blank is obtained by detaching flakes from the mass by using percussion with rest. The mass is held in place by the left hand but rested on either a wooden block or a padded anvil stone. This produces smaller flakes but eliminates much of the curve from the ventral surface. After detachment, this flake blank is further straightened by using a hammerstone and direct percussion to remove the bulbar part and the curved distal end, as previously described. But the billet, or hammerstone, must be swung with considerable velocity to overcome the lack of inertia of the flake and prevent its movement with the blow. The slow blow allows the flake to move with the blow, but the high speed blow is delivered before movement of the flake can be of any consequence.

If the flake is of vitreous material and has the proper dimensons, it can serve as a blank, or preform, without modification. If the ultimate result is a small point, then it is entirely possible to eliminate the preforming stage, use the flake as is, and make the entire artifact by pressure alone. However, reducing the rough piece to the finished artifact by pressure alone requires a greater output of energy than when the worker uses percussion to remove surplus material.

Blades

A blade is a specialized flake with parallel or sub-parallel lateral edges, the length being equal to, or more than, twice the width. Cross sections are plano-convex, triangular, sub-triangular, rectangular, trapezoidal, and those with more than two crests or ridges. The more typical is trapezoidal. On the dorsal side they bear the scars from removal of one, two, or more previous blade removals.

Blademaking is the most efficient way of utilizing the raw material for blanks. When good quality material is scarce, blades represent a frugal and economical means of conserving stone. Blades can also serve a dual purpose. They may be used freshly struck from the core as good cutting implements and, when dulled, they may be modified into projectile points. As previously stated, blades lack strength and are considerably weaker than thick flakes or blanks made by the core technique. Also, the one or more longitudinal ridges on the dorsal side resulting from previous blade removal weakens the blade. At the margins of these ridges, there are usually characteristic minute fissures which act as scoring agents, much the same as when glass is scored with a glass cutter. These fissures and crests of the ridges cause the blade to be weakened if pressure or percussion force is induced to the ventral side of the blade. Therefore, the blade is strengthened by removing the dorsal surface by pressure retouching from the ventral to the dorsal surface causing the blade to be plano-convex in transverse section. If the blade is large enough, its lateral margins may be turned, then both faces—the dorsal and ventral sides—of the blade can be retouched and the transverse section will be bi-convex.

A blade large enough to serve as a blank for a projectile point can be removed from a core by either simple direct percussion, indirect percussion, or a combination of pressure and percussion. The blade must exceed the length, width, and thickness of the proposed artifact. If properly designed, it has the outline of the proposed point, thereby requiring a minimum of flaking for its completion.

Core Tool Technique

The core tool technique is used to reduce the mass to a single finished artifact. When the rough material is a nodule, cobble, natural slab, or a thick flake, the percussion core tool technique is used to remove unwanted and surplus material and ultimately obtain a single finished artifact from the inner portion of the mass. Here the core technique involves reducing the raw material by direct percussion: first by roughly blanking the cobble, then preforming the blank, and finally pressure flaking the preform into the completed artifact. In this case, the core—or nucleus—is the tool whereas, in blademaking, the core is the discard. Generally, this technique is considered wasteful and is used only when an abundance of material is available. The term "core tool" can present a problem of definition because all flaked implements become cores. Final definition must depend on examination to determine the ultimate intention of the worker. The core tool technique should not be confused with the core technique of detaching blades and flakes from a core, for the debitage flakes from the core tool manufacture may or may not be usable. Unless there is a shortage of material, the worker generally makes no attempt to detach usable flakes during this process.

For almost all flintknapping, a low seat is desirable for it has the advantage of raising the posterior above the level of the feet and enables the worker to use the thighs and knees for support. When doing percussion work, and for increased leverage during pressure work, the left knee or the top of the thigh is used as a support for the wrist of the left hand holding the objective piece. The seated position also permits the worker to use the right thigh as a fulcrum and hinge for the right elbow, thereby increasing the accuracy of the blow. Also, as the blow is struck, the knees may be gradually brought together to increase the accuracy of the percussor's contact and deliver the blow at the correct angle to a predetermined point on the platform of the objective piece. Since flakes are always removed from the obscure side of the artifact, the fingers of the left hand are continually examining the surface to properly align the blow of the percussor with a ridge. This is true of the left hand fingers whether one is making blanks, preforming, or finishing.

Method No. 1

Using the above described position and method of striking, an initial flake is detached from one end of the cobble by striking with a hard hammerstone at a low angle. Then the cobble is *turned* and the second blow delivered on the plane surface left by the detached flake, and so on around the perimeter of the cobble. As the blow is struck on the margin of the objective piece, the left hand involuntarily responds to the subjected force of the percussor, causing the left hand to roll the objective piece upward, synchronizing the blow with the point of contact. This involuntary response and synchronization is acquired and developed only by continual practice. The worker is usually unaware of these muscular motor responses, much like the blinking of the eye. This manner of striking and rolling the left hand detaches strongly curved flakes from the alternate margins and, therefore, removes all of the original surface. It also eliminates the need to prepare individual platforms. For, by turning the cobble and alternating the flake removal, the plane surface left by the previously detached flake serves as the platform for the next flake removal.

These flakes are characterized by accentuated bulbs of percussion, wide platforms, and a small semicircular scar on the ventral side of the platform part. The dorsal side of the flake will usually retain a portion of the exterior surface and the ventral side will be strongly curved, have lateral edge fissures, and strong compression rings and eraillure flake scars are common on the bulbar part. These flakes are rapidly expanding and, due to the irregular exterior of the original material, they will lack any uniformity of size and shape. But, when flatter flakes are desired, the roll of the left hand is prevented by holding it tight against the inside of the left thigh.

The next series of flakes will be detached around the perimeter of the piece by delivering the blows on the margin into the body of the blank to thin and reduce it in weight and size. This reduces the material to a suitable blank and makes it ready for preforming. Flakes detached by this technique will have less curve than the cortex flakes.

Method No. 2

The first step of making a core tool from a cobble is to remove opposite ends of the cobble by striking at a low angle with a hard hammerstone. First one end of the cobble is removed, then the cobble is reversed and a similar flake removed from the opposite end and opposite side. This produces a flake scar surface which can be used as a platform contact area to make a bifacial and bi-directional core. The core will be tabular with flakes removed from the long axis and on both faces and not around the perimeter as in Method #1. The detached flakes may be used for certain tools to perform various functions with little or no modification. For example: the primary flakes removed from each end of the cobble can readily be adapted for strongly curved end scrapers simply by turning the margin (beveling) at the distal end of the flake. The next two longitudinally detached flakes will be long, expanding, and flat and are well suited for unifacial cutting implements or side scrapers. The next four longitudinal elongated flakes will retain cortex backing on one margin and have a sharp cutting edge on the other margin. These can be used as backed knives without any modification. The balance of the elongated flakes, or blades, can serve as blanks for projectile points or as unmodified cutting implements. When the edge dulls, they may be resharpened by pressure retouch, or they can be further altered into projectile points.

After a flake, or blade, is detached from the core a slight overhang from the bulbar scar is left and two ridges are established on the core. This overhang, or lip, must be removed to re-align the platform either above a single ridge or between the two ridges which have resulted from previous flake removal. Ridges limit the expanding of the flake. If the platform is between two ridges, the flake will be wide and trapezoidal in section; if the platform is above the single ridge, the flake will be narrow and triangular in section. If the surface of the core is plane and devoid of ridges, a conchoidal, rapidly expanding flake will result. In order to control the dimension of the flake, the worker must preconceive and plan the surface of the working face of the artifact, or core, prior to removing a flake.

After the cobble has been thinned by the removal of bi-directional and bi-facial flakes and blades longitudinally, the lateral margins are removed in much the same manner as described in Method #1 until a blank is formed. This method of reducing a cobble to a blank permits the worker more usable flakes if he prepares individual platforms for detaching blades or specialized elongated flakes.

Preforms

A preform is derived from a blank (Fig. 5a-g) and is an essential stage of tool manufacture. It is an unfinished, unused, contemplated form of the proposed artifact, larger than and without the refinement of the completed tool. Preforms are made by direct percussion and are characterized by thick, irregular edges showing no pressure retouch or use flakes, have deep bulbar scars, and no means of hafting. The term "preform" is used to denote an early stage of flaked implement manufacture and should not be confused with the term "blank."

In the case of the long barbed Hohokam points, preforms must be designed to produce a completed artifact which is long and narrow. If the point is to be made by the core tool technique, then the mass must be preformed to a long narrow shape (Figs. 5a-g, 6a-b). If a flake or blade is used as the blank, then the worker must mentally orient the artifact within the blank to ultimately preform the flake into the approximate shape of the finished artifact. Naturally, all preforms must be slightly larger than the finished piece.

I first used the term "preform" at the Western Typology Conference, Idaho State University, Pocatello, Idaho, 1962, and had derived this word from one used by dealers in precious stones. The jewelry trade refers to stones which are rough-ground into various forms, prior to faceting and final polish as "preforms." In archaeology, the term denotes a stage of artifact manufacture not suitable or intended to be a functional tool. In the case of an unfinished stone implement, due to an emergency, or lack of weapons and tools, there may have been occasions when the aboriginal used a preform for a working purpose. In this case, the preform is no longer just a preform, but has become a functional implement showing use. Generally, preforms are common to areas where raw material must be transported some distance, for preforming reduces the bulk and saves transporting quantities of rough, imperfect and inferior material and waste flakes. When carried a long distance, preforms often show signs of being abraded on all surfaces, probably the result of one preform rubbing against the other. These abrasions are evident on Clovis artifacts recovered from the Simon Site in Idaho and are commonly noted on preforms found in caches (Butler 1963; Butler and Fitzwater 1965).

Because of the amorphous nature of the lithic material, there is no hard and fast rule or mandatory technique of roughing out a preform. The general idea is to systematically reduce and thin the mass to a desired weight and shape which will conform to the proposed pressure work required to produce the finished artifact. But preforming is not a haphazard art, and the removal of each flake must be considered and evaluated to conform with the changes in surface character which occur as flaking progresses. Preforming debitage flakes will lack uniformity, have large platform areas and well-defined bulbs of percussion.

The amount of force required to detach flakes is relative to the size of the percussor, the velocity of the blow, and the desired dimensions of the fracture. The proximity of the blow to the leading edge will vary the intensity of the required force. If the blow is delivered near the leading edge, the force required is diminished and a thin flake detached; if the impact is away or inward from the leading edge, the force must be increased and a thick flake is removed. The seasoned experimenter obtains a sense of "feel" and can adjust to the irregularities of the stone and the point of impact. There is no substitute for practice.

Direct percussion flaking of flint-like materials can be compared to a game of billiards. In this game, the amount of force varies and no two shots are made at exactly the same angle. The same is true in shaping a piece of irregular lithic material into a preform. Compare the cue ball to the percussor and the ball being struck to the lithic material being worked. The amount of force is relative to the velocity of the projected ball and is constantly changing in much the same way as one must change the amount of force of the percussor when removing flakes of various sizes. The angle at which the cue ball strikes the target ball controls the direction in which the ball is projected and is comparable to the angle at which the percussor strikes the objective piece to detach a flake at a certain angle.

Consider the matter of depicting force. The angles of force may be illustrated but there is no way, in flintknapping, to measure the foot pounds of force or the interval of contact of diversified percussors on the objective piece. Diagram sketches depicting each and every percussion motion and all the factors dependent on the nature of lithic materials—imperfections, miscalculations, changes of angles of force—would become so cumbersome that the illustrations would be practically useless. It behooves the student who is serious about learning the fundamentals and refinements of stone tool manufacture to practice and experiment.

To correctly use a percussor, one must: (1) develop great striking accuracy, (2) be able to relate the proposed fracture area to the size and velocity of the percussor, (3) coordinate both the angle of the blow and the path of flight of the percussor with the angle of the platform, (4) remember that the curvature or straightness of the path of flight of the percussor determines, in part, the curvature or straightness of the flake, (5) determine the amount of inertia of the preform with or without the support. The amount of resistance or yield of the objective piece will determine, to some degree, the interval of contact, and (6) the amount of resistance or yield of the percussor will determine the time or interval of contact between the percussor and the objective piece. The softer the percussor, the longer will be the interval of contact which will lessen the force and reduce the shock.

Preforming Method No. 1

The billet, or hammerstone, used for preforming is designed with a rounded working end to permit greater striking tolerance of the edge. Also, the rounded end gives the percussor a greater area of contact surface and, therefore, a glancing blow can be delivered to the edge without striking too far into the body of the preform. The tolerance of the blow is the distance of the tangent of the arc of the rounded edge of the percussor. For precision flaking, the rounded-end billet, or hammerstone, has a distinct advantage over the discoidal hammerstone—for the flatter discoidal surface limits the width of the contact area between the percussor and the objective piece.

The seated position of the worker is the same as described under blanks, but the preform can be held freehand, or placed on either the *outside* or the *inside* of the left thigh which has been padded with several layers of leather or hide. The left hand loosely holds the blank by one margin with the working margin supported by the thigh but exposed for percussion contact.

All irregularities must be removed, the blank straightened, thinned, narrowed, and roughly shaped into the form of the proposed artifact. The irregular parts are removed by preparing platforms on both the lateral margins in line with ridges left from flake scars resulting from the "blanking" stage. Should the irregularity be massive, the edge is beveled (turned) and then an abrasive stone is used to grind and slightly round the platform part of the edge to make is stronger and more resistant to crushing. If the irregularity is less massive, then the platform is beveled (edge turned) by removing small short percussion flakes from the margins in a direction opposite that in which the proposed thinning and forming flake will be detached. Then, by percussion, very small short flakes are removed from the edge in the same direction as the proposed flake. This orients the long axis of the proposed thinning and forming flake and eliminates any overhang. However, the beveled platform (turned edge) is more vulnerable to collapse if the overhang is not removed.

Platforms may be prepared individually by beveling (turning the edge) and/or grinding, or they may be prepared along both margins around the perimeter. Personally, I prefer the latter method, for the prior and complete platform preparation allows the worker to gauge the intensity of the blow, keep the rhythm uniform, and detach flakes without pause or interruption.

To reduce breakage caused by shock, thinning is started on the platforms at the distal end of the blank. The percussor is directed in a straight line to the platform, but at slightly less than a right angle to the long axis and angling toward the gravitational center of the objective piece. The striking angle will vary according to the desired thinness of the preforming. The thinner the preform, the flatter the striking angle; the thicker the preform, the steeper the striking angle. The intensity of the blow is predetermined by the artificer who gauges the force by the size of the area to be fractured. Determining the necessary amount of force requires much practice and a knowledge of the material being worked. After considerable practice, one develops a feel and coordination of the muscular motor habits and becomes keenly aware of the sounds made by successful flake removal. The ears are nearly as important as the eyes when fracturing stone. The proper alignment of force with the objective piece causes distinctive sound vibrations. Much consideration of material and concentration is required during flintknapping and conversation is difficult during this part of the experiment.

After each flake is detached, the flake scar is examined to allow for any required adjustment in the amount of force and to determine if it is necessary to change the angle of both the blow and the objective piece. After the preform has been thinned from the tip (distal end) approximately one quarter the length of the blank, then the base is thinned. The end of the preform is reversed and the worker starts at the base and works along the lateral margin in this same manner until the irregular surface has been removed and thinning has intersected the previous work. Then the artifact is turned and the same platform preparation and flaking done on the other lateral margin and on both faces. This process may have to be repeated several times before the preform is ready for pressure flaking. But, to provide additional strength, the preform must be left wider at the mid-section.

As the preform becomes increasingly smaller, thinning and forming flakes detached from the margins must be reduced in size, for the greater force necessary to detach larger flakes, or a fortuitous blow, will cause the preform to break. The percussion blow transmits shock waves between the tip and base and, unless this shock is properly dampened, the end opposite that receiving the force will fracture. Shock is dampened by resting the end being worked on the padded thigh and directing the force of the blow toward the gravitational center of the preform.

When all irregularities are removed from both faces and the lateral margins are made acute and regular, then the edges must be strengthened. This is not always necessary when working siliceous stone, but is essential with vitreous materials to prevent platforms from crushing and the flakes from hinging or step-fracturing during the next stage of percussion finishing. One method of strengthening is to first turn the edge (bevel) and then grind and slightly round the edge with an abrasive stone.

At this stage, a smaller billet is substituted for the larger one which was needed for the initial thinning, and the striking pattern is changed. The blow is now delivered in an arc-like motion to detach flakes which curve over the surface of the preform. The size of the flakes are governed by the styles of the platform, the angle of the blow, intensity of force, and the amount of contact surface on the margin. The surface of the artifact controls the form of the flake; for example, a plane surface produces an expanding flake and the ridged surface will detach an elongated flake.

Hohokam points encompass numerous forms, stylistic variations and techniques. The long, narrow, serrated or barbed styles are the most elaborate. These intricate styles range in length from one to four inches and, therefore, the preforms must necessarily be longer and narrower than other points of this size to allow for barbing and serrating. The sides, or lateral margins, must be reduced with considerable care to retain the preform shape of the proposed artifact. The narrower the preform becomes, the more vulnerable it is to breakage and, therefore, the worker must decrease the size of the detached flakes and space them closer together to prevent fracturing the piece.

