RELATION OF THE CONE FRACTURE TO FLINT-LIKE MATERIALS

Prehistoric stone tools of flint-like or isotropic materials are generally made by subjecting sufficient force to lithic material to exceed its elastic limit, thereby inducing fracture and detaching a portion of the stone. The detached piece is a flake but is also a cone part. Some flakes are half cones, others are quarter cones or parts of cones. Full cones result from force directed in from the margin at 90° to the plane surface. Half cones result when force is directed at 90° on a right angle margin and quarter cones are formed by the force being directed vertical to the corner of a rectangular block (fig.). ~~Other cone parts are the result of kinds and types~~ of force and combinations ~~of conditions~~. An understanding of the correlation of the cone principle ~~in relation~~ to the detachment, forces involved, & the behavior and fracture of ~~the~~ lithic material will help clarify the mechanical principles involved in lithic technology.

Ancient ~~Ancestral~~ man--~~whether by instinct or reason~~--took advantage of the fracture angle of the cone of force and the nature of the isotropic material to systematically detach ~~these~~ flakes (coneparts) to form his stone implements. When he learned to predetermine the thickness, width, length, form and size of the flakes and calculate & control the detachment, he was able to produce a variety of styles and tool types.

The detached material can assume a variety of forms: all will have a complete or portion of the cone of force. These parts removed from near the margins are called flakes. Some flakes are specially designed, elongated flakes called blades. Flakes resulting from early stages of artifact manufacturing often appear to be aberrant and without design, where in reality they are due to the amorphous nature of the rough material or individual platform preparation.

The flake form is usually directly related to the exterior surface of the material and the fracture angle of the cone of force. The shear plane is the same as the fracture angle of the cone and is tangential to the direction of applied force. Therefore, the force is applied at an angle to the fracture plane of the proposed flake or flake scar. Normally the flake form will correspond with the exterior surface. This rule is not applicable to very thick flakes where the thickness is greater than the surface conformation, shape, structure or design. The form of the cone part can be designed by first preparing the surface. A plane surface will allow the flake to expand from the point of applied force, resulting in a typical conchoidal or shell-like cone part. A predesigned ridge or ridges will restrict the expansion of the flake and its detachment will result in a cone part called a blade. Another example of flake form control is the use of ridges to prevent the expansion of the flake. When the worker aligns pressing forces with a pre-established ridge and removes a series of elongated cone parts it will result in what is known as parallel flaking.

The term cone of force is used in this text to denote the visible part of the cone without implying the type of applied force. Many texts refer to the cone of force as the "bulb of percussion" thereby denoting that the cone part, or flake, was detached by the percussion technique. There are other techniques of flake detachment, and cones may be formed by pressure, indirect percussion and various other methods. Unless one has basal margin. Therefore, the direction of applied force is different from the fracture angle of the cone. One must bear in mind that a flake scar which is derived from the fracture angle of the cone results from force which is applied at other than a right angle or perpendicular to the central axis of the cone and is tangential to the direction of force.

A common inverted funnel can be used to illustrate the cone principle. The stem of the funnel representing the direction in which force is applied. The sides of the funnel represent the fracture angle of the cone, and the apex of the cone (platform) is the part of the funnel where the neck or stem joins the flared part of the funnel. In order to determine the direction of applied force which detached a flake or cone part, the funnel can be overlaid on the flake or cone scar and the stem of the funnel will indicate the direction at which force was applied. The flare of the funnel sides may not be quite the same as the angle of the cone but the stem can indicate the approximate direction of force. Or one can make an isosceles triangle from cardboard or a piece of plastic and affix the apex of the triangle to a small dowel to be used as an indicator to determine the direction of force. The guage will resemble an inverted "Y". The angles of the isosceles triangle's sides should correspond to those of the cone of force. This small tool is a useful device for showing the direction of applied force to remove a flake or blade from an artifact or core. The gauge helps in discriminating between nature-facts and those intentionally made by man. The gauge helps to determine the angle in which force was applied and when the angle or angles represented by flake or blade scars are known, one may then reconevidence, such as flakes or flake scars bearing attributes, diagnostic features and characteristics which determine the employment of a certain technique, then it is better to use the term "bulb of force" or "cone of force." When the technique has been determined, it should then be signified by using the correct term--either "bulb of percussion" or "bulb of pressure."

