RELATION OF THE CONE PRINCIPLE TO FRACTURE OF FLINT-LIKE MATERIALS

Prehistoric stone tools of flint-like or isotropic materials are generally made by subjecting sufficient force to exceed the elastic limit of the material to induce fracture and detach 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. (see reverse) An understanding of the correlation of the cone principle in relation to the detachment, behavior and fracture of lithic material will help clarify the mechanical principles involved in lithic technology.

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 (cone parts) to form his stone implements. When he learned to predetermine the thickness, width, length, form and size of the flakes and control the detachment, he was able to produce a variety of styles and tool types.) The flake form is directly related to the exterior surface of the material and the fracture angle of the cone. The shear plane is the same as the fracture angle of the cone and is tangental 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.

The <u>Cone</u> <u>of</u> <u>Force</u> will be used in this text to denote the visible part of the cone without implying the type of applied force. Most texts refer to the cone of force as the "bulb of percussion" thereby denoting that the cone - or flake - was detached by the percussion technique. There are many techniques of flake detachment and cones may be formed by pressure, percussion and various other methods. Unless one has evidence - such as flakes or flake scars bearing attributes, diagnostic features and characteristics - which determine the employment of a certain technique, Full cones result from force directed in from the margin at ninety degrees to the plane surface~~, in from the margin~~. Half cones result ~~from~~ when force is directed at ninety degrees on a right angle margin and quarter cones are formed by the force being directed vertical to the corner of a rectangular block. Other cone parts are the result of kinds and types of force and combinations of conditions.

then it is better to use the term "bulb of force" or "cone of force". When the technique has been determined, then it should 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 the 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 thin and form the artifacts are the negative cone parts.

When lithic material is subjected to stress, the force waves radiate in ever-expanding 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 basal margin. Therefore, the direction of applied force is different than 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 tangental to the direction of force. A common inverted funnel can be used to illustrate the cone principle. The ~~neck~~ 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. 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 in 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 a gauge to interpret the direction of force. The gauge 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 devise for showing the direction of applied force to remove a flake or blade from an artifact or core. The gauge helps in discriminating between naturefacts and those intentionally made by man.* 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 of the cone by inducing shear from opposing bi-polar forces, (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 have definite direction and magnitude. When force is applied, the material compresses and the force radiates tangental to the direction of applied force. The type of applied force determines the formation or spacing of compression rings around the circumference of the cone which undulate in much the same fashion as sound waves. For example, blows of high velocity with a hard hammerstone

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The gage helps to determine the angle in which force was applied and when the angle or oagles are known, one may then reconstruct the action that was involved in the forming of the implement. Should a row of flake scars removed in sequence be present along a margin indicating consistand directions of force applied with the same intensity, the probability that it was a product of mans skill rather than a result of action by nature. Too the row of flake scars must all bear the same amount of erosion, erosion diferential will indicate that the flakes were removed at different times, wether by nature or by man differences in erosion will be more characteristic of nature than of mans remodification of an artifact. Too the angles of force causing flake detachment from alternate directions along a margin and in sequence would be highly unlikely to be an action of nature. Violent disturbances from natural causes in vitrious materials can produce single objects resembling psudo artifacts, but they will not occur in numbers that show preconception of design, and intent.

The <u>cone of force</u> will be used in this text, to denote the visible part of the cone without implying the type of applied force. Most text refer to the cone of force as the " bulb of percussion", denoting a technique or method in which the cone or cone part was detached' from the core or implement, whereas cones may be formed by pressure and other techniques. Unless one has evidence to support the use of a certain technique and the flake or flake scar bear atributes, ~~and~~ diognostic features and characteristics that determine that a certain technique was used then the term "bulb or cone of force" should be used.