Method No. 2, Hand-Holding, Supported on Inside of Left Thigh

Another method of percussion preforming is to hold the blank transversely across the inside of the fingers of the left hand, with the back of the hand resting on the inside of the left thigh. The tip of the middle finger is placed on the obscure side of the blank at the intended point of impact and to denote the ridge which will guide the flake across the obscure face of the blank. After each blow, the middle finger is relaxed and the detached flake dropped before another blow is struck. It is often necessary to flake the entire surface several times before the preform assumes the desired form.

After the first large irregularities are removed and the preform straightened as in Method #1, the edge is prepared for the next series of flake removal. Edge beveling can be done by an alternate technique of turning the margin. The edge of the preform is pressed inward against the edge of a smooth anvil stone at right angles to the face of the proposed artifact. When the bevel is approximately at a 45° angle, then the edge is rubbed forward and backward against the anvil stone in a cutting motion to remove any sharp, weak edges. After each margin has been flaked, the edge must be re-prepared for platform purposes in order to flake the opposite side from the opposite margin. The blank is percussion-flaked bifacially and bilaterally in this manner until it is preformed into the proposed shape of the finished point.

The percussion tool used in these experiments was a section of antler with the end rounded to transmit sufficient force to the marginal platform to detach a flake of the desired dimension without prematurely breaking the preform. Antler is semi-yielding and, therefore, prevents platform crushing of the brittle obsidian being worked.

Wielding the antler percussor with the proper velocity is a manipulative art which is difficult to describe. Proficiency of use can only be attained by long practice and the trial and error method. The percussor is directed at less than right angles to deliver a glancing blow to the edge. At the instant of contact, the percussor is directed inward and the full impact of the blow delivered to the platform. This prevents the percussor from riccocheting and simultaneously removes a flake from the obscure side of the artifact. This is continued around the perimeter of the preform until all irregularities and imperfections are deleted, for these are difficult to overcome with the final pressure technique. Considerable control of all factors (velocity, direction of force, angle of force, angle of the objective piece, area to be fractured, point of contact) must be exercised to terminate the flake in a feather edge rather than permitting a step or hinge fracture.

Method No. 3, Free Hand Holding Without Support

When one becomes as skilled at freehand percussion work as Dr. Francois Bordes, then the thigh support may be eliminated and the preform successfully made by freehand percussion. However, this takes great skill and keen judgment and should not be tried by the novice.

The worker may either stand or sit for this work and the only support of the artifact is the fingers of the left hand. The percussion tool can be either a hammerstone or an antler billet with a rounded working end. There are several ways of holding the preform, depending on the surface condition of the blank and on whether one is striking the tip, base, or margins of the piece. In each case, the part being worked would have to be left exposed for striking.

One method is to support the piece lengthwise on the slightly curled fingers of the left hand with the index finger supporting one end of the piece and the thumb exerting slight pressure on top of the preform to prevent movement. The middle finger slightly protrudes from the lateral margin of the preform, but is in line with the ridge on the obscure side where the blow will be struck and the flake detached. This manner of holding is used so the middle finger can accurately guide and control flake detachment in collateral flaking and thinning.

The percussor strikes a glancing blow on the margin of the blank at the tip of the protruding finger. This is not as foolhardy as it may seem, for the finger is relaxed and will move out of the path of flight before the percussor makes contact. Care should be exercised in holding the preform for the support of the left hand acts as a fulcrum and the blow causes the distal end of the preform to flip upward and, possibly, to break.

Blows are delivered with sufficient velocity to detach the flakes. The amount of velocity will depend on the type and resistance of the material being worked and the size of flakes detached. Since the size, condition, and material of the blank is always variable, there is really no way to explain here the amount of velocity needed and one can only experiment under various conditions to determine the necessary force.

Flakes are detached on the obscure side and fall between the first and second fingers which are spread apart. When the hand is unprotected by the glove or pad, this spreading helps reduce injury to the hand. Padding or gloves are not desirable, for the bare fingers are more sensitive for constantly feeling the surface to determine the ridge to guide and control the flaking. Generally, viewers of a demonstration concentrate their attention on the wielding of the percussor by right hand and the action of the left hand goes unnoticed. However, high speed photography shows that the fingers of the left hand are constantly in motion examining the obscure surface of the artifact during flake removal. For this reason, the left hand becomes more fatigued than the right.

After each blow, one must check to see if the flake is detached and allow it to drop from the hand. When one becomes skilled, then he will know by feel and sound if detachment is complete and will automatically drop the flake without inspection. But if a second blow were delivered with the flake still in the hand, then it would be driven into the hand; or, when the percussor was re-positioned for a new blow, the upswing could drive the flake into the face or eye, or other severe injury could result. Only by continual practice can one become proficient in the use of the hammerstone or billet, become familiar with materials, develop accuracy, and most important, learn to control the angles of delivered forces and the many diverse forces involved.

Generally, flaking is started at the base of the preform where the flakes will be the largest and consequently the fracture area greater. The percussion blow is delivered to angle the flakes toward the gravitational center of the preform. As flaking progresses toward the tip, the spacing interval of the flakes is decreased.

There are five methods of determining the order of flake removal during preforming:

(1) Flakes are detached from one margin from the base to the tip, terminating the flakes by feathering at the median line to thin one-half of one face. Then the preform is turned and worked from the base to the tip on the opposite margin, detaching flakes from one-half of the opposite face. We now have a preform thinned on one-half of both faces from opposite margins. Then the artifact is reversed end-for-end, and flaking begun at the tip toward the base with the detached flakes meeting and intersecting those removed from the opposite margin. Then the preform is turned and the same technique applied on the opposite face from the tip to the base until both surfaces of the preform are flaked.

(2) The worker can flake one-half of the face of the preform by detaching flakes from one margin from the base to the tip. Then the preform is reversed and flaking continued from the tip to the base, detaching flakes from the opposite face but the same margin. We now have a preformed thinned on one-half of both faces from one margin. Then the preform is turned and the same technique applied on the opposite margin from base to tip and tip to base with the flakes meeting and intersecting previously detached flakes.

(3) Flaking can be from base to tip on one margin, then the artifact turned and flaked from tip to base on the same face but on the opposite margin. We now have a preform with one face thinned. This procedure is then repeated on the opposite face.

(4) The worker may alternately thin one face before proceeding to the second face. A flake is detached from one margin then, after each flake removal, the piece is rotated and a flake detached from the opposite margin but on the same face. This technique is continued from the base to the tip, having each flake intersect the flake scar from the opposite margin until one face of the preform is thinned. Then the same method is applied on the opposite face, alternately flaking from opposite margins, but on the same face.

(5) Another sequence of flake removal is to remove flakes from base to tip alternately from the same margin but from opposite faces. The objective piece is turned over and end-for-end after each flake is terminated and detached at the median line of the artifact. After one margin is flaked, the opposite margin is worked in the same manner. When completed, the lateral margins will be sinuous and slightly wavy. This technique is recommended when removing right angle edges.

Aboriginally, most preforms show the use of one of these methods of flake removal, but some indicate that the flakes were detached at random with no specific order. This difference in behavior patterns could be considered a trait.

PRESSURE TOOLS

Pressure flaking is the technique of applying force through an intermediate tool (compressor) to form, thin, prepare platforms and edges, and to design the basal end of the artifact for hafting, such as notching, barbing and stemming. It is also used to sharpen, serrate, and to make blades.

The pressure tool may be a simple one, such as an elongated pebble, piece of bone or antler, the edge of a shell, or merely a suitable piece of hardwood. Or it may be more sophisticated and composite, such as the Eskimo pressure tools designed with ivory or bone handles and inserts, or bits at the working end. Composite tools are fairly common and are made by using a handpiece of various mediums and inserting bits of ivory, bone, antler, or metal at the tip. Pressure tools are selected according to the style and the proposed type of flaking.

For the simplest pressure technique, a coarse-textured cobble is used as both the anvil and compressor. The cobble is placed on the ground, or held between the knees, and the flake or blade (blank) is held at an angle against the anvil. To form the artifact, the worker presses the flake on the anvil stone and either pushes or pulls to detach flakes from the margins of the blank. This process is continued until the artifact assumes the desired form. Flakes removed by this technique are random, short, steep; often the edges of the artifact are crushed, and there is a predominance of small step fractures on the surface of the artifact. Unrefined as it may be, this technique is useful for backing blades, making simple scrapers, turning an edge to make it more regular, and to provide a platform surface for later removing individual flakes with a hand-held pressure tool.

A similar technique deletes the anvil and the worker finger-holds the preform and uses a compressor to apply the force. The compressor may be a pebble, bone, shell, antler, or any material which has sufficient strength to remove small flakes. Pressure tools used in this technique will generally be difficult to recognize because the sides, rather than the tip, of the pebble are used. The sides of the pebble first become abraded with scratches and minute striations and, when repeatedly used, a slight concave indentation will form. This holding method gives the worker greater control of the inward and outward forces and he can detach longer flakes and produce a more acute edge than is possible with the anvil technique. But this method is more successful for retouching flakes and blades than it is on core tools. This is one pressure technique used by the Australians to resharpen the edges of their tools.

The pebble compressor is held between the thumb and index finger of the right hand and the preform is held between the thumb and slightly separated index and middle fingers of the left hand. As the compressor is pressed and rolled upward on the margin, pressure is exerted by the thumb of the left hand on the preform. This detaches flakes from the visible face of the edge which are directed toward the median line of the artifact. This technique indents the edge and leaves a slight projection which is then used as a bearing surface to seat the compressor to remove the next flake, and so on across the entire edge of the artifact. Flakes removed in this manner are usually short and rapidly expanding. Because of the shortness of the detached flakes, this technique is also used to turn, or bevel, the edge and may be repeated on the opposite side to make the edge bifacial. This technique can be used to make small, random-flaked arrowpoints, but the flake scars will vary in size. It is also successfully used to make backed flakes and blades, gravers, perforators, for incising implements, for making indentations (strangulations) on flakes and blades which can then be used as shaft smoothers or small draw knives, and for forming and shaping microliths. It is unlikely that debitage flakes removed by this technique would be recovered for, because of their minuteness, most are crushed or broken in the process of removal.

The Australians use another pressure technique which produces similar edge character and this has been described by Gould (1966, 1968a, 1968b) and Tindale & Lindsay (1963). The workman uses his teeth to sharpen the edge by holding the piece between the teeth and pressing and pulling the artifact downward to remove small random flakes from the margin. This experiment has not been explored by the writer for obvious reasons. It is still a wide open field for those intending to replace their existing dentition.

When a more refined pressure technique is used to remove individual flakes, the tool is a piece of antler, bone, horn, shell, wood, or metal which is shaped to a blunt point at the working end. Pressure tool tips are rounded because a sharp, pointed tool would not have sufficient strength to remove a flake without breaking the pointed tip. If the tip of the pressure tool is pointed, it would not be sufficiently strong to detach flakes without the tip of the compressor breaking. But a rounded tip provides sufficient strength to apply both inward and downward pressures. The diameter and size of the tool will depend on the size of the flake removed. As the detached flakes become progressively smaller, a tool with a smaller tip is substituted. These tools cannot be mistaken for awls and perforators because the abrasions and scratches on the tip are deep and cross-hatched (Semenov 1964).

A composite pressure tool consists of a handle with a bit (pressure point) affixed at one end. Handles may vary in length, depending on individual preference and the size of flakes to be detached. The longer handle increases the leverage and, therefore, will detach longer flakes.

Short composite pressure tools have a handle about the same length as the width of the hand with rounded bits of bone, antler, or metal inserted at the working end. Tools with blunted tips are used for pressure retouch and those with pointed tips are used for notching. I find the short composite pressure tool ideal for detaching small, narrow flakes which curve over the face of the artifact. The shorter handle permits the worker to use a slight wrist movement to curve the flakes past the median line of the artifact. However the short-handled tool does limit the size of the detached flakes.

When the long-handled pressure tool is held between the inside of the right forearm and against the side of the worker's body, the leverage is increased. When using the long-handled pressure tool, the preform is held in the left hand with the leading edge vertical to the palm, and the back of the hand is rested on the inside of the left thigh. The back of the right hand, holding the pressure tool, is placed on the inside of the right thigh and the tip of the tool is placed on the margin of the artifact. As the hands exert inward and outward pressure, the knees are brought together to enable the worker to apply additional force. Using this type of tool and technique increases the leverage and enables the worker to detach flakes two inches in length.

We cannot exclude from pressure tools the elaborate composite pressure flakers of the Eskimos. Handles are of medium length and are of bone or ivory with one end curved and flared to fit under the wrist and around the heel of the hand. This extension gives added leverage not possible with a shorter composite pressure tool. A slot is made on the underside of the unflared end of the handle and a bit inserted and made secure with leather strips of sinew. By slotting and hafting on the underside, pressure can be applied to the bit and the force will be applied upward against the handle rather than bearing down on the lashings. Some of the slots for holding the bit are slightly concave and some are flat. If flat, the slot is slightly angled and, therefore, if the exerted pressure loosens the bit, a tap or two on the bit will tighten it in the handle. Some of the bits are designed with two workable ends—one end for notching and the other end for pressure flaking. The worker merely loosens the bit and reverses ends for each type of work (Personal communication: William Irving, George MacDonald, Jorgen Meldgaard).

For experimental purposes, I have made similarly designed implements but, lacking bone or ivory, have used plastic, antler, or wood for the handle. This type of pressure tool is comfortable and very satisfactory for keeping the flakes in alignment during detachment.

There is still another type of composite pressure tool but it is used only on artifacts larger than the Hohokam points. The handle is a short wooden crutch with a top bar at right angles to the shaft and a bit inserted in the working end. This permits using the shoulder to increase and supplement the pressure exerted by the hands and arms.

PRESSURE FLAKING

There are numerous ways of pressure flaking and the application of force is not comparable in any way to that of percussion. Percussion is the detaching of flakes by striking and is usually concerned with only one angle of force in relation to the transverse section of the artifact. But the pressure technique involves pushing off the flakes and, generally, two forces must be considered and coordinated, first the inward and then either the downward or outward. The inward force must be sufficient for removal of a flake of predetermined dimension but not enough to detach the flake until the downward or outward force is applied.

Before the worker can start pressure flaking, the hand holding the objective piece (material being worked) should be protected with a pad of leather or other suitable material to prevent detached flakes from being driven into the flesh (Fig. 10a). If necessary, the objective piece may be rested on the padded thigh, or on rests of wood, stone, or any medium which will support the piece as it is held in place by the fingers or heel of the left hand (Fig. 11b).

If wood or stone is used for the rest, it should be covered by a thin layer of yielding material so the objective piece will be evenly supported, otherwise accidental fracture could occur.

Pressure flaking instructions will be given for a right-handed person, holding the objective piece in the left hand and the pressure tool (compressor) in the right hand.

Regularizing the Preform

The preform is examined for any surface irregial, such as vugs and crystal pockets, or miscalculations in percussion work such as step or hinge fractures. These irregularities must be eliminated and the surface made regular before successful pressure flaking can be accomplished.

Step Fractures

Should the irregularity be a step or hinge fracture, a short pressure tool with a flat thin tip is used to remove the balance of this flake.

A step fracture occurs when a flake terminates prematurely in a right angle break. This step fracture must be removed for it would be impossible to detach a pressure flake from the margin and delete this obstruction. The tip of the pressure tool is placed on the right angle break of the step fracture and pressed downward as almost simultaneous outward force is applied to detach the mass from the face of the artifact. If the right angle break of the step fracture has enough bearing surface to withstand these two forces, then the balance of the broken flake will detach. If it does not detach, then the worker must establish a larger platform. To do this, the pressure tool is seated on the margin of the artifact directly above the right angle break and the worker deliberately terminates a second flake in a step fracture in the same place as the original break. This establishes a larger platform. The pressure tool is then seated on this platform and downward and outward force applied to detach the unwanted mass. Should this second flake cause too much malformation of the preform and make it impossible to seat the tool for removal of the mass, then the worker must attempt to remove a flake on the same face but from the opposite margin which will intersect and terminate at the right angle break of the step fracture. This is done by establishing a platform on the opposite margin directly in line with the right angle break and applying inward and downward pressure to remove the mass, intersecting and terminating at the step fracture break.

Hinge Fractures

A hinge fracture terminates in a concave break rather than the right angle break of the step fracture. Removal of the hinge fracture flake is accomplished in the same manner as the step fracture. However, this type of termination makes it relatively simple to remove the irregularity because the pressure tool will not slip from the concavity.

Irregularites

If there are crystal pockets or differences of homogeneity in the material, it is better to pressure flake around these areas rather than try and force the flake through the obstruction. For, if an attempt is made to flake through the mass and fracture occurs before its intended termination, the irregularity would be further accentuated.

Other irregularities resulting from direct percussion preforming, such as unevenness and large crests left on the margins of the flake scars, must be removed to make the objective piece regular and uniform for the final pressure flaking (Fig. 5f). To remove these irregularities it is often necessary to strengthen the platform by localized grinding on the platform area. Without this special preparation, the platform is apt to collapse before the desired flake is detached because the mass to be removed is thick and offers more resistance than the unprepared platform could tolerate. These irregularities are removed and the preform thinned with an antler pressure tool. The preform is placed on the pad in the left hand and the tip of the pressure tool carefully seated on the prepared platform. Force is applied by pressing inward toward the palm of the hand and then downward until the irregularity is detached. No effort is made to remove these irregularities in an orderly manner other than what is necessary to make the preform straight and smooth on both faces. It is during this stage that many artifacts are broken because of the size of flakes necessary to delete the irregularities.