The following interpretation of the cone principle is based on the study and results of numerous experiments in replicating aboriginal flaking techniques. Circumstances have not permitted controlled laboratory investigation of exact angles related to force, inertia, mass, motion, velocities and properties of materials, but the experiments have been verified by duplicating and comparing both cone and cone scars on isotropic materials formed by both man and nature. Slight variations of the angle of force do occur, but when all conditions, elements and circumstances are the same, the fracture angle will be the same. Archaeologically, the positive portion of the cone is the detached flake and the cone scars which form and thin the artifacts are the negative cone parts.

When lithic material is subjected to stress, the force waves radiate in ever expanding waves and circles from the point of contact, compressing the material and causing a cone to be formed. Vitreous isotropic materials are generally highly elastic, some more so than others, and when the applied force exceeds the elastic limit of the material, fracture results. Fracture starts at the apex or vertex of the cone and terminates at the struct the action that was involved in the forming of the core or implement.

Should a row of flake scars removed in sequence be present along a margin indicating consistant directions of force applied with the same intensity, the probability is that it was a product of man's endeavor, rather that a result of action by nature. The row of flake scars must all bear the same amount of erosion. Erosion differential will indicate that the flakes were removed at different times. Differences in erosion will be more characteristic of nature than of man's remodification of an artifact. The angles of force causing sequential flake detachment from alternate directions along a margin would be unlikely in a natural action. Violent disturbances from natural causes in vitreous materials can produce single objects resembling artifacts, but they will not occur in numbers that show preconception of design and intent. There are exceptions to the rule of using the fracture angle of the cone and also the gauge to determine the direction of force; i.e.: (1) splitting or shearing of the cone by opposing bi-polar forces when due to inertia, (2) cone collapse due to excessive compressive force.

The apex of the cone of force is not pointed like a mathematical cone for the truncated part at the apex acts as a bearing surface to receive the applied force thereby forming a cone on the isotropic material. The diameter of the cone truncation will correspond to the size of the implement used to apply the force. In order to form a cone, the force must be definite direction and magnitude. When force is applied, the material compresses and the force radiates tnagentially to the direction of the applied force. The type of applied force determines the formation or spacing of the compression rings around the circumference of the cone. The compression rings undulate in different degrees of intensity, comparable to water or sound waves. For example, blows of high velocity delivered with a hard hammerstone cause the wave interval to be closely spaced while a slow blow with a soft percussor will cause the wave interval to be widely spaced, approaching those produced by pressure. Force is applied in different ways and each method produces compression rings in the form of waves of varying intensities and spacing starting at the cone truncation to the termination of the fracture or until the force is disipated. The waves seem to be quite regular pulsations that start at the apex of the cone and continue to the termination of the cone fracture. The wave spacing depends on the type of applied force and the properties of the material (see types of force).

A cone of force is anything shaped more or less like a mathematical cone. A cone is a solid figure described by the revolution of a right-angled triangle about one of the sides containing the right angle, that side remaining fixed. If the fixed side be equal to the side containing the right angle, the cone is called a right-angled cone. If it be less than the other side, it is an obtuse angle cone; and if greater, it is an acute angled cone. The axis of the cone is the fixed straight line about which the triangle revolves. The base of a cone is the circle described by that side containing the right angle which revolves. Similar cones are those which have their axes and the diameters of their bases proportional. The mathematical cone and the cone of force are comparable except that the apex of the cone of force is truncated and corresponds with the platform part or proximal end of a flake or blade.

In determinative mineralogy, a feature called conchoidal fracture is a surface more or less like the surface of a shell, and the term is characteristic of certain vitreous isotropic minterals. The term is used for identification of the fracture of minerals when they break, presenting on the negative side a concave surface like that of the interior of a bivalve shell and on the positive side a convex one like that of the exterior. The interior of the shell is the negative cone scar and the ~~outside~~ exterior is the positive part of the cone. The hinge part of the shell is the cone truncation or the part receiving the force to induce fracture.

Elasticity is the quality or condition of being elastice or springy: that inherent property in materials which allows them to recover their original form or volume after ~~an~~ external pressure or force has been dissipated. Elasticity is the utmost extent or limit to which elastic materials can be extended or compressed without fracturing. Vitreous or isotropic materials used in the lithic industries are almost perfectly elastic. Degrees of elasticity are dependent on the homogeneity of the micro-crystalline structure--the more vitreous, the more elastic. For example, obsidian and other glassy material is considerably more elastic and springy than quartzite; and natural flint is stiffer than thermally treated flint which has been made vitreous by artificial means. When vitreous material is worked, cones will either shear or be formed deeper into the mass than when approximately the same amount of force is applied to more granular material. The more granular material appears to dissipate the cone-forming force more readily than does the glassy material.

