TECHNOLOGY OF STONE TOOLS

A study of lithic technology reveals the progress of primitive man for approximately 2,000,000 years of making and using tools and weapons of stone, wood, and bone, which is a predominance of approximately 99.5% of human history. But artifacts made of organic materials are generally perishable and the most enduring identifiable tools of prehistoric man are those made of stone.

The earliest man can be identified as human as much by association with stone tools as by his anatomy. For this reason, the techniques of making stone tools are of great importance in the study of human origins and dispersals. Flake scars on the artifacts are the result of various flintknapping techniques and consequently furnish evidence and diagnostic characteristics of at least the last stage of manufacture. Further, a microscopic study of functional scars on the edges can give some basis for theoretical functional analysis. Reducing the initial mass of lithic material to the finished product requires many stages of manufacture, discarding waste flakes during the process. These debitage flakes are usually more diagnostic than flake scars for their size, thickness, shape and degree of curvature can reveal several manufacturing steps. They can indicate the technique for they retain the bulb of applied force (platform area), show the method of platform preparation and innumerable other characteristics which indicate the technique. For this reason, a careful study of the flaking debris is a prime requisite in determining the manufacturing technique.

Flintknapping is one of the earliest industrial arts of man - a process of man's ability to induce and control the fracture of stone to form functional implements. The pebble or cobble culture of Olduvai is the oldest known form of working stone by a simple percussion technique of detaching one or more flakes from a cobble to leave a sharp cutting edge. Certainly man's first attempt at flintknapping was elementary, but as cultures developed in the stone age we see the progress of new and more sophisticated tool types evolve which required new flaking techniques.

Prehistoric lithic technology is the science of systematic knowledge of forming stone into useful cutting, chopping and other functional implements. But lithic technology comprises two factors - the method and the technique. The method is in the mind; the technique in the hands.

Method is the logical manner of systematic and orderly flaking process, or the preconceived plan of chipping action based on rules, mechanics, order and procedure. Method verifies historians' theories that flintknapping was not a haphazard art but, rather, a carefully planned process of making stone tools to suit a specific functional purpose. The shape, length, width, thickness, form and technique of applied force to fashion the tool was predetermined by the toolmaker before the initial fracture of the raw material. He also determined what tools he would use in the process before the initial break of the lithic material.

The technique represents the application of the method by the worker with a suitable fabricator to form the stone into his mental conception; each technique producing distinct flaking character and technological attributes. Manner is part of the technique and is the mode or characteristic style of preparation and application of forces to form the artifact by a definite method. Manner is the determined angle and application of force - whether percussion by the straight line or curved blow, pressure by pressing or snapping, indirect force by percussion or pressure, etc. Technique is the ultimate result of the method applied in a predetermined manner.

A single technique is the simple basic principle of detaching by percussion, or pressure a sharp usable flake. But each of these manners of delivering force vary with the intention and tool type and consequently we have multiple techniques. Technique variables can also be modified to suit the material, intention or the fabricator.

If the pattern of applied force is consistently repeated, then a more sophisticated tool can be formed by reducing the mass to the desired functional form. The freshly detached flakes serve adequately as cutting implements and if they show functional scars they are utilized flakes. Most techniques are complex. Blademaking, per se, whether by percussion, pressure or indirect percussion is not a single technique. But blades made by simulated conditions, represented by a variety of platform preparation, degrees, kinds and angles of force, use of rests or anvils, variations of rhythms and muscular motor habits, and use of diversified fabrication tools represent varieties of blademaking techniques.

A complex technique is a combination of multiple individual techniques. For example - the Folsom point merges a percussion technique for preforming, a pressure technique for forming and the fluting technique for detaching the channel flakes (Crabtree 1966). Other methods combine percussion, indirect percussion and pressure to form more sophisticated tools. Most tool types are the end result of a method of independently applying forces in alternate degrees, ways, and at varying angles from the initial to the final stage of fabrication.

A study of technology is pertinent to typology, for careful analysis of the various stages of the manufacturing process can give clues to the technique and the functional need. Technological evaluation is based, in part, on understanding the muscular motor habits and rhythmic removal of flakes. After the rough material has been reduced to a stage where the worker can repetitiously remove a series of flakes from the margin, the mind, eye and muscular responses often develop a rhythmic and subconscious reaction to applying the force. Experience and habit eventually cause the worker's muscles to respond subconsciously to induced forces. The hand holding the piece being worked subconsciously moves or rolls to counteract the force applied by the percussor or compressor. As a result, the subconscious response of maneuvering and manipulation, the holding hand generally becomes more fatigued than the hand applying the force. The direction and amount of force needed to detach a flake of a given dimension becomes intuitive when the worker becomes familiar with the components of the lithic material, can relate the size and weight of the fabricator, and expertly apply the technique.

The finished artifact usually reveals only the final series of flakes so the modern typologist generally relies primarily on theory and morphology to define the technique. Typology based solely on morphology implies function - such as scrapers, wedges, awls, borers, burins, etc. -" but tells or verifies nothing of the living habits of the group. Morphology is certainly a part of the method and technique but the technology must be defined to verify the types which emerge from industries. Artifacts may be identical morphologically, but made by entirely different techniques.

There is nothing as potent as experiment for verifying lithic techniques. It allows the worker to record all the stages of manufacture, to study the characteristics of the debitage flakes, and to prove or disprove the theory. The analyst can best verify his theories by experiment. He need not become proficient at flintknapping but even a try will familiarize him with the mechanical and physical problems involved in the manufacture, and emphasize the importance of preparation and the correct angle and proper application of the required amount of force. Different tool types with like characteristics are pertinent to individual assemblages so even the experiment remains empirical until the worker has produced an exact replica of the aboriginal artifact. Experiment is the end result of hypothesis based on theory but now supported by fact even though, in this instance, the aboriginal approach may parallel or vary slightly.