Turning the Edge (Fig. 10a)

After the surface of the preform has been made uniform by removing irregularities, step and hinge fractures, then the edges are made even and straight. The artifact is held on the pad in the palm of the left hand. A rod-like pressure tool—bone or antler tine—is substituted for the composite tool for, at this stage of edge preparation, the handle part of the composite tool would interfere with the work. The side of the rod is used rather than the tip, and the rod is placed parallel with the edge at a right angle to the longitudinal axis of the artifact. As the right hand presses the tool downward, it also applies inward pressure to the leading edge. A shearing motion results and the projections are removed in a straight line. This action is repeated bifacially and bilaterally until the preform has straight edges. Edges turned on only one margin will be beveled and may be misinterpreted as being the result of function whereas, in reality, this is merely a method of platform preparation.

Holding

The pressure tool, whether it be antler or a composite one, is held in the palm of the right hand with the fingers curled tightly around the handle. The tip of the pressure tool is placed as close to the index knuckle as possible and yet permit clearance between the knuckle and the leading edge of the artifact. The closer the knuckle is to the tip of the pressure tool, the greater the attained leverage. The wrist of the right hand is held rigid and in line with the forearm.

For purposes of clarifying the text, let us review the position of the preform in the left hand. The artifact is held horizontally in the palm of the hand with the obscure face resting on the palm and the visible face upward and apparent to the worker. Flakes detached to thin and form the artifact are always detached from the obscure face (Fig. 10a, b). There is one exception and that is the removal of microflakes to establish an individual platform surface for seating the pressure tool. These are removed from the visible margin.

To detach flakes which will curve beyond the median line—or to the opposite margin—the left hand holding the objective piece is relaxed with the fingers exerting just enough pressure to support the artifact. This permits the artifact to slightly roll when pressure is applied, thereby detaching a curved flake. Excessive pressure of the left fingers will frequently cause the artifact to break when pressure is exerted by the right hand. The left hand must be protected by padding to fit the palm of the hand—either leather, cloth, fiber, shredded inner bark (sagebrush, cedar, etc.), a grooved piece of wood, or a padded stone. But the palm of the hand must be cupped to prevent the padding from touching the part of the surface of the artifact being flaked. This manner of padding and cupping the palm will allow clearance for the flake detachment and thereby avoid premature fracture. Different paddings offer different resistance to the objective piece and, therefore, will vary the flake character. By holding the left hand rigid and using a resistant pad, the applied pressure will detach flakes which terminate with a feathered edge. If the pad is soft, then the artifact will move and curved flakes will result.

The orientation of the preform on the padding and its position in the left hand will determine the angle of the flake scars on the objective piece. Oblique or diagonal flake scars result when the objective piece is placed at an oblique angle on the pad in the cupped palm and the pressure directed in alignment with the left forearm (Fig. 10c). Collateral flake scars result by holding the preform in the palm of the left hand transversely to the left forearm and applying pressure at right angles to the long axis of the objective piece (Fig. 10b). The last series of flake scars on the long, narrow, barbed Hohokam are generally collateral (Fig. 2a-c), indicating that the artifact was held in the transverse position and flakes removed at right angles to the lateral margins. Flake scars on the distal end directed from the tip toward the base usually indicate that the point was repositioned in the hand and the force directed diagonally from the tip toward the base to prevent the tip from breaking (#3 and #4 Hohokam points; see Conclusions). However, this is not generally true of the #1 and #2 Hohokam points, for they are collaterally flaked throughout.

The order of flaking is a matter of preference. One soon becomes accustomed to removing the flakes in a series along one edge from left to right (from the base to the tip) or vice versa, or by removing them alternately from the same margin but opposite faces. An exception is the herringbone (double oblique) flaking which is attained by flaking on one margin on the same face in a direction from left to right (from the tip to the base) and then on the opposite margin from right to left (from the tip to the base). There are some examples of this in the #4 category Hohokam points. Each order of flake removal may be considered a diagnostic trait. Personal preference is to detach flakes from left to right (base to tip) on one margin, then turn the artifact and flake from the opposite margin from tip to base. This develops a rhythm and dependable muscle response in preparing platforms and removing flakes directly in line with the ridge left by the previous flake detachment. This order of flake removal is typical of #3 style Hohokam points (Fig. 4a-c).

The method of holding the long, narrow, barbed Hohokam artifact for final surface flaking is to place it on a pad at right angles across the cupped palm of the left hand with one end resting on the heavy muscle of the thumb. The curled fingers apply gentle but firm pressure to keep the point in position. The tip of the pressure tool is firmly seated at a right angle to the longitudinal axis of the point on the leading edge near the base (Fig. 10b). The edge has previously been made regular by abrading to prevent collapse from applied pressure. Force is applied by simultaneously bringing together the knees and applying pressure from the hands, arms, and shoulders. Hand pressure must be applied in two directions, inward in the direction the flake is to be detached and, almost simultaneously, exerting outward pressure in a direction toward the palm of the hand but away from the artifact. Adequate inward pressure must be applied to prevent the tip of the pressure tool from slipping off the margin of the artifact. The inward pressure detaches the flake at the platform part and directs the flake across the face of the artifact. The outward pressure detaches the flake. The ratio and blending of the inward and outward forces is only attained after long experience. Since these forces cannot be seen and are difficult to describe, the worker develops a "touch" and "feel" for the necessary amount of each force to detach each particular style and type of flake.

To provide strength, the long, narrow, barbed Hohokam point (Fig. 2) must be left thick at the median line. The edges must be made thin so they can ultimately be deeply notched and some of the notches altered into barbs. This is achived by detaching flakes which leave large bulbs on the margin and which are quite wide in relation to their length and terminated by feathering at the median line. This leaves the median line fairly thick and the edges slightly concave. The interval of placing the tool on the margin, the width of the tip of the pressure tool, and the amount of platform detached with the flake determines the width of the flake. If the tip of the tool is set far back on the platform, the detached flake will be wide and thick at that part, for the platform is adhering to the detached flake. If the tip of the tool is set near the edge of the platform, a thin flake will be detached with less platform adhering.

The objective piece (material being flaked) is placed in the hand with the obscure face resting on the palm and the visible face upward. But, before any pressure flaking can be done, platforms must be established for seating the pressure tool. Individual platforms are established by removing one or more microflakes from the edge to prepare a surface for seating the compressor. A bluntly pointed pressure tool is placed slightly under the margin and then pushed upward to detach a short flake from the visible margin of the artifact. The detached flake, or flakes, leave a slight bulbar scar on the margin which will be the platform for seating the tool. The tip of the pressure tool is then seated on this bulbar scar (platform) and pressure applied inward and then outward until the flake is detached and feathered at the median line on the obscure face of the artifact.

After this first flake is detached from the obscure side, then the second platform preparation is made. One or two microflakes are removed on the obscure side of the same margin next to the first platform to align the second platform with the ridge left by removal of the first flake. After the flake has been detached from the second platform in the above described manner, then another platform is made in the same way as the first, but directly in line with the ridge or crest left by the detached flake. This determines the interval of spacing. This technique of platform preparation and flake detachment is continued along the entire margin of the artifact from base to tip, flakes becoming progressively smaller and the spacing interval closer as the flaking process nears the tip. Pressure is applied to the platform on the margin, first inward and then downward. When these pressures are coordinated, the force will remove a flake from the obscure face. But if the piece is held with the margins vertical, the pressure is applied downward and outward. The downward force is applied on the platform at right angles to the longitudinal axis of the artifact and the force is directed from one margin to the opposite edge. As the flakes are pressed and guided across the face of the artifact, the adjustment of the ratios between downward and outward forces cause the flakes to terminate at a predetermined point.

When one margin has been completely flaked, the artifact is turned and reversed and the same platform and pressure flaking technique is applied on the opposite margin and the same face, but now from tip to base. Since the flaking is now started at the tip, the first flakes detached will be small and will become increasingly larger as they near the base of the artifact. Flakes are terminated at the median line to meet and intersect those detached from the opposite margin. When pressure is applied to the tip, it must be directed toward the base, otherwise the tip will snap and break. We now have an artifact flaked on one face.

After one face is completely flaked, the artifact is turned and reversed and flaking is continued in the same manner on the opposite face from left to right, starting at the base to the tip and then turning and reversing the artifact and flaking from the tip to the base. The interval of spacing is the same but now the worker places the tip of the pressure tool on the platform on the visible edge and aligned with the ridge left from the flake detached on the opposite face. The ridge defining the flake scars on the opposite face is used as the platform and when the flake is detached it also removes most of the platform. All flakes are terminated at the median line. This order of spacing is to provide more material to support the necessary amount of pressing force to remove this series of flakes.

To obtain a smooth and regular surface on points such as the long, narrow Hohokam points (Fig. 2a-c) it may be necessary to pressure flake the entire surface several times before exact and precise control of the flake scar pattern is achieved, duplicate flakes detached, and the piece made ready to be notched. Also, after each stage of flaking, it is necessary to re-align, straighten and smooth the margins. As each series of flakes is removed, the dimension and weight of the artifact is changed. The worker is very much aware of this and, therefore, when preforming, he gauges the size and weight of his preform to allow for these changes and ultimately produce the desired size and shaped point. If the preform is not made large enough, then it may be necessary to delete one or more of the intermediate flaking stages, but this will produce variables in the character of the completed point. Also, when one is making a projectile point, or other flaked artifact, the worker may encounter imperfections or non-homogeneity in the material which may cause the artifact to be malformed or to break. To overcome this, the worker must alter the intended design and make his work conform to these unforseen conditions. The ultimate result will then be a completed artifact which is much different in design than originally intended. Therefore, variations of form can often be related to non-homogeneity of the material, multiform, lack of standardization of blanks and preforms, and the human factor of error in not considering all conditions such as proper forces, nature of tools, angles, and resistance of the material. It is never a simple act to flake both margins and both surfaces without error. Even for the master, absolute perfection of stone flaking is rare rather than a regular occurrence. This is because so many factors are dependent on mental and muscular coordination, proper preparation, variable forces and quality of material, to name a few. For example, a long lanceolate projectile point having both surfaces covered with narrow, parallel flake scars may have required the removal of as many as two hundred flakes, and the removal of each flake would require the same preparation and conditions as the removal of a single blade-like flake. The principles of the technique of parallel flaking closely resemble the principles of the blademaking technique. Aboriginal workers accomplished in the principle of parallel flaking would certainly have no trouble making blades. Sites which seem to substantiate this theory are the Lena River, Siberia, and some of the Cape Denbigh, Alaska, cultures. Conversely, it does not follow that the blademaker could master the art of parallel pressure flaking.

Notching

Before the point is notched, the edges are checked for regularity and straightness. Any minor corrections or slight imperfections of the edge can be corrected by holding the point in the fingers and gently pressing off any irregularities or projections resulting from the hand-held pressure flaking (Fig. 12d). The tip may also be sharpened in this manner.

There are several notching techniques as well as many styles. Serrations and denticulations are diminutive notches and the fabricating technique is much the same as for notching. The majority of notches are either designed in the form of a V, or they are made in the shape of an elongated U with parallel sides. The most common form of notching is the making of indentations on the base of the artifact to facilitate hafting. Another form of notching is the making of indentations along the lateral margins of the artifact and probably these were designed to increase penetration and restrict withdrawal.

The notching technique requires pressure tools which are smaller and thinner than the regular pressure flaking tool. Notching tools can be single incisors of rodents such as beaver, rabbit, squirrel, packrat, porcupine, enamel plates derived from molars of large herbivores, valves of shellfish, edges of flakes and blades made of untreated siliceous rock, nut shell, and metal. The width of the notches is variable and is governed by and depends on the size of the notching implement and the design of the notch.

The side, or edge, of the notching tool is used rather than the tip or pointed end, for the sharply pointed tip would not withstand the pressure necessary to remove flakes within the notch. The major part of aboriginal notching indicates the use of the pressure technique rather than indirect percussion. There are, however, examples of large knives and lance or spear points bearing notches which are too large to be pressure flaked and quite probably the notching flakes were detached by indirect percussion (punch and percussor). Experiments in notching by indirect percussion reveal that this technique limits control and increases the breakage percentage. I find that indirect percussion is only useful for notching when the size of the notch exceeds that which can be made by pressure. Pressure notching permits the worker to direct and control the forces necessary to remove a flake within the notch and to prevent fracture of the artifact.

Notching is a very exacting technique, for the force must be applied to the margin at exactly right angles to the longitudinal axis of the artifact and this makes the piece vulnerable to breakage. If the force is directed at either more or less than a right angle to the long axis, the breakage factor will be increased (Fig. 11d). To stabilize the projectile point to withstand the notching pressure, thumb support must be provided at the point of notching.

To begin notching, a short flake is removed from the margin which will correspond to the desired width of the proposed notch. The tip of the pressure tool is placed on the margin and pressed downward, not inward. This removes a microflake which will make a small notch, bevel the edge, and make a platform at that part. The width of the notch should be slightly larger than the width of the notching tool. The margin is generally thin and the first flake must be detached with care or it will remove the corners at the edge of the artifact. Until one has practice in notching, it is better to remove several small flakes to attain the desired width. The tip of the pressure tool is used to remove the first flake, or flakes, and then, because of the additional pressure required, the edge of the pressure tool is used to remove the principal notching flakes.

The indented margin is now beveled so the artifact is turned and a single microflake is removed diagonally on the same face at the two points where the bevel intersects the edge. The beveled platform is now free and isolated as a projection but still retains part of the original bevel. Then the edge of the pressure tool is aligned with the beveled platform and pressure applied first inward and then outward in a rolling motion to detach a flake. The ratio of the downward and outward pressure will determine the length of the detached flake. However, if the downward pressure is excessive in relation to the outward pressure, a step fracture will result and then it will be impossible to deepen the notch beyond the right angle break of the step fracture. Removal of the first notching flake will form a bevel scar within the notch on the opposite face.This bevel is used and prepared as a platform in the described manner for the next flake removal on the opposite face. After each flake is removed, the artifact is turned and the platform prepared, if necessary, for additional notching flakes. This is continued until the notch reaches the desired depth. It is important to note that the notching flakes must form a bevel alternately to serve as a platform. If the bevel is lost in this process of notching and becomes rounded within the notch, then no additional flakes can be removed. If multiple deep notches are to be made on the margins, then only one lateral edge is notched at a time. The methods of platform preparation are much the same in all positions described.

Following are five different methods of holding, notching, and serrating.

Method A: Simple Free-Hand Rolding (Fig. 11 c, d)

This method is used to notch and serrate artifacts which are reasonably thin, or at least having thin margins, and also for those that do not require the removal of large flakes to accomplish the notching.

The thumb of the left hand is placed on the side of the artifact at the desired point of notching and as near in line with the pressure tool as flake detachment will permit and yet clear the thumb and avoid injury. The thumb of the right hand holding the notching tool is pressed against the underside of the middle finger of the left hand which is curled around the thumb of the right hand, thereby locking the two hands together. This provides both leverage and stability. As the thumb of the left hand exerts pressure against the side of the artifact the right hand applies pressure from the edge of the notching tool to the platform in a rotary motion until a flake is removed. Then the artifact is turned and a notching flake is removed from the opposite face in this same manner. When the notching is made for hafting purposes, I generally work alternately on both margins of the projectile point. As the notching progresses toward the median line, this alternating process will indent both margins evenly and in a direct opposite line. When basal notches are worked on a projectile point and the notch has reached the desired depth, the bevel is intentionally crushed. This eliminates any sharp edges for the hafting.

Method B: Resting the Back of the Left Hand on the Inside of the Left Thigh (Fig. 12 a-c)

The worker assumes a seated position on a very low stool. The back of the left hand is rested on the inside of the left thigh and the back of the right hand, holding the pressure tool, on the inside of the right thigh near the knee. Then simultaneously with the application of hand pressure, the knees are brought together, exerting additional force to the artifact. Pressures provided by the legs allow the worker to remove larger notching flakes than could be removed by simple free hand holding.

Method C: Massive Notching by Pressure

This method is used to notch large lance points or knives for hafting. The technique is much the same as described in Method B, the difference being in the holding position of the artifact and its position between the thighs. The artifact is held in the left hand with the long axis parallel to the left thigh and the edge to be notched pointed upward. To provide additional leverage, the artifact is held well in between the thighs close to the body. The side of the pressure tool is placed on the beveled margin and the shoulders and back are brought forward exerting force as pressure is applied to the artifact by the hands and thighs. The left hand, holding the artifact, also aids by being pressed to the right until the flake is removed. This method permits a large lunate notching flake to be detached. Flakes are removed alternately as previously described.

Method D: Using a Solid Support to Rest the Artifact

This solid support method is necessary when the objective piece is very narrow or thin, or a combination of both. If a yielding support, such as the hand or a pad, is used, the artifact will flex and break when pressure is applied to the margin. Therefore, the artifact must be supported by an unyielding material, such as a piece of wood or an anvil stone covered by a thin piece of leather or similar material (Fig. 11b). The support must be placed directly under the part of the artifact where pressure will be applied. This support method can also be used to replicate the extremely narrow Hohokam points and their multiple notches. Series of small flakes can be removed from both margins and both faces until the desired depth is reached. Because of the hard support and the unidirectional pressure, the flakes are feathered out at the median line of the artifact. To serrate and notch, flakes are removed first from one margin on both faces in a direct line and then on the other margin and both faces in a direct line. This style of flaking produces an artifact that is diamond-shaped in transverse section. This method of holding is typical of the small attenuated, serrated points commonly made of obsidian (Fig. 3).