Paragraph 3 - Page 2 then Page 21 + 22 P 3 + 4 Cone Trunc

To induce fracture in isotropic minerals, the limit of elasticity must be exceeded. Sometimes when the worker is detaching a thick blade from the core, the blade will break when the rebound or recoil exceeds the elastic limit of the material. Rebound can be deterred by reduced velocity, longer interval of contact or by dampening. Rebound fracture surfaces are an exception to the cone principle and cannot be compared to the cone of force.

Cone parts in the forms of flakes or blades have almost universal distribution while intentionally made complete or full cones have limited occurrences. But even though the aboriginal flintknapper did not use this technique for forming artifacts, he did make full cones when he was perforating stone. I have noted use of the full cone removal technique in the State of Colima, Mexico and Jacques Tixier has found examples of the use of this technique to perforate beads in Egypt during the Chalcolithic (personal communication). The Egyptian bead making technique exhibited slight technological differences from the Mexican method of perforations. In Egypt, beads were made by using a very small tube drill to first drill half way through flakes of vari-colored chalcedony and then the balance of the material was punched out by removing a full cone with a cylindrical truncation. Surplus material was then removed from around the perforation, making the bead discoidal. In Colima, Mexico, perforations of obsidian were made by removing minute complete cones from the margins of eraillure flakes.

Eraillure flakes are specialized flakes. They are generally circular concavo-convex and are formed between the flake and the core by direct percussion. The eraillure flake either falls free or remains partly attached to the core. The dorsal side of the flake is usually without compression rings and the convex side has a good reflecting surface. The piece is made regular and the sharp edges removed around the circumference by pressure flaking. Perforations in the discoidal eraillure flake are made by using a pointed drill to drill an indentation approximately half way through the disc. If the flake is to have one perforation in the center, the hole is drilled in the middle on the concave side. If two holes are to be made, they are drilled opposite each other slightly in from the margins. After the drilling has established an indentation, a sharp punch of very resistant material is seated in the indentation and the punch struck, removing a cone from the opposite face to complete the perforation. The graduated discs with the center perforation are then strung the same as beads; and those with perforations in from both margins are attached side by side. The method may sound very simple but, in reality, it is difficult as the force necessary to remove the cone is very exacting and the least miscalculation will fracture the discoidal rather than remove a cone. The technique may have been used by the Maya to make the initial perforation in eccentrics, but then the holes were enlarged by additional flaking, thereby destroying any remnant of a cone scar.

Experimentally, I have perforated lithic material by the above mentioned techniques. One method is to select or make a plane surface and then using a hard percussor with a convex surface on the striking end deliver a hard sharp blow at the center of the plane surface to establish a full cone. The impact between the percussor and the plane surface of the objective piece must be at 90° or vertical; otherwise the cone will be acute, obtuse, or malformed. The blow will cause a cone to be formed within the lithic material. Then a flat tabular piece is removed parallel to the plane surface by striking just below the margin at a point which will determine the desired thickness of the detached flake. The blow is struck at approximately 45° to the plane surface. The thickness of the tabular flake should correspond to the depth of the cone fracture. If the thickness of the tabular flake is less than the depth of the cone fracture, the cone will often remain on the core. If the thickness of the flake is more than the cone fracture, then the cone will be removed with the flake. If the cone is removed with the tabular flake, in order to complete the perforation and remove the cone, a punch with a tip no larger than the truncated part of the cone is used to complete the cone fracture. The perforation on a tabular flake may then be enlarged by additional flaking to make a circle or bracelet.

Another full cone experiment is accomplished by projecting a hard missile at high velocity with a pneumatic gun or a sling shot. Certainly this is not an aboriginal technique but is excellent for examination of cone character such as fracture angle of the cone, different velocities, shock wave, cone truncation, cone collapse and angles of impact. In lieu of the air rifle or sling shot, a thin flexible piece of hard wood can be used in the manner of a spring. A pea-sized pebble is placed on the tabular material to be perforated and the piece of hardwood is secured by the hand at one end and the opposite end is pulled back. When it is released it strikes the small pebble and the impact perforates the material by removing a cone. Shattering is common until the correct velocity is achieved.

