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

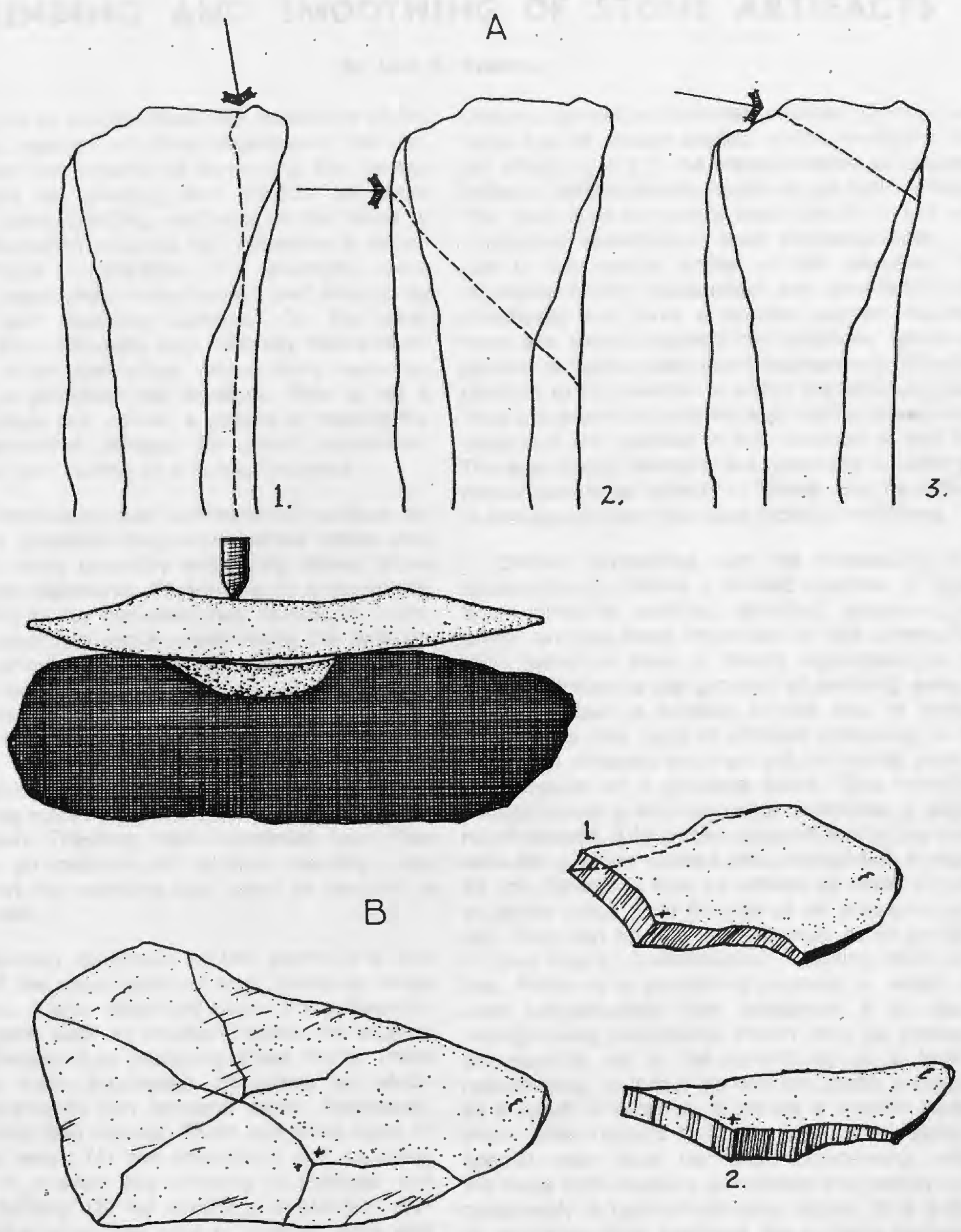

Fig. 2 **A,** distal ends of three blades showing types of burins which can and cannot be manufactured by pressure or percussion: (1) right angle burin, (2) acute angle burin, (3) attempt at obtuse angle burin which by this method is impossible to manufacture; **B,** process of producing pseudo-burin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

GRINDING AND SMOOTHING OF STONE ARTIFACTS

By Don E. Crabtree

To arrive at a comprehensive evaluation of the diagnostic features of stone implements, the analyst should be capable of separating the diverse implications of grinding and attrition on stone artifacts. Some grinding and wear is the result of the manufacturing process but, generally, it represents a later modification. For example, some Neolithic implements were formed and shaped by grinding and abrading surfaces. On the other hand, we find unifacially and bifacially flaked stone artifacts which are often made more even by grinding or polishing the surfaces. This is not a forming action but, rather, a means of making the artifacts smoother perhaps for easier penetration, withdrawal and cutting of a hunted mammal.