Method E: Use of a Pad in the Palm of the Left Hand (Fig. 10b)

This style of holding is much the same as used in regular pressure retouch flaking. The tip of the tool is used rather than the edge or side. Since the sharp tip is weaker than the edge of the spatulate style pressure tool, the tip must be slightly rounded to make it stronger. The tip may be modified to suit the particular style of notching or serrating. Generally, it is blunted so the edges will clear the sides of the notches, but this limits its use to the making of expanding and wide notches. This type of pressure tool is more suitable for modifying the bases of stemmed projectile points or those with large corner notches.

A sharp-pointed pressure tool is useful only for shallow and minute flaking of the margins and lateral edges. Minute denticulations (serrations) can be made by placing the tip of the sharp-pointed pressure tool as close to the leading edge as possible and pressing downward, not inward, causing a microlunate flake to be removed—typical of the light, thin, side-notched Hohokam point (Figs. 4, 6a-c).

There are several styles and techniques of serrating the lateral edges. (1) Flakes may be removed from one side and one margin and the artifact turned and the opposite face and margin flaked in a similar manner, or a combination of unilateral and unifacial flake removal. (2) Serrating flakes may be removed alternately from the same margin, producing edges resembling the teeth on a saw. (3) The flakes may be removed bifacially by using the negative pressure bulb on the same margin on the opposite face as a platform to define moderately deep serrations with sharp edges. (4) Serrating flakes may be removed along one lateral margin but sufficient space must be allowed between the flakes to permit turning the artifact and removing serrating flakes between the flake scars on the opposite face and the same margin. This technique causes the edges to be sinuous, sharp, and saw-like. (5) Another style of serrating calls for the use of a pressure tool with a slightly rounded tip, similar to one used in regular pressure retouch. Flakes are removed over the face toward the median line. However, they are spaced to leave projections on the margins which will serve as serrations. Instead of a unidirectional pressure, a bidirectional pressure is used by first pressing inward and then outward. The point may also be turned and flakes removed in line with those removed from the opposite face, causing the previous indentations to be deepened. If this technique is used, the artifact is both retouched and serrated at the same time. Each change in method may serve as a technological trait.

Barbing

Barbing is akin to notching but differs in that notches have square edges and corners, whereas barbs curve in a gentle sweep toward the base of the artifact and the curved edge is serrated:

Notch *Barb*

Barbing is begun by first notching as previously described along the marginal edges of the projectile point to determine the depth and spacing of the proposed barbs. The palm of the left hand holding the artifact is padded with a piece of leather and a sharply pointed piece of bone is used as the pressure tool. Then the distal edge of the notch must be rounded and the square corner removed to form the gentle curve of the barb. This shaping is accomplished by bifacially pressure flaking the distal edge of the notch. A predominance of downward, and a minimum of inward pressure is applied along the distal edge of the notch until it is rounded and slanted toward the proximal (basal) end of the point. First one face of the barb edge is pressure flaked in this way, then the point turned and the same technique applied to the opposite face of the barb edge. When the barb is properly shaped, then the distal edge of the barb is serrated and made sinuous by detaching small bifacial pressure flakes alternately from this same edge (Fig. 2a, 12a-c).

Tipping

The distal ends of projectile points must be made sharp to allow penetration of both the artifact and the shaft. The technique of tipping of a Hohokam point is generally uniform, but represents only one tipping technique. However, a number of variations do occur in the utility points which are of a random nature (Fig. 1).

The distal end of the projectile point is placed flat on a solid surface which has been previously covered with a single piece of leather or hide. This padding conforms with any slight irregularities in the artifact and supports and provides uniform resistance during the application of pressure. The compressor is a slightly rounded but semi-pointed piece of bone. (Fig. 11b).

The point of the pressure tool is placed on the margin of the tip and downward pressure is applied vertical to the lateral edges. This produces flake scars on the tip which are collateral and at right angles to the lateral margins. No inward pressure is applied. This single direction of vertical pressure to the edge causes the flakes to terminate at the median line of the tip, thereby forming a ridge down the center. This technique of tipping is somewhat unique but is one of the technological traits of the Hohokam points. The most common method of tipping is to finger-hold the tip of the point and press the flake off diagonally from the tip toward the base, leaving a chevron or herringbone pattern on both faces of the tip (Fig. 12d).

A technique other than projectile point making which deserves mention is that of making large ovate flakes from the exterior surfaces of waterworn cobbles. The flakes are of tough, granular, coarse-textured material and are three to six inches across. The form is plano-convex, the plano side being quite flat with little or no bulb of percussion, having little or no compression rings and feathering on all margins. The convex side of the flake is the semi-rounded surface of the waterworn cobble and is quite smooth.

The absence of the bulb of force is characteristic of the cone of percussion being split rather than the worker using the fracture angle of the cone of force (percussion). The intentional splitting of the cone to cause its shear involves many physical problems not yet fully understood. Great force is subjected to the rounded surface of a granular cobble (generally with no evidence of a platform) and the large flake is removed from the surface of the spheroid cobble or small boulder. The exact technique is yet unresolved by experiment. Experiments to date have been by hurling the cobble against a large anvil stone and the use of bipolarism, but is still unsatisfactory for repeated uniform results. The flakes are excellent multipurpose implements and serve well for forming bone, antler, or soft stone. They may be used as scrapers, choppers, fleshers, digging tools, etc. Their granular edge makes an ideal saw and a right angle cut can be made by using the smooth dorsal side as a bearing surface. Using the granular edge, wood, antler, and bone can be formed or notched with comparative ease and speed for this granular flake is superior to one of vitreous material which lacks its abrasive qualities.

Archaeologically, these specialized flakes have received little recognition but have been noted to occur on the Fraser River, several sites in Idaho, and Snaketown (Personal communication: Charles Bordon, Earl H. Swanson, and Emil Haury respectively).

CONCLUSIONS

The excavations at Snaketown have revealed an occupation of skilled and ingenious people who were professional specialists in the arts and sciences, particularly in the stoneworking industry.

After viewing the results of only one phase of their stone tool industry, i.e. the projectile points, there is no doubt that the points were made by master toolmakers. Not all of the stoneworkers were skilled, for the utility points show less ability and certainly not the sophisticated techniques of the elaborate barbed points. It seems clear that the Hohokam had their master toolmakers, and some of the hunters made their own points as best they could. Their flaked stone tools include several distinct types and styles, diverse manufacturing techniques, and a preference for some materials.

Apparently over a long span of time, the Hohokam devised, accumulated, retained, and refined diverse techniques of working stone by the flaking process. Pride of workmanship seems to equal, if not surpass, actual functional value. Proof of their extraordinary flaking ability is their extensive use of quartz crystal which is extremely difficult to flake because it lacks homogeneity. Each style appears to have been intentionally designed to serve a definite function. The elaborate barbed forms are difficult to make and it takes several hours to complete just one point. Certainly they must have been designed for a very special purpose more complicated or more important than just for hunting game. The utility points would have been adequate and suitable for killing small game and they can be made from a common flake in just a few minutes. So why go to all this trouble to make such an elaborate point for just hunting? As yet, we do not know the intended function of these elaborate points.

A representative collection includes points such as:

1. The elaborate long, narrow, barbed, or multiple notched points (Fig. 2*a-c*).
2. Small points with multiple notches about one-half the length of the margins (Figs. 2*d-h*, 1*j*).
3. Thin triangular side-notched (Fig. 4).
4. Small, random flaked utility points (Fig. 1*a-e, f-i, k-m*).

1, 2. The first two categories show a high degree of sophisticated specialization of workmanship and material preference. Examples of Type 1 (barbed points) and their features in common are: (a) Indentations at the base are made deeper than the marginal barbs for hafting purposes, but this causes the base to be weakened. Upon withdrawal, breakage very close to the base could occur. The general form, fragile nature and style of the base would indicate the point is intended for one shot only. (b) Point is well oriented. Bifacially pressure flaked with expanding and graduated marginal flaking. (c) Very straight with longitudinal alignment. (d) In relation to the base, distal end is thicker but terminates in a sharp point. (e) Distal ends are narrow and attenuated in relation to the length. (f) Flake scars are collateral, or at right angles to the long axis. (g) Flakes terminate by feathering at the median line. (h) Before notching, the width of the flake scars become progressively smaller as the flaking advances from the base to the tip (distal end). (i) Base of point is bi-convex but, as the point becomes increasingly narrower, it gradually becomes diamond-shaped in transverse section. Tips are broken on all of the barbed points.

3. The triangular points exhibit flaking techniques ranging from very simple but well controlled pressure work to highly refined workmanship. They would be very adequate for hunting and for defense. Some points in this category are isosceles-triangular in shape and the pressure flaking shows diversity of workmanship. Some are flaked by a simple embryonic technique and others reveal highly refined and skilled flaking ability. One example (Fig. 4a), a side-notched point, shows unbelievable skill approaching perfection. The point has been pressure flaked to a remarkable degree of thinness. Final retouch flakes are terminated without error at the median line. The edges are perfectly straight and the point is in perfect bifacial balance. The hafting notches have been expanded internally and the lateral margins are minutely serrated. Magnification is required to measure the spacing interval of these serrations, approximately 1 mm. Due to the worker's skill, this style of point differs from similar side-notched points because of its perfection and the above mentioned characteristics. Side-notched points have a wide geographical distribution in the United States (e.g. Jennings 1957; Lehmer and Jones 1968; Swanson and Bryan 1964; Swanson, Butler, and Bonnichsen 1964; Swanson and Sneed 1966) but they do not approach the perfection of this particular type of Hohokam point.

4. The utility points lack uniformity in both materials and workmanship and indicate that they were made by less discriminating and not as skilled workers. Aboriginal paleo-Indian hunting sites such as Clovis, Eden, Folsom, and Agate Basin yield stone tools which show consistent and quite uniform patterns of flake removal. But the Hohokam points show a wide diversity of form and techniques.

Some of the long barbed chert (quartz) poi
are polished on the basal edge and on the pro
mal sides of the barbs. This could be intentional or accidental. It may be a polish put on the base by the worker to prevent cutting the hafting medium. The polishing on the uppermost parts of the barbs could have been put there by the worker to prevent the point's withdrawal and to insure inflicting

a grievous wound which could ultimately result in death. If the polish were intentional rather than accidental, this would increase the worker's time of finishing the long barbed point and further substantiate the theory of a more specialized function than merely for securing game.

But the Hohokam cremated their dead, so we must consider that this may be an accidental glaze rather than a polish—the result of the intense fires of the cremation. Some of the obsidian points found in the cremation were softened and deformed by the heat. Obsidian is a natural glass and has a natural blending of oxides which would lower the altering temperature. Quartz (chert) softens at 2912°F. However, if it is mixed with metallic oxides or calcium, it would soften at a lower temperature. The presence of bone (calcium) within the cremation could act as this agent and thereby impart a glaze that could be interpreted as polish. The question of glaze versus polish can probably be answered by examination with a petrographic microscope.

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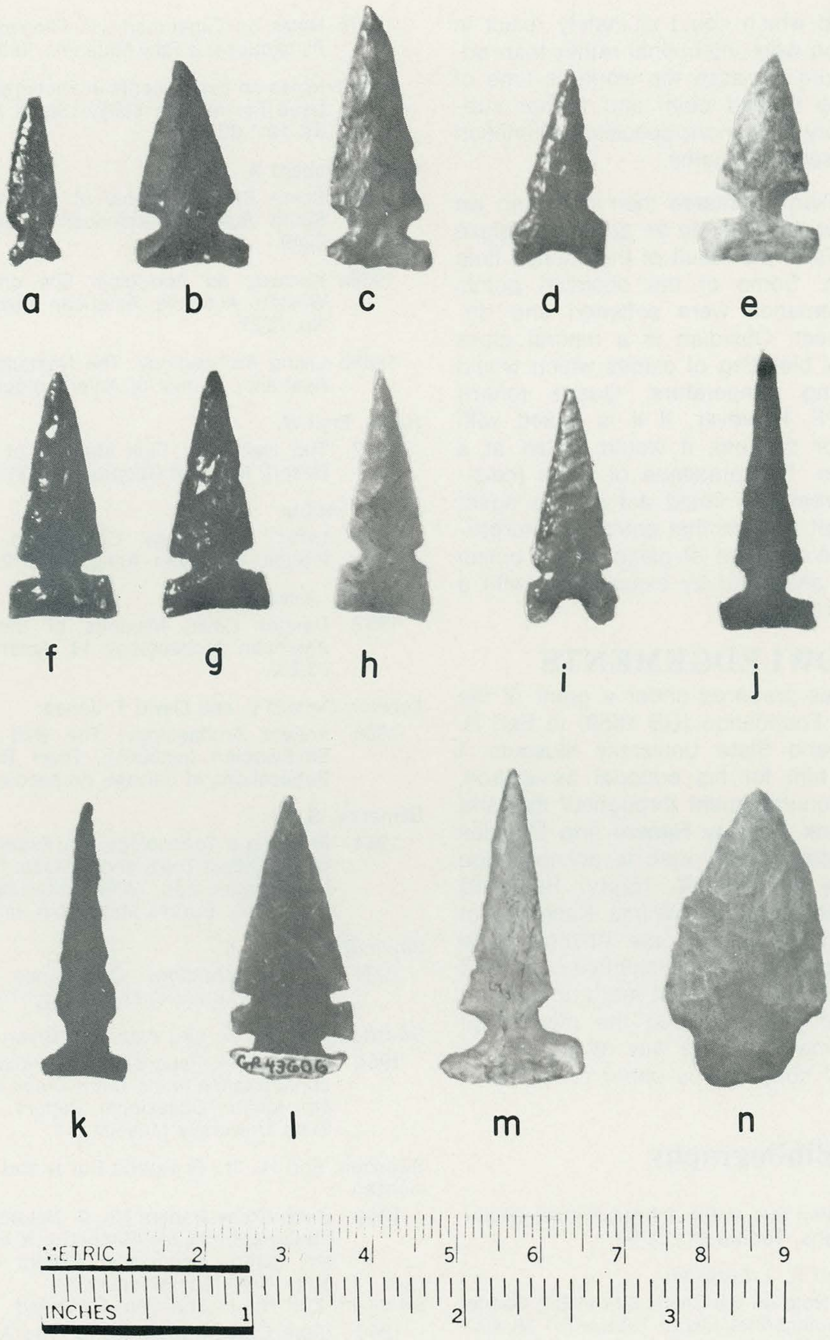

Fig. 1 Hohokam points: **a-e**, inferior workmanship, **a** obsidian; **b** basalt; **c** brown jasper; **d** red jasper; **e** grey siliceous rock; **f,g** obsidian, amber when held to light; **h** grey semi-opaque chalcedony; **i** silver sheen obsidian; **j,k** red jasper; **l** grey siliceous rock; **m** evidence of thermal treatment, translucent chalcedony; **n** chalcedony retains natural texture indicating no thermal alteration, step fractures indicate material did not respond well.

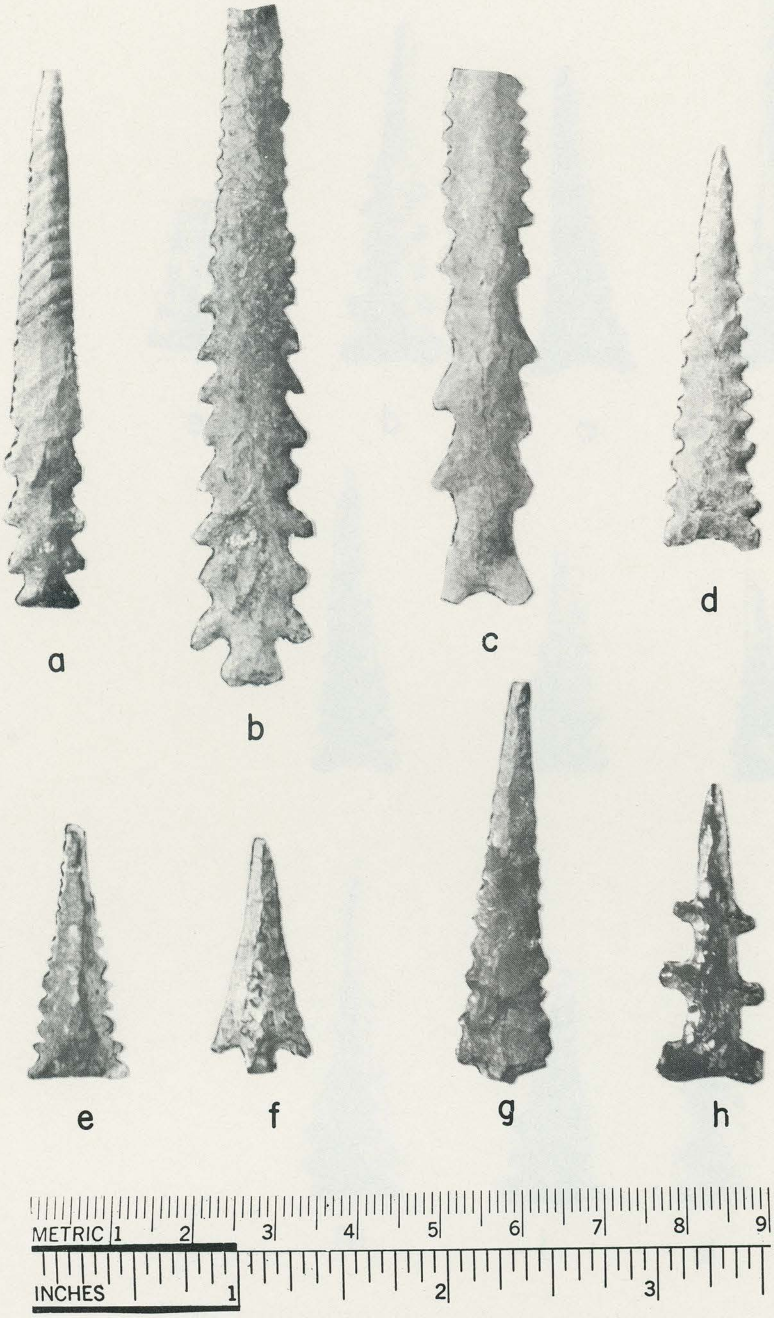

Fig. 2 Hohokam points: **a-c** long barbed style; **d-h** smaller examples.