Another full cone experiment involves selecting a piece of lithic material with a natural flat surface or by making a flat surface to receive the impact and then imbed the stone in wet sand. The plane surface is placed upward and then struck vertical with a hard percussor. The size and velocity of the percussor must correspond with the size and inertia of the objective piece. This method will perforate the piece by removing a full cone but until one becomes proficient at the technique, he will have more failures than successes.

Natural Cones of Force

Since cones and cone parts are the result of force applied to isotropic materials, they may be the result of natural ~~causes as well as the intentional~~ or human ~~calculation and application of~~ force ~~by man~~--either by pressure or, more commonly, by percussion. Natural forces result from a wide variety of causes and may, under the right conditions, form cones and cone scars on stone which will be similar to those made by ~~mad~~ man. However, natural scars on lithic material are generally random and do not reflect the preconception, planned order, rhythms and muscular motor habits necessary for man to produce his tools. Close examination and analysis of the scar character and the fracture angle of the cone of force will indicate the direction of applied force and may reveal that they are a natural random imitation rather than the preconceived and calculated human endeavors ~~of man~~.

Flakes intentionally detached by man have sharp edges and generally leave sharp edges on the objective piece prior to performing functional chores. Utilized tools may exhibit dulled edges but generally have a distinctive wear pattern. Natural fractures produce flakes and cores with abraded edges due to indiscriminate pressure and percussion.

Natural cones of force are common in lithic deposits where movement occurs. Natural movements of rocks whether by changes of elevation or water action or any force or forces which cause contact by pressure or percussion can induce cones of force on the fractured stone. However, in this case, the negative bulb of force will be more noticeable in vitreous stone with isotropic properties than in granular rocks. One pebble striking another will form a cone of force on both pebbles if the force exceeds the elastic limit of the material. The cone will penetrate the material equivalent to the amount of force, the inertia and the velocity. Reduced force may not form a cone on the stone while great force may cleave the object at the fracture angle of the cone. If the material is resting on an unyielding support and the force is directed opposite the support, it is possible for the cone of force to be sheared. Vitreous stone which is rolled and tumbled for some distance will soon be covered with intersecting cones which penetrate at different depths because of the variable intensities of subjected force. This is a good gauge for selecting suitable material for making tools. Vitreous rocks having this cratered surface are generally superior material for stone tool manufacture. Non-vitreous materials which are naturally rolled or tumbled cause the cone to collapse and the rocks to become smoothed and rounded.

An understanding of the cone principle formation in isotropic minerals can help one determine and discriminate between natural and intentional fracture. A cone of force is formed by applying the force at right angles to the plane surface. Because the fracture angle of the cone is tangential to the direction of applied force, one can determine by the fracture angle of the cone the angle of applied force. By using the fracture angle gauge and overlaying the cone scars, the direction of force is obvious. In nature, it is unlikely that flake scars will be alternated along a margin and be directed in sequence with changing angles of force. Also, if the flakes leave scars along one margin and one face with consistent angles of flake removal and each scar overlaps the next in sequence, we can safely rule out a natural occurrence. By using the fracture angle gauge, one can determine the angle of force in relation to the fracture angle of the cone. Fracture due to natural forces inducing cone removal will be highly variable in both direction and intensity. Flakes detached by natural causes will have crushed and abraded edges and the thinner weaker areas will be reduced more rapidly than the thicker stronger parts. The edges of pseudo tools become rounded and abraded from interaction with and associated lithic materials. The flake scars are also abraded but in different degrees because nature does not remove all flakes in sequence. It is highly improbably that man would remove just one flake, use the tool, and then detach another flake and so on in order to exhibit differential wear on the individual scars. When problematical and questionable examples of lithic materials are examined it is well to have a representative population and study the fracture angle in relation to the direction of force to resolve the question of man vs. nature.

Lithic materials at or near the natural deposit result in errosional forms and flakes that have a resemblance to those formed by man but are, in reality, the products of nature. When quantities of vitreous minerals with isotrophic properties are subjected to force, flakes can be removed which may be thought to be flakes and cores made by man. Natural forces that may form pseudo artifacts are the settling of underlying formations, earthquakes, diastrophism, exfoliation, development of internal strains and stresses, temperature changes, formation of crystalline minerals after the initial deposit, movement by water or ice, and any natural gravitational changes causing movement of the material to be subjected to force by another mass resulting in fracture.