FLINTLIKE MATERIAL FRACTURE AND THE CONE PRINCIPAL

Prehistoric Stone tools ~~made~~ of flint-like or isotropic minerals are generally made by subjecting enough force to lithic material to exceed its elastic limit ~~to the material until the the elastic limit of the material is exceeded, thereby causing fracture to take place displaceing a portion of the material~~ and thereby induce fracture & detach a portion of the stone ~~to induced and a portion of the stone is detached~~. The detached piece is a flake and is also a cone part.

Ancestral man - ~~wether~~ whether by instinct or reason- took advantage of the fracture angle of the cone of force and the isotropic nature of the material to systematically detach these cone parts to form his stone implements ~~to form artifacts by aplying force. Learning to detach and control at will flakes of variable dimensions,~~ ~~When he had learned to control the detachment~~ When he learned to predetermine & control the variable dimensions & detachment of the flakes, he was able to produce a variety of ~~tool~~ styles and tool types. An ~~understanding~~ explanation of the correlation of the cone ~~principal~~ principle & behavior fracture in relation to ~~the~~ detachment of the lithic material will help clarify the mechanical principals involved in Lithic technology.

Page 7

The following interpretation~~s~~ of the cone principle is based on the study & results of numerous experiments ~~and observations~~ in replicating aboriginal flaking techniques. Circumstances have not permited controlled laboratory investigation of the exact angles related to force ~~properties of materials~~, inertia, mass, motion, velocities + properties of materials ~~and force~~, but experiments have been verified by ~~comparing~~ duplicating & comparing ~~and compared to~~ both cone and cone scars on isotropic materials formed by both man and nature ~~in isotropic materials~~. 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.

Since Cones and cone parts are the result of ~~transmitting~~ ~~applied~~ force applied to isotropic materials, they may be the result of ~~this force may be due to~~ natural causes or ~~it may be~~ the intentional calculation application by ~~of~~ man ~~wether it be~~ either by pressure, percussion, indirect percussion, or the combination of pressure and percussion ~~or by use of the tool~~.

Archaeologically the positive portion of the cone is the detached flake ~~cone or portions of a cone can be compared to positive flakes~~ and the cone scars which thin & form the artifacts ~~negative cone scars compared to the~~ negative portion of the cone which are the negative cone parts. ~~flake scars that are present on implements and cores.~~ Natural forces result from ~~are the result~~ of a wide variety of causes and may, under the right conditions, form cones and cone scars on stone which are similar to those made by man. However the scars are generally ~~they are~~ random and do not reflect the ~~without~~ pre-conception, planed order, rhythms and muscular motor habits necessary for man to produce his tools. Close examination and analysis of their character and the fracture angle of the cone of force ~~which~~ will indicate the direction in which force was applied may reveal that they are an imitation rather than a duplication of mans endevors. Flakes ~~detached~~ intentionally detached by man have sharp edges and generally leave sharp edges on the objective piece. Utilized tools may exhibit a dulled edge but generally show a distinctive wear pattern. ~~their becoming dulled by performing usefull functions, while those~~ Fractures made by natural causes ~~nature~~ lose their edges from being ~~by natural movements being~~ abraided by indiscriminate pressure and percussion.

Stone artifacts are formed by controling the detachment of ~~detaching controlled~~ flakes of variable but predetermined thickness, width, length, form, and size. If the student of lithic technology can ~~correlate the principle~~ of the cone and its behavior in relation to the fracture of isotropic material, the mechanical principles involved in flint knapping will be clarified.

It is most evident in mans long history of making stone tools that he preconcievedthe fracture angle of the cone of force when applying force to remove a flake. The shear plane is the same as the fracture angle of the cone and tangenetal to the direction of applied force, therefore the force is applied at an angle to the frzcture plane of the proposed flake or flake scar. When lithic material is subjected to stress, the force waves radiate in ever expanding circles from the point of contact compressing the material causing a cone to be formed. Vitrious isotropic materials are generally highly elastic, some ### having this quality more than others, and when the applied force exceeds the elastic limit of the material, fracture results. Fracture starts ar the apex or vertex of the coneand terminates at the basal margin. Therefore the direction of applied force is different than 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 tangenital to the direction of force. A common inverted funnel can be used to illustrate the cone principle, the neck of the funnel being the direction in which the force is applied. The sides of the funnel, the fracture angle of the cone and the apex of the cone or platform is the part of the funnel where the neck or stem joins the flared part of the funnel. To show the direction in which force was applied to detach a flake or cone part the sides of the funnel are are alligned with the flake or cone scar and the stem will show the direction in which the force was applied. The flair of the sides of the funnel may not quite be the same as the angle of the cone