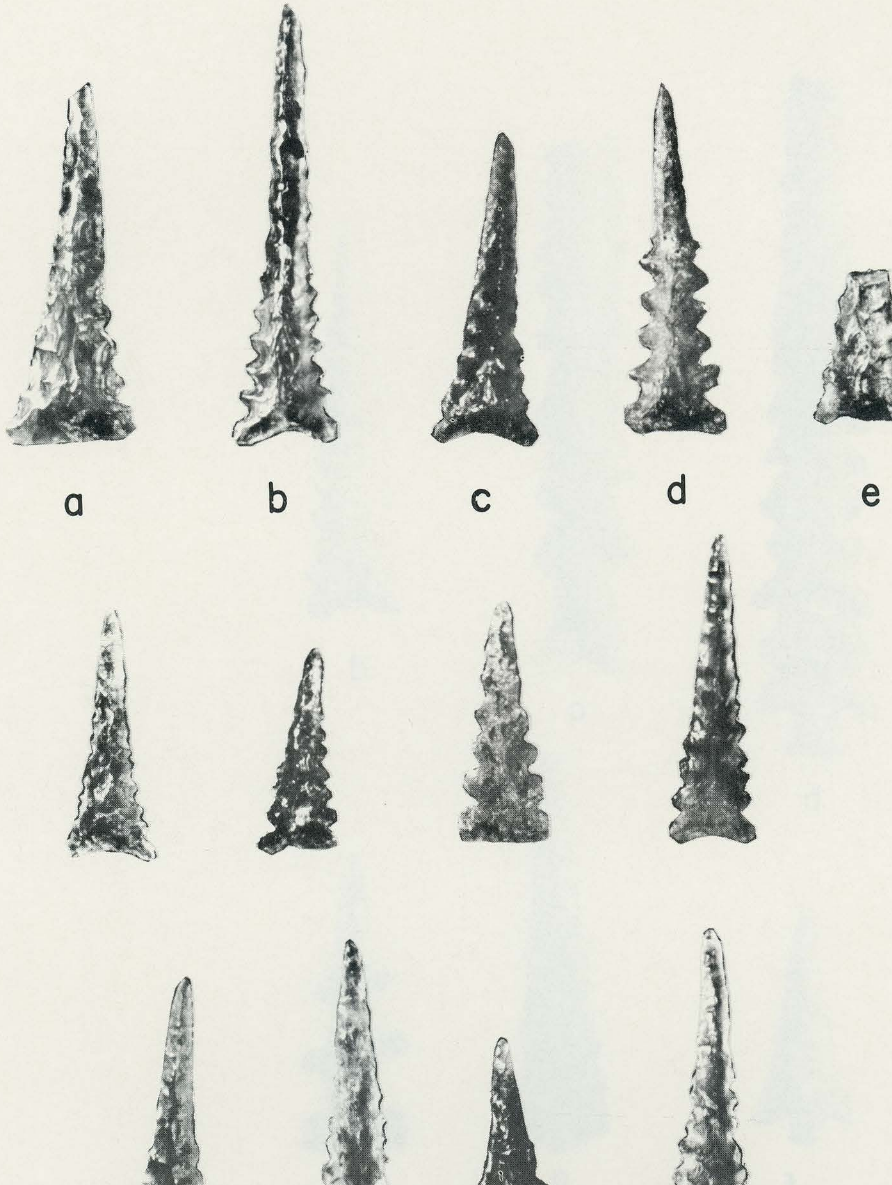

Fig. 3 Hohokam points: **a-m,** shorter, narrower, more consistent in form and technique than those in Fig. 2; **m** quartz crystal, others obsidian.

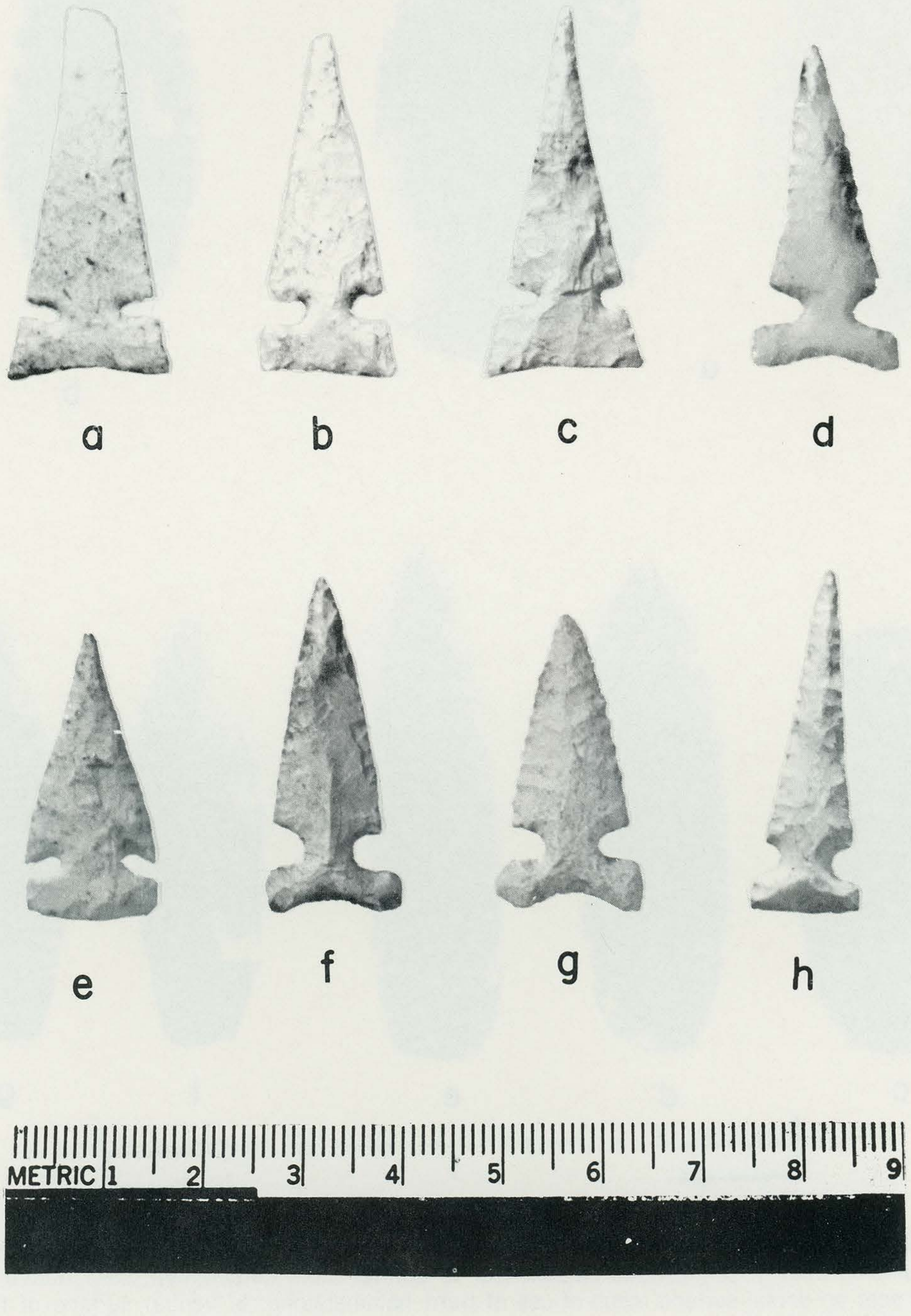

Fig. 4 Hohokam points: **a-h,** side-notched points showing variability of notching arising from position and direction of notches in relation to body of point.

Fig. 5 Crabtree replicated points: **a,** dorsal and ventral views of thick obsidian flake detached from water-tumbled cobble, single ridge established to control flake detachment, step fractures on first flake scar on dorsal surface result of use of hard hammerstone; **b,** ventral surface of flake blank after straightening by percussion, marginal flake scars intersect initial flake scar; **c,** dorsal surface of blank after surplus material removed, sometimes mistaken for ovate bifacial knife; edges irregular with no evidence of pressure flaking; **d-g,** percussion preforms in final stage before pressure flaking, scars random, irregular edges, deep bulbs of force, compression rings prominent in flake scars.

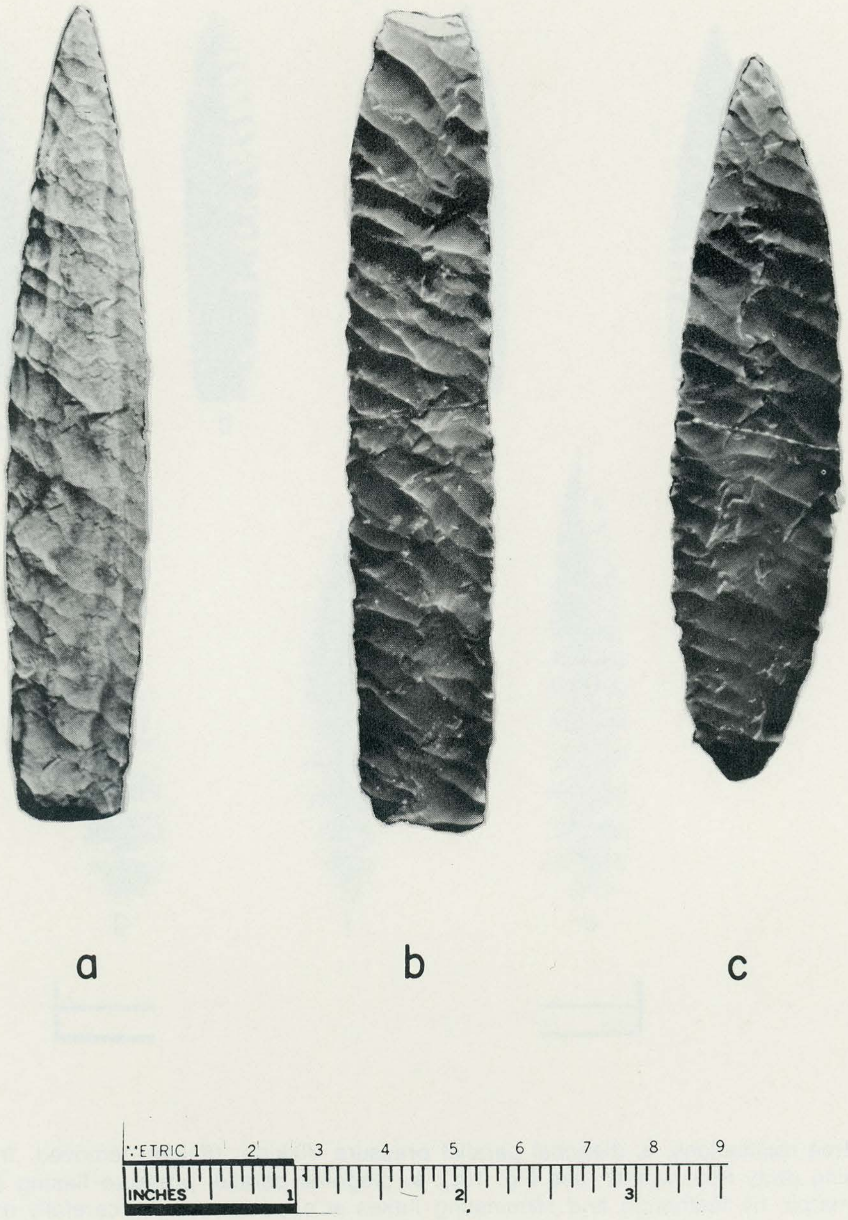

Fig. 6 Crabtree replications: **a,** preform in first stage of pressure flaking (silicified sedimentary stone from Nevada); **b,** preform in first stage of pressure flaking (Harrison County, Indiana flint), step fractures on face will be eliminated in next stage of pressure retouching; **c,** preform in pressure stage, broken by improper support and incorrect angle of pressure, and repaired (Indiana flint).

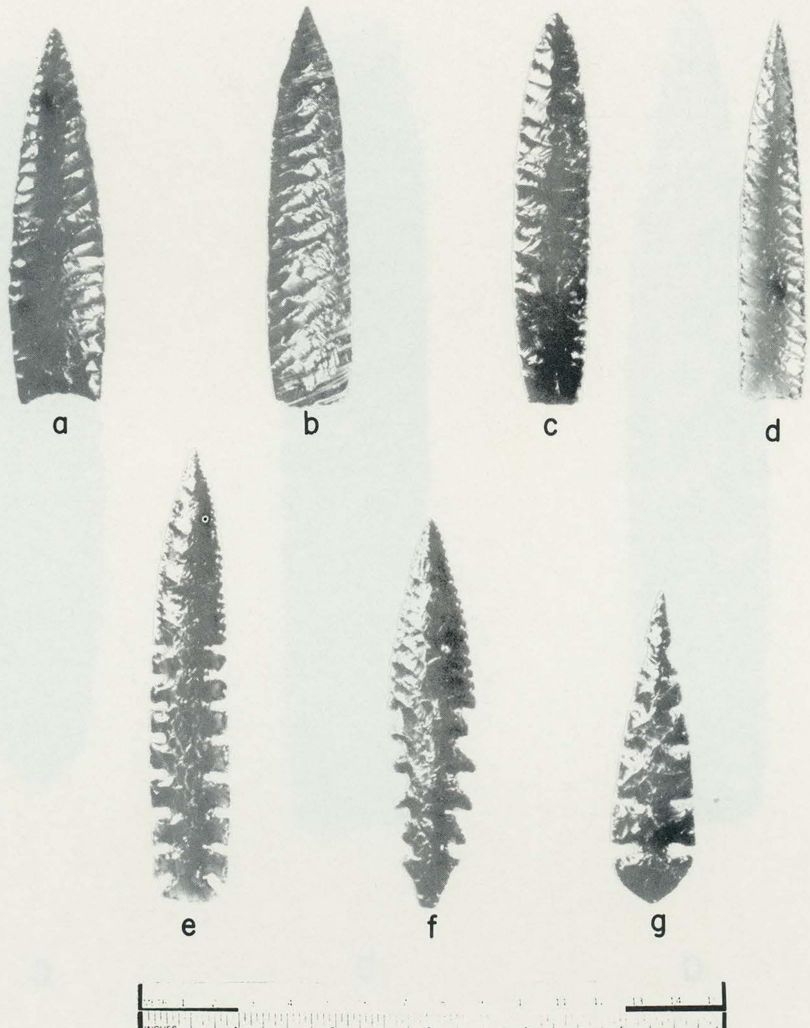

Fig. 7 Crabtree replications: **a,** diagonal parallel pressure flaking (flakes removed from margins by pressing away from worker, see Fig. 10**c**); **b,** diagonal parallel pressure flaking (flaked from only one margin by feathering and terminating flakes at opposite margin, carefully controlled, held in same manner as **a,** but left hand allowed to rotate slightly with follow-through of pressure tool as flakes were curved and detached); **c,** collateral pressure flaking, typical of Hohokam, flakes detached by directing pressure at right angles to lateral margins and terminated by feathering at median line, point solidly supported against inside of left thigh (Fig. 10**b**) to prohibit rolling as flakes removed, heavy bulb of force causes margins to be thin, with medial portion thicker for strength; **d,** diagonal parallel pressure flaking, done by supporting back of left hand on top of left thigh keeping angle and spacing constant; ideal material, working conditions, and platform preparation necessary for this style; **e,** pressure flaking, stage before converting notches into barbs by removing distal edges of notched portion; **f,** notching stage of barbing, distal edges of barbs slightly serrated, basal character conforming to pressure preform, a deviation not characteristic of Hohokam points; **g,** stage of notched point before barbing.

