TOOLS USED FOR MAKING FLAKED STONE ARTIFACTS

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 materials from which tools and artifacts are made, ~~and the implements used to secure the raw material~~, can have much meaning when interpreting the functional scars and wear patterns of the tool and resolving the various techniques and stages of manufacture of artifacts.

The quarrying and mining of raw material for artifacts is a very exacting and hazardous job, for much strength is needed to ~~pry loose~~ Break & dislodge large blocks of stone and the worker is subjected to ~~pieces~~ The hazards of sharp stone flying thru the air and striking and cutting him. The stone must be removed in large enough blocks to produce artifacts of adequate size and, further, it must not be subjected to battering and bruising by indiscriminate pounding during mining. Cracked, bruised and weakened stone is not useable for the manufacture of artifacts and most quarries give mute evidence of poorly mined and rejected material.

Each source and occurance of raw material involves different sets of problems; the more massive the stone - the more difficult to remove the raw material. Should the raw material be found on the surface, the problem of mining or quarrying was eliminated. But, if the stone was found in situ, then an assemblage of tools had to be designed to mine the raw material before it could be worked into useful artifacts. The quarrying, mining, quartering, blanking and rudimentary preforming was done, generally, by the use of hammerstones. Wood, antler, bone or stone picks, wedges and scrapers could 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 and, after several hours of strenous labor, succeeded only in removing one or two usuable pieces of stone. This has convinced me of the tremendous amount of force and ingenuity necessary to detach large flakes or pieces of useable material for the making of artifacts. Itis also hazardous, for when mining in this fashion, the worker must either strike toward himself, or sideways, and, therefore, it is difficult to avoid being struck by flying flakes and thereby receiving a severe wound. Yet I have examined some of the large quarrying flakes removed by the aboriginal and found some of them to be as large as twelve to fourteen inches long, six to ten inches across and an inch and a half in thickness.

Removing flakes of this size would necessitate the use of a hammerstone of considerable weight and of very tough material with resistance to shock and it would have to be wielded with more velocity than could be obtained by just holding the hammerstone in the hands. The mechanical problems involved in breaking over a hundred square inches of flint-like material could not be overcome by just using a hand-held hammerstone for the mining implement. It is possible that the aboriginal employed the use of three or four men and that they attached thongs to their weighty hammerstones and used them in a manner similar to that which the Eskimo uses for tossing persons on a blanket.

One can generally determine the manner in which the percussion tool was held by the type of scars on the hammerstone. Hafted hammerstones ~~that have seen much use~~ will, generally, show a groove in the mid-section, however, some hafted hammerstones do not show this groove. A hammerstone that has been hafted will show scars on just one ~~end~~ - or ~~they can be on~~ both ends - but they will have this definite and restricted pattern. Unhafted, hand-held hammerstones may be identified by the absence of grooves in the midsection and the irregular pattern of scars on all parts of the tool. This is theresult of the worker changing the position of the tool in his hand. The crumbling and abraiding of the hammerstone will indicate the manner in which it was held and also the direction in which it was propelled. The techniques of using the hammerstone will be described fully under the coverage of the core method.

It seems logical that quarrying was confined to those who were physically able and ~~very~~ were skilled in mining and then, no doubt, the raw material was passed to other specialists to be finished in a series of stages until the artifacts were finally completed. The aboriginals' skill in removing raw lithic material from ledges and blanket veins in great quantities with only the aid of simple mining tools is, indeed, a tribute to his ingenuity.

The study of quarry sites, the mining tools and the techniques of removal should be of much interest to the researcher, as it involves more problems than just the levering out of boulders or nodules. It is, indeed, unfortunate that a cross-section of the debris and debitage of a quarry hasn't the stratigraphy of that found in an occupation site. The act of quarrying and preforming causes a mingeling of the rejected and broken tools, unfit materials, waste flakes and the flakes from several stages of artifact manufacture. To be able to draw definite conclusions of the process of mining and artifact fabrication, a detailed study must be made not only of the flakes, but also of the tools used. Certain flakes have characteristics that can only be made by special percussion implements and, therefore, the flakes can be related to the tool. In my own, as well as the aboriginal's workshop sites, one can, at random, pick out flakes and relate them to certain percussion tools and certain techniques.

To date, I have not made a detailed study of quarry sites, but only surface examination. Large quarry sites are not numerous in the Americas, for large sources of material are comparatively rare. Some of the sites I have surface surveyed are: the obsidian deposits of central Oregon, the Flintridge, Ohio site, the Wyandott cave and Harrison County, Indiana flint deposits, the Madison, Montana and Yellowstone River, the

Spanish Diggins in Wyoming and a very large site of chalcedonic material in Northern Nevada; as well as numerous small sites in the Western United States and Mexico. These sites demonstrate the use of many different technological methods, as well as the use of many different percussion tool types - from the very rudimentary to the more refined. I have never found any but stone tools on the surface at a quarry, but an excavation might prove there were other types - such as those made of antler, wood, bone and, perhaps in the North, ivory. Tool types noted were: oviate, discoidal, lenticular, cylinderical, spherical, conical, biconical and they come in a range of sizes. These various hammerstone types are designed to fit a certain phase in the making of an artifact, or to suit a certain type of mining operation. Their shape is governed by the manner in which they were held and the specific type of work they were to do. The oviate, spherical, conical or biconical tools were able to impart the blow to the material and restrict the force to a confined area. The degree of curvature or convexity of the surface of these percussion tools will place the force of the blow on a limited and predetermined area. A percussion tool with either a convex or pointed working surface, will result in the making of a well-defined cone or a partial cone.

~~of a 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 artifact, will have, at its proximal end, a remnant of the cone. The flattened apex of the cone will denote the area contacted by the percussor. A fine definition of the cone will indicate that a hard hammerstone was used. If the percussor was a soft hammer, it will contact more surface area and will conform with the surface being struck and will result in a diffused bulb of force without a defined cone.

Discoidal and lenticular types of percussion tools are used on both cores and artifacts for striking a confined area such as prepared platforms, and they are held in a different manner and provide a different functional need. Holding is between the thumb and fingers, such as one would hold a saucer edgewise. The striking surface of the hammerstone is around the entire perimeter and it is rotated to insure an even, uniform surface on the leading edge. A percussion tool of this type allows the worker to concentrate the force of the blow on a predetermined constricted area. Due to this concentration of force, the platform is preparedby abrasion, or grinding, so it will withstand, without crushing, 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 at quarries very simple forms of scrapers and they are usually made on wide flakes of material pertinent to the quarry. Their function may have been the removal of soil from the overburden and to expose crevices and cracks to assist in the mining operation. ~~Also~~ Occasionally found are abraiding stones used to remove the overhang for platform preparation, but these are more commonly found some distance from the quarry where the stone was carried to receive the more refined techniques of finishing the artifact.

Stone hammers were the chief tool used to mine the flintlike material. But, selection of a hammerstone was not accomplished by indiscriminately picking up the first cobble or rounded boulder that was available, as the broken and utalized 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 that of an avocado to as much as twelve and fourteen inches in diameter and then weighed from one and a half to as much as twenty or thirty pounds. For toolmaking, they vary from the size of a walnut to about that of a pear. For blade making they are of various sizes; from the very small for micro-blade removal to the very large for detaching bigger flakes. Hammerstones is compatiable in size to the dimèntions of the flake being removed. Percussion tools are of both hard and soft stone, depending on what particular type of work is to be accomplished. Selection must include size and material to suit each function. Normally, hammerstones are selected from waterworn boulders or cobbles - 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.

= Requisites of the hammerstone are: proper size, tenacity or toughness of material, correct hardness or softness(hard stone, soft stone, antler, horn, bone, wood, ivory)

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-section of the artifact. Examination of some of the very thin bifacial artifacts reveal that the flake scars are many times greater than the cross-section area, 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 being 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 both 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.

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, after repeated use, some hard hammerstones will become softened until they have the same qualities of a soft hammerstone.

It is important that the percussion tool be of a material other than one that has the vitreous qualities of flint for, upon impact, the flakes from the hammerstone will be projected toward the user causing cuts and injury. However, when no other material was available, hammerstones of flint-like materials were used. Flintlike 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, making it almost impossible to avoid shattering of the artifact or raw material. Also, a hammerstone of like material will break just as easily as the raw material, or the artifact, and, if it is hand-held or unhafted, there is a possibility of the hammerstone collapsing and causing 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. However, occasionally, they madeuse of the dinasour 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 the artifact. 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 reached completion. Many artifacts were finished by the use of the hammerstone alone. It is difficult to define all of the methods, techniques, types of percussion tools, degrees of skill of the toolmakers and the multitude of artifact types without having a specific quarry site and making an intensive analysis and appraisal from a controlled excavation.

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 caribu, 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. 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 and the tines are excellant for doing pressure techniques.

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 caribu has a thinner but tougher exterior than either the elk, reindeer or deer. The tough exterior of the caribu antler makes it ideal to use as billets 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 are very heavy, enabling the worker to remove large blades from a core.

Don: Give something on Elk antler.

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 hammer-stone; 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 than the billet and are heavier. 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 provide inertia for the artifact. Blow must not be directed towards the face of the stone anvil and through the lithic material, for the blow will be opposed by the anvil and the opposing forces will either cause shattering or will induce strains in the material, thereby rendering it worthless. The blow must be applied in such 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 opposition. 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 using this technique, 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 without being unduly harsh. The aboriginals 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 found in the quarry.

By using a hammerstone, these blocks, nodules, or masses of material are then formed into blanks, later to be made into preforms and ultimately finished into artifacts. The hammerstone is used to pare all of the undesirable material such as cortex, inclusions, vugs and improper texture from the blank. The blank is now oviate or 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 evidence, however, that large bifacial artifacts were made at the quarry.

Billets

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 Dr. R.A. Stirton, I was doing some paleontological reconisance 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 Piutes 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. Upon inquiry, 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 and was delighted with the results. Prior to this, I had always used the hand-held hammer-stone 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 difused bulb of force. The billet struck flakes had much the same character as those of the aboriginals. 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.

<u>Indirect Percussion</u>

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. 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. The percussor may be a rod, billet, club of wood, or hafted stone hammer. The anvil or support may be of materials with sufficient resillency to support the artifact without causing shock. Indirect percussion may be accomplished with or without the use of the anvil, however, when the anvil is used, a flater flake is produced.

When working with the indirect percussion method, holding devises suffice as a poor substitute for a second person. Since holding devises were, no doubt, made of wood and lashings, no records remain except the information given by the early writers and observers. There are many designs for clamps, vises and securing mediums and they are limited only by the individuals ingenuity.

The use of the indirect percussion method by the aboriginal concerns the writer because of the apparent lack of evidence of the intermediate tools. My experiments demonstrate 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 are the tools shown to me by Dr. Luther R. 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 cylinderical in shape. The perimeter of one end showed functional scars which indicated that the hard outer surface of the 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. Further study of workshop areas should provide additional information on the use of indirect percussion tools.

The indirect percussion method allows the worker to place the intermediate tool on the core or artifact with extreme accuracy, and it permits striking with greater precision than when using the direct percussion method. 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. This technique also terminates the flakes at the distal end without margin - or what is commonly called "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 2nd person strikes a projection on the crutch, it then becomes an intermediate tool. Tip of the crutch is placed on the core, or artifact, and the first person applies pressure with his chest to the crutch, while the second person simultaneously strikes the projection at 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 use. The chest crutch has proven satisfactory for removing the channel, or fluting, flakes from the Lindenmeier type Folsom.

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 2nd person against two wooden pegs driven into a log; or he may hold ~~by two~~ 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 while the 1st person removes a flake ~~to remove a flake~~. When using stakes, 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. But, because this technique requires ~~required~~ two persons and I have had no one avialable 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 this same method, but substituting for the second person, a suitable clamp or holding device.

The materials ~~tips~~ of the indirect percussion tool are very important for successful flaking. Tips must be of a material that will withstand the shock delivered by the percussion tool, for the tip of the tool has a tendancy 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~~

The use of stone for an intermediate tool has both advantages and disadvantages. The stone selected must have the qualities of toughness 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 the experimenter's hands.

The use of bone, either hafted or unhafted, for an intermediate tool has not proven very satisfactory, for it splinters and breaks when subjected to shock from the percussion implement.

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

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.

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 and restricted to a small group of aboriginals and did not play a large part in stoneworking.

PRESSURE TOOLS

Pressure tools are used to apply force to the perimeter of an artifact to detach, with accuracy and precision, flakes from the surface and, ultimately, design a functional tool. The percussion method does 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 and 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. 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 ename, 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 materials were 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 re-designed to overcome the tool inadequacy and this results in a distinctive flake scar. For successful flaking, the worker must be familiar with the properties of the material of which the pressure tool is made.

Antler is one of the best materials for making tools for pressure work. 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, the diet of the animal the rateof 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 and fibrous nature, has the ability to resist abrasion, yet it is soft enough to prohibit crushing the edges; thereby, allowing the platform and the flake to be removed together, leaving an edge on the artifact that is razor sharp.

Bone pressure tools are normally more brittle than those of antler. Bone from different animals, birds, reptiles and fish has 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 resort to the use of the limb bones. 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 abraided the tip of the pressure tool becomes, the more firmly it may be seated on the platform without slipping. Bones found with polished tips, no doubt, served a functional purpose - other than just as flaking tools. 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 and by abraiding the distal ends slightly, they make good pressure tools for light retouch. The penis bones of certain carnivors, such as wolf, bear, seal, etc. are even better than the splints of the horse, as they have a greater diameter and, initially, require little or no reshaping. The long bones of mammals should be cut longitudionally - either by scoring deeply and splitting, or by sawing.

Cannot bones can sometimes be split by repeatedly applying a chisel the full length of the bone on the backside and then tapping it with a hammer until it parts. 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 animals such as the elephant, walrus, hippopotamus, mammoth, and the narwhale. 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 has elasticity, it is fine grained, and will withstand abrasion. Also, it is stronger than bone and not as brittle. The best grade of ivory for pressure tools seems to be thatfrom 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 thetusk. It is also interesting to note that mature adults provide the bestivory. Ivory from the Hippo is ideal for the tip of the chest crutch - such as thatused 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 animal oils.

The use of mammoth ivory for my stone working 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 thatof the recent elephant. Possibly this is due to dehydration and a loss of animal oils. To date, I have not had an opportunity to experiment with the tusk of the Narwhale 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 Hopwellians and the Meso-americans. The limited supply prevented, no doubt, 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 amount of experiments that can be done in an alloted time. Time and uniformity of tools areimportant factors in conducting experiments. Since the metal produces the same results as the antler tine, it is substituted merely as atime-saver. I have conducted sufficient experiments over the years using every conceivable tool material to prove the parallel results of each and the mechanics of working the stone remain the same when sub=stituting copper for the tip.

I use metal for my experiments for it is a time-saver and because of its homogenity, availability and many forms. However, among the metals, I do have a preference. Hard drawn copper has the qualities which are so necessary for making pressure tools that are not found in other metals. The degree of softness of copper closely resembles that of antler or ivory. This is important, for it allows the flinty material to slightly imbed itself in the copper without slipping. This permits the flaker to remove an edge without crushing and still leave it sharp. When placed on a platform, the copper tip will let the worker apply both inwardand downward pressure without slipping and crushing the edge. Copper pressure tools areeasily sharpened, they resist slipping, and they have sufficient tensil strength for most experiments.

Soft iron and bronze are also satisfactory, but brass and aluminum - known to engravers as adry metal - are much too slick. They are mentioned here only because they have been tested in my experiments but I doubt they were ever used by the aboriginal. Tools made of bronz, brass and aluminum have a tendency to slip. Engravers are well awareof this trait in these metals and call them dry metals because they allow the engraving tool to slip. The same slipping occurs when they are used as tips for pressure tools.

Iron may beused for pressure tools if it is soft or has been slightly annealed. Cast iron and steel are too hard to allow the stone to slightly imbed in the tool and, therefore, the result is slipping and crushing of the edgeof the artifact.

Certain seed pods such as cocoanut, black walnut and possibly others of a hard durable shell, can be used for pressure flaking. The cocoanut shell is preferred. Comparedto most woods, it lacks the fiberous nature ordinarilly found in wood.

Hard wood is very useful as a percussion tool. However, when used for pressure work, it rapidly loses its shape and becomes fiberous and soft. For pressure work, it lacks the strength and qualities found in other more desirable materials. 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 imbed in the wood without removing a flake. I have not had access to some of the more exotic woods for my experiments but many varieties may have the qualities necessary for pressure work.

Shells of mollusks, both fresh and salt water varieties of bivalves and univalves can be used for both percussion and pressure tools. Because shell is composed of calcium carbonate and albumen, it has both the hardness and texture necessary for the retouch work of pressing off flakes. However, shell must be selected from the varieties that are of the correct shape, thickness and form. Composition of shell is variable and the denser varieties are to be preferred.

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 - which was previously explained. The useable part of the tooth is the enamel. The teeth of most mammals are classified as incisors, canines and grinders, but there is a vast difference in structure and size, depending largely upon the food and habits of the animals.

Incisors of some rodents may be used for pressure work, particularly for fine retouching, serrating and notching. The teeth of beaver, marmots and other members of the rodent family are well suited for this type of pressure tool. The canines of the many carnivors provide an array of sizes that may be used for assorted pressure tools. The sides of molars from the large varieties of ruminats 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 it is preferred 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 pressure tool for applying pressure to the edge ~~of the artifac~~t to resharpen the 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 type of flake scars. They are usually overlapping and of assorted dimentions. 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 flintlike materials and a variety of pebbles of assorted composition.

Pressure tools range from the very simple to the more complex. The simplest known tools would seem to be the pebble tools used in Australia and described by Norman Tinsdale ( ). He has observed the bushmen using their teeth to sharpen the stone knives for use in the circumsision rites. I also, have found tooth enamel to be a very satisfactory medium for pressure flaking and have often used the exterior plates of enamel as a notching tool in the making of projectiles. Tinsdale also refers to the use of pebbles for removing pressure flakes by means of hand-holding the pebble and rolling or pressing it on the edge of the artifact. I have experimented with 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 replacable bits. The bits serve a dual purpose - one end for shaping and edging, the other for notching. Meldgaard has found the bits,or pressure tips, to be made of iron, bronz, 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 correspondence) "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."

MacDonald has observedthe differences in construction and holding methods and I am sure from a study of the artifact produced by these tools that a difference of techniques of flake removal could be discerned. Different types of pressure tools and different methods of holding will produce identifiable surface character results 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 protection to 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 froma piece of leather cut from the neck area of the plains' Bison. It is thick, yet soft enough to conform with the palm of the hand. Leather is cut to fit the palm of the hand and a hole is provided for the thumb.
I also use leather as a dampening agent and for reducing shock to the artifact.

Strips of hide areused to serve the handles of the pressure tools and rawhide and sinew are used to secure the tips on tools.

Pads of leather, or hide, are most 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 bladeletts 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 attached. 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 with 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 ~~applied~~ to exceed the weight of the worker. To measure the relation of 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 cross-piece 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 most useful for retouching large bifacial artifacts by means of pressure alone.

Abraiding tools:

The use of abraiding and grinding materials ~~are~~ is 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 functional purpose.

Material for abraiding tools can be of any substance with loosely adhering grains of sand or of compacted volcanic tuff. The substance must be soft enough to allow the grains to loosen as the abrasive becomes dulled, which 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 abraiding stone - preferably a loosely cemented sandstone or a cemented or compacted volcanic tuff. This type of sharpening results in grooves being worn in the abrasive stone from repeated use. Sometimes these functional scars are erroneously called arrowshaft smoothers; however, from grinding, the base of the grooves is usually semi-concave or an inverted boat shape - whereas, arrowshaft smoothing scars are parallel the entire length of the abraiding stone.

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

After repeated use of the abraiding 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.

A brochure of abrasive products will list endless types and kinds of abrasives ~~products~~, each designed to abraid specific materials. For my experiments I, too, have used many kinds of natural abrasive rocks for grinding and polishing purposes, depending on their availability. In the Western United States there is an abundance of volcanic rocks and one of the favorite materials of the aboriginals for repointing antler and bone tools was a compacted volcanic tuff; while in the Eastern United States varieties of sandstone were used.

Lever

The use of the lever as a pressure tool has received scant mention by the early observers 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 primarly 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 fully covered under "laboratory experiments".

Wearing of Tools

There are definite holding patterns of pressure or percussion tools which are characteristic and compatiable with each technique. Manner of holding when striking or pressing will result in the contact portion of the tool becoming abraided 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 diffusedbulb 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 is 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 thick flake removal. Flattening of the tip of the pressure tool denotes a straight downward thrust characteristic to removing blades by pressure.

Pressure tools used for retouching an artifact will show the edge striated and abraided from the center of the tip toward the base and the tip of this tool will tend to sharpen itself from the repeated use. When the pressure tool is pressed downward on the edge of the artifact, it will develop 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 errode 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 edgeof the tool becomes worn, the tip of the tool will resemble an hourglass or will have a strangled appearance.

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