Both intentional and unintentional surface attrition is a possible diagnostic feature which may be useful when correctly evaluating flaked stone implements. Intentional attrition can be a diagnostic trait related to the manufacturing technique. Unintentional wear can aid in determining the function of a tool or may permit the identification of natural causes. I know of no publication which has described this particular attribute but it can be a valuable key to the manufacturing process or functional hypothesis. Recently there has been considerable interest in the study of functional wear on the edges of tools which appear to be the wear pattern resulting from continual use. This would be an example of attrition resulting from function on the working part used to perform a specific task.

The primary emphasis of this paper is a discussion of the main types of wear found on stone implements. It also describes some of the diagnostic characters such as striations which the student must be aware of in analyzing these items. There are three main processes discussed by which stone implements can become worn: intentional, unintentional, and natural. There are three types of intentional wear: (1) the smoothing and rounding of bases to prevent the severing of lashings and to aid in hafting; (2) the abrading of platform surfaces to strengthen the area of applied force and aids in flake and blade removal; and (3) the grinding and polishing of one or two faces to reduce friction and drag to allow for repeated deep cutting. There are also three types of unintentional wear: (1) the wear on the acute edge angles of stone implements due to function, which tends to remove particles from the working surface and to create a ground or polished surface; (2) the functional use of obtuse angles, which creates a similar effect; and (3) the transportation of unhafted artifacts, which creates facets on all high surfaces. The final type is natural wear which is not man made, but nevertheless must be considered. It is due to the natural action of the elements. The striations chiefly associated are generally multidirectional and have a circular pattern; however, there are some unidirectional striations which are parallel or subparallel. Unintentional wear striations conform to the manner in which the tool was used. They are generally uniform and start at the working edge and are oriented in the direction of tool use. The associated striations are generally random and minus pattern or direction. These can be difficult to distinguish from the other types of striations.

Before proceeding with the discussion, it is appropriate to define a limited number of terms. Such terms as attrition, grinding, striations, and polish are the most important in this connection; their definition here is chiefly applicable to this paper. Attrition is the process of wearing away or grinding down a surface by the use of friction. Grinding is one type of attrition indicative of the use of an abrasive such as grit, or solids such as a whetstone or a grinding stone. This technique usually leaves a rounded edge which has a slightly rough texture. It is a dual-purpose technique which weakens a plane surface and strengthens a rounded one. Striations may be viewed as small scratches which result from the use of an abrasive material. They can be either intentional, as in grinding, or they may be unintentional, resulting from function. Polish is a smoothing process in which one uses progressively finer abrasives; it is also a strengthening procedure. Polish may be produced intentionally, as in the smoothing of a face to reduce drag; or it may be unintentionally produced, as a result of function. It leaves a smooth surface which often reflects light and may appear shiny. A special note must be made concerning polish. We know from lapidary processes that polish is not necessarily a type of attrition; rather, it is a form of molecular flow involving the surface molecules of the material. The molecular flow tends to smooth the surface but cannot fill up a scratch. This flow creates a thin layer which is harder and smoother than the natural surface.

Abrasion, grinding and polishing on the basal margins of projectile points have been observed limits the ready availability of adequate abrasive materials in this area. It was undoubtedly more difficult to obtain good abrasive materials than to secure the proper stone for the artifacts. I know of cnly one archaeological source of abrasive materials in situ—this is a piece of mica shist containing garnet crystals which was excavated by Dr. Marie Wormington at Kersey, Colorado—an Agate Basin butchering site. The artifacts at this site bore evidence of grinding and smoothing at the basal parts but I do not recall a smoothing of the faces. However, a re-examination of the artifacts may reveal that the points were designed for repetitious use or to serve the dual purpose of knives for butchering or tips for spears.

Unintentional or functional attrition, as opposed to intentional grinding and smoothing, should be considered before making a final appraisal of a collection. It is common to find in collections large pointed bifaces which apepar to have functioned as hafted digging or planting tools showing attrition on both margins and both faces apparently the result of repeated thrusting into the soil. Silica sand and grit has an abrasive and burnishing action on stone artifacts. Flints and siliceous materials used to make artifacts are approximately the same hardness as quartz sand and the abrasive action is very slow compared to the worker intentionally grinding with an abrasive material harder than quartz. Also the character of functional abrasion is quite different than intentional smoothing. Striations resulting from functional alteration start at the working end and are directed toward the base in one direction and the leeward side of any protrusions will not be altered by abrasive action. Details of functional polish and attrition of implements other than projectile points should be noted and compared in order to form a basis for intended function. Corn polish or silica deposits acquired from reaping grain, grasses or other vegetable materials having a high silica content are not to be confused with wearing away attrition and intentional abrasion. As opposed to these functional wear patterns, intentional smoothing is done from both directions or by a rotary motion and will have corresponding striations. The margins are not affected by intentional surface smoothing.