So one may quickly make an isosceles triangle from cardboard or a piece of plastic and then afix the apex of the triangle to a small dowel. The angles of the triangles sides to corespond to these of the cone of force. This small tool is a most useful devise to show the direction that force is or was applied to an artifact or core to remove a flake or blade. The gage helps in discriminating between naturefacts and those intentionally made by man. The gage will resemble an inverted " Y ". There are exceptions to the rule of using the fracture angle of the cone and also the gage to determine the direction of force : (1), Splitting of the cone by inducing shear from opposing bi-polar forces. (2), Cone collapse due to excessive compressive force.

isosceles

The apex of the cone is not pointed as a mathematical cone, the truncated part at the apex is the part that recieves the applied force causing a cone to be formed in the isotrophic material. The truncated part of the cone is the part contacted by the applied force and acts as the bearing surface. The diameter of the cone truncation will corespond to the implement used in applying force. In order form a cone , the force must have definite magnitude and direction. Upon the application of force the material is compressed and the force is radiated in the direction in which the force is applied. The type of force may cause compression rings to be formed around the circumference of the cone. The type of force used to form the cone or cone part causing compression rings to undulate in much the same fashion as sound waves, for instance blows of high veloicy using a hard hammerstone causes the wave interval to be closely spaced while a slow blow with a soft percussor will cause the wave interval to be widely spaced or aproaching those caused by pressure. The different ways in which the force is applied produces compression rings in the form of waves of varying intensities and spaceing, compensing at the cone truncation. 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 spaceing is due to the type of applied force and the material.

(see types of force)

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, which sides remains fixed. If the fixed side be equal to the other 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 , 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 the apex of the cone of force is truncated and corespomds with the platform part or proximal end of a flake ~~or the proximal end of the flake~~ or blade. In determitive mineralogy, a feature called conchoidal is characteristic to certain vitrious isotropic minerals presenting a surface more or less like the surface of a shell. Used for identification in the fracture of minerals when they break ~~as to~~ present on the negative side ~~one fragment~~ a concave surface like that of the interior of a bivalve shell, and on the positive side ~~other~~ a convex one, like that of the exterior. The interior of the shell is the negative cone scar while the outside is the positive part of the cone, the hinge part of the shell the cone truncation or the part recieveing the force causing fracture.

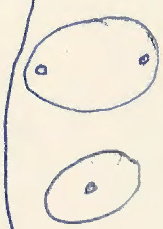
Elasticity is the quality or condition of being elastic : that inherent property in materials by which they recover their original form or volume after an external pressure or force has been dissapated : also springiness. Vitrious or isotropic materials used in the lithic industries are almost perfectly elastic, Degrees of elasticity are dependent on the homogenity of the micro-crystalline structure, the more vitrious, the more elastic, i.e. ~~eg.~~ obsidian and other glassy material is considerably more elastic and springy than quartzite, and natural flint is stiffer than thermal treated flint which has been made vitrious by artificial means.

When vitreous material is worked, Cones will either shear or be formed deeper into the mass, than when the ~~using~~ ~~###~~ aproximately the same amt of force ~~in vitrious materials than those which are more granular.~~ is applied to more granular material. The more granular material appears to dissipate ~~dissapate~~ the cone forming ~~forming~~ force more redily than does ~~in the~~ glassy rocks.

~~The limit of~~ Elasticity is the utmost ~~limit or~~ extent, or limit to which elastic materials can be extended or compressed without fracturing. ~~destroying their elasticity.~~ To induce ~~In order to cause~~ fracture in isotropic minerals the limit of elasticity must be exceeded. ~~Also upon causing fracture by the application of force, the part detached~~ Sometimes when the worker is detaching a thick blade from the core, it will ~~sometimes~~ break ~~fracture~~ from the rebound or recoil ~~which~~ exceeding the elastic limit of the material. Rebound can be detered by reduced velocity, longer interval of contact, or dampening. Rebound fracture surfaces canot be compared to the cone of force and is an exception.

Cone parts in the form of flakes or blades have almost universal distribution, while intentionally made complete or full cones have limited occurances, to date. However aboriginal making of full cones was used for making perforations rather than normal artifact forming. Independent use of full cone removal occurs in both the New and Old worlds, Mexico and North Africa. I have noted the technique used in the State of Colima, Mexico and Jacques Tixier (personal Comunication) has found examples of full cone removal used to perforate beads in Egypt during the Chalcolithic. The Egyptian bead making exhibited slight technological differences than the Mexican method of perforations. Those from Egypt were first drilled half way through flakes of vari-colored chalcedony with a very small tube drill and then the balance of the material punched out removing a cone with a cylinderacle truncation. Surplus material was then removed from around the perforation making the bead discoidal.

Perforations in obsidian made by removing minute complete cones from the margins of eraillure flakes has been noted by the writer in Colima, Colima, Mexico. The eraillure flakes are a specialized concavo convex generally circular, formed by direct percussion between the flake and the core. the eraillure flake either falls free or remains partly atached to the core. The dorsal side of the flake is usually without compression rings and the convex side has a good reflecting surface. The sharp edges around the circumference are removed by shearing, and the piece made regular.



Indentations are made by using a pointed drill, slightly in from both edges and opposite from each other on the concave side. A sharp punch of some very resistant material is placed in the indention and then by percussive means tiney cones are removed to complete the perforation. The graduated disks are then atached side by side and not strung as a customary bead.

The method may sound very simple, but in reality, it is most difficult to do as the force used 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 eccentrics in making the initial perforations but the holes have been enlarged by additional flaking, thereby destroying any remnant of a cone scar.

Experimentally I have perforated lithic material by the above mentioned techniques plus others. One method is select or make a plain surface and then strikea hard sharp blow with a hard percussor, it having a covex surface on the striking end. The impact between the percussor and the plane surface of the objective piece must be at 90 degrees or vertical other wise the cone will be acute, or malformed. The blow will cause a cone to be formed within the lithic material, Then a tabular flake is removed parallel to the plain surface. The thickness of the tabular flake should corespond 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, ~~while~~ 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 flakethen ~~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 tabular flake may then ~~have the hole~~ be enlarged by additional flaking to make a circle or bracelet.

Another fuel cone experiment ~~in cone making is to~~ was by projecting a hard ~~projectile~~ missile at high velocity ~~by using~~ with a pneumatic gun or a sling shot. Certainly this is an not aboriginal technique, but is excelent for examination of cone character, such as fracture angle of the cone, different velocities, shock waves, cone truncations, cone collapse and angles of impact. In lieu of the air rifle or sling shot, a thin flexiable piece of hard wood can be used in the manner of a spring by securing one end, then pulling back on the other and ~~then~~ releasing it to strike a pea size rounded pebble placed on the tabular material to be perforated by the impact removing a cone. Shattering is common until the correct velocity is achieved.

Another cone experiment ~~in making cones is to~~ involves selecting or making a flat surface on the lithic material to recieve the impact ~~on the lithic~~ material and then imbed it in wet sand.

The plane surface ~~to be~~ is placed upward and then struck vertically with a hard percussor, the size and velocity of the percussor must corespond with the size and inertia of the objective piece. This method will easily make a cone but failure is more common than success if one atempts to perforate the piece by removeing an entire cone.