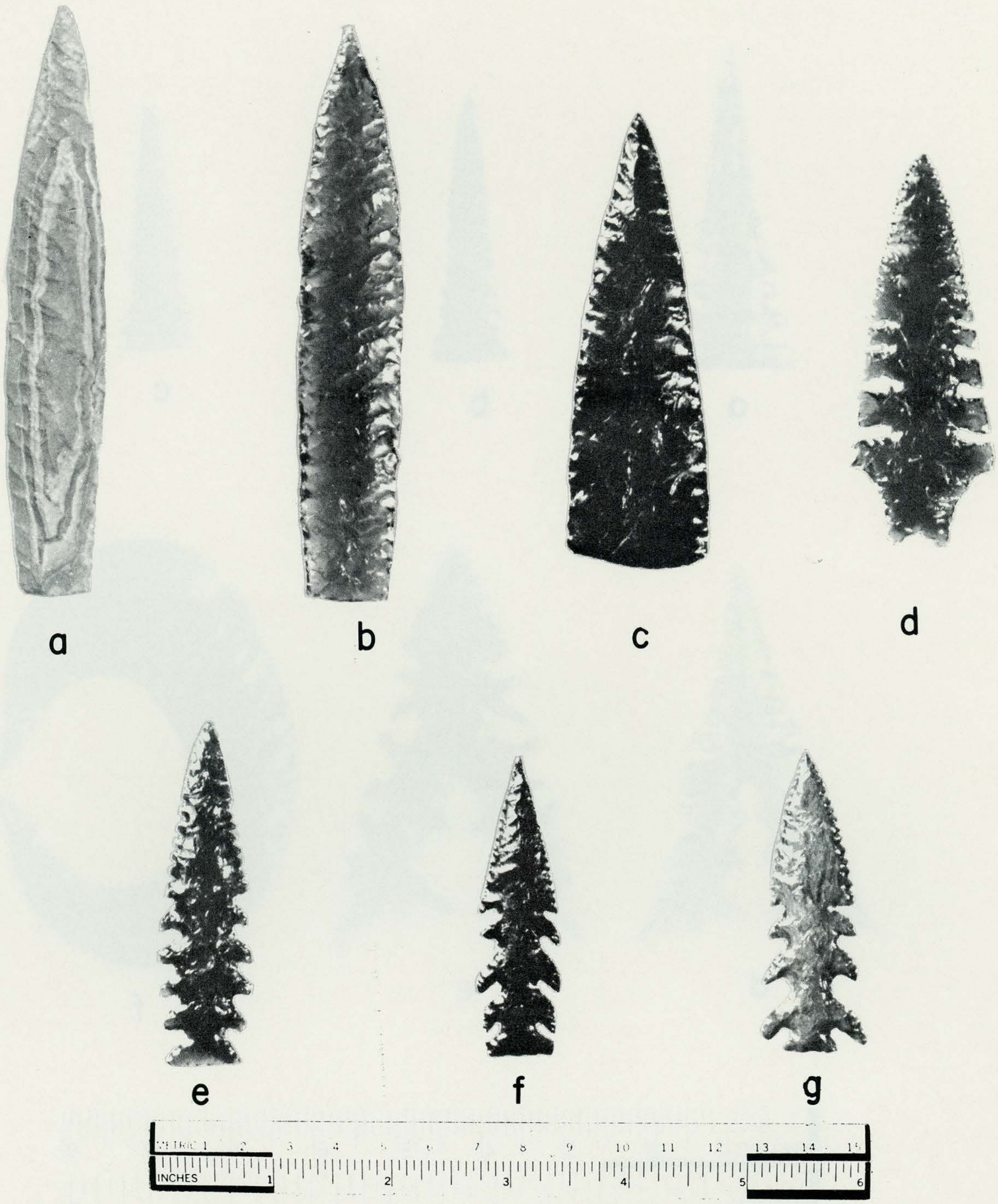

Fig. 8 Crabtree replications: **a,** second stage pressure flaking of preform with flakes directed at diagonal angle across face of preform; **b,** preform with parallel diagonal pressure flaking done by pressing away from worker, angle of flake scars are same on both faces of margins; **c,** preform showing pressure thinning by terminating flakes at median line and intersecting flakes detached from opposite margin, detached flakes thin, uncurved, point evenly flaked on both faces; **d,** barbed point with serrated distal end; **e-g,** serrations and barbing similar to Hohokam styles.

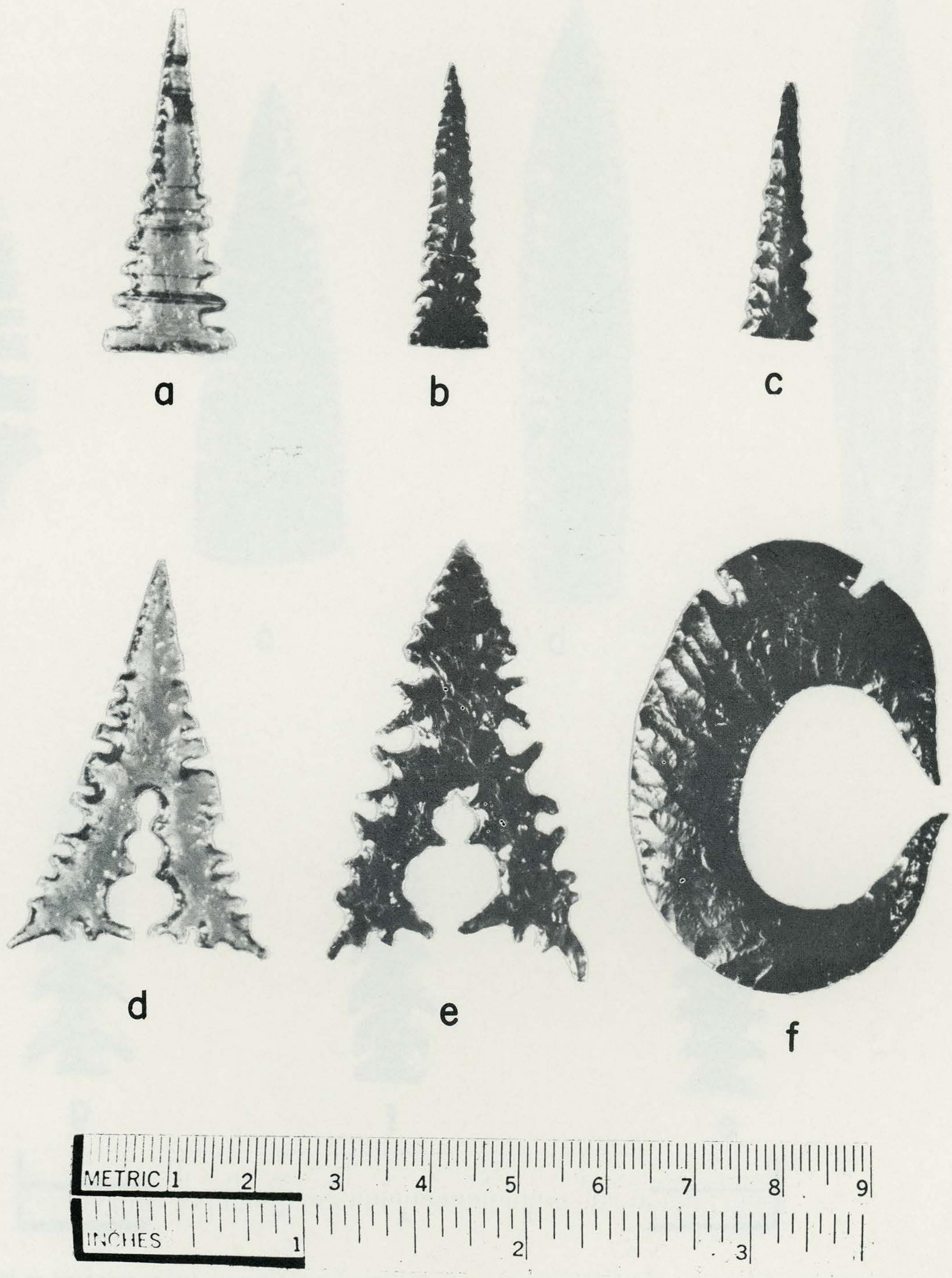

Fig. 9 Crabtree replications: **a-c,** points replicating Hohokam in Figs. 2,3. Downward pressure greater, applied at right angles to longitudinal axis, then inward pressure applied, rigid support used. **d-f,** replicas of Mayan lithic material fram British Honduras showing elaborated multiple notching.

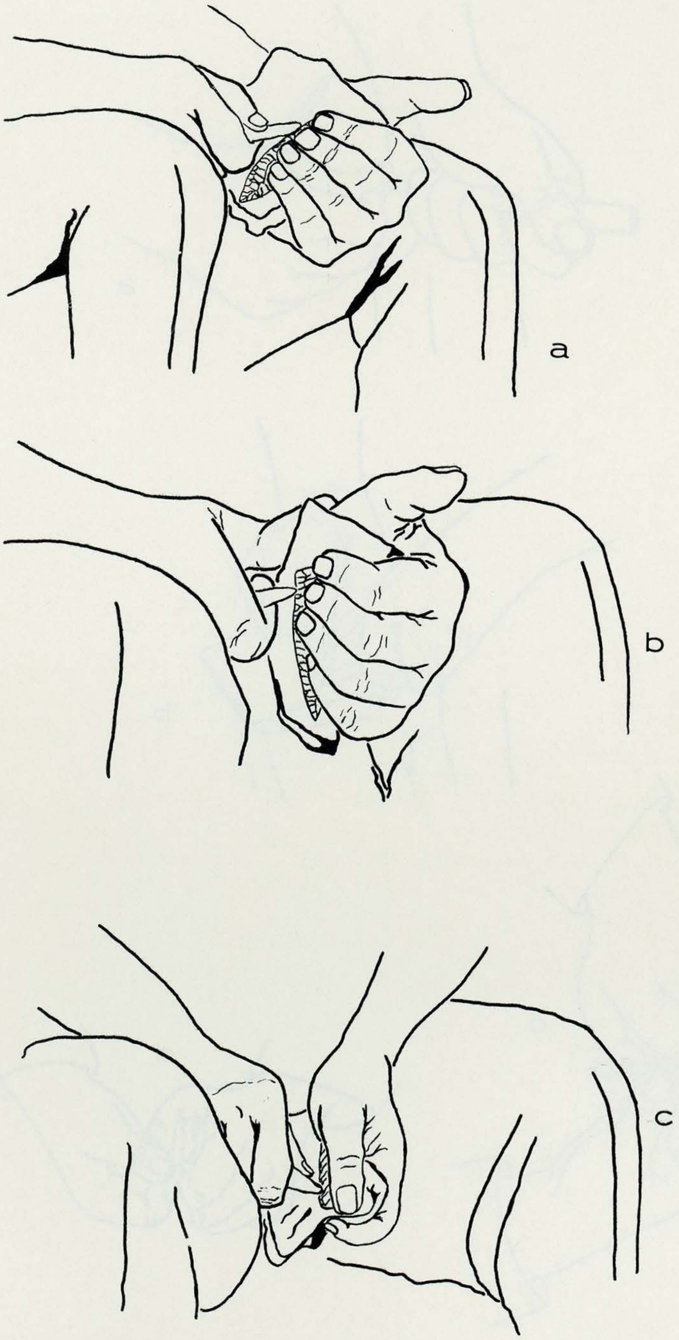

Fig. 10 **a,** position for method of turning edge to produce bevel, a stage of platform preparation; **b,** pressure flaking method using back of left hand supported against inside of left thigh, exerting greater force; collateral or diagonal flaking may be done in this position depending upon angle at which force is applied in relation to lateral margin of point; **c,** pressure flaking method for diagonal parallel flaking; force directed at angle to lateral margin and applied away from worker; knees may be used to exert greater force.

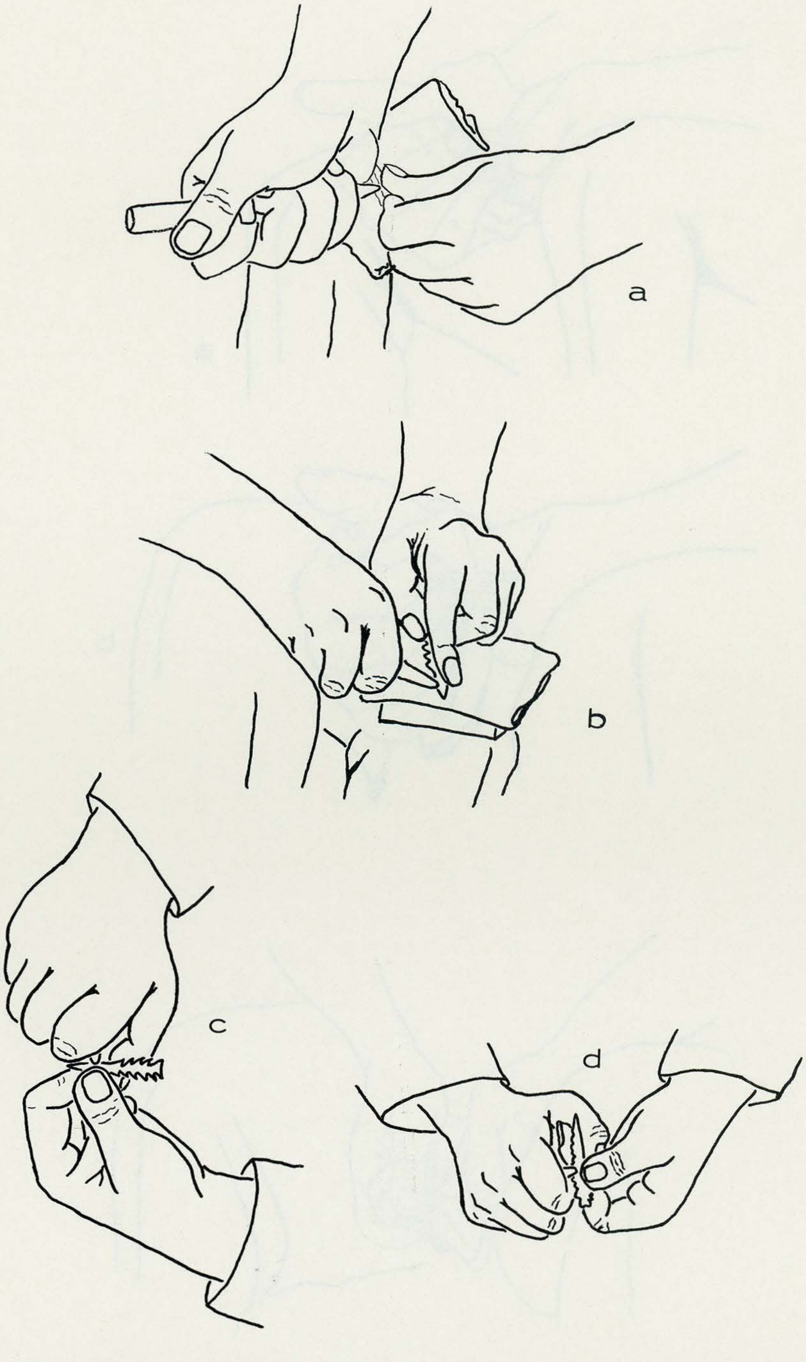

Fig. 11 **a,** pressure flaking method used by Australian aborigines; force applied away from worker, method of support may vary; **b,** pressure flaking method in which force is exerted away from worker, use of wood shown as solid support, but softer support such as top of thigh may be used; **c,d,** simple freehand holding method used for notching and serrating points with thin margins not requiring removal of large flakes; right thumb pressed against underside of middle finger, left hand, which locks two hands together for leverage and stability.

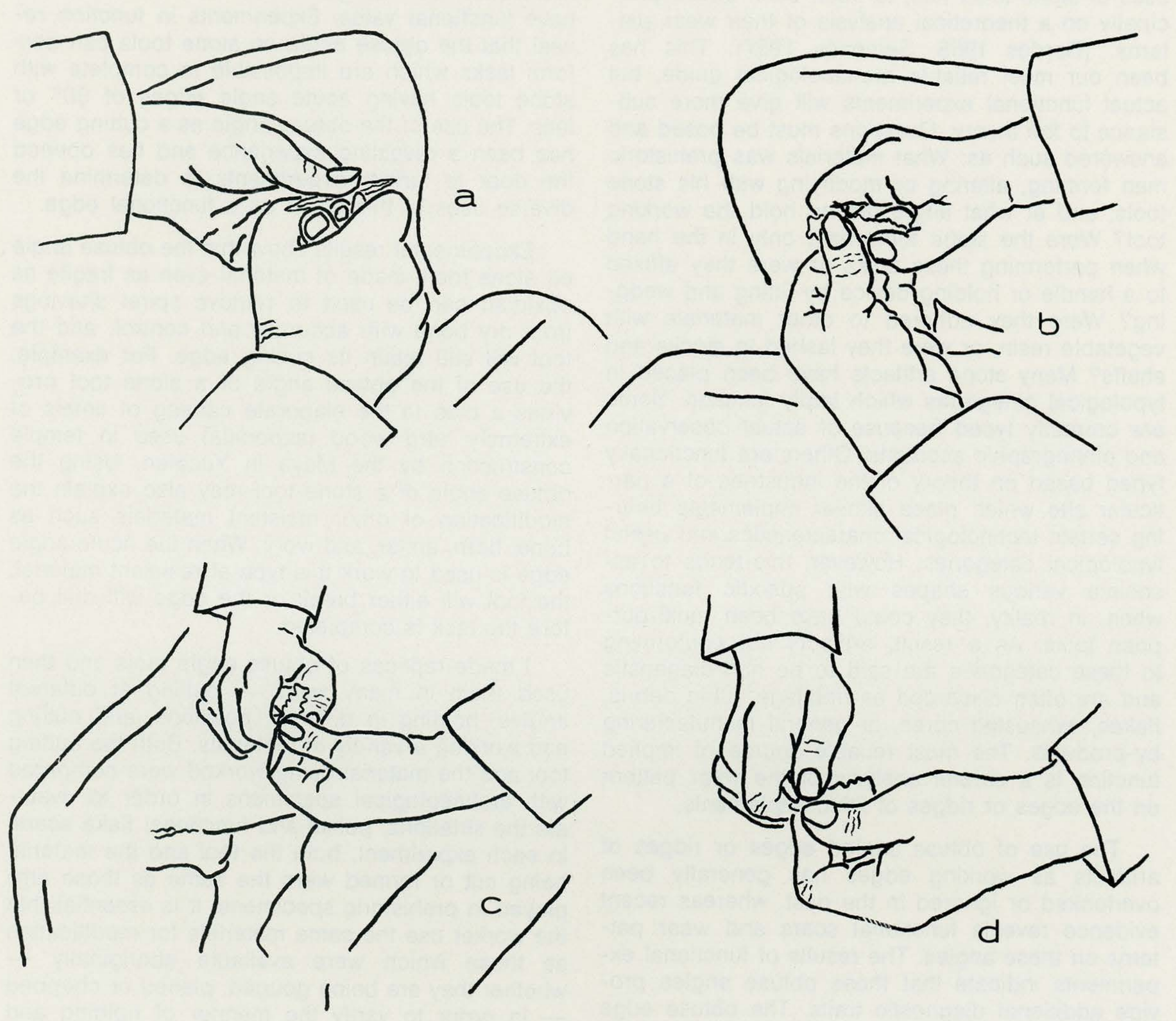

Fig. 12 **a-c,** three views of pressure notching with left hand rested on inside of left thigh, knees may assist for additional force; interlocking right thumb and fingers of left hand provide further leverage and stability; **d,** simple freehand holding pressure method used to correct irregularities along margin of point and to shape and sharpen tips.