The unintentional wear and functional attrition found on scrapers, adzes and their flakes, hoes and other cutting tools having acute angle margins should be the subject of a separate study. This study is not included here for it is complex and should contain an explanation of how the tools were held, hafted, used, and the tasks performed on specific materials.

We also find unintentional abrasion on the faces of elongated bifaces which have the appearance of knives or spearpoints and this wear could easily be confused with the intentional smoothing of thrusting spears and knives. Another paper, "The Obtuse Angle as a Functional Edge" (Crabtree, 1973) explains how some implements were used as files, hones and rasps. This paper also explains how the surface of a biface is characterized by a series of flake scars directed inward from both margins to and across the median line. These ridges made an adequate rasp-like implement to use as a forming tool when working on hard resistant materials. When they are continually used on a hard surface, such as jade, the ridges will become rounded and smoothed until they resemble intentionally ground and smoothed bifaces predesigned by the worker to reduce friction and drag. This planing action was also applied by prehistoric man to the ridges on cores.

When one evaluates artifacts to determine intentional grinding due to facial smoothing or unintentional attrition due to functional processes, one should also consider friction due to natural causes. One perplexing example owing to the lack of provenience is the group of unhalfted artifacts which has been transported long distances and the specimens have become burnished and abraded on all surfaces as a result of rubbing together in the carrier's yielding pouch. When they are carried unprotected in the leather pouch, the continuous movement acts as an abrasive on all surfaces and, therefore, the attrition will be more pronounced on the margins and ridges of the flake scars. The artifacts may be made of stone of similar hardness but the surfaces will still become burnished and worn from such movement. This type of wear is more characteristic of blanks, preforms and unhafted artifacts. The large ovate bifaces from the Simon Clovis site bear these characteristic marks. This does not apply to finished projectile points which exhibit intentional smoothing.

I have noted examples of surface smoothing and polishing on projectile points and broken sections which are superb examples of flaking but which were out of context with associated artifacts. I have often found these worked pieces on the surface of comparatively recent Indian campsites in association with arrowpoints. The arrowpoints were made from simple flakes entirely by the pressure technique exhibiting random flaking by an inferior knapping technique. Many were curved on the ventral side with a minimum amount of flaking on that side. Those recent points show a lack of skill and the impatience of the worker can-

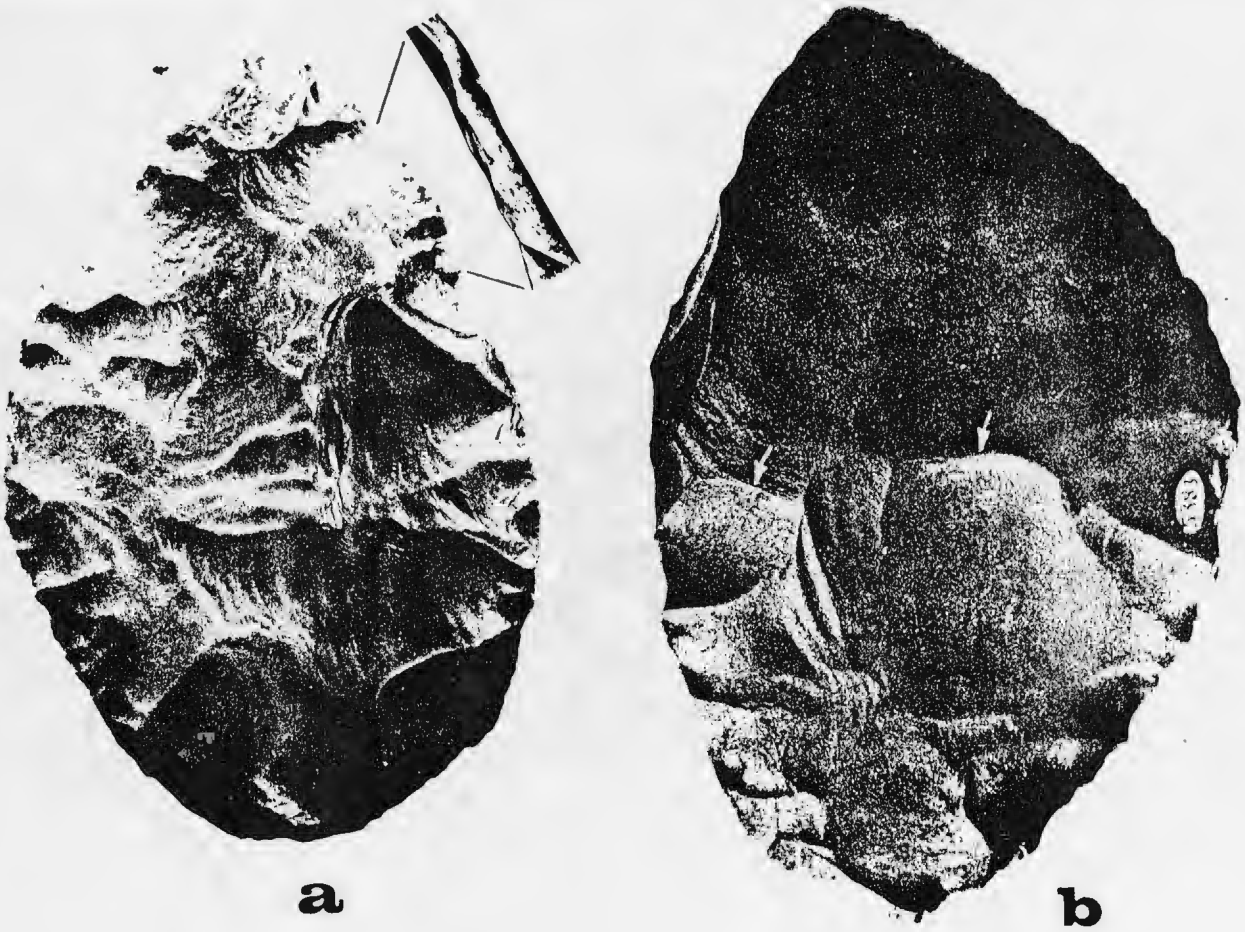

Fig. 1. Examples of intentional and unintentional wear. **a,** large biface (20.5 x 13.3 x 1.3 cm) from the Simon Clovis site, Idaho, showing intentional edge grinding (see edge view) used to enhance manufacture. **b,** large biface (15.6 x 10.0 x 1.7 cm) from the Simon Clovis site, Idaho, showing unintentional surface wear possibly the result of transport (note flake ridges on the center left [see arrow] of the biface are clear and sharp while the ridges near the center [see arrows] are smooth and rounded due to wear.)

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.

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 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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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 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

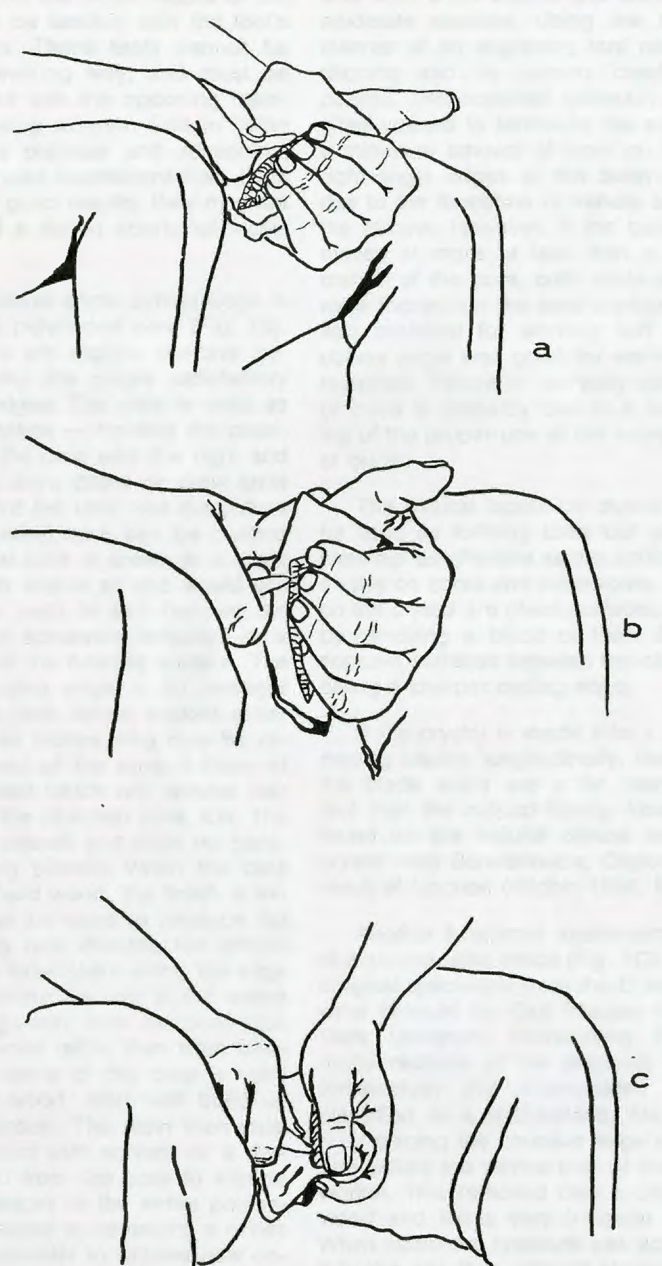

Fig. 10 **a**, position for method of turning edge to produce bevel, a stage of platform preparation; **b**, pressure flaking method using back of left hand supported against inside of left thigh, exerting greater force; collateral or diagonal flaking may be done in this position depending upon angle 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.

not be compared to the parallel flaking on the precision pieces found in apparent association on the surface of the ground. These sophisticated pieces were perhaps held in esteem by a later owner because of their aesthtic value or perhaps were fetishes of the medicine man. Since their workmanship is discordant with the arrowpoints associated with the campsite, it is possible to assume that they were transported a considerable distance and were unintentionally smoothed and polished by the movement during travel.

Unintentional and natural attrition can also be the result of action of the elements, as in the case of ventifacts. Another example of natural abrasion of lithic tools are those found in association with the abrasive sands of beaches, seas and lakes. The turbulence and movement of sandy sediments and water in suspended loads,. bed loads and boiling springs can induce a polish on artifacts found under these conditions. These are only a few factors to be considered when making a final evaluation of abraded flaked stone artifacts.

It is not easy for the student who has not worked stone to differentiate between intentional, unintentional and natural abrasion. However, there are a few clues which can help his analysis. Intentional grinding and smoothing are generally obtained by a rotary motion so that the striations will be multi-directional. If the worker grinds in a back and forth motion then the striations will be parallel or sub-parallel. The margins are not affected by intentional grinding.

Unintentional functional attrition will leave striations on the stone which will conform with the manner in which the tool was used. Striations will be more consistently uniform as opposed to the rotary motion of the intentional grinding. Also the margins will generally show abrasion. Natural abrasion and polish will be random and minus pattern or sustained direction. Since the possibilities for producing wear on artifacts are very great it is wise to test hypotheses about the causes of wear by carrying out experimental work designed to replicate manufacturing and use processes.

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and described in various texts as a technique for preparing platforms prior to flaking. It has also been noted that grinding is evident and perhaps even limited to the surfaces and basal portions of Clovis points and other Paleo-Indian projectile points of the New World while the grinding and abrasion of platforms on blade cores generally has a universal distribution. However, intentional abrasions of flaked surfaces has remained unnoticed or overlooked and little is known of the extent and distribution in time and space of this smoothing process and purpose.

Abrading the platform surface aids the stoneworker in detaching flakes and blades because it strengthens the area where force is applied thereby preventing crushing of the platform which would result in only a partial removal of the flake or blade. The smoothing and rounding of the acute edge of the proximal end of the projectile was, undoubtedly, done to prevent severing the lashings or servings when the stone tool was inserted and affixed to the shaft. Intentional abrasion was quite common among the Paleo-Indians due to their advanced technique of precision platform preparation and the possible use of their implements as thrusting spears. The stoneworker seldom, if ever, ground the basal portion of the artifact classified as an arrowhead because he realized it would not survive more than one flight without breaking. However, an exception is the Hopewell beveled notched points which were used repeatedly as knives. These show polishing at the hafted part which was apparently affixed to handles with lashings. We can hypothesize then that we can separate projectile points and thrusting spears intended for continuous and repeated use by the grinding or lack of grinding on the basal portion. Those intended for hafting and sustained and repeated use would be intentionally ground at the basal portion—those intended for a one-shot kill would lack this basal grinding and polish.

Surface attrition of one face (uniface) and two faces (biface) is sometimes overlooked by the analyst as one of the diagnostic traits of prehistoric man and, therefore, not included or described in reports. However, this can be a pertinent diagnostic feature. The ground and polished faces I have observed in collections have generally been on Paleo-Indian artifacts and apepar to be an intentional smoothing of the surfaces rather than the result of function. Recently, Gene Titmus recovered a chalcedony knife in mint condition which was worked with parallel diagonal flaking and exhibited superior skill and exquisite workmanship. This was a surface find from the Shoshone Basin in South-central Idaho. This knife-like ovate is approximately 12 cm. long, 5 cm. wide and 4 mm. thick with very sharp margins. The ridges of the flake scare on each face have been ground and polished with accuracy and precision. When the surface is prepared by this smoothing process, friction and drag are substantially reduced thereby allowing repeated deep cutting action with a minimum of effort. When deep penetration is desired—whether the implement is used as a knife or thrusting spear—the smooth surfaces of both faces facilitate the cutting or thrusting. The spectacular Clovis points from the Simon site in Idaho (Butler, 1963) are superb examples of intentional surface smoothing. They are designed for killing large game animals by the deep penetration of thrusting spears. It is unlikely that they were affixed to a foreshaft and propelled by the throwing stick or atlatl. It is even possible that the Simon points were used for butchering in which case the surface smoothing would make the job easier. Once a spear is thrown or cast the hunter is weaponless and unless the projectile scores a fatal hit the stone point will be fractured. This manner of killing would require a backup supply of spears to accomplish the kill. It would seem unlikely that a single throw or cast of the spear would result in the instant kill of an animal as large as some of the extinct bison or elephant. However, a shorter spear fitted with the classic Simon polished fluted point is ideal for repetitious deep thrusting of the spear at closer proximity and should have resulted in a quicker kill. A skillful hunter could have used this type of thrusting implement indefinitely bearring accidental breakage from mishandling or the tip striking bone. When one considers the manufacturing skill and meticulous precision necessary to produce this fluted biface with ground surfaces it seems evident that it was intended for a thrusting spear and not a projectile. The steps involved in arriving at the end product include many stages of manufacture plus grinding and polishing, indicating that the worker was trying to produce an implement which might endure through many kills.

It was not an easy task to secure the proper abrasive media, which must be of the hardness of seven on the Moh's scale, for rubbing and lapping the stone. Abrasive materials having a hardness of eight or nine are usually found in metamorphic rocks, or in stream gravels derived from such rocks. Garnet is probably the most common. Corundums are harder than garnet but have a limited distribution. The Columbia River Plateau has a predominance of extrusive basalts which are geologically comparatively recent. This restricts the exposures of metamorphic rocks and consequently

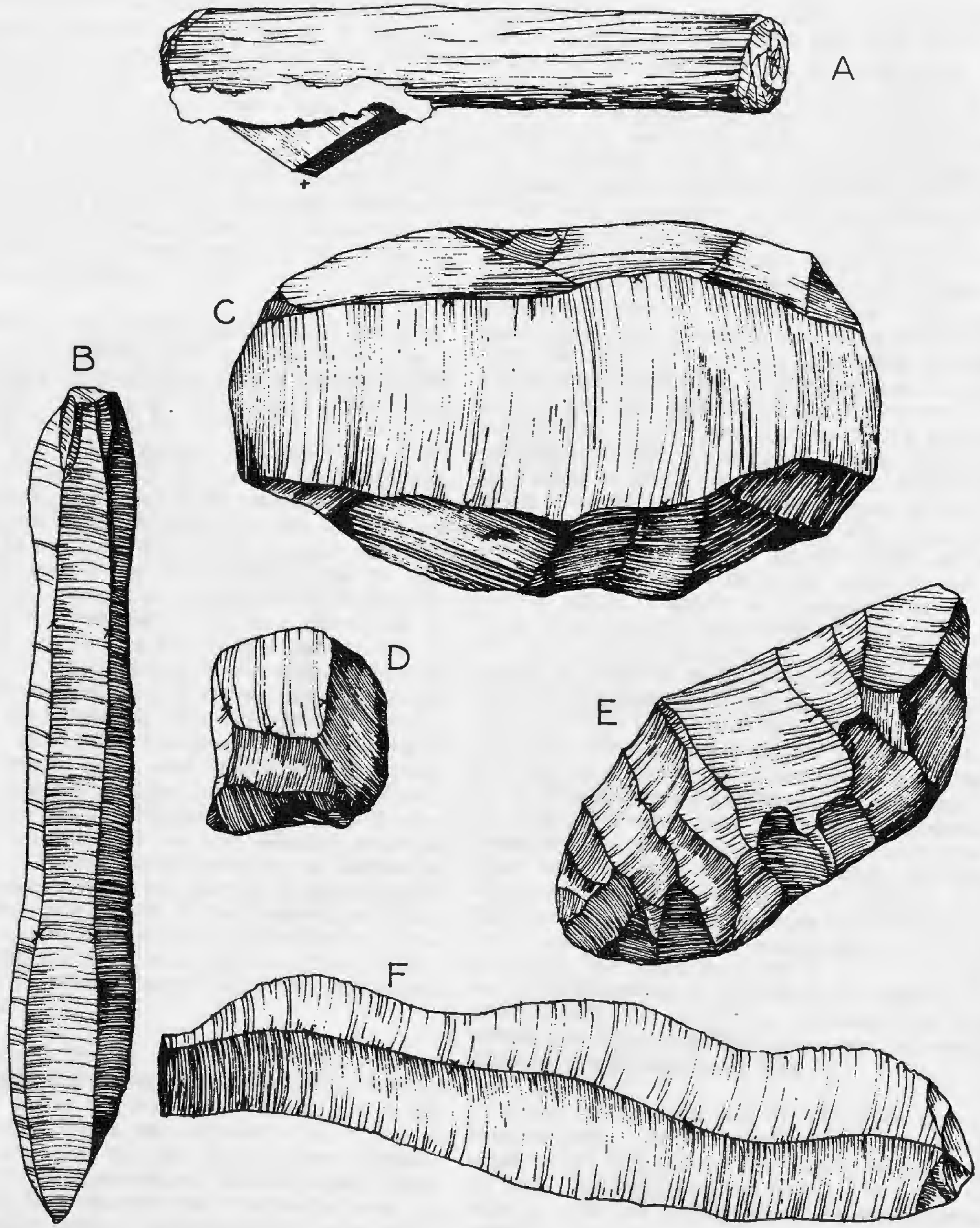

Fig. 3 **A,** example of hafted pseudo-burin having superior cutting edge; **B-F,** five examples of locations of obtuse angles; **B,** a prismatic blade with two long and usable obtuse angles; **C,** a levallois-like core with two very pronounced obtuse angle ridges; **D,** a debitage flake with three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

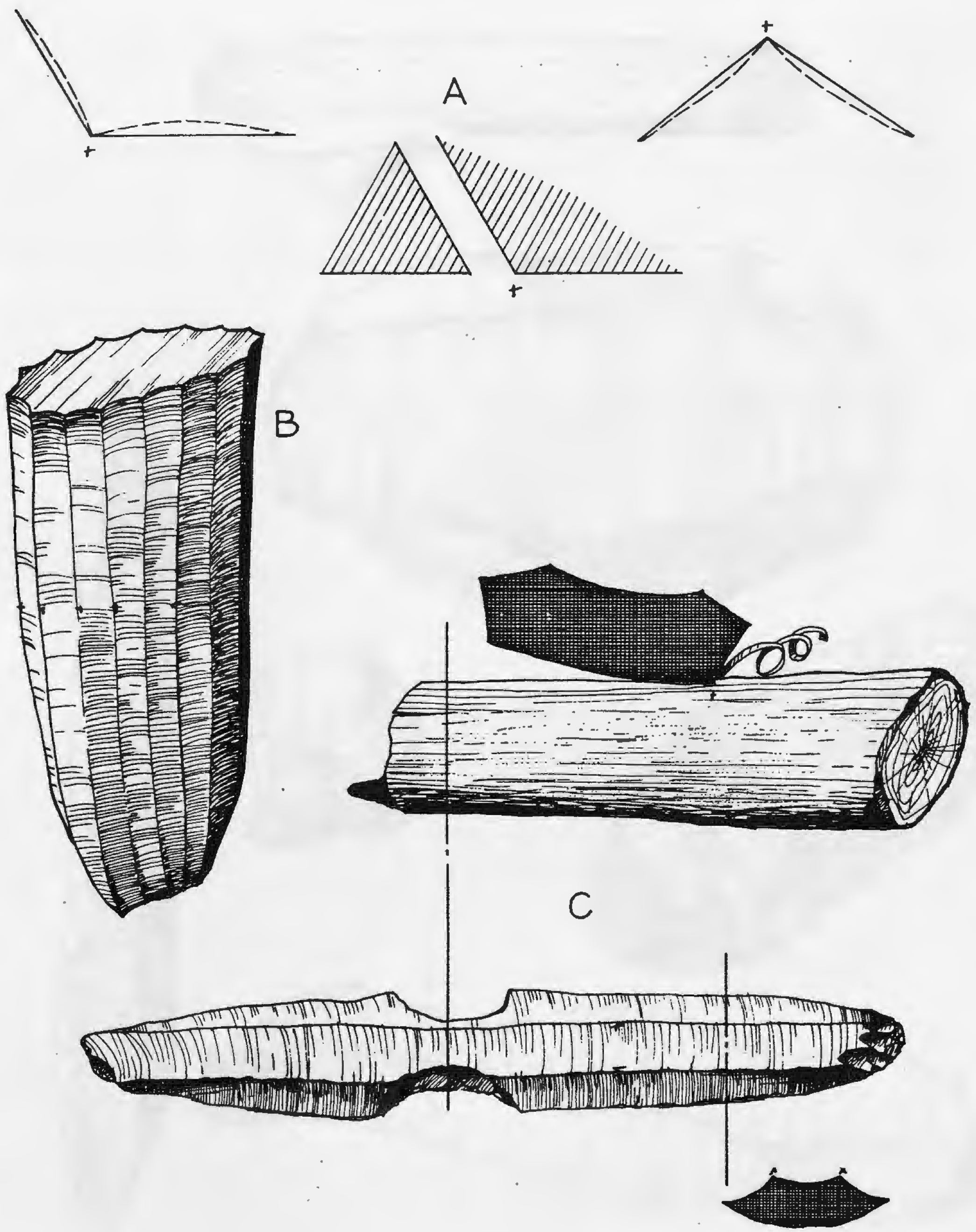

Fig. 1 **A,** functional obtuse angle is one greater than 90° and usually less than 130°. Shaded drawing contrasts obtuse and acute angles; line drawings outline flake shape in contrast to perfect straight angle; **B,** polyhedral core, an excellent obtuse angle tool with numerous working edges; **C,**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

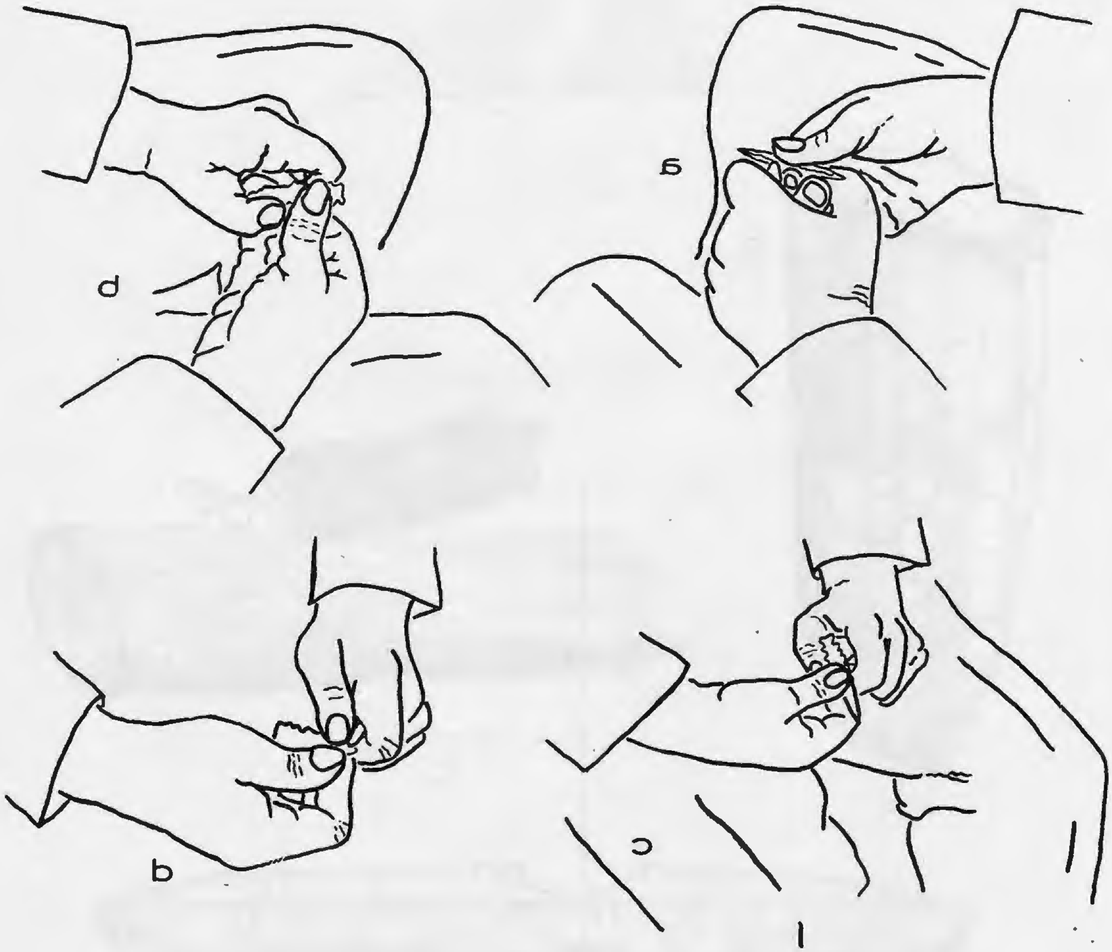

Fig. 12 **a-c**, three views of pressure notching with left hand rested on inside of left thigh, knees may assist for additional force; interlocking right thumb and fingers of left hand provide further leverage and stability; **d**, simple freehand holding pressure method used to correct irregularities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