The distribution of questionable artifacts mingled and co-mingled within a deposit of geologically occurring lithic materials presents complex problems not found in places somewhat remote from the source. Materials out of context and in a foreign geographical and geological horizon indicate movement of the lithic materials by artificial means other than nature and limit their chances of being formed by nature. For example, at the Ayachuco shelter on the side of a cliff, a stream cobble which was altered at one end by the removal of successive flakes was found by MacNeish. (MacNeish, 1969) In this case, we can be sure that this was man-made and not a naturefact.

The determining of the geological occurrence of vitreous material (minerals) is important before making a final appraisal of questionable flakes or artifacts. Minerals lending themselves to flaking generally occur naturally in several categories: i.e. blanket veins, horizontal beds of chert, silicified sediments, siliceous sandstones (quartzite) not metamorphased quartzite, ignimbrites, obsidians and basalt, siliceous filling of cavaties, i.e. fault zones, vesicular basalt, pseudomorphs and as concretions in sedimentary rocks (flint in limestone). These materials may be redeposited ~~by being~~ in the form of cobbles or boulders in alluvium. Quite naturally, vitreous minerals in the form of alluvium or occurring naturally which are rolled and bruised prior to redeposition are rounded since the corners or protuberances are less resistant to battering. During the movement, the striking of one piece of stone against the other will detach flakes. Rounded or ovoid materials are more resistant to fracture than angular manterials. The investigator can expect to find somewhat different styles of natural flake and flake scars in deposits of materials depending on their geological occurrence. Angular material deposits can fracture into core-like pieces with an occasional scar at the corner, or corners, which will resemble a blade core. Thin tabular pieces will have an edge that will appear to be a burin core. The right angle margins of the tabular or angular pieces will have random conchoidal scars of assorted sizes, the edges being somewhat crushed and abraded. Flakes which match the flake or blade scars should be in association.

Starch fracturing is not uncommon in natural deposits of obsidian and siliceous vitreous minerals and causes some ~~very~~ interesting pseudo artifacts to be formed, many resembling blade cores and blades. However, with starch fractured material there is no bulb of force but there are occasional rings of compression.

When rounded, spheroid material is fractured--whether by nature or man--it must receive considerably more force than angular material. Natural application of forces will vary in intensity, while those made by man will be more uniform. An exception is the Australian technique of fracturing the stone by throwing which detaches irregular and aberrant flakes. Before a rounded mass will break, the force must be applied at approximately 90° to the surface, otherwise the blow will glance or ricochet without accomplishing fracture.

Natural fracturing by violent battering shears the cone of force, leaving no bulb of force or a poorly defined one with closely spaced compression rings. When the force is excessive and the cones of force collapse, the debris is angular and the flakes are sub-triangulate in section, similar to an orange segment. The force waves will be closely spaced with expanding shatter lines originating at the point of applied force. When the cone is sheared there will be no evidence of the bulb of force, the fracture plane is quite flat and the compression rings are also closely spaced.

APPLYING THE PRINCIPLE OF THE CONE TO FUNCTIONAL FLAKE SCARS

A careful study of the use flake scars on stone tools can sometimes determine their functional performance and also indicate the manner of holding. Past studies of such scars have placed emphasis on the plane of fracture, but have not considered the angle of applied force which is, in turn, governed by the angle at which the artifact is held when performing a specific function.

For the purpose of encouraging further and more detailed study of these scars, I would like to postulate a potential use of applying the technique of flintknapping to more clearly define these functional scars. It is conceivable, and I believe possible, that the principle of the cone as applied to intentional fractures in tool making could be useful in diagnosing functional flake scars.

Two angles of force must be interpreted and these angles are indicated by the type, length and termination of the use flake. Applying the principle of the angle of the cone to the negative flake scar could very well determine the angle at which the artifact was held. The use flakes may be related to the cone FRACTURE angles and direction of applied force and, ~~in turn,~~ used to show the manner in which the tool was held. When the tool was used as a chopping implement by impact or percussion the fracture angle of the use flakes and the cone remains relatively constant. When the tool is hand held and pressed rather than projected two angles of force must be considered. It is possible that a single direction of pressure force could be applied until the cut is terminated. If the cut does not terminate two directions of pressure are used to complete the cut. Should an involuntary use flake be detached it will correspond to the proportion of the forces, changing the fracture angle of the normal percussion cone of force. When a flake or blade is used as a knife for cutting flesh, hide, sinew, or materials with minor resistance, it can be held at the proximal end between the thumb and forefingers and drawn toward the worker, the strokes being parallel to the long axis of the blade or flake. When used with care in this manner, the edge may become polished after long use. Twisting or any side pressure will cause the tool to nick on the side opposite where the pressure is applied. The nick will weaken the edge and if the tool continues to be used the projection resulting from the nick will detach a flake longitudinally and this process will continue until the tool is resharpened or abandoned. The functional scars will be short and steep in a direction away from the user, toward the distal end of the blade. When the acute edge contacts bone or some hard resistant material it will crush. When the flake or blade is used with care it only becomes dulled by abrasion and will have no visible flake scars. This abrasion is probably due to the material being cut by contaminated earthy substances.

When the flake or blade is drawn sideways, the use flakes will be detached from the face opposite the resistance. The angle of the use flakes will depend on the holding position of the flake or blade and the amount of downward pressing force. The use flakes will lack regular spacing and uniformity. The leading edge will usually show crushing which should not be confused with intentional retouch. An example is the common scraper used for removing fat, flesh and tissue from skins--the scraper is held vertically and drawn toward the worker. This type of function will detach use flakes at the scraping edge from the ventral to the dorsal side. However, use flakes would only be present if the scraper edge contacted some material resistant enough to erode or scar the scraper edge by removing a cone part. If the scraper does not contact hard materials, the edge will just receive a polish. Since function does not always produce use flake scars on a tool, there are other means of determining if the flake has been used. A quick field test is to run the finger along the edge carefully to determine the sharpness. If it is extremely sharp, we can presume it has not been used--if dulled, or smooth to the touch, then we presume functional abrasion. The use of the binocular microscope is often necessary to determine wear patterns, or functional polish. Often striation may be observed showing the direction of use, but will not determine the angle at which the tool was held.

On the other hand, implements that appear to be scraper-like objects were used by the Australian aboriginals for forming and shaping wood. The tool was hafted and used in much the same manner as one would use an adze. (Gould and Tindale, personal communication). These artifacts were secured to a shaft of hard-wood or fixed to the proximal end of the spear thrower (throwing stick) with native adhesive, (spinifix or blackboy gums) and then used in much the same manner as one uses a hand held wood working chisel. The functional side of the artifact was the ventral side of the flake, and when the tool has been used the functional scars will be on this side. If the functional edge is slightly curved, then the cutting edge was oriented near the bulbar part of the flake. If the functional edge is to be flat, the cutting edge is oriented towards the distal end of the flake. After the flake was secured in the tool, the aborigine used his teeth, a pressure technique, to sharpen the edge or retouched the edge by striking with a piece of hard wood. The sharpening flakes were removed from the ventral to the dorsal side of the flake, being curved or flat, the angle of the cutting edge conformed to the hardness of the material being worked. It is possible that counterparts of the Australian implements have a much wider distribution than history records. The use flakes may be useful in determining the difference between tools called scrapers and those used as an adze. The scraper is drawn towards the worker with the ventral side of the flake facing the worker. Any use flakes removed during the scraping action will be from the ventral to the dorsal side of the implement. When the tool is to be used as an adze, the ventral side is towards the material being worked and any use flakes will be removed from the ventral side of the modified flake. The different positions of the use flakes may be useful in separating ~~the to~~ those diverse functions performed by tools similar in outline and form.

In Australia large flakes, two and a half to five pounds, are unifacially flaked by direct percussion to be used as hand held choppers, (hand ax). The ventral side of the flake facing the wooden material being worked. Like the Australian adzes, function will detach flakes from the ventral side of the tool. The cone of force resulting from function penetrates the stone in the same direction as the impact and the use flake terminates in a step fracture rather than a hinge. Use flakes do not necessarily appear on all specimans because when they are resharpened the functional scars are eliminated. Sometimes use scars will not appear on functional edges due to a build-up of resins and wood fibers which will only cause the edge to dull.

During the past two million years, man has produced a vast assortment of artifacts, many designed to perform specific functions, others multi-functional and possibly some were for non-functional ceremonial purposes. Sometimes, after tools had performed their original intended task, they were often modified into other tools and then used for other purposes. One can often imply function by examining the design, but by using the cone principle one is able to reconstruct the forces necessary to detach a use flake of certain dimensions and direction.

Cone Truncation is at the apex or proximal end of the cone of force and is called the platform part of the flake or blade. The top of the core is the platform and when a flake or blade (cone part) is removed a portion of the platform (cone truncation) is also removed.

The size of the cone truncation is the area contacted by the percussor or compressor. The character of the cone truncation (platform) is the most diognostic part of a blade or flake. The cone truncation may be flat or at an angle depending on the type of core or the applied technique. The truncations, or platform parts, are often modified by a variety of methods corresponding to techniques, stages of work, and the ultimate intention of the tool maker. Some truncations are simply the natural cortex of the stone, others a plane fracture surface, or by removing two or more flakes to isolate the platform or truncation, single bulbar scars are used to seat the flaking tool, and other truncations are strengthened by abrading and sometimes by polishing.

The yield of the percussion tool and the portion of the platform part contacted by applied force will make a large cone truncation and often eliminate the classic cone scar, leaving a diffused bulbar part on the flake and flake scar. The use of a hard semi-pointed or sharply convex hammer will leave a well defined cone scar. Some techniques cause the cone truncation to crush or collapse in which cause no bulb of force to be visible.

The natural tumbling action which forms intersecting cones on vitreous lithic materials is similar to the pecking technique used by man to reduce and shape implements. The process is called pecking and is a percussionary technique of repeatedly striking the object to cause cones of force to intersect one another thereby freeing the material between the fracture planes. A percussor of vitreous material is desirable because after continued use it will develop slightly projecting positive cones. These positive cones on the percussor will in turn form multiple cones on the material being reduced by pecking from a single blow. A percussor of the proper material will remove a quantity of material from the objective piece in a short time. Experiment has shown that when the worker use a percussor of the proper weight and material, he can groove a basalt or granite maul in less than one hour. Pecking was a common technique in the Neolithic times and implements of flint-like materials were pecked in this manner before final smoothing and polishing. When pecking is used to reduce non-vitreous material the cones are often crushed, new ones made and then crushed causing a rapid reduction of the material. The percussion cone technique was used to form and groove axes and mauls, inscribe petroglyphs, make bowls and mortars, to make heads for war clubs, shape masonry and make ornamental carvings.

Pressure Flaking

The fracture angle of the cone and the interpretation of the direction of applied force can only be used when the pressure is in one direction. Commonly the pressure technique requires the force to be applied in two directions, in the direction of the proposed flake and away from the piece being worked. Characteristic uni-directional pressure scars indicate that the flake is quite flat and terminates without curving. Projectile points with a diamond shaped transverse section are examples of the single direction force. Pressure retouch used in beveling and sharpening is often a uni-directional application of the pressing force. The flakes detached by bi-directional pressure use the cone principle but pressure is applied in two directions and the pressure tool may be held at different angles from vertical to the direction of the proposed flake scar. The pressure tool tip is first seated firmly on a prepared area that will withstand the pressure necessary to detach the flake of a pre-determined size without crushing. Pressure is then applied in the direction of the proposed flake even if the pressure tool is held tangentially to the direction of applied force. As outward pressure is gradually increased, the inward pressure is maintained and the pressure must be sufficient to prevent slipping. The flake will start to part at the proximal end, removing a cone affixed to the proximal end of the flake. The inward pressure will then guide the cleavage to its termination. The cone of pressure shifts its position as the outward pressure is increased and the shift continues until the fracture angle of the cone is reached and the elastic limit of the material has been exceeded. The proportion of inward and outward pressing forces are coordinated and adjusted to the desired flake or blade termination. The fracture angle of the cone is used in pressure flaking but only the uni-directional pressure scar can be measured by using the gauge (fig.).

Conclusions

An examination of the behavior of cones of force in isotropic materials is a necessary part of understanding lithic technology. Unless the direction of force is related to the fracture angle of the cone, the action of the stone worker cannot be reconstructed, ~~not~~ nor can functional flake scars be interpreted to fit a specific use. When the mechanics of cone fracture are understood, a realistic interpretation of the specific character of flaking products and by-products of workshop areas can be made which will aid in defining separate industries, definite traits and attributes. The character of cone fracture is governed by a set of conditions. A replication of the conditions causing cone fracture will result in similar characteristics of flake and flake scars. The character of the cone parts represent the developmental stages of artifact production from their inception to the finished product, showing the worker's intention, the diverse techniques and tools used.