THE OBTUSE ANGLE AS A FUNCTIONAL EDGE

By Don E. Crabtree

The interpretation of the diverse functional uses of stone tools has, to date, been based principally on a theoretical analysis of their wear patterns. (Bordes 1968, Semenov 1957). This has been our most reliable archaeological guide, but actual functional experiments will give more substance to the theory. Questions must be posed and answered such as: What materials was prehistoric man forming, altering or modifying with his stone tools, and at what angle did he hold the working tool? Were the stone tools held only in the hand when performing these tasks or were they affixed to a handle or holding device by fitting and wedging? Were they adhered to other materials with vegetable resin, or were they lashed to stocks and shafts? Many stone artifacts have been placed in typological categories which imply function. Some are correctly typed because of actual observation and ethnographic accounts. Others are functionally typed based on theory of the industries of a particular site which place similar implements bearing certain technological characteristics into useful typological categories. However, this tends to associate various shapes with specific functions when, in reality, they could have been multi-purpose tools. As a result, artifacts not conforming to these categories are said to be non-diagnostic and are often discarded as debitage, lithic debris, flakes, exhausted cores, or general manufacturing by-products. The most reliable source of implied function is a careful analysis of the wear pattern on the edges or ridges of lithic implements.

The use of obtuse angled edges or ridges of artifacts as working edges has generally been overlooked or ignored in the past, whereas recent evidence reveals functional scars and wear patterns on these angles. The results of functional experiments indicate that these obtuse angles provide additional diagnostic traits. The obtuse edge of a tool will often show polish when it is used continually on homogeneous materials. Striations or scratches on the obtuse edge are the result of abrasive contamination, while occasional minute step fractures are due to improper holding, too much pressure, or the non-homogeneous nature of the material being worked.

We know from experiments and from archaeological evidence that the acute angle of a flake or blade is an excellent cutting edge for yielding materials, but we have failed to consider the functional value of the obtuse angle of more than 90° and less than 130° (Fig. 1A). The obtuse angle of more than 130° has proven so far to be too flat to have functional value. Experiments in function reveal that the obtuse angle on stone tools can perform tasks which are impossible to complete with stone tools having acute angle edges of 90° or less. The use of the obtuse angle as a cutting edge has been a revealing experience and has opened the door to further experiments to determine the diverse uses of this angle as a functional edge.

Experimental results show that the obtuse angle on stone tools made of material even as fragile as obsidian can be used to remove spiral shavings from dry bone with accuracy and control, and the tool will still retain its cutting edge. For example, the use of the obtuse angle of a stone tool provides a clue to the elaborate carving of lintels of extremely hard wood (sapodilla) used in temple construction by the Maya in Yucatan. Using the obtuse angle of a stone tool may also explain the modification of other resistant materials such as bone, horn, antler, and ivory. When the acute angle edge is used to work this type of resistant material, the tool will either break or the edge will dull before the task is completed.

I made replicas of obtuse angle tools and then used them in many ways — cutting at different angles, holding in different positions, and cutting and working a variety of materials. Both the cutting tool and the material being worked were compared with archaeological specimens in order to evaluate the striations, polish and functional flake scars. In each experiment, both the tool and the material being cut or formed were the same as those employed in prehistoric specimens. It is essential that the worker use the same materials for modification as those which were available aboriginally — whether they are being gouged, planed or chopped — in order to verify the manner of holding and function. Some implements having acute angle edges, such as the obsidian blade, require light force for cutting soft materials. The thumb and index finger furnish sufficient force for these light cutting tasks; but when the obtuse angles of tools are used for cutting, more force is required — much the same principle as our modern lathe. The acute angle can be used to work softer material while an obtuse angle is used to work more resistant material. The angle of the tool edge must correspond to the resistance of the material being worked. During the functional experiment, the worker must keep in mind the brittle nature of the stone tool and he must be familiar with the tool's strong and weak areas. These tools cannot be twisted or used in a levering way, and must be kept in correct alignment with the opposing resistance of the material being worked. Skill in using any hand tool requires practice and reasoning, which necessitate continued experimentation. Even when experiments yield good results, they may not compare to the work of a skilled aboriginal workman.

One source of an obtuse angle cutting edge is a blade scar ridge on a polyhedral core (Fig. 1B). The parallel blade scars are slightly concave between the ridges, making the ridges satisfactory obtuse angle working edges. The core is used as one would use a draw plane — holding the proximal and distal ends of the core with the right and left hands. The modern draw plane or draw knife can only be pulled toward the user, but the obtuse angle edge on a polyhedral core can be pushed or pulled. The polyhedral core is drawn at a slight angle rather than at right angles as one would use a modern plane. When used in this fashion, the depth of the cut may be accurately adjusted by a slight change of angle of the bearing surface. The obtuse angle of the cutting edge is far stronger than an edge of 90° or less. When soaked antler is worked, shavings three inches long may be removed with a single pass of the core. I know of no single edged metal tool which will remove material with the speed of the obsidian core, too. The cuts are very clean and smooth and show no bruising of the surface being planed. When the core planer is used on very hard wood, the finish is excellent and the core can be used to produce flat surfaces. It is surprising how durable the obtuse angle edge can be. Use flake scars along the edge generally result from holding the tool at the wrong angle, or lack of homogeneity from contamination of the material being planed rather than from function. When the obtuse angle of the core is used repeatedly on resinous wood, resin will build up and impair the cutting action. The resin then must be scraped off or removed with solvent, or a new blade must be detached from the core to expose two new sharp cutting edges or the entire polyhedral core can be rejuvenated by removing a series of blades around the perimeter to expose new obtuse angle cutting edges.

The surprising and excellent results of using the obtuse angles of a core as a shaping and forming tool for antler, hardwood and bone prompted me to look for similar angles or other artifacts to use in cutting experiments. Similar experiments with both burin blades and cores resulted in only moderate success. Using the burin core in the manner of an engraving tool resulted in the core slipping and its corners breaking after a few passes. This occurred generally when the tip was lifted upward to terminate the cutting action. After a minimum amount of work on hard material, the right angle edges of the burin core would crush due to the formation of minute step flake scars on the margin. However, if the burin blade were removed at more or less than a 90° angle to the margin of the core, both acute and obtuse angles were formed on the core's edge. The acute angle was excellent for working soft woods, while the obtuse angle was good for working more resistant materials. Failure to correctly use an angle of 90° or more is probably due to a lack of understanding of the proper use of the many prehistoric styles of burins.

The natural facets on quartz crystals can also be used as forming tools but are neither as efficient nor as effective as the artificially made obtuse angles on cores and other tools. The natural facets on the crystal are plane surfaces, while those made by removing a blade or flake from a core leave concave surfaces between the obtuse angle ridges, giving a sharper cutting edge.

If the crystal is made into a blade core by removing blades longitudinally, the obtuse angles of the blade scars are a far more efficient cutting tool than the natural facets. However, the bruises found on the natural obtuse angles of a quartz crystal from Bandarawela, Ceylon may well be the result of function (Allchin 1966, fig. 30).

Another functional experiment involved the use of a strangulated blade (Fig. 1C). Obsidian archaeological specimens from the El Inga site in Ecuador were brought by Carl Phagan to the 1970 Idaho State University Flintworking Field School. We made replicas of the originals from obsidian. In archaeology this strangulated blade has been classified as a spokeshave. We attempted to use it by placing the concave edge on a wooden shaft and pulling the ventral side of the blade toward the worker. This removed only a slight amount of the wood and left a very irregular cut on the shaft. When additional pressure was applied to the blade, it broke. We then noticed striations on the ventral side of the El Inga specimen between the two opposing concavities which comprised the strangulation. These striations gave us a clue to the manner in which the implement was held and used. The striations indicated that the slightly convex ventral side of the blade was placed flat on the wooden shaft after being shaped. The convex surface acted as a bearing and aided the adjustment of the depth of the cut being made. When we used the strangulated blade in this manner, it made a flat smooth cut and required little force to remove a clean shaving. Both concavities served well as cutting surfaces. The opposite concavity on the blade permitted the worker to tilt back the blade to terminate the cut. When used in this manner, the blade did not break because little force was necessary to remove shavings from the material being worked.

Further functional experiments with the strangulated blade showed that the angle of the cutting edge of the blade could be made acute for soft materials or obtuse for cutting harder materials (Fig. 1C). If the cutting edge was too acute or was used improperly, use flakes were removed from the *ventral* side of the blade rather than the concave portion of the strangulation. Many tools other than blades exhibit an obtuse angle, and these can be simply and rapidly made or resharpened. Often by the removal of a single flake a new working edge is exposed. It is possible to misinterpret this single sharpening flake as a tool when it is only a reconditioning or resharpening flake.

Robert Heizer showed me obsidian cores from Papalhuapa, Guatemala which were formed by blade removal but which also showed evidence of function on the obtuse angle ridges. The blade scar ridges on the cores were dulled which indicated that they could have been used as planes, wedges, reamers, drills, anvils or pointed percussors for making soft stone figures, and some could have been sectioned to be used as preforms for ear plugs. This site is important because it is near the source of raw material and should illustrate many manufacturing steps which can be related to ethnographic accounts. A preliminary report of this site has been published by John A. Graham and Robert F. Heizer (1971). In 1970, Dr. Junius Bird, from the American Museum of Natural History, gave me a collection of six obsidian cores from Oaxaca, Mexico which all showed signs of wear on the obtuse angle ridges. Obsidian polyhedral cores from the Metro excavations in Mexico, D.F. shown to me by Jose Luis Lorenzo in 1970, showed apparent use of blade scar ridges. Included was one core which indicated that the distal end was used as a drill or reamer until the core was worn to a smooth cylindrical shape. I collected obsidian polyhedral cores from Teotihuacan, Puebla, Colima, and the coast of the State of Nayarit, all of which bear evidence of the use of blade scar ridges as cutting and forming edges. Through personal communication with Denise de Sonneville Bordes (1970), I learned that she has noted evidence of functional scars on the dorsal ridges of blades from the Upper Paleolithic of Southern France. Personal examination of a blade from the Clovis site at Murray Springs, Arizona (1966) showed intensive wear and polish on the dorsal ridge while the lateral margins were still quite sharp. This suggests that the ridge was used as a cutting implement *before* the blade was detached from the core. When the ridge became dulled, a blade was detached from the core to expose two fresh useful ridges. The core with multiple obtuse angle ridges would have been an ideal implement for rapidly shaping the shaft wrench made from the long bone of a mammoth found at Murray Springs (Haynes and Hemmings, 1967). Occasionally cores are noted which are not exhausted for further blade detachment, but their ridges bear evidence that they were used for shaping tools while the core was still of adequate size for a specific function.

Functional polish appearing on some aboriginal artifacts presents problems of use analysis. Use polish is frequently observed on scraping and agricultural tools which usually have acute angle working edges. Scraping generally rounds or polishes the working edges, conceivably due to the abrasive nature of sandy soils on wet hides. The polish noted on agricultural tools could well be the result of continual digging and tilling, but polish and edge rounding also appear on tools which have acute and obtuse angle working surfaces. A tool with a rounded polished edge ceases to cut or plane and will only function when an excess of force and energy is applied by the worker. However, the rounded polished edge will work well as a burnisher. It is difficult to understand why prehistoric man would use an edge until it acquired a polish when a more functional edge could be established by detaching a flake to expose a new, sharp edge.

Diverse functional experiments were performed over a considerable period of time: cutting antler, bone, grass, hardwood, etc. using tools with both acute and obtuse angle edges. Yet there was never a sign of polish on the edge, and use flakes were detached only when the tool was used improperly.

Due to the durability of the stone tool and the amount of use and abuse necessary to establish functional polish or scars, criteria for determining function must be approached with caution. Many tools may have performed their task and been abandoned before they exhibited any functional scars or polish: to wit — the axe. When an axe is used, most dulling is due to misuse rather than from chopping clean wood.

Obtuse Angle Burin

The success of using the obtuse angle for forming and shaping by the planing technique prompted me to experiment with slotting implements. An obtuse angle burin appeared to be the logical tool for cutting strips from antler and bone to make harpoons, needles, awls and similar implements.

It is a simple task to make a burin by modifying a thin flat flake from a right angle to an acute angle by either percussion or pressure (Fig. 2A). However, establishing an obtuse angle on the burin becomes an apparently impossible task (Fig. 2A). When the worker is making an acute-angle burin, he can strike off a spall having an obtuse angle. This spall is the bulbar part, so even though the spall is obtuse it has a rounded edge which will not cut. An effort was made to produce an obtuse angle burin by detaching a flake with an edge of less than 90° (burin spall). The platform had to be tilted to receive the force; but when pressure was applied the tool would slip, and if percussion were used the percussor would ricochet. At this time it appears mechanically impossible to make an obtuse angle burin by either pressure or percussion using the established technique.

This failure caused me to mentally review aboriginal collections examined in the past which may have contained this characteristic. I recalled seeing a handful of such flakes from the Arctic shown to me by Dr. Fred Johnson of the Peabody Institute which resembled broken ostrich shell and had margins with double edges of 90°. One margin of these flakes had an obtuse angle and the other margin had an acute angle. Both edges of all margins were 90° to the dorsal and ventral sides of the flakes. This seemed abnormal, since snapped flakes or blades generally have one edge of the margin with a 90° angle while the other edge of the margin is rounded due to the breaking or snapping process. This breaking or snapping process does not produce a margin with a double 90°; therefore this double 90° angle presented a question of manufacturing technique. Dr. George Agogino had also sent me a flake assemblage from the Lindenmeier site which contained a number of flakes with the same type of fracture as the Arctic specimens. Ruthann Knudson also had a similar assemblage of flakes from the Claypool site in Colorado which contained a number of flakes exhibiting double 90° angle edges. These were termed pseudo-burins because the fracture force was different than the force applied to make normal burins, which are struck or pressed off longitudinally from the edge of the flake.

The shattered flakes of the Peabody collection had the appearance of the debitage of a broken window pane supported by its casing and broken by the force of a thrown rock or ball. The breakage was caused by both the support of the casing and the force of the projectile. Fractures resulting from this type of breakage commonly have double 90° edges on one margin.

Using the support and projectile principle, an experiment was made to replicate this style of fracture. An indentation was made in a soft stone to resemble a "nutting stone" (Fig. 2B). The flake was then placed over this concavity and a punch of pointed stone or antler was placed on the flake and aligned with the concavity. The punch was dealt a sharp blow causing the flake to shatter. The force applied to the punch over the nutting stone concavity produced the desired double 90° edges. This type of intentional fracture will produce flakes with edges at right angles to the ventral and dorsal surfaces of the original flake. It will also cause the flake to break geometrically into pieces resembling triangles with both obtuse and acute angles (Fig. 2B).

The use of the concavity and the punch may be only one of several ways to produce this distinctive style of fracture. The pseudo-burins must be selected from the flake shatter which is composed of both acute and obtuse angle burin-like objects. When the pseudo-burins are affixed to a handle with adhesive, (Fig. 3A), the obtuse angle of the pseudo-burin will outlast and outcut burins of 90° or less when used on hard materials.

Because of the infrequent appearance of the classic burinations of tools from Middle America, the unidentified pseudo-burin may have been used to accomplish the same function as the conventional burin.

In conclusion, limited experiment and limited examination of paleolithic implements indicate that more lithic debris should be retained and intensively examined and should not be discarded as non-diagnostic. It is entirely possible that distinct technological traits, characteristic modes of use, manners of holding or hafting, and the nature of the material being worked can possibly be defined by this lithic debris. We also may find multi-purpose implements. It has been a revelation to find that for some tasks a thin, sharp acute-angled edge will not perform as well as an obtuse-angled edge. Aboriginal tools bearing an obtuse angle working edge may not fall into the categories of well defined types. Some may be asymmetrical or without definite form, but a careful study of the wear patterns on the obtuse angles may determine the amount and type of function, and the way in which these tools were used.

My functional experiments were hampered by the lack of imperative "know how" of the aborigine in using lithic tools, and it is doubtful if today we can ever approach his functional skill with stone implements.

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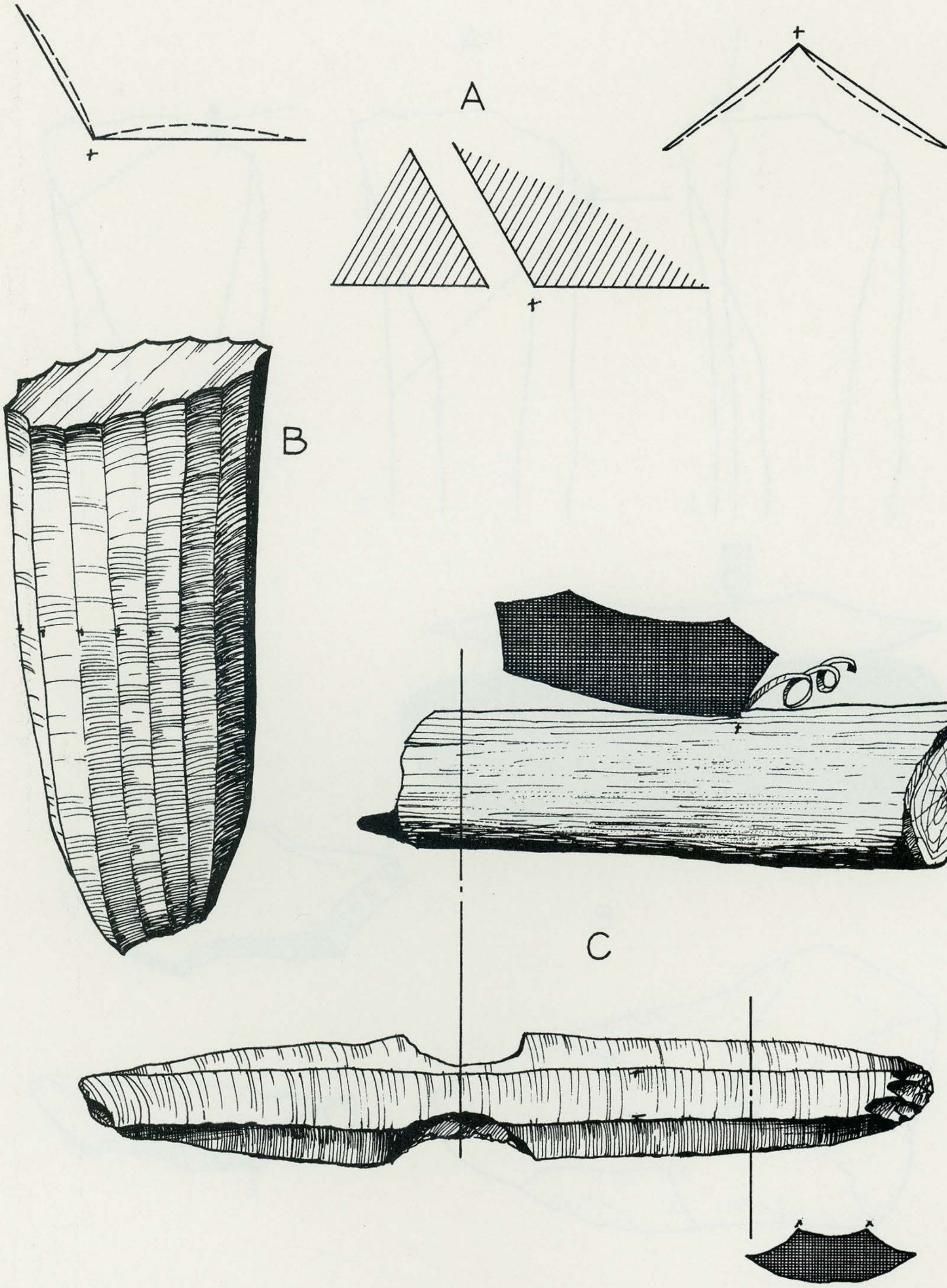

Fig. 1 **A,** functional obtuse angle is one greater than 90° and usually less than 130°. Shaded drawing contrasts obtuse and acute angles; line drawings outline flake shape in contrast to perfect straight angle; **B,** polyhedral core, an excellent obtuse angle tool with numerous working edges; **C,** strangulated blade with two manufactured obtuse edges, two cross-sections show difference between unmodified blade section and manufactured working edge.

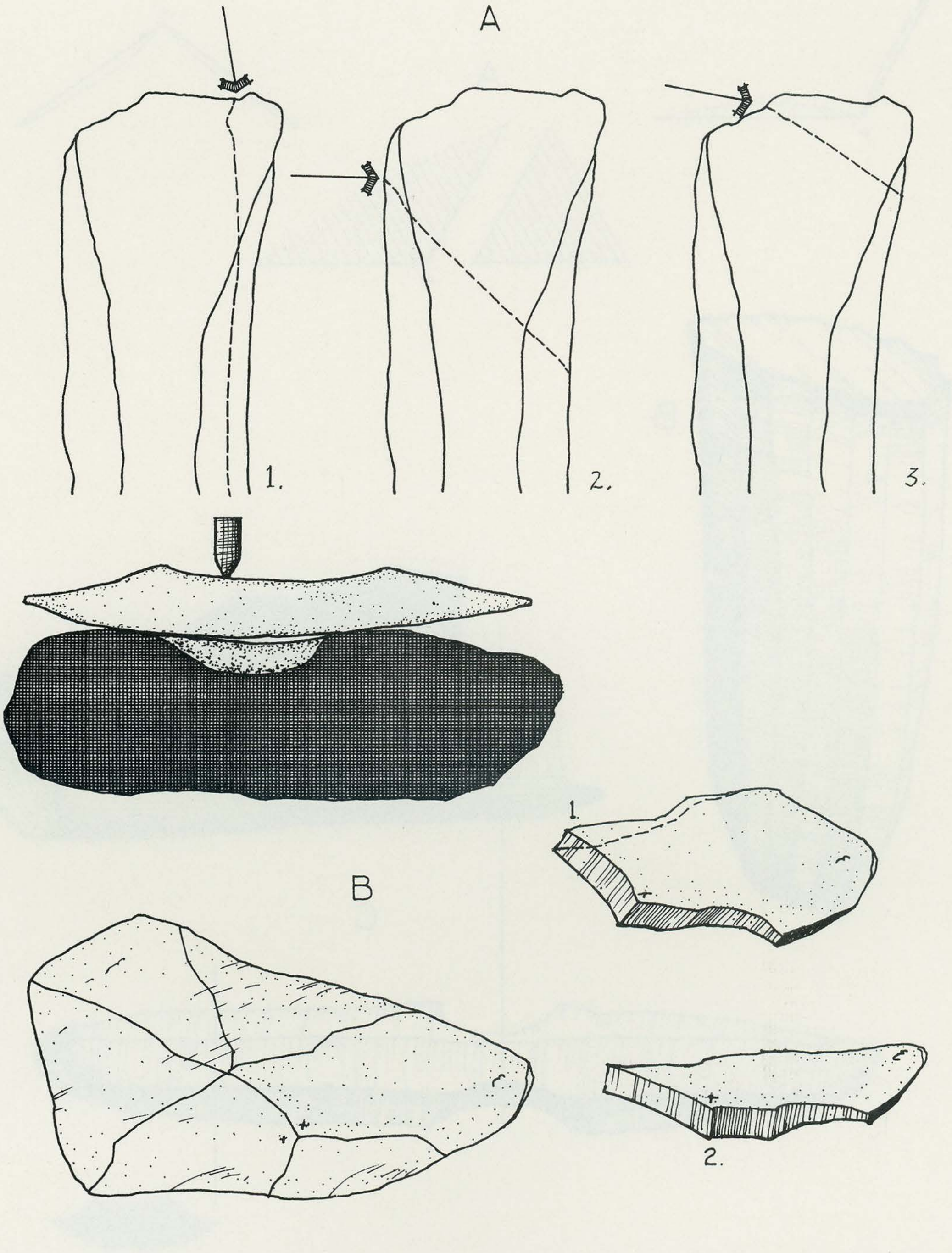

Fig. 2 **A,** distal ends of three blades showing types of burins which can and cannot be manufactured by pressure or percussion: (1) right angle burin, (2) acute angle burin, (3) attempt at obtuse angle burin which by this method is impossible to manufacture; **B,** process of producing pseudo-burin starting with flake on "nutting stone," then showing broken flake and on single piece having (1) acute angle, and (2) obtuse angle.

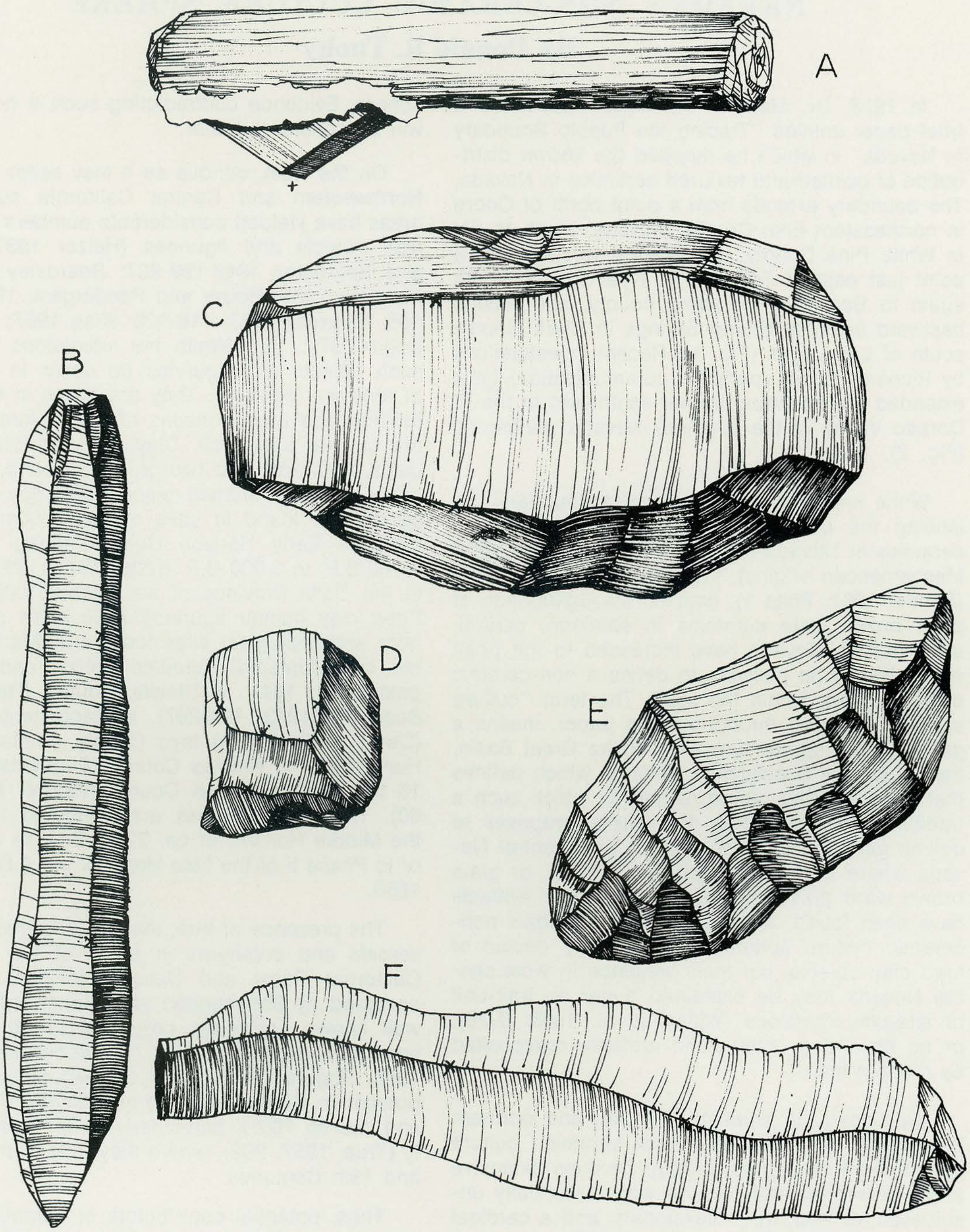

Fig. 3 **A,** example of hafted pseudo-burin having superior cutting edge; **B-F,** five examples of locations of obtuse angles; **B,** a prismatic blade with two long and usable obtuse angles; **C,** a levallois-like core with two very pronounced obtuse angle ridges; **D,** a debitage flake with three different obtuse angles on dorsal surface; **E,** a rude biface with number of obtuse angles; **F,** percussion blade with single strong obtuse angle.

NEVADA'S NON-CERAMIC CULTURE SPHERE

By Donald R. Tuohy

In 1928, Dr. Mark R. Harrington published a brief paper entitled "Tracing the Pueblo Boundary in Nevada" in which he mapped the known distribution of painted and textured ceramics in Nevada. The boundary extends from a point north of Cobre in northeastern Elko County, Nevada, south to Ely in White Pine County, and thence westward to a point just east of Tonopah in Nye County, south again to Beatty in the same county, and thence eastward again to Stump Springs in Clark County south of Las Vegas (Fig. 1). Recent investigations by Richard Brooks (personal communication) have extended the boundary farther southward to the El Dorado Valley of the southern Nevada panhandle (Fig. 2).

While knowledge of the precise boundary delimiting the occurrence of painted and textured ceramics in Nevada (of ultimate Southwestern and Mesoamerican origins), has been essentially static (Shutler 1961: Plate 1), data on the distribution of plain brown ware ceramics in southern, central, and northern Nevada have increased to the point where it may be possible to define a non-ceramic culture sphere within the state. The term "culture sphere," as used throughout this paper, means a geographical sub-culture area of the Great Basin, the Lacustrine Subsistence tradition which defines that area, and the period of time in which such a tradition persisted. Thus, this paper proposes to delimit geographically an area in west-central Nevada where neither painted nor textured, or plain brown ware potsherds, or other ceramic artifacts have been found. As we shall see, Nevada's non-ceramic culture sphere is not entirely devoid of fired clay objects, but their presence in west-central Nevada may be explained either as trait-unit or site-unit intrusions (Willey et. al. 1955: 9-26), or as historic or prehistoric artifacts redeposited by modern man.

Until now, the southern, central, and northern boundaries of Nevada's non-ceramic culture sphere were unmapped largely because extensive areas of west-central Nevada were essentially unsurveyed, at least by professionals, and a cardinal principle of distribution studies requires that data be complete. Having said this, I will beg the question somewhat, because much of western Nevada still remains archaeologically unknown. Nevertheless, let us examine such data as do exist to support the postulation of a non-ceramic culture sphere. Evidence contradicting such a postulation will be considered later.

On the west, curious as it may seem, both the Northwestern and Central California sub-culture areas have yielded considerable numbers of baked clay objects and figurines (Heizer 1937; Heizer and Beardsley 1943:199-207; Beardsley 1954:69; Meighan 1953; Heizer and Pendergast, 1955: 181-185; Elsasser 1963: 118-120; King 1967: 138-142; Ragir 1972: 25). While not ubiquitous spatially, such objects and figurines do occur in a variety of temporal contexts. They are found in the Early, Middle, and Late Horizons of the Central California cultural sequence. Clay pots, perforated clay discs, biconical and two-grooved, round, cylindrical, and pecan-shaped pieces, and rice size clay pellets are found in sites of the Windmiller Culture, an Early Horizon Culture dating from ca. 4,000 B.P. to 3,000 B.P. (Ragir 1972: 123), located in the Delta Province of the Interior Valley Zone. Fired clay human figurines have been recovered from archaeological sites located in Marin, Sonoma, and Humboldt Counties (Heizer and Pendergast 1955: 181), in Shasta County (Heizer and Beardsley 1943: 199-207), in Sacramento County (Davis 1959: 20), in Inyo County (Wallace 1957; Hunt 1960), in Plumas County (Stephenson 1968: 16-19), and in Lassen County (Riddell 1960: 58-60). These occurrences are attributed largely to the Middle Horizon of ca. 2,000 B.C. to A.D. 400, or to Phase II of the Late Horizon, ca. A.D. 1600 to 1850.

The presence of true, thin-walled, fired ceramic vessels and potsherds in areas of the Southern California Coast and Desert Provinces formerly occupied by Shoshonean and Yuman speakers is well known and does not need to be repeated here (Elsasser 1960 Map 7; Kroeber and Harner 1955; Rogers 1936). Fired clay figurines are also present in Southern California (Bryan 1964; True and Warren 1961), particularly in San Diego County (True: 1957: 292), where they date from the 18th and 19th Centuries.

Thus, potential contributors of ceramic vessels and other baked clay objects are found throughout California culture history, although as a primary source for such artifacts, California may be virtually excluded from consideration. This is particularly true of Central and Coastal California whose aboriginal inhabitants resisted and ignored