NATURAL FLAKES AND CORES

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 calculation and application by man - either by pressure, or more commonly percussion. Natural forces result from a wide variety of causes and may, under the right conditions, form cones and cone scars on stone which are similar to those made by man. However, the scars 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 their character and the fracture angle of the cone of force will indicate the direction in which force was applied and may reveal that they are an imitation rather than a duplication of mans endeavors.

Flakes intentionally detached by man have sharp edges and generally leave sharp edges on the objective piece prior to performing functional use. Utilized tools may exhibit a dulled edge but generally show a distinctive wear pattern. Fractures made by natural causes lose their edges from being abraded by indiscriminate pressure and percussion.

NATURAL CONES OF FORCE

Natural cones of force are common almost everywhere, they are more noticeable in vitrious than granular rocks and particularly those with the properties of isotropisim. Natural movements of rocks, wether by changes of elivation or the action of water, any force or forces that cause contact by pressure or percussion will cause cones of force. One pebble striking another will cause a cone of force to form on both pebbles if the force exceeds the elastic limit of the material. The cone will penetrate the material to a distance equal to the amount of force, ###the inertia and the velocity, reduced force may not cause a cone to form, while great force may cause the object to be cleaved at the fracture angle of the cone. Also it is possible for the cone of force to be sheared when the material is resting on an unyeilding support and force directed opposite the support. Vitrious rock rolled and tumbled for some distance will soon be covered with intersecting cones that have penetrated to different depths extent because of the variable intensities of subjected force. Vitrious rocks assume a characteristic surface that identifies the material as having the possibility of being suitable to be usefull material for flaked stone tools. Non vitrious materials allow the cone to colapse and become smoothed and rounded.

Determination of natural fracture

By understanding the cone principal ~~in the~~ formation in isotropic minerals ~~is a usefull tool in understanding fracture by intention and the products of nature~~ can help determine & descriminate between natural & intentional fracture. A cone of force is formed by ~~the application~~ applying of the force at right angles to the plane surface. One ~~can then tell at which~~ Because the fracture angle of con determine by the fracture angle of the cone is tangential to the direction of applied force the angle ~~the~~ force ~~was~~ applied to ~~cause the fracture angle of the cone. Too~~

By using the fracture angle gage and overlaying the cone scars, the direction of force is obvious. In nature It is ~~most~~ unlikely that ~~alternated~~ 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 consistant angles of flake removal and each scar overlaps the next in ~~order~~ sequence we can safely rule out a natural occurrence, a ~~natural replication is quite~~ nil/. ~~Either by eye or for the inexperienced~~ By the use of the fracture angle ~~gage~~ 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. ~~During natural flake removal any usefull edge will be~~ Flakes detached by natural causes will have crushed and abraided edges and the weaker areas will be reduced more rapidly than the thicker stronger parts. The edges of ~~natural~~ psudo tools become rounded and abraided, from interaction with associated lithic materials. The flake scars are also abraided but in different degrees because nature does not remove all flakes in sequence.

It is highly immprobable that man would remove just one flake, use the tool then detach another and so on in order to exhibit differential wear on the individual scars. When problamatical and questionable examples of lithic materials are examined it is well to have a represenitive population and study the fracture angle in relation to the direction of force to resolve the question of man versus nature.

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then detach another and so on in order to exhibit ~~diferential~~ differential wear on the individual scars. When problematical and questionable examples of lithic materials are examined it is well to have a represenitive population and study the fracture angle in relation to the direction of force to ~~when~~ ~~resolving~~ resolve the question of man versus nature.

~~NATUREFACTS~~ Natural flakes

Lithic materials at or near the ~~place of deposition by nature~~ the natural deposit result in erosional forms and flakes that have a resembelence to those formed by man ~~and~~ but in reality are the products of nature. When quanities of vitreous minerals with the properties of isotropisim, ~~vitrious and upon being~~ are subjected to force ~~cause~~ flakes ~~to be~~ can be removed ~~may often~~ which may be misconstrued ~~with~~ as flakes and cores made by man. Natural forces that may ~~cause~~ form psudo attifacts ~~to be formed~~ are the ~~seteling~~ settling of underlying formations, earthquakes, diastrophisim, ~~any natural gravitational changes causing movement of the material,~~ exfolation, developement of internal strains and stresses and tempERAture changes, formation of crystaline minerals after the initial deposit,movement by water or ice, and any other ways in which natural elements will cause one mass of lithic material to ~~cause force to be~~ subjected force to another mass,causing fracture.

The distribution of questionable artifacts mingled and co mingeled within a deposite of geologically occuring lithic materials present complex problems not found in places some what remote from a 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 ~~an~~ example at the Ayachuco shelter on the side of a cliff ~~containing~~ a stream cobble which was altered at one end by the removal of ~~alternate~~ SUCESSIVE flakes was found by McNeish is unlikely to be a Naturefact.
McNiesh, 1969

The geological occurance of vitrious material (minerals) is ~~most~~ important before a final ~~apraisial~~ of questionable flakes or artifacts. Minerals lending themselves to flaking generally occur ~~##############~~ naturally in several catagories, blanket veins , ~~eg.~~ horizontal beds of chert, silicified sediments, silicious sand stones (quartzite), not meta Quartzite. ignimbrite, obsidians and basalt. Silicious filling of cavities eg. ~~falt~~ zones, vesicular Basalt, psudomorphs and as concretions in sedimentary rocks, (flint in limestone). These materials may be re-deposited by being ## in the form of cobbles or boulders in alluvium. Quite naturally, vitrious minerals ~~upon being~~ rolled and bruised prior to re-deposition in the form of alluvium or occuring naturally are rounded , since the corners or protuberences are less resistant to battering. During the the movement of one piece of stone against ~~the~~ other flakes ~~will be removed~~. ~~The~~ rounded or ovoid materials ~~become~~ more resistant to fracture than material ~~that is angular~~. The investigator can expect to find somewhat different styles of flake and flake scars in deposits of ~~natural~~ materials depending on their geological occurance. ~~Deposits of~~ angular material ~~will~~ ~~have~~ core-like pieces with an occasional scar at the corner or corners that will resemble a blade core. ~~or~~ thin tabular pieces will have an edge that will appear to be a burin core. The right angle margins of the tabular or anglular pieces will have ~~assorted~~ random chonchoidal scarsof assorted sizes. The edges being somewhat crushed and abraided. ~~There should also occur~~ flakes ~~that~~ match the flake or blade scars.

Starch fracturing is not uncommon in natural deposits of obsidian and silicious vitrious minerals and causes some very interesting psudo artifacts to be formed, many will resemble blade cores and blades . However with starch fractured material there is no bulb of force but there are ocassional rings of compression.

Rounded spheroid material ~~upon~~ being fractured ~~by~~ nature must recieve considerably more force than ~~the~~ angular, and before a rounded mass will break ~~the application~~ ~~#######~~ ~~of~~ force ~~will have to be near~~ 90 degrees to the surface, ~~other forces~~ will ### glance or riccochett without ~~causing~~ fracture ~~to take place~~. Natural application of forces will ~~have different~~ intensities, while those made by man will be more uniform, ~~unless~~ the Austrailian technique of ~~smashing~~ by ~~throughing~~ is used. Natural fracturing by violent battering ~~causes~~ the cone of force ~~to~~ ~~collapse of shear~~, generally ~~without good or well~~ defined bulbs of force. When the force is excessive and the cone of force collapses the debris is angular and the flakes are sub-triangulate ~~having the character of a segment of an orange~~. The force waves ~~are~~ closely spaced with expanding shatter lines originating at the point of applied force. When cone shear ~~takes place~~ ~~there is no~~ 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 the functional use and also the manner of holding. Past studiesof such scars has placed emphasis on the plane of fracture, but has 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 ~~and~~ 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 angles and ~~the~~ direction of ~~the~~ applied force and ~~then~~, in turn, be used to show the manner in which the tool was held. ~~When a tool is used by impact or percussion the~~ When, for example, the tool was used as chopping implement by impact or percussion
~~fracture angle of the cone is quite constant, as with chopping implements.~~
the fracture angle of 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 ~~is used and a cut made with the pressure made in one direction until~~ could be applied until the cut is terminated.

~~it terminates.~~ But If the cut does not terminate then two directions of

pressure are used to ~~terminate the cut being made,~~ complete the cut. Should an involentary

use flake be detached it will corespond to the proportion of the forces,

changeing 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 restance, it can be held at the proximal end between the thumb

and fore fingers ~~at the proximal end~~ and drawn ~~tward~~ toward the worker, ~~with~~

the strokes being parallel to the long axis of the blade, or flake.

When used with care in this manner ~~and with care~~ the edge may become polished after

long use. Twisting or any side pressure will cause the tool to nick/ ~~and~~ on the side opposite where the Pressure is applied.

The nick will weaken the edge if the tool continues to be used ~~continued use after a nick is caused weakens the edge~~ and the projection resulting

~~caused by~~ from the nick will ~~cause~~ detach a flake ~~to be removed~~ longitudinally ~~longstudnally~~ and

this process will continue until the tool is resharpened or abandon.

The functional scars will be short and steep in a direction away from

the user - or ~~tward~~ toward the distal end of the blade. When the acute edge

contacts bone or some hard resistant material ~~the edge may~~ it will become crushed.

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 contamination of the material being cut by 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 ~~not have~~ lack regular spaceing ~~and lack~~ and uniformity, the leading edge will usually show crushing ~~and is~~ which should ~~not~~ to 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 ~~being~~ drawn tward the worker. This type of ~~use~~ function will ~~cause any~~ detach use flakes ~~to be removed~~ at the scraping edge from the ventral to the dorsal side. However, use flakes would only be present if the scraper edge contacted some ~~resintant~~ material ~~hard~~ resistant enough to errode or scar the ~~stone~~ scraper edge by removeing a cone part. If the scraper ~~did not make such contact~~ does not contact hard material, then the edge ~~would~~ will just recieve a polish. Since function does not always produce use flake scars on a tool, there are other means to determine if the flake has been used. ~~a~~ quick field test ~~to determine if the flake has been used~~ is to carefully run the finger along the edge to determine the sharpness. If it is extremely sharp we can presume it has not been used - if dulled, then or smooth to the touch then we presume functional. The use of the binocular microscope is often necessary to determine wear patterns, or functional polish ~~from use~~. Often striations may be observed showing the direction of use, but will not determine ~~not~~ the angle ~~in~~ at which the tool was held.

On the other hand, implements that appear to be scraper-like objects were used by the Australisn aboriginals for for forming/ and shapeing wood. They hafted and used the tool in much the same manner as one would use an adz./ Gould and Tindale, (personal Comunacation) These artifacts were secured to a shaft of hard-wood or ########## were afixed to the proximal end of the throwing stick (SPEAR THROWER) by using an adhesive spinifix gum and then used in much the same manner as one would use a hand-held wood chisel. The use side of the artifact was the ventral ####### side of the flake., if the cutting edge was to be slightly curved, it was oriented near the bulbar part of the fake and if flat twards the distal end of the flake. After the flake was made secure it was sharpened by using the teeth or by striking with a piece of hard wood. The sharpening flakes were removed from the ventral to the dorsal side of the flake. The exposed cutting edge then conformed to the ventral side of the flake, being curved or flat, the angle of the cutting edge conformed to the hardness of the material being worked. Any flakes removed # by function are on the ventral side of the flake tool. It is very possible that the counterparts of the Austrailian implements have a much greater distribution than is ordinarly concieved. The difference in the position of the use flakes may be usefull in separating the two functions performed by tools simular in outline. (insert)

The use flakes may be useful in determining the difference between tools called scrapers and those used as an adz. The scraper is drawn twards the worker with the ventral side of the flake faceing 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 adz, the ventral side is twards 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 usefull in separating the two/diverse functions performed by tools simular in outline and form.

In Australia

Large flakes, two and a half to five pounds are unifacially flaked to be used as hand held Choppers with the ventral side faceing the wooden material ~~(wood)~~ being worked. Like the Australian adzes, function will detach ~~Any use~~ flakes ~~will also be remove~~d from the ventral side of the tool~~, much the same as the Australiian adzes.~~ ~~The~~ cone of force resulting from function penetrates the stone in the same direction as the impact ~~was recieved#~~ and the use flake terminates in a step fracture rather than a hinge . Use flakes do not necessarily ~~nessarly~~ appear on all specimans, because when they are resharpened the functional ~~they~~ scars are eliminated. Sometime use ~~functional~~ scars will not appear ~~resin and compressed wood fiber often causes dulling rather~~ on functional edge due to a build up of resins & ~~than the edge being fractured.~~ wood fibers which will only cause the edge to dull.

Dur~~r~~ing the past two million years man has produced a vast assortment of artifacts, many designed to perform specific functions, ~~and~~ others ~~diverse~~ multi-functional, and ~~######~~ possibly some were for non-functional ceremonial purposes. ~~The tools~~ Sometimes tools were often modified into other tools after ~~they~~ tools had performed their original the task ~~of first intention~~ and then used ~~after modification~~ for another purpose. One can often imply function by examining the design, but by using the cone principal one is able to reconstruct the forces nessary 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 ~~(Fr. talon)~~. The top of the core is the platform, and upon removing ~~a cone part or a~~ a flake or blade (cone part) a portion of the platform (cone truncation) is removed ~~which is the cone truncation.~~

The size of the cone truncation is the area contacted by the percussor or compressor. The character of the cone truncation (platform) ~~or the platform part~~ 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 ~~used.~~ The truncations, or platform parts, are often modified by a variety os methods coresponding to techniques, stages of work, and the ultimate intention of the tool maker. Some truncations are simply ~~characterized~~ ~~by using~~ the natural cortex of the stone, others a plane ~~plain~~ fracture surface, or by removeing 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 abraiding and sometimes by polishing.

The yeild of the percussion tool and the portion of the platform part contacted by applied ~~as~~ force ~~is applied~~ will make a large cone truncation and often eliminate the ~~same~~ classic cone scar, leaving a diffused ~~causing the~~ bulbar part bulbar part on the flake and flake scar ~~to be difused.~~ The use of A hard semi-pointed or sharply convex hammer will leave ~~yeild~~ a well defined cone scar. Some techniques cause the the cone truncation to crush or collapse in which case no bulb of force will be visible ~~The cone ### truncation may not be obvious at when it crushes or collapses when some techniques are used.~~

Multiple cones of Force made & used by Man

The natural tumbling action ~~that~~ which ~~takes place in forming~~ forms intersecting cones ~~was~~ on vitreous lithic materials ~~was~~ is similar to the pecking technique used by ~~man to~~ ~~cones ## also used by # man to in~~tentionally reduce and shape implements. The process is ~~usually~~ called pecking, and is a percussion~~aly~~ary technique of repeatedly striking the object ~~repetitiously causing~~ to cause cones of force to intersect ~~with~~ one another thereby freeing the material between the fracture planes. A percussor of ~~A~~ hard vitrious material is desirable because ~~rather than non-vitrious material is used to the advantage because the vitrious rock~~ after continued use it will develop slightly projecting postive ~~cones. slightly projecting from the percusser~~. These positive cones on the percussor in turn will form multiple cones on the material being ~~pecked~~ reduced by pecking from a single blow ~~on the material being reduced~~. A percusser of the proper material will remove a quantity of ~~considerable~~ material from the objective piