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NOTES ON EXPERIMENTS IN FLINTKNAPPING: 4

TOOLS USED FOR MAKING FLAKED STONE ARTIFACTS

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We cannot fully explore the flaking tools of the aboriginal without also including a consideration of the implements used to secure the raw material for the making of stone artifacts The mining implements are most important, for they give a clue to the mining techniques.

The quarrying and mining of raw material for artifacts is an exacting and hazardous job, because much strength is needed to pry loose large blocks of stone and the worker is often struck by sharp flakes flying through the air. The stone must be removed in large enough blocks to produce artifacts of adequate size and must not be subjected to battering and bruising by indiscriminate pounding. Cracked, bruised, and weakened stone is not usable for the manufacture of artifacts and most quarries give mute evidence of poorly mined and rejected material.

Each source of raw material involves different sets of problems. The more massive the block of material desired, the more difficult it is to remove and also more difficult to protect from bruising. If the raw material were found on the surface, the problem of mining was eliminated. However, if the stone was found **in situ,** then an assemblage of tools had to be designed to mine it properly before it could be worked into useful artifacts. The quarrying, quartering, blanking and rudimentary preforming were done, generally, by the use of hammerstones. Wood, antler, bone or stone picks, wedges and scrapers could also be used to remove the overburden, expose cracks and fissures in the lithic material and lay bare any irregularities that could be used as striking or wedging platforms for mining with percussion tools.

I have done much quarrying for lithic material and have used sledges, mining bars, wedges, jacks, and abandoned aboriginal tools for the work. After several hours of strenuous labor, I succeeded only in removing one or two usable pieces of stone. This has convinced me of the tremendous amount of force and ingenuity necessary to detach large flakes or pieces of usable material for the making of artifacts. When mining, the worker must either strike toward himself, or sideways, so that he is often hit by flying flakes Some of the large flakes quarried during prehistoric times were twelve to fourteen inches long, six to ten inches across and an inch and a half thick.

Removing flakes of this size requires a heavy, shock-resistant hammerstone. The mechanical problems involved in breaking over a hundred square inches (108-210 cu. inches) of flint-like material could not be overcome by just using a hand-held hammerstone. Three or four men may have worked together by attaching thongs to their weighty hammerstones.

DIRECT PERCUSSION

Percussion tools seen at quarries include ovate, discoidal, lenticular, cylindrical, spherical, conical, and biconical shapes. These tools are found in many sizes. Various hammerstone types are designed to fit certain phases in making artifacts or to suit certain types of mining operations. Their shape was governed by the manner in which they were held and the specific type of work they were to do. The ovate, spherical, conical or biconical tools were used to restrict the force of a blow to a confined area. A percussion tool with either a convex or pointed working surface will make a well-defined cone or a partial cone. The apex of the cone will be the same size as the area contacted by the percussor. The piece of material, called a flake, removed from either the core, or the artifact, will have, at its proximal end, a remnant of the cone. The flattened apex of the cone will indicate the area contacted by the hammer. A fine definition of the cone will indicate that a hard hammerstone was used. If the percussor is a soft hammer, it will contact more surface area and will conform with the surface being struck This results in a diffused bulb of force.

Discoidal and lenticular types of percussion tools are used on both cores and artifacts for striking a confined area such as a prepared form. They are held in a different manner to answer a different functional need. The one is held between the thumb and fingers, as one holds a saucer edgewise. The striking face of the hammerstone is around the entire perimeter and it is rotated to insure an even, uniform surface on the leading edge. Because force is concentrated in this way, the platform is prepared by abrasion, or grinding, so it will not be crushed by the force of the blow. Flakes removed by this type of tool will show a different character on the proximal ends than those removed by other types of tools.

It is common to find simple forms of scrapers at quarries and they are usually made on wide flakes of material obtained from the quarry. Their purpose may have been to remove soil from the overburden and to expose crevices and cracks to assist in the mining operation. Abrading stones are also found. These were used to remove the overhang from the top of the core face for platform preparation, but such stones are more commonly found some distance from the quarry. In such places it seems that the artifact was finished.

Stone hammers were the chief tool used to mine the flint-like material. Selection of a hammerstone was not accomplished by indiscriminately picking up the first cobble or rounded boulder that was available, as the broken and utilized percussion tools found in a quarry would lead one to believe. Percussion tools used for mining, or tool making, are usually of tough, granular stone which has good resistance to shock and abrasion. For mining, they range in size from three inches in diameter to as much as twelve and fourteen inches in diameter and they weighed from one and a half to as much as twenty or thirty pounds. For toolmaking, hammers vary from one to four inches in diameter. For blade making they are of various sizes; from the very small for microblade removal to the very large for detaching bigger blades. Hammerstone size is related to the dimensions of the flake being removed. Percussion tools are of both hard and soft stone, depending on what work is to be done. Selection must include size and material to suit each purpose. Normally, hammerstones are selected from waterworn boulders or cobbles. They are then used in their natural form, or slightly altered to fit the specific problem of the mining of the quarry or of fabricating the artifact, whichever the case may be (Fig. 1 a-d).

Hard stones are normally those with a high silica content, such as agate, flint and chert nodules, chalcedonic rocks, and certain types of hard basalts and rhyolites, diorites, andesites, quartzites, and others of this general consistency. These are useful to induce great shock with a minimum amount of velocity. This is important when removing large flakes from the ground mass, and also for rough preforming.

The shock from the hammerstone to the artifact becomes critical when the area of the flake to be removed becomes greater than the cross-sectional area of the object, and some artifacts reveal only a part of the scar because of the overlap of subsequent flakes. Thinning of artifacts to this degree required a different technique other than those merely hand-held and struck with a hammerstone. Direct percussion with a hammerstone has certain limitations of accuracy and, even with soft hammerstones, the shock on the artifact is excessive. This shock factor may be partly overcome by the use of different types and sizes of percussion tools. The hafted hammerstone, or billet, affords a partial solution to this problem by allowing the speed of the percussor to be increased. Critical thinning requires a change in tools and methods. For excessive thinning, it is well to use a billet or to design a suitable hafting for the percussor and make a proper isolation of platforms. (Fig. 1 d-h).

Percussion tools made of softer stone, antler, horn, bone, ivory and wood, are useful for removing smaller flakes and blades and will not bruise the material. Agate hammerstones used on obsidian will cause shattering, collapse of platforms, induce unseen stresses and will render the material useless. A softer percussor will not have these ill effects. However, some hard hammerstones will become softened from repeated use until they have the same qualities as a soft hammerstone. Softening is caused by overlapping cones on the point or edge of the hammer.

It is important that the percussion tool be of a material other than one that has the vitreous qualities of flint, agate, chalcedony or those with a pronounced conchoidal fracture for, upon impact, they will project flakes toward the user causing cuts and injury. However, when no other material was available, hammerstones of flint-like materials were used. Flint-like hammerstones were usually discoidal and doubly convex, with the edges battered and rounded around the entire perimeter. The rounded edge gives a resistance to breakage not found in an angular piece. A hammerstone of flint-like material is much more difficult to control, for it causes excessive shock to the material being mined, or worked. It is almost impossible to avoid shattering of the artifact or raw material. A hammerstone of such material will break just as easily as the raw material or the artifact. If the hammerstone is hand-held, it may collapse and cause injury to the worker's hand. There are, however, areas such as portions of Utah, Northern Arizona and New Mexico where material for good hammerstones is limited because of the Permian sediments, and the aboriginal had to resort to the use of chalcedonic types of material for percussion tools. Sometimes aborigines in that area used dinosaur gastroliths.

Percussion hammerstones can be in a variety of shapes and sizes, but size and shape must be in relation to each mining operation, or with each technique in the stages of production of a stone tool. Hammerstones normally graduate in size from large to small as the flaking work progresses. Large, heavy hammerstones are necessary for the quarry work, smaller percussion tools being used as the artifact nears completion. Many artifacts were finished by the use of the hammerstone alone.

In addition to hard and soft hammerstones, percussion tools are of antler and other organic materials. Antler is carefully selected from prime antler of the caribou, moose, elk or large deer. Old, dehydrated, weathered antler is entirely too brittle to use as a tool. The bulbar end of the antler is the ideal portion to use for percussion work, since it is composed of both bone and antler with none of the soft spongy interior found in the balance of the antler. It has more weight and, therefore, imparts better balance to the billet. It is best taken fresh from the animal, as the shed antler loses much of its mass. The initial cut should be made close to the skull and then cut about ten to twelve inches from the burr. The extension of the antler provides the handle. The base and large parts of the antler are used for percussion work (Fig. 1 e-g) and the tines are excellent for pressure flaking (Fig 2b, 3a and f).

The amount of spongy bone in the interior of the antler varies with each animal and each species has antler of different quality. For example, the antler of caribou has a thinner but tougher exterior than that of the elk, moose, or deer. The tough exterior of the caribou antler makes it ideal for use as a billet for percussion work, but some are unduly light. When heavy percussion work is required, the bases of the antler are best. The base of the moose antler is straight and some moose antlers are very heavy, enabling the worker to remove large blades from a core.

Percussion tools of antler and other organic materials may be used as the striker employing two different percussion techniques.

1. The worker holds the section of antler, or other material in the hand in the same manner as one holds the unhafted hammerstone; i.e., held vertically by the fingers. Percussion tools held in this manner are used primarily for making blades or removing flakes from a core. These tools are normally shorter and heavier than the billet. The ends, not the sides or corners, are used.
2. Antler is used in the billet technique, i.e., the percussor is held at one end in the manner in which one holds a hammer handle.

When the antler is used in the same manner as a hammerstone, it eliminates the end shock to a degree not possible with a hammerstone, and a very forceful blow may be delivered without bruising the edge of the core. There is also an absence of incipient cones when repeated blows are delivered to a core by the antler billet and the flake scars are more diffused than when using the hammerstone.

After good material has been secured either from the surface or by quarrying, the next step is to reduce the blocks or boulders into either core tools, flakes or blades. This was done by both the writer and prehistoric man with the use of stone percussion tools. My experiments incorporate the use of the anvil to support the rough lithic material. The anvil is used when quartering the rough mass of material as well as when removing large flakes and blades. The use of the anvil is not as the name would imply. One normally thinks of an anvil as an object on which metals are pounded and shaped. In flintknapping, the anvil is used to support the material and proe inertia for the artifact. The blow must be directed towards the face of the stone il and through the lithic material, for the w will be opposed by the anvil and the op-ing forces will either cause shattering or l induce strains in the material, rendering worthless. The blow must be applied in ich a manner that the force will be deflected away from the resistance of the anvil This causes a shearing effect from the opposing forces, yet they are not in direct oppositon. The immobilization of the lithic material on the anvil allows the stone to be cleaved with the application of a minimum amount of force.

The shape and conformation of the anvil must suit each specific function, whether it be used as a simple support, or to strike against when using the block-on-block technique. When this technique is used, the anvil must be hard and resistant. Anvils can be of mediums other than stone. They may be of antler, bone, horn, wood and materials that are semi-yielding. Prehistoric people probably made use of anvils for quartering and for blade and flake removal. These are sometimes hard to recognize in the debitage, for they are usually of the same material as that ound in the quarry.

By using a hammerstone, these blocks, odules, or masses of material are then formed to blanks, later to be made into preforms id ultimately finished into artifacts. The ammerstone is used to pare all of the un-esirable material such as cortex, inclusions, vugs (crystal pockets) and improper texture from the blank. The blank is now ovate or must be further reduced to the stage of a discoidal, thick and excessively heavy. It must be further reduced to the stage of a preform which can be transported to the place of occupation for the final finishing. The preform will be larger than the finished artifact but the general shape will be roughly the form of the completed tool. There is little evidence that all the stages of artifact manufacture were completed at the quarry site, for rarely is the quarry a suitable place for the time-consuming work of flintknapping. It appears that the aboriginal preferred to rough out blanks and preforms at the quarry and do his finishing under the more comfortable conditions of the campsite. There is some evidence, however, that large bifacial artifacts vere made at the quarry.

Billets, rods, clubs, or hafted tools may be of soft stone, antler, wood, horn, shell, ivory or bone

I first became aware of the use of billets in 1938 when, with the late Dr R. A. Stirton, I was doing some paleontological reconnaissance work for the University of California. We were camped at a ranch which had been established in the early seventies in the vicinity of Walker Lake, Nevada. The elderly owner told of the Paiutes who had lived there when he was a boy. Any hard wood left unguarded would be taken by these Indians, and the spokes of the buggy wheels and tool handles would constantly disappear. The Indians told him that they used this hard wood in the making of stone knives. The rancher had never observed them making the stone knives, but he said they did use what he called "flint spikes" for their arrows. When we later found a deposit of obsidian in Northwestern Nevada, I was able to try the wooden billet technique. I applied the handle of my prospector's pick to the obsidian nd was delighted with the results. Prior to this, I had always used the hand-held hammerstone as my percussion tool for roughing out a preform and then resorted to hand-held pressure for finishing. The wood billet worked very well as a tool for the intermediate thinning stage. Whereas the hammerstone made artifacts with well-defined bulbs of percussion, the wood billet allowed the removal of wide, thin flakes with a very diffused bulb of force. The billet struck flakes had much the same character as some of the prehistoric ones. This also led me to consider the technological patterns related to the tools used in the manufacture of artifacts. Since then, I have found very distinct flake types that may be related to both tools and technology.

INDIRECT PERCUSSION

The use of indirect percussion involves the use of an intermediate tool to receive the force of a percussion implement. This allows the force to be projected through the intermediate tool to the pre-established platform on the artifact. Indirect percussion allows the operator to keep the angle constant and to accurately place, with control and precision, the tip of the intermediate tool. This method allows and produces uniform flake removal. However, indirect percussion, does present the worker with the problem of holding the preformed material For good results, two persons are required one to hold the artifact and the other to hold the punch and strike The intermediate tool may be composite or of the same material The punch may be of antler, horn stone, wood, ivory or metal (Fig 1 g, 2 b & c 3 a) The percussor may be a rod, billet club of wood, or hafted stone hammer (Fig 1 d-h) The anvil or support must be of materials with sufficient resiliency to support the artifact without causing shock If the material of the anvil is too hard it will crush the contact point of the artifact Anvil, or support may be of soft sandstone, wood, antler, or a pad of fiber, bark or hide may be placed between the artifact and the support to further dampen the shock Indirect percussion may be accomplished with or without the use of the anvil, however, when the anvil is used, a flatter flake is produced.

Holding devices suffice as a poor substitute for a second person. Since holding devices were no doubt, made of wood and lashings, no records remain except the information given by the early writers. Catlin, Sellers and Torquemada. There are many designs for clamps, vises and securing mediums and they are limited only by the individual's ingenuity (Fig. 2 a).

The use of the indirect percussion method by aborigines concerns the writer because of the apparent lack of evidence of the intermediate tools. My experiments convince me that this method is very useful in certain stages of the making of flaked stone artifacts. However, the only real evidence I have ever seen of prehistoric man's use of this method is the tools shown to me by Dr. Luther S. Cressman These tools were made from sections of antler cut near the base of the skull at right angles to the long axis of the antler. These were about one and a half inches in length and were cylindrical in shape. The perimeter of one edge of the cylinder was placed on the lithic material and then struck by another implement The scars also indicate that it was rotated to provide even wear on the surface end which contacted the artifact.

The indirect tool provides a larger surface area to receive the blow and, therefore, force can be delivered with greater intensity and more velocity, thereby producing flatter flakes. By flatter, I mean a flake with less curve This technique also terminates the flakes at the distal end without margin, or what I call "feathering", without hinge or step-fractures.

The indirect tool has proven to be most useful for the removal of large blades from cores One tool used for this method is a wooden chest crutch with a projection on the distal end which receives the blow The chest crutch used by one person is a pressure tool, but if a second person strikes a projection on the crutch, it then becomes an intermediate tool The tip of the crutch is placed on the core, or artifact, and the first person applies pressure with his chest to the proximal end of the crutch, while the second person simultaneously strikes the projection at the distal end of the end of the crutch. This method allows the worker to exert both downward and outward pressure, while the second person delivers a blow to the crutch with a billet, or percussion implement. This same type of crutch tool is used for making polyhedral cores, but pressure alone is used. The chest crutch has proven satisfactory for removing the channel, or fluting flakes in replicas of the Lindenmeier type Folsom point (Crabtree 1966, Fig. 13, p. 27). This type of tool is also used, and good results obtained, on large bifacial artifacts. However, two persons are required for this method, the first person to apply pressure to the crutch and the second person to reposition the artifact and hold it in the proper position after each flake removal. Should the applied pressure be insufficient to remove a flake, then the second person may assist by striking the projection at the distal end of the crutch.

If a second person is available, the artifact may be hand-held by the second person against two wooden pegs driven into a log. The second person may also hold the artifact edgewise against two stakes secured in the ground, sufficiently close to support the artifact, yet providing space for the pressure crutch or indirect percussion tool When stakes are used, a piece of wood, or similar material, must be placed flat on the ground between the stakes to support the artifact and prevent it from being driven into the ground. Because this technique requires two persons and I have had no one available to help, there is still need for further experiments. When two persons are not available, then blades can be removed from a core by using s same method, but substituting for the nd person a suitable clamp or holding ice.

The materials of the indirect percussion l are very important for successful flaking. s must be of a material that will withstand the shock delivered by the percussion tool, for the tip of the tool has a tendency to collapse, or disintegrate from repeated impact with the stone. The tip of the intermediate tool must be blunt to provide greater strength and to withstand the shock of sudden impact. The tines of deer and elk antler are useable as tips, but are short-lived for they must often be repointed as they become soft or split from use.

The use of stone for an intermediate tool has both advantages and disadvantages. The stone selected must be tough and be sufficiently hard to withstand the impact of the percussor. If the intermediate stone punch is used unhafted, its size leaves little space for placing and holding it on the artifact or core. The stone tool also creates more shock waves and a more pronounced bulb of force. Hafting of the intermediate stone tool aids in dampening the shock and prevents injury to e experimenter's hands.

The use of bone, either hafted or unfted, for an intermediate tool has not proven y satisfactory, for it splinters and breaks en subjected to shock from the percussion plement.

The use of hard wood is unsatisfactory and does not lend itself to this particular technique for the wood will dissipate the force of the blow and it also splinters excessively.

Ivory is one of the best materials for making tips for the punch for it is resistant to splintering and breakage and it does not slip or soften as easily as antler.

Copper tips have proven to be one of the best materials for this type of experimenting. They, too, need to be resharpened often, as they become blunt in a short time, but they do retain their point longer than antler. The use of copper as a tool was probably limited to a small group of aborigines in the New World and did not play a large part in stoneworking.

PRESSURE TOOLS

Pressure tools are used to apply force to e perimeter of an artifact to detach, with accuracy and precision, flakes from the surface and, ultimately, design a functional tool. The percussion methods do not allow the degree of control and duplication of precision flakes that one can achieve with pressure. Pressure flaking permits the worker to control each individual flake, thereby producing an artifact that is regular in form, with a sharp cutting edge.

Pressure flaking implements used to alter stone from the rough to the finished artifact are made of many materials and are of numerous forms and various sizes (Fig. 2 b-d, 3 a, b, d, f-i). Size of tool varies depending on stages of fabrication of the artifact. Pressure tools may be made of antler, bone, ivory, fresh- or salt-water shell, hard wood, metal, seed pods (nut shell), teeth and parts of tooth enamel, stone (flakes, blades), pebbles, natural crystals, jade, and flaked stone pressure applicators. I suspect that what the flaking tool was made of was governed, to a certain extent, by what material was available, what type of work the tool was intended to accomplish, the type of material being worked, and what techniques were being used. The type of materials chosen and the design of the tool depended on what steps of manufacture the toolmaker intended to accomplish and on the planned design and size of the finished artifact.

The materials of which pressure tools are made are important: first, because of their availability; second, because of the choice of the individual or group preferences; third, because of the skill with which they were used; and fourth, because of the desirable qualities of the materials used for pressure tools. The material of the pressure tool is responsible, to a degree, for the technique and character of the completed artifact. Techniques used are pertinent to the material of the tool, for the different qualities of pressure tool material vary. Some lack strength and must be designed to overcome this weakness, resulting in a bit of greater dimension. Other pressure tool material has the ability to adhere to, and not slip on, the artifact. When slippage does occur, the platform must be redesigned to overcome the tool inadequacy and this results in a distinctive flake scar.

Antler is one of the best materials for making tools for pressure work. (Fig. 2 b, 3 a and f). Its only disadvantage is that the tip must be constantly sharpened to keep the point uniform. Antler is also variable in quality depending on the genus and speices, the diet of the animal, the rate of growth, the calcium content, and on which part of the antler is used for the tool. It is important that the antler be free of natural oils and greases and it can be cleaned by soaking in wet wood ash. Degreased antler will provide traction between the tip of the pressure tool and the edge of the artifact. When using different mediums in my experiments, I find that antler, because of its hard structure resists abrasion, yet is soft enough to prevent crushing of edges. This allows the platform and the flake to be removed together, which leaves a razor-sharp edge on the artifact.

Bone pressure tools are usually more brittle than those of antler (Fig. 3 b, g-i). Bones from different mammals, birds, reptiles, and fish have variable qualities, depending on which part of the anatomy they represent. Ribs, if they are large enough, are preferable to the long bones but, unfortunately, these are not readily available and often one has to reso to the use of the limb bones (Fig. 3 h). Bone also must be degreased so it will provide more traction between the tip of the pressure tool and the material being flaked. A polished tip is undesirable. The more abraded the tip of the pressure tool becomes, the more firmly it may be seated on the platform without slipping. Bones with polished tips were not pressure flakers, but probably served as awls. Bone tools for certain pressure work can be made from the whole bones just as they are taken from the animal and they require only a slight amount of shaping. The splints, two on each side of the cannon bone of a horse, are solid and pointed. If the distal end is abraded slightly, a splint makes a good tool for light retouch (Fig 3 i). The penis bones of certain carnivores, such as wolf, bear, seal, etc are even better than the splint of horses and similar mammals because they have a greater diameter and require little or no reshaping (Fig. 3g). The long bones of mammals should be cut lengthwise, either by scoring deeply and splitting, or by sawing. Cannon bones can sometimes be split by tapping a chisel along the backside of the bone. The bones of birds and fish are usually too brittle and light for any use except notching and for light pressure retouch.

Ivory constitutes the greater part of the tusks of certain mammals such as the elephant, walrus, hippopotamus, mammoth, and the narwhal It has proven to be a very satisfactory medium for flaking flint-like material, but it, too, has many grades and qualities. Ivory makes a very good pressure tool for it is fine grained, elastic, and withstands abrasion It is stronger than bone and not as brittle The best grade of ivory for pressure tools seems to be that from equatorial Africa. It seems to be more durable and have more elasticity than other ivory. Ivory resists shock and splintering better than either antler or bone. Walrus ivory is also very good, particularly that near the tips of the tusk. It is also interesting to note that mature adults provide the best ivory. Ivory from the hippopotamus is ideal for the tip of the chest crutch, such as that used for the removal of blades from the polyhedral cores. It appears to be harder than that of the elephant, mammoth or walrus, and it also resists slipping. Apparently this is due to a lack of natural oils.

The use of mammoth ivory for my stoneworking experiments has been limited to a single section of fossil ivory tusk from Siberia. It has proven satisfactory for pressure tools, but is considerably more brittle than that of the recent elephant. Possibly this is due to dehydration as well as a loss of oils. To date, I have not had an opportunity to experiment with the tusk of the Narwhal but feel it probably played little or no part in the stoneworking industries.

My favorite material for a tool is hard-drawn copper. It was also used to some extent by the Hopewellians (Shetrone, personal communication, 1940) and the Mesoamericans (Museo Nacional de Antropologia de Mexico, D. F. contains archaeological specimens which illustrate this). The limited supply may have prevented widespread use. There may be some opposition to the use of metal in experiments. However, my concern when experimenting has been to resolve the behavior of flint-like materials under percussion and pressure and the metal tip saves repeated sharpening and increases the number of experiments that can be done in an allotted time. Time and uniformity of tools are important factors in conducting experiments. Since the metal produces the same results as the antler tine, it is substituted merely as a time-saver. I have conducted sufficient experiments over the years using every conceivable

·l material to prove the parallel results of h, and the mechanics of working the stone ɿain the same when substituting copper for tip (Fig. 2 c and d, 3 d). Hard drawn copper has qualities not found in other metals. ɔ degree of softness of copper closely re-sembles that of antler or ivory. This is im-portant, for it allows the flinty material to be slightly imbedded in the copper so the tool will not slip. This permits the flaker to remove an edge without crushing, so that it remains sharp. When placed on a platform, the copper tip will let the worker apply both inward and downward pressure. In summary, copper pressure tools are easily sharpened, they resist slipping, and they have sufficient tensile strength for most experiments.

Soft iron and bronze are also satisfactory, but brass and aluminum, known to engravers as a dry metal, are much too slick. They are mentioned here only because I have tested them, but I doubt they were ever used by natives. Tools made of bronze, brass and aluminum have a tendency to slip. Iron may be used for pressure tools if it is soft or has been slightly annealed. Cast iron and steel are too hard to allow the stone to be imbedded in the tool. The result is slipping and crushing of ɿe edge of the artifact.

Certain seed pods such as coconut, black ɿlnut and possibly others of a hard durable ell can be used for pressure flaking. I pre-r coconut shell among these materials. Its ɔerous nature is different from that found in most wood. Hard wood is very useful as a percussion tool. However, when used for pressure work, it rapidly loses its shape and becomes splintered and soft. Ebony has proven the most satisfactory for pressure work, however, there may be many other woods of greater hardness and durability. When a wooden tool is used for pressure retouch, the tip of the tool must be placed well back from the edge of the artifact. This is done to provide a greater bearing surface on the wood, otherwise the stone will be imbedded deeply in the wood so that a flake will not be removed.

Shells of mollusks, both fresh and salt water varieties of bivalves and univalves, can be used for both percussion and pressure tools (Fig. 3 j). Shell has both the hardness nd texture necessary for pressing off flakes. owever, shell must be selected from the varieties that are of the correct shape and thickness. Composition of shell is variable and the denser varieties are better.

Teeth make a good pressure tool for retouching an artifact. The use of teeth gives much the same results as pressure work done with nutshell. Mammal teeth consist of dentine and enamel and, in some cases, ivory, as previously mentioned. The usable part of the tooth is the enamel. The teeth of most mammals are classified as incisors, canines, premolars and molars; but there is a vast difference in tooth structure and size among mammals. Incisors of some rodents may be used for pressure work, particularly for fine retouching, serrating and notching. The incisors of beaver, marmots, and other rodents are well suited for this kind of pressure tool. The canines of the many carnivores provide an array of sizes that may be used for assorted pressure tools. The sides of molars from the large varieties of ruminants are well suited for notching tools. But, because of their brittleness, tools made from teeth must be used with care and their use is limited to the removal of small flakes. One exception to this rule is the tooth of the sperm whale. This tooth seems to be midway between ivory and the enamel from a normal tooth and I prefer it over other teeth for flaking tools. Sperm whale teeth are not unduly brittle, they are large enough to form a variety of pressure tools, and they can be compared favorably to the qualities of antler and ivory.

Stone may be used as a pressure tool for applying pressure to the edge to resharpen an artifact. However, stone upon stone will slip and, therefore, it is difficult to use this as a tool and still control and duplicate flakes. The use of pebbles will result in a distinctive flake scar. Such scars are usually overlapping and of assorted dimensions. Jade is one of the toughest and most satisfactory to use as a pressure tool. However, it is expensive and not readily obtainable. My experimental tools of stone have been of jade, crystals of quartz and sapphire, flakes and blades of flint-like materials and a variety of pebbles of assorted composition. Pressure tools range from the very simple to the more comlpex. The simplest known tools would seem to be the pebble tools used in Australia and described by Norman Tindale (1965). He has observed the aborigines using their teeth to sharpen stone knives for use in the circumcision rites. As mentioned above. I have found tooth enamel to be a satisfactory medium for pressure flaking and have often used the exterior plates of enamel as notching tools in the making of projectile points. Tindale refers to the use of pebbles for removing pressure flakes by hand-holding the pebble and rolling or pressing it on the edge of the artifact. I have tried this technique and have obtained satisfactory results.

The most complex pressure tools are probably those used by the Eskimo. They are made of ivory, antler and horn and have replaceable bits (Fig. 3 b). The bits serve a dual purpose, with one end for shaping and edging, the other for notching. Melgaard (personal communication, Nov. 1964) has found the bits, or pressure tips, to be made of iron, bronze, ivory and bone. Bone is most common, usually being the rib of the walrus. Rib bone is harder and more flexible than that of the long bones and, therefore, more satisfactory as a tool. The Eskimo designed a hand-held pressure tool which conformed to the worker's hand and provided sufficient hand surface contact to avoid unduly tiring the flaking hand.

Two other types of hand-held pressure tools from the Arctic are noted and described by George MacDonald of the National Museum of Canada (personal communication). "Those from the Western Arctic, around Norton Sound, are made in two pieces; they are elbow shaped and fit into the hand. They are very comfortable to use and allow much pressure to be exerted. They are made of a variety of material from wood to musk ox horn and bone. The flaking bit is invariably of ivory. I have not seen any of metal, but our samples are from a restricted area and time (ca 1886). The second type is from the Hudson Bay area collected in 1907-9. They are made of a single piece of caribou antler. They are generally larger than the Alaskan type and are held in a different manner. They also have cuts on the shaft to hold a pad of leather in place. Some are now missing this pad. The tips of these specimens are also grosser than on the Alaskan specimens and may have served slightly different purposes. It does not appear that fine retouching could be accomplished with them" (National Museum of Canada, Specimen numbers IV-C-511, IV-C-511a, IV-C-516, IV-C-516a, IV-E-204, IV-E-205, IV-E-206, IV-E-207).

MacDonald has observed the differences in construction and holding methods. I am sure that a study of artifacts produced by these tools would show differences in the methods of flake removal. Different type of pressure tools and different methods of holding will produce identifiable surface characterstics that may be traced in time and space.

Leather hide or skins are very useful in the stoneworking industries, for they provide a means of protecting the worker's hands. A protective material is most necessary for the left hand when one is doing hand-held pressure work. My favorite pad for the left hand is made from a piece of leather cut from the neck area of the Plains bison. It is thick, yet soft enough to conform to the palm of the hand. Leather is cut to fit the palm of the hand and a hole is provided for the thumb (Fig. 3c). I also use leather as a dampening agent to reduce shock to the artifact. Strips of hide are used to serve the handles of the pressure tools and rawhide and sinew are used to secure the tips to the handle (Fig. 3b). Pads of leather, or hide, are also useful for protecting the limbs for both percussion and pressure work.

SHOULDER CRUTCH

The shoulder crutch is used for pressure retouching and for the removal of small bladelets from cores. The crutch is of wood and designed with a cross piece to rest against the shoulder with staff about 14" to 18" long (Fig. 2d). A suitable pressure tip is attached to the distal end of this staff. The length may be variable, to suit the comfort and size of the individual worker. Use of the crutch allows the flaker to exert the greatest amount of pressure when hand holding an artifact. It enables the worker to take advantage of the leverage between the shoulders and the knees. This, in combination with using the muscles of the legs and thighs in opposition to the back and shoulders, creates many times the amount of force that can be obtained with a simple hand-held pressure tool. This method allows the amount of applied force to exceed the weight of the worker. To measure the amount of force, I have placed a small bathroom scale between my knees and put the tip of the crutch on the scales and the crosspiece of the crutch against my chest or shoulder. I was able to exert a force of 300 pounds, yet I weigh only 165. This tool is

t useful for retouching large bifacial arti-
s by means of pressure alone.

ABRADING TOOLS

The uses of abrading and grinding ma-
als are endless. They are used to sharpen the tips of the pressure tool and for grinding the edges of artifacts for platform preparation. The bonding of the abrasive, the fineness or coarseness of the grains and their hardness make them suitable for this purpose.

Material for abrading tools can be of any substance with loosely adhering grains of sand or of volcanic tuff. The substance must be soft enough to allow the grains to loosen as the abrasive becomes dulled. This prevents the pores of the abrasive material from clogging and glazing. This is most important when grinding antler, bone, ivory, or tooth enamel.

When the pressure tool is being ground and sharpened, it is pushed, pulled, and rotated across the abrading stone, preferably a loosely cemented sandstone or volcanic tuff. This type of sharpening results in groves being orn in the abrasive stone from repeated use ig. 3e). Sometimes these functional scars e erroneously called arrowshaft smoothers; wever, from grinding, the base of the oves is usually semi-concave or an inverted it shape, whereas, arrowshaft smoothing rs are parallel the entire length of the rading stone.

Abrading tools used for platform preparation may be of a much harder material, as flint-like material does not clog the pores of the abrading stone, but only dulls the abrasive grains. As the grains become dulled, a new fresh area may be used.

After repeated use of the abrading tool, multiple parallel cross-hatching lines, or slight grooves, will appear on the surface of the tool. Sometimes they will resemble an overlap of lines such as those we are familiar with in the game "tic, tac, toe". These scars result from exposing new abrasive surfaces on the whetstone.

LEVER

The use of a lever as a pressure tool re-
ived scant mention from early observers 3., Catlin, Sellers and Torquemada) of aboriginal flintworkers. Yet, the use of levers and fulcrums must have played some part in the stoneworking industries. Since the materials from which the levers were made were not of the quality to withstand fire, or the ravages of time, there is much lack of evidence of their use. I find the use of the lever to be most important in resolving the mechanical behavior of flint-like materials. I have used this device primarily on cores to interpret the amount of force and the relationship of the downward and outward pressures for removal of blades under controlled conditions. A detailed account of my results with this device will be given in another place.

WEARING OF TOOLS

There are definite holding patterns of pressure or percussion tools which are characteristic of each technique. The manner of holding when striking or pressing will result in the contact portion of the tool becoming abraded from continued use. This contact surface portion of the tool can be diagnostic in determining the manner in which the tool was held and gives a clue to which technique was used.

The pointed (conical or bi-conical) ends of the hammerstone permit the worker to strike in a restricted area. A tool of this shape and with its identifiable scars is generally used for the removal of blades by percussion. A hammerstone with a flatter, or semi-convex surface, is generally used to remove wide flakes with a diffused bulb of percussion. The diffusion of the bulb will depend, largely, on the amount of surface contacted by the hammerstone. Should the hammerstone be used for thinning and striking as on the edge of a bifacial artifact, facets will develop on the tool from wear, for as one edge becomes worn, the hammerstone must be turned to expose new striking surfaces of the tool. Blows delivered by the hammerstone for thinning purposes are struck in a different manner than those delivered for blade or wide flake removal. Flattening of the tip of the pressure tool denotes a straight downward thrust characteristic of removing blades by pressure.

Pressure tools used for retouching an artifact will show the edge striated and abraded from the center of the tip toward the base and the tip of this tool will tend to sharpen itself from repeated use. When the pressure tool is pressed downward on the edge of an artifact, the tool develops facets and it must be repeatedly sharpened Hand-held pressure tools used for trimming flakes or turning edges will show scratches and erosion of the sides of the pressure implement The micro grooves on the tip of the pressure tool will be approximately at a right angle to the long axis of the tool

The tip of the notching pressure tool is not used, for it lacks sufficient strength to remove the material from the notch. The thin edge of the notching tool is placed against the edge of the artifact in such a manner that the tip of the tool extends above the artifact and pressure is exerted to either notch or serrate. Continued use of the notching tool will erode a concave area in the edge of the pressure tool. When the tool becomes too worn to serve any further use, the opposite edge can then be used. As the working edge of the tool becomes worn, the tip of the tool will resemble an hourglass or will have a strangled appearance.

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BIBLIOGRAPHY

Crabtree, Don E.

1966 [Notes on Experiments in Flintknapping :2] A Stoneworker's Approach to Analyzing and Replicating the Lindenmeier Folsom. **Tebiwa 9:1: 3-39.**

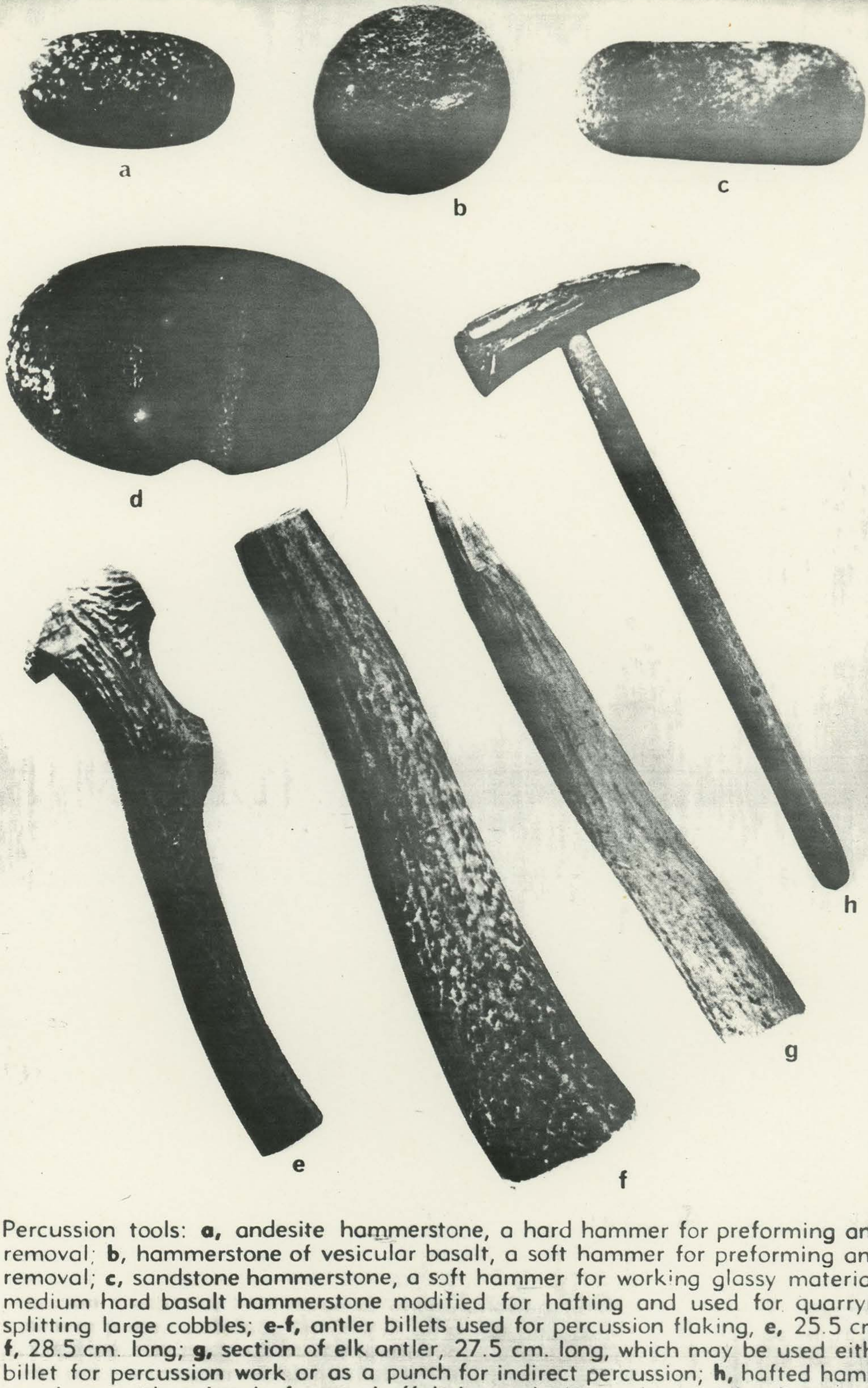

Fig. 1 Percussion tools: **a,** andesite hammerstone, a hard hammer for preforming and blade removal; **b,** hammerstone of vesicular basalt, a soft hammer for preforming and blade removal; **c,** sandstone hammerstone, a soft hammer for working glassy materials; **d,** a medium hard basalt hammerstone modified for hafting and used for quarrying and splitting large cobbles; **e-f,** antler billets used for percussion flaking, **e,** 25.5 cm. long; **f,** 28.5 cm. long; **g,** section of elk antler, 27.5 cm. long, which may be used either as a billet for percussion work or as a punch for indirect percussion; **h,** hafted hammer, 30 cm. long, with a head of water-buffalo horn which may be used for direct or indirect percussion.

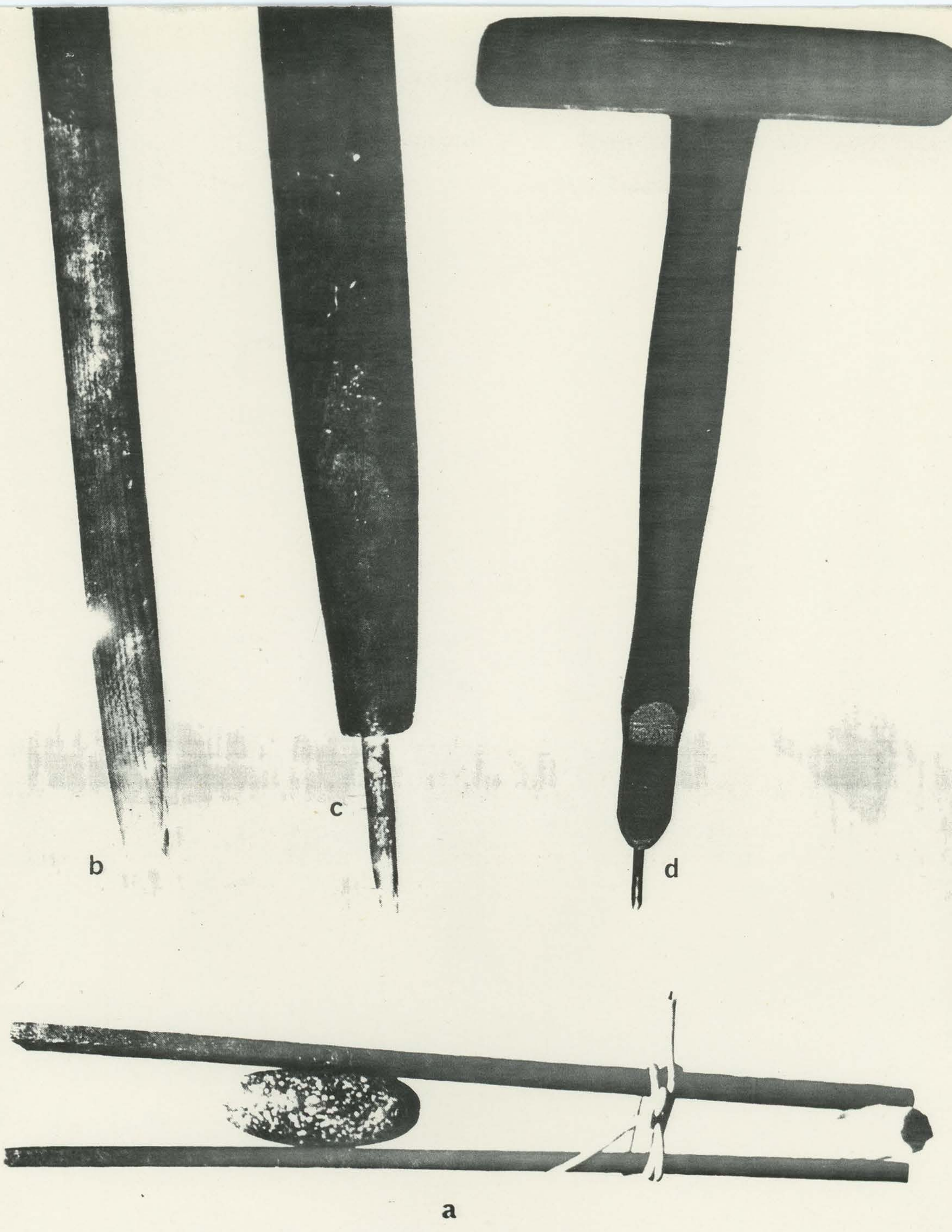

Fig. 2 **a,** clamp used for holding cores when removing flakes and blades by indirect percussion or pressure; **b,** wood haft with an antler tip, 38.1 cm. long; **c,** wood haft with a copper tip, 29.5 cm. long. both **b** and **c** may be used as pressure tools or as punches for indirect percussion, **d,** short crutch with crosspiece and copper tip, 40.2 cm. long, used for pressure retouching or for removing blades by pressure.

Fig. 3 Pressure tools: **a,** elk antler insert, 9.5 cm. long, may be hafted or used as is for pressure or indirect percussion; **b,** Arctic style pressure tool, slotted antler with bone insert, 19.4 cm. long; **c,** leather pad for hand protection when doing certain types of pressure flaking, 17.3 cm. long; **d,** awl handle with copper tip, 15.5 cm. long; **e,** an abrading stone used to prepare tips of pressure tools; **f,** elk antler tine, 12.2 cm. long; **g,** a baculum used as a pressure tool, 14.8 cm. long; **h,** pressure tool made with a piece of long bone, 16.3 cm. long, **i,** splint bone used as a pressure tool, 11.1 cm. long; **j,** pressure tool made of heavy marine shell, 10.2 cm. long.