The important factor of both analysis and experiment is to consider the traits of each stage of manufacture and evaluate the technical methods of the work from start to finish. Many techniques have been replicated by the stoneknapping experiments of François Bordes, Jacques Tixier, L. S. B. Leakey, Alfred S. Barnes, Leon Coutier, Francis H. W. Knowles, D. F. W. Baden-Powell, Kenneth Oakley and Don Crabtree. Their experiments have defined the intentional from the miscalculation, the novice work, the rejuvenation, the importance of preparation of cores and preforms, grinding and polishing of platforms and edges, the aboriginal use of thermal alteration of lithic materials, the value of debitage analysis, the amount and angles of applied force, the significance of the correct percussor or compressor, the subtle blending of techniques, and many more factors which are technological features.

Limited space prohibits the analysis and classification of the hundreds of prehistoric lithic techniques and their variable attributes which make up the stone age. Complete coverage of individual techniques and their pertinent characteristics would fill volumes. Descriptive details would have to be given of each experiment and then related and compared to aboriginal work with the text profusely illustrated. Therefore, descriptions will be condensed to a dictionary version of the basic techniques of percussion, pressure and some indirect percussion.

MATERIALS

The first concern of the toolmaker is obtaining good lithic materials (Crabtree 1967a). The shape and functional performance of the tool is governed by the quality of the material and the skill of the worker. Flint, fine-grained basalt, chert, chalcedony, jasper and the volcanic glasses were widely used aboriginally for they are solids having the properties of a heavy liquid. All have the necessary qualities of elasticity, homogeneity; are cryptocrystalline, isotropic and highly siliceous. Homogeneity allows the worker to fracture the stone in any direction. The material must also be free of flaws, cracks and inclusions; otherwise it would break prematurely or cause step and hinge fractures.

Technology of Stone Tools

Coarse-grained rock will not fracture smoothly but tends to crumble from the applied force. Other materials such as feldspar and slate will fracture only along certain lines and cannot be controlled by the worker. The quality of material has a direct relationship to the applied technique and determines superior or inferior workmanship. Of course, there is always the human factor of finding good work on poor material and poor work on good material, which denotes the skill of the worker.

Flint was widely used and made almost indestructible tools, but when obsidian was available it seemed to be preferred by stone age man. Undoubtedly this is because it is a volcanic glass and leaves an extremely sharp cutting edge. But when obsidian is used, the percussor must be different from that used for harder materials, and the blows lessened or dampened. For digging, boring or scraping tools the worker preferred a tougher material and was not so much concerned with the sharp edge. Stone age man was very selective about his raw material, for his very survival depended on his knowledge of suitable stone for implements of specific function. Certain groups ranged in areas where there was a scarcity or lack of good material and, in this case, they had to make do with what they had. Very often the analyst will refer to work as "crude" whereas the material is poor and only superior skill would permit flaking. So the word "crude" should be qualified according to the material.

Technology of Stone Tools

Many lithic minerals can be improved for flaking by the aboriginal method of thermal alteration (Crabtree and Butler 1964) which recent archaeological evidence indicates is contemporaneous with the advent of pressure flaking. The stone is buried in sand and slowly heated to moderate temperatures of from 400° to 900° F., depending on the type of material. Then it is left to cool undisturbed for at least twelve hours. This process relieves stresses and strains in the stone and it becomes more elastic without becoming brittle. The alteration makes the stone more vitreous and the worker can make tools with more precision and with much sharper edges. Each material responds differently to heating and one must become familiar with the stone being altered to determine the temperature and alloted time of heating and cooling. The alteration time period depends on the size of the piece being heated--larger pieces requiring more time than flakes. The workability of natural glassy materials, like quartz crystal and obsidian, are improved by heating, but the texture changes are not as noticeable as treated siliceous rocks. Some materials do not require alteration for they respond very well to pressure flaking in their natural state. It is not necessary to treat materials to accomplish pressure work, but the alteration improves the material. It requires less energy to induce fracture, and the worker has greater control over flake removal. When toughness is a prime factor such as that required for diggers, choppers, awls, borers, scrapers, etc. then untreated siliceous material is desirable.

After heating, the natural surface retains its original texture and only the inside part under the cortex will show the change. This makes it difficult to determine alteration on finished tools that have had all the surface removed in the final stage of flaking. But if a facet of the original surface remains on a thermal-treated artifact, the change can be easily noted. Heating also often causes color changes in the material--yellows changing to red and other natural colors altering accordingly. Alteration can be verified on aboriginal flakes if the dorsal side of the flake is coarse-textured and the ventral side is glassy.

THE CONE PRINCIPLE

When a flake is detached from the parent mass, it forms a cone or a part of a cone. The flake is the positive cone part and the scar is the negative cone part. This principle works in much the same way as the cone formed on plate glass when shot with a BB gun. When the pellet strikes the pane at right angles to the flat surface, the force radiates outward in widening circles at an angle tangential to the direction of impact and finally the force exceeds the elastic limit of the glass and a cone is removed from the opposite side of the point of applied force. If the energy of the pellet is insufficient and the force is dissipated, the cone will penetrate only part way--or not at all--and only a cone part will form. If the velocity of the pellet is too great, then the cone will shatter.

The ideal whole cone is formed by percussion--having the ratio of the size, weight and hardness of the projectile proportionate to the force and velocity of the blow. Detachment of a complete cone is generally by percussion and usually used only for perforation. Removal of cone parts is synonymous with both percussion and pressure flaking. When using the pecking technique, the worker removes half cones, quarter cones, overlapping and intersecting cones, or leaves the cone intact with the parent mass.

Flakes are cone parts and the fracture angle of the cone is the ventral side of the flake. The apex of the cone (proximal end of the flake) where the force is applied is called the platform part. Examination of the platform angle and the fracture angle of the cone will determine the direction of applied force. Because of the amorphous nature of most raw material, the worker must constantly calculate the fracture angle of the cone to determine the direction of applied force in order to remove flakes at an angle different from the direction of force by the percussor or compressor. Both the position of the material being worked and the direction of the applied force are constantly changing in the initial stages of manufacture. This enables the worker to select the platform area and determine the correct angle of applied force.

Cone splitting is an exception to the rule of using the fracture angle of the cone. The cone is split by supporting the working piece, thereby setting up opposing forces and causing the cone to shear. In this case, the fracture is quite flat and the positive and negative surfaces have little or no bulbs of force.

FLAKING IMPLEMENTS

The forming of the artifact from the initial break of the raw material to the finished tool usually requires several stages of manufacture and the use of several different kinds of fabricators (Crabtree 1967b). Some tools are made entirely by percussion and some entirely by pressure. Others are initially started by percussion and then finished by pressure. Others are made by the punch (indirect percussion) technique. Each method requires a separate tool kit. But the compressor or percussor (fabricators) must be of material different from the stone being worked.

Quarrying material *in situ* requires a special tool kit including levers, large hammerstones, thick pick-like objects of either flint-like stone or pointed pieces of bone or antler and large broad flat scraping flakes to remove debris. If the rock is surface material the quarrying tools are unnecessary, but the stone must be tested for the necessary flaking quality. The stone is struck with a simple hammerstone to expose the inner surface to test for fine texture and homogeneity. When the blow produces a ringing sound, it denotes homogeneous material free of cracks, flaws and inclusions. If the blow emits a dull thud--then the worker knows the piece is not homogeneous.

ABRASIVES

Implements and artifacts formed first by flaking or pecking and then ground or polished are usually associated with the Neolithic period. However, abrasive materials and polishing agents are not necessarily affiliated with this period and were used early in time for platform preparation and for removing sharp edges for hafting purposes.

Abrasives serve both to weaken and strengthen the platform area. When the platform is roughly abraded, the surface is weakened, the pressure or percussion tool will not slip, and the amount of force necessary to induce fracture is reduced. If the platform part is rounded, it is strengthened which prevents its crushing, thereby insuring the complete removal of the flake or blade.

Abrasive stones were also used to sharpen the tips of pressure tools and punches. Continual use of the abrasive stone formed grooves of a distinctive pattern which are often mistaken for arrow shaft smoothers. Flakes of coarse granular stone were used as a saw to form implements of bone, antler, wood and soft stone. They were far more efficient than the edge of a vitreous flake or blade.

PERCUSSION

Percussion requires that the fabricator be large and heavy enough to induce sufficient force to exceed the elastic limits of the stone to cause fracture. Percussion tools are hafted or unhafted hammerstones of different hardness, texture and size; billets or rods of wood, antler, bone, ivory and horn; and the worker may even use an anvil for support of the working piece.

The type of hammerstone material and the technique is determined by the quality of material being worked and the stage of manufacture. The hardness or softness of the hammerstone controls the interval of contact between the percussor and the flint-like material, for the time of contact is proportionate to the yield and density of the percussor. If the hammerstone or billet is of sandstone, wood, antler or bone, then the interval of contact is prolonged. If the percussor is of flint, steel or hard wood, then the interval of contact is shortened. If the percussor is soft, it must be large and weighty and the velocity of the blow must be increased; for if the piece being worked is small and a soft percussor delivers a slow blow, the artifact will move with the applied force. The density of the percussor must correspond to the size and type of material being worked, and the applied technique. If the stone being worked is sufficiently inert, the size and weight of the percussor may be increased and the velocity of the blow decreased to the point where the applied force will almost approach pressure. A very hard percussor often will crush or shatter the flake or artifact and so is used for only a few techniques. Relatively soft percussors contact a larger area than hard percussors, causing the cone of force to have a larger truncation and the flakes to have diffused bulbs of percussion.

The wear pattern on percussors can be of diagnostic value in interpreting techniques. The position and depth of the wear pattern, striations, bruising and battering aids in reconstructing the manner in which the percussor was held, the way the blow was delivered and the probable stage of manufacture. Experiments revealed that an elongated cobble with wear pattern on one margin was actually a hammerstone used for blademaking, whereas it had previously been defined as a rubbing stone (Crabtree and Swanson 1968). Scarring can indicate whether the percussor was projected in an arc-like or straight line blow. Battering on one or both ends can indicate that the tool was used as a hammer to section large pieces of lithic material. The wear pattern on some percussors reveals that they were used for pecking rather than for flake removal.

THROWING

The simplest and probably one of the earliest methods of toolmaking was by throwing the raw material with great force against an anvil stone to break or shatter it into usable pieces with sharp edges. These flakes could be used "as is" or the edges sharpened by modification. Observers have noted this technique in recent times among the Australian aborigines (Gould and Tindale, personal communication 1969). However, it is sometimes necessary to use this method to make the first break on spherical material having no flat surface on which to apply the force. Rounded surfaces slant with the direction of the blow, so the force must impart great energy to prohibit the ricochet of the cobble or percussor. Spheroids which are broken by throwing often shatter, splinter, exfoliate or split, depending on the weight of the cobble and the velocity of the throw. Throwing generally detaches planoconvex exfoliated flakes with closely spaced compression rings but no bulbs of force. If the cone shatters, the flakes will be angular and pointed with a flat surface. When angular material is thrown, the results are unpredictable.

HAND-HELD DIRECT PERCUSSION

Using this technique, the worker holds the objective piece in the hand, or hands, and strikes it against an anvil stone. This is a hazardous method, for the flakes fly in the direction of the worker and the fingers between the anvil and the piece being struck are vulnerable. However this technique can be used to make: burins from flakes or blades; to remove ends from tranchet cleavers; to detach Levallois flakes from specially prepared cores; to remove blades from cores; and to sever elongated pieces of lithic material by holding both ends and striking the mid-section against the anvil stone. The break is flat and each half is well suited for a blade or flake core.

BI- POLAR

This technique requires placing the objective piece on an anvil stone and striking with a percussor. Small pebbles and cobbles may be fractured in this way, much the same as one would crack a nut. Force is induced from both the anvil and the percussor, causing cones of force to form at both ends of the pebble or cobble, not necessarily leaving cone scars. When the force is in direct opposition, the cones exceed the elastic limit of the material and it shatters. The debris will resemble segments of an orange.

The ideal bi-polar fracture is to form a cone at each end of the material by directing one of the forces slightly off-center which will split or shear the pebble. Shearing radiates the force waves from one end or the other, usually from the end having the least contact with the percussor or anvil. This technique seldom leaves a positive or negative bulb of force scar. But the bi-polar shearing technique leaves force wave scars at the area of least contact and the opposite end may show signs of crushing.

Archaeological texts often erroneously indicate that blades made by the bi-polar technique have bulbs of percussion at both ends. Experiments contradict this theory. Blades removed from an anvil-supported core must have the leading edge of the core's base free of contact with the anvil which prohibits a bulb at both ends. Also, the force must be directed tangentially rather than perpendicularly to the face of the core, and the detached blade will have one bulb of force at the proximal end. If the bi-polar technique is used for blademaking, the force is in direct opposition from anvil and percussor and the blade will collapse and there will not be bulbs of percussion on both ends. Cores can have blade scars on the same face and bulbar scars at both ends, but this is not true of blades. Anvil-supported cores produce flatter blades than when hand-held or placed on a yielding support. The anvil is useful in many techniques but the force is normally not applied in direct opposition to the anvil. A true bipolar technique is used to shape and to back a flake or blade. It involves detaching crushed flakes from one margin to form a right angle and blunt the edge opposite the cutting part.

DIRECT FREEHAND PERCUSSION

This is a technique of holding the objective piece in one hand and striking with a hammerstone or billet to detach flakes or blades. All of the diverse variations of this technique will probably never be known, but it prevailed during the entire stone age until metal implements were available. The technique was used to make simple tools by striking vertically to the margin of a lithic cobble with a hard hammerstone to remove rapidly expanding flakes with pronounced bulbs of force and sharp edges. If the process is continued, the worker can remove several flakes from a cobble, making a core chopping tool. If the cobble is turned after each flake is detached and the previous flake scar is used as a striking platform for the next flake removal, the worker can make a bifacial tool such as a simple pointed handax. The handax served as a multi-purpose implement--for cutting, chopping, boring, digging, etc. Clactonian implements were made with this technique and were thick and strong and able to withstand considerable abuse. Progressively through time, man improved his percussion methods and developed more diverse and sophisticated techniques of flake removal with greater control of (1) platform, (2) width, (3) length, (4) thickness, (5) curvature, and (6) termination.

(1) A platform area may be a natural or prepared flat surface to receive and withstand the applied force. The platform can be made by removing a flake or flakes, or can be prepared by abrasion, by creating the proper angle by pressure or percussion, or by removing the overhang. (2) The width of the flake or blade is controlled by the surface area of the material. Plane or flat surfaces allow the flake to spread while a ridge, or ridges, will confine the force and allow a long flake or blade to be formed if the angle and degree of force is correct. The natural or prepared angle of the ridge or degree of convexity control the width of the flake or blade. (3) Length is controlled by the surface area. If a ridge is established and continuous force applied, the flake or blade will be longer and will terminate at the end of the ridge. If the surface is plane, the flakes will spread and terminate short. Termination is controlled, in part, by the angle of the applied

force. (4) Thickness is primarily controlled by where the force is applied on the platform. Near the edge gives a thin flake or blade and away from the edge gives a thick flake or blade. However, if the platform is made strong by abrasion, the blow may be near the edge and a thick flake detached without the platform collapsing. (5) The straightness of the flake or blade depends on the inertia of the material. Large masses of stone will remain inert because of their size and weight. If the piece is small it can be supported by either a clamp or placed on an anvil. If the working piece is held loosely in the hand and rolls with the blow, the flake or blade will be curved. Another factor is the manner of the blow--an arc-like blow will cause curving while the straight line blow will produce straighter flakes and blades. (6) Termination. Flakes or blades may terminate by predetermined techniques--feathering, hinge or step fractures, or by carrying through to detach the opposite end of a core or margin of the artifact (lamés outrepassée, Tixier, 1963). The traits of flake and blade termination is the result of regularity or irregularity of the material surface and the amount and angle of force.

INDIRECT PERCUSSION

Indirect percussion is used for making and finishing tools and requires the use of a punch (indirect tool). The punch is a semi-pointed or blunt rod-like object of tenacious stone, bone, antler, horn, ivory or hard wood. The selection of the punch type depends on the quality of the material being worked, the technique and the worker's preference. The percussor imparts the force through the punch to the established platform. Indirect percussion allows the worker to accurately place the tip of the punch on the platform and maintain, with precision and control, a constant angle during the percussion. The punch technique is more accurate than direct percussion and detaches straighter and more uniform flakes and blades with small platforms (Bordes and Crabtree, 1969). However, the punch technique does present a problem of holding the preformed material. For good results, two persons are required--one to hold the stone tool or core and the other to hold the punch and deliver the blow; or the worker can hold the working piece between his feet and deliver the blows himself. He may also improvise a vise by lashing two pieces of wood together with sinew and use a stone as a wedge to hold the material inert.

For indirect percussion it is necessary to place the tip of the punch on the edge of a prepared platform of a preformed core or biface, depending on whether blades are to be made or the biface is to be thinned and made regular. The piece may be placed on an anvil of stone, bone or antler. The punch is held at an angle tangential to the proposed flake or blade scar and a blow struck with the percussor in a straight line to the punch. The percussor may be a simple hafted or unhafted hammerstone, billet of hard wood, antler or bone--the weight and size depending on how much force is needed to fracture an area of predetermined size. Characteristics of punch flakes and blades are small platforms and a standardization of size and form. A lip is often present on the ventral side at the proximal end of the flake or blade and they have less undulations than those made by direct percussion.

Another technique of indirect percussion is to place the objective piece at an angle on an anvil or a fixed punch and strike the blow on the artifact. A yielding percussor is used to eliminate bruising and to detach a flake from the part contacting the anvil or punch. A simple burin core may be made by placing the corner of a truncated flake or blade on an anvil and striking the margin of the flake with the percussor to remove a burin blade. The fixed punch can be used to notch large bifacial tools like hoes and large lanceolates. The tip of the punch is seated near the margin on the opposite face. The biface edge is placed horizontally to the vertical fixed punch and a light blow is delivered at a ninety degree angle to the exposed face of the artifact and slightly inward to the fixed punch. After each flake is removed, the biface is turned over and the operation is repeated until the notch has reached the desired depth. The resulting flakes are lunate, resembling the quarter moon.

Technology of Stone Tools

PRESSURE FLAKING

Pressure flaking tools are of many materials and are of various forms and sizes. They range from a simple elongated pebble or deer antler tine to the more complex composite tools such as the elaborate pressure tools of the Arctic carved from ivory to fit the hand and with replaceable bits. Stone pressure tools are rare. The most commonly used were of organic materials such as bone, ivory, hard wood, horn, shell and whatever materials were available (Crabtree 1970). Rodent teeth and small bits of shell were used for denticulations, notching, barbing and serrating. There are ethnographic accounts of the Australian aborigine using his teeth in a biting motion to sharpen dull stone tools. Pressure tools are used to apply force with accuracy and precision to the edge of the proposed artifact to detach controlled flakes. The pressure technique permits the worker to feel and control individual flake detachment to produce an artifact that is regular in form and with a sharp cutting edge.

Pressure blades can be removed from a core by using a chest or shoulder crutch or a staff held by both hands. When using both hands, the core must be secured in a vise or clamp--two logs lashed together with sinew and a stone used as a wedge to hold the piece firmly in place (Crabtree, 1968c).

Technology of Stone Tools

There are many methods of detaching flakes--random, parallel, diagonal, chevron, collateral, oblique, etc. But, technically, they all have basic methods that involve placing the pressure tool on a prepared or natural platform on the margin of the preform and applying pressing force to detach a flake on the obscure side. The varieties of pressure techniques are infinite and vary with (1) the worker's design of the artifact, (2) combinations of inward and downward pressure, (3) various hand and body positions, (4) many designs of platforms, (5) use of supports such as anvils, hands, etc., (6) varieties of pressure tools, (7) methods of holding, (8) superior and inferior lithic materials, and (9) intended function.

The artifact is held at a right angle on a pad in the cupped palm of the left hand with one end resting on the heavy muscle of the thumb. The curled fingers apply gentle but firm pressure to keep the artifact in position. The back of the left hand holding the artifact is positioned on the inside of the left thigh, giving additional support. The tip of the pressure tool is firmly seated at a right angle to the long axis of the artifact on the leading edge near the base. The edge has previously been made regular and a platform established by removing small flakes or by abrading to prevent crushing. Inward and downward pressures are applied simultaneously bringing together the knees and applying pressure from the hands, arms, and shoulders. The width of the flake, rather than the length, generally governs the amount of pressing energy. Flakes are detached from the underside (obscure side) of the artifact and the worker must "feel" rather than see his work.

Generally, pressure flakes are small and thin as compared to those made by percussion or indirect percussion. An exception is the pressure technique of detaching burin blades which are relatively thick compared to their width. Contrary to popular belief, flakes detached by the hand-held pressure technique may exceed two inches in length and are often mistaken for percussion flakes. Pressure blades made by using the crutch may be as long as ten inches when the lithic material is vitreous. Unfortunately, the last stage of pressure flaking detaches small flakes which are seldom recovered for analysis. They are also thin and have a tendency to collapse even though they detach and terminate properly. Breakage is due, in part, to support of the artifact by the palm of the hand. Pressure flakes are usually twice the width of the flake scar. When a ridge is used to guide flake removal, the detached flake retains half the previous scar on the dorsal side.

There are two methods of using the cone principle to apply pressure. Pressure force applied in only a downward direction will cause the flake to be removed tangentially to the direction of the applied force, much the same as direct percussion. These flakes are generally short with a feathered termination and have salient bulbs of pressure. The second and most commonly used method is to apply pressure in two directions--pressing inward in the direction of the desired flake and simultaneously pressing away from the margin. This shifts the fracture angle of the cone and when the proximal end of the flake starts detachment, the downward force is stopped but the inward force is continued. If the applied force is guided by ridges or convexities, long, narrow flakes can be removed. Without the ridge control, the flakes will spread regardless of the technique.

Pressure flaking is used for shaping, toolmaking, sharpening, modification, preparation, etc. Special selected flakes can be modified into small tools or projectile points and percussion preforms pressure flaked into bifaces. Also, flakes and blades are straightened by removing pressure flakes from the ventral surface at the proximal and distal ends until the curve is eliminated. Pressure flaking is also used to remove irregularities and make uniform margins on preforms and other implements to be finished by pressure flaking.

When the artifact has been made regular, the worker can rhythmically remove uniform flakes and develop a systematic constant use of muscular motor habits which respond to consistent ratios of inward and downward pressing forces. The tip of the pressure tool is seated in line with a ridge left by the detachment of the previous flake and the worker presses to remove one-half of the previous scar. Correct placing of the pressure tool on the margin demands practice and skill to insure firm contact and prevent slipping as the downward force is applied. "Feel" is developed to coordinate the ratio of the inward and downward forces. Improper ratio of too much downward force will cause the flake to terminate short and make an acute edge on the margin of the artifact. The platform must adhere to the detached flake to leave a sharp edge. A series of such flakes detached from a margin will leave an extremely sharp edge even though slight irregularities may exist. A pressure flaked margin on an artifact, flake or blade can be made either acute or obtuse, depending on the intended function.

Pressure flakes and their corresponding scars are generally more uniform, have better definition and constant elements of character and, therefore, are more diagnostic than those made by percussion. It is often necessary to pressure-flake some artifacts several times before they are sufficiently uniform for the final flaking. Since only the last stage of flake scars remain on the artifact, the analyst may not consider previous stages of pressure work in his analysis.

Early ethnographic accounts of explorers, historians and observers have noted different manufacturing techniques of stone implements

Technology of Stone Tools

(Ellis, 1940) of both the North American Indians and other groups in the world. Comparatively recent work by Ishi, one of the last Indians to flake stone (T. Kroeber, 1964) and personal communications A. L. Kroeber, 1939) and a few Australian aborigines (Gould, Tindale and Birdsell, personal communication, 1969) are our most dependable sources of information. Of all the accounts of manufacturing flaked implements, the only one to mention thermal alteration is an observation made by J. W. Powell in 1875 and quoted by Lowie (1924) regarding the stone work of the Plateau Shoshoneans.

> "The obsidian or other stone of which the implement is to be made is first selected by breaking up larger masses of the rock and choosing those which exhibit the fracture desired and which are free of flaws; then these pieces are baked or steamed, perhaps I might say annealed, by placing them in damp earth covered with a brisk fire for twenty-four hours. Then, with a sharp blow they are still further broken into flakes approximating the shape and size desired. For the more complete fashioning of the implement, a tool of horn, usually of mountain sheep, but sometimes of the deer or antelope is used. The flake of stone is held in one hand, placed on a little cushion made of untanned skin of some

animal, to protect the hand from the flakes which are to be chipped off, and with a sudden pressure of the bone tool, the proper shape is given. They acquire great skill in this, and the art seems to be confined to but few persons who manufacture them and exchange them for other articles."

Don E. Crabtree
Idaho State University
The Museum
Pocatello, Idaho

Technology of Stone Tools

MINERALS COMMON TO FLAKED STONE TOOLS

MATERIALS, highly silicious mineral compounds.

- General Kinds of Stone
  - Obsidian
  - Ignimbrite
  - Basalt
  - Rhyolite
  - Welded tuff
  - Chalcedony
    - Flint and Chert
    - Agate
    - Jasper
    - Silicified sediments
    - Silicified wood and other Pseudomorphs
  - Opal
  - Quartzite
  - Quartz Crystal

- Grade
  - Desirable
    - Isotropic
    - Cryptocrystalline
    - Homogeneous
    - Elastic
    - Vitreous
    - Adequate size
  - Undesirable
    - Cleavage plane
    - Inclusions
    - Non-homogeneous
    - Vesicular
    - Inherent stress or strain
    - Crystal pockets
    - Fissures
    - Checks
    - Molecular unbalance
    - Frozen

Technology of Stone Tools

(Materials)

- Source
  - Surface
  - Alluvium
  - In situ
    - Quarries
    - Veins
    - Outcrops
    - Ledges
    - Concretions
    - Fault zones
    - Filled voids
- Texture
  - Vitreous
    - Glassy
    - Dull
    - Micro-impurities
  - Granular
    - Fine
    - Medium
    - Course
- Color
  - All colors and combinations of colors

Technology of Stone Tools

LITHIC RESIDUE fractured by:

- Natural elements
  - Natural expansion
  - Natural contraction
  - Diastrophism
  - Rapid temperature changes
  - Internal force
    - Exfoliation
    - Dehydration
    - Expansion
    - Contraction
  - External force
    - Pressures from overburden
    - Unconsolidated lower strata
    - Freezing
    - Ice movement
    - Water motivation
    - Gravitational adjustment
- Artificial elements
  - Hoofed animals
  - Man
  - Intentional thermal fracture
  - Intentional fracture, producing flakes and cores
  - Intentional thermal treatment
    - Heated
      - More elastic
      - Texture change
        - Relieve stress
        - Sharper edges
      - Color change
    - Unheated
    - Overheated
      - Crazed
      - Heat cracks and checks
      - Potlids
      - Exfoliation
      - No bulbs of force

Technology of Stone Tools

(Lithic Residue)

Cores
- Conical
- Cylindrical
- Rectangular
- Unifacial
- Bifacial
- Multifacial
- Bi-polar
- Exhausted
- Utilized
- Nuclei implements
- Lena River core
- Levallois core
- Shirataki core
- Others

Flakes
- Percussion
- Indirect percussion
- Pressure
- Pressure and percussion

Size
- Small
- Medium
- Large

Micro-flakes
- Minute retouch
- Notching
- Serrating
- Platform preparation

Length
- Short: width = length
- Medium: 2 x width = length
- Long: 3 x width = length
- Extra long: 4 or more x width = length

Width
- Conchoidal (flat)
- Circular (bi-convex)
- Expanding (sub-triangulate)
- Wide expanding: width several times length

Thickness
- Thin
- Normal or average
- Thick

Tabular, Acute, Obtuse, Right angle margins

Technology of Stone Tools

FLAKES

- Straight
- Flat
- Curved
- Spiral
- One dorsal ridge
- Two or more dorsal ridges

- Margins
    - Parallel
    - Sub-parallel
    - Ovate
    - Irregular

- Proximal end
    - Size of platform
    - Preparation of platform
        - Flaking
            - Character
            - Order
        - Isolation
        - Abrading
        - Grinding
        - Angle of platform
        - Character of bulb of force
            - Salient
            - Diffuse
    - Force scars
    - Eraillure
    - Marginal striations
    - Direction of dorsal scars
    - Size of cone truncation
    - Platform overhang

- Distal end
    - Compression rings
    - Undulations
    - Shock fracture
    - Feathered termination
    - Hinge fracture
    - Step fracture
    - Reverse hinge
    - Termination removing distal material

Technology of Stone Tools

(Flakes)

- Specialized flakes
  - Blades
    - Prismatic
    - Micro
    - Parallel sides
    - One dorsal ridge
    - Two or more dorsal ridges
    - Burin blades
  - Sidestruck flakes
  - Channel flakes
  - Hinge flakes (dorset knife)
  - Eraillure
  - Reverse hinged flakes
  - Rejuvenation flakes
  - Transient flakes
  - Levallois flakes
  - Shiratakı platform flake

Technology of Stone Tools

TECHNOLOGICAL FEATURES of flaked artifacts, projectiles, knifes, etc.

- Faces
  - Dorsal and ventral
  - Irregular, random (indiscriminate pressure or percussion)
    - Rough out
    - Blank
    - Preform
  - Regular
    - Wide
    - Medium
    - Narrow
    - Parallel (right angle to margin)
    - Oblique
    - Double oblique
    - Flaked from one edge and one margin
    - Flaked from one edge to opposite margin
    - Sequence of flake removal
    - Indicate direction of force by compression rings
    - Angle of flake removal
    - Thinning technique
    - Termination of flakes
      - Feathering
      - Step
      - Hinge
      - Meet at median
    - Depths of ridges and troughs
    - Character of bulbs of force
    - Unflaked surface
    - Flat flaking
    - Curved flaking
    - Number of flakes per inch

Technology of Stone Tools

(Technological Features)

- Edges
  - Angle
  - Irregular
  - Regular
    - Curved
    - Straight
    - Beveled
    - Sharp
    - Dull
    - Sinuous
    - Alternating
    - Detached opposite ridge on other face
    - Abraded (functional)
    - Ground
    - Polished
    - Serrated
      - Shallow
      - Medium
      - Deep
      - Technique
        - One face
        - Both faces
        - Alternate faces
        - Serrated as retouched
        - Crushed
- Basal aspects
  - Thinning
  - Fluting
  - Grinding (one to three flakes from one or both faces)
  - Grinding
  - Polishing
  - Hafting technique
    - Stemmed or shouldered
    - Notching
      - Corner
      - Side
      - Base
        - Straight
        - Concave
        - Convex
        - Recurved
      - Barbing
    - Unstemmed
    - Unnotched
      - Traces of adhesive

Technology of Stone Tools

(Technological Features)

<u>Transverse Section</u>

- <u>Plano-convex</u>
- <u>Convex</u>
- <u>Bi-convex</u>
- <u>Diamond</u>
- <u>Rectangular</u>
- <u>Trapezoidal</u>
- <u>Beveled</u>

<u>Tips</u>

- <u>Transverse</u>
- <u>Attenuated to blunt</u>
- <u>Micro-burins on tips</u>
- <u>Re-pointed</u>
- <u>Direction of flake scars on points</u>

Technology of Stone Tools

TOOLS FOR MAKING FLAKED STONE ARTIFACTS

- Direct percussion
  - Quarries
    - Large tenacious hammerstones
      - 20-40 pounds
    - Picks
      - Stone
      - Antler
    - Digging sticks
    - Levers and bars
    - Wedges
      - Stone
      - Wood
      - Antler
    - Hafted and unhafted hammers
      - Stone
  - Quartering
    - Medium size, hard hammerstones
  - Cortex removal
    - Medium hard, medium size, hammerstones
  - Blades and flakes
    - Pointed or bi-pointed hard hammerstones
    - Edge of medium size and medium hard hammerstones
    - Medium size, soft hammerstones
      - Glassy materials
    - Anvils or supports
    - Shape of percussor
      - Spherical
      - Round
      - Ovate
      - Bi-convex
      - Cylindrical
      - Discoidal
      - Faceted
      - Consumed or exhausted
      - Percussors conforming to material and size
        - For flakes or blades

Technology of Stone Tools

(Tools for Making Flaked Stone Artifacts)

- (Direct percussion)
  - Core preparation
  - Cores and core tools
    - Hammerstones of assorted shapes, sizes and hardness
    - Billets
      - Antler, Horn, Wood, Bone and Stone
  - Route outs
  - Large flakes
  - Blanks
  - Preforms
    - Hammerstones
    - Billets
  - Thinning
  - Finishing, soft hammerstones and billets
  - Sharpening
    - Wooden billets
- Indirect percussion
  - Punch and percussor
  - Anvil and percussor
    - Holding device
    - Second person
  - Pressure flaking
    - Antler tines
      - Moose
      - Deer
      - ?Caribou
      - Elk
    - Horn
      - Antelope
      - Goat
      - Sheep
      - Bovines
        - Buffalo
        - Cattle
    - Ivory
      - Mammoth
      - Elephant
      - Walrus
      - Narwhale
      - Whale

Technology of Stone Tools

(Tools for Making Flaked Stone Artifacts)

- (Indirect percussion)
  - (Pressure flaking)
    - Bone
      - Mammal ribs and long bones
    - Wood
      - Selected, hard resistant woods
    - Teeth
      - Rodent
      - Exterior enamel
      - Carnivore
    - Metal
      - Copper
      - Iron
    - Shell
      - Mollusca
  - Notching
  - Barbing
  - Serrating
  - Denticulations

Technology of Stone Tools

REFERENCES CITED

Bordes, Francois and Don E. Crabtree

1969 The Corbiac Blade Technique and Other Experiments. Tebiwa 11:2:1-21. Idaho State University Museum. Pocatello, Idaho.

Crabtree, Don E.

1966 A Stoneworker's Approach to Analyzing and Replicating the Lindenmeier Folsom. Tebiwa 9:1:3-39.

1967a Notes on Experiments in Flintknapping:3. A Flintknapper's Raw Materials. Tebiwa 10:1:8-24.

1967b Notes on Experiments in Flintknapping:4. Tools Used for Making Flaked Stone Artifacts. Tebiwa 10:1:60-73.

1968 Mesoamerican Polyhedral Cores and Prismatic Blades. American Antiquity 33:446-478.

1970 Flaking Stone Tools with Wooden Implements. Science 169:3941: 146-153.

Technology of Stone Tools

Crabtree, Don E. and B. Robert Butler

1964 Notes on Experiments in Flintknapping:1. Heat Treatment of Silica Minerals. Tebiwa 7:1:1-6.

Crabtree, Don E. and Earl H. Swanson

1968 Edge-ground Cobbles and Blade-making in the Northwest. Tebiwa 11:2:50-58.

Ellis, H. Holmes

1940 Flint-working Techniques of the American Indians: An Experimental Study. Ohio State Museum, Columbus, Ohio.

Kroeber, Theodora

1964 Ishi in Two Worlds. Univ. of Calif. Press. Berkeley.

Lowie, Robert H.

1924 Notes on Shoshonean Ethnography: Exploration of the Colorado River and Its Tributaries, Explored in 1869-1872. Vol. XX Part III. American Museum Press, N.Y.

Tixier, Jacques

1963 Typologie de l'Épipaleolithique du Maghreb. Memoires du Centre de Recherches Anthropologiques et Ethnographiques II. Arts et Métiers Graphiques. Paris.

Technology of Stone Tools

SELECTED ADDITIONAL REFERENCES

Allchin, Bridget

1966 The Stone-Tipped Arrow. Barnes and Noble Inc. New York.

Avebury, Rt. Hon. Lord

1913 Prehistoric Times. Henery Holt and Co., New York, and Williams and Norgate, London.

Ball, Sydney H.

1941 The Mining of Gems and Ornamental Stones by American Indians. Bureau of American Ethnology. Anthropology Papers 13. Bull. 128.

Bordaz, Jacques

1970 Tools of the Old and New Stone Age. The Natural History Press. Garden City, New York.

Bordes, Denise de Sonneville

1967 La Prehistoire Moderne. Pierre FANLAC. Perigueux.

Bordes, Francois

1962 Typologie du Paleolithique ancien et moyen 2 vol. Bordeaux.

Technology of Stone Tools

(Bordes, Francois)

1968 The Old Stone Age. World University Library. McGraw-Hill Book Company. New York, Toronto.

1969a La France au temps des Mammouths. Librairie Hachette.

1969b Reflections on Typeology and Techniques in the Palaeolithic Arctic Anthropology VI-1.

Brothwell, Don and Eric Higgs

1963 Science in Archaeology. Basic Books Inc. New York.

Caldwell, Joseph R.

1966 New Roads to Yesterday. Basic Books Inc. New York.

Clark, J. G. D.

1964 Proceedings of the Prehistoric Society for 1964. H. K. Lewis and Co. London.

Coles, J. M. and E. S. Higgs

1969 The Archaeology of Early Man. Fredrick A. Prager Publishers. New York.

Technology of Stone Tools

Cook, Angel Garcia

1965 Analisis Tipologico de Artefactos. Instituto National de Anthropologia e Historia. Mexico D. F.

Cornwall, I. W.

1966 The World of Ancient Man. The New American Library. New York.

Crabtree, Don E.

1939 Mastodon Bone with Artifacts in California. American Antiquity 5:130.

1968a Archaeological Evidence of Acculturation Along the Oregon Trail. Tebiwa 11:2:38-42.

1968b Experimental Manufacture of Wooden Implements with Tools of Flaked Stone. Science 159:3812:426-428.

1968c Mesoamerican Polyhedral Cores and Prismatic Blades. American Antiquity 33:446-478.

1969 A Technological Description of Artifacts in Assemblage I, Wilson Butte Cave, Idaho. Current Anthropology 10:4:366-367.

Technology of Stone Tools

Figuier, Lewis

1876 Primitive Man. Chatto and Windus. Piccadilly. London.

Holmes, W. H.

1897 Stone Implements of the Potomac-Chesapeake Tidewater Province. Bureau of American Ethnology. Fifteenth Annual Report (1893-94). Smithsonian Institute.

1919 Handbook of Aboriginal American Antiquities. Bureau of American Ethnology. Smithsonian Institute.

Howell, F. Clark

1965 Early Man. Time Incorporated. New York.

Kroeber, Theodora

1964 Ishi in Two Worlds. University of California Press. Berkeley.

Leakey, L. S. B.

1960 Adam's Ancestors. Harper Torchbooks. Harper and Brothers. New York.

Technology of Stone Tools

Lubbock, Sir John

1872 Prehistoric Times, Manners and Customs of Modern Savages. D. Appleton and Co. New York.

Melgaard, Jorgen

1964 Anders Kragh, Man Og Flint. Rhodos, Copenhagen.

Oakley, Kenneth P.

1959 Man the Tool-Maker. Phoenix Books. University of Chicago Press.

Osborn, Henry Fairfield

1916 Men of the Old Stone Age. Charles Scribner's Sons. New York.

Petersen, Eric Brinch

1966 Klosterlund-Sonder Hadsund-Bollund, Les Trois Sites Principaux du Maglemosien Ancien en Jutland Essai de Typologie et de Chronologie, ACTA Archaeologica. Ejnar Munksgaard. Copenhagen.

Pfeiffer, John E.

1969 The Emergence of Man. Harper and Row. New York.

Technology of Stone Tools

Pond, Alonzo W.

1930 Primitive Methods of Working Stone Based on Experiments of Halvar L. Skavlem. Logan Museum Bulletin 2:1. Beloit, Wisconsin.

Powell, John Wesley

1957 The Exploration of the Colorado River. Abridged from 1st ed. of 1875. University of Chicago Press.

Semenov, S. A.

1964 Prehistoric Technology. Barnes and Noble, Inc.

Tixier, Jacques

1962 Missions Berliet Tenere. Tchad, Extrait des Documents Scientifiques, A. M. G. Paris.

1964 Fiches Typologiques Africaines, Pieces Pedonculees Ateriennes du Maghreb et du Sahara. Epipaleolithique du Maghreb, Congres Panafricain de Prehistoire et D'Etudes Quaternaires. Museum National D'Histoire Naturelle. Paris.

White, A. M., Lewis R. Binford and Mark L. Papworth

1963 Miscellaneous Studies in Typology and Classification. University of Michigan, Ann Arbor.

Wormington, H. M.

1957 Ancient Man in North America. Denver Museum of Natural History. Denver, Colorado.

1961 Prehistoric Indians of the Southwest. Denver Museum of Natural History. Denver, Colorado.

Wormington, H. M. and Richard G. Forbis

1965 An Introduction to the Archaeology of Alberta, Canada. Denver Museum of Natural History.

Technology of Stone Tools

SOUND FILMS ON LITHIC TECHNOLOGY

Dr. Earl H. Swanson, Idaho State University Museum, Director

Shadow of Man

The Flintworker

Ancient Projectile Points

Alchemy of Time

The Hunters Edge

Dr. J. Desmond Clark, University of California, Director

Blades and Pressure Flaking

Craig Fisher, N. B. C. News New York, Director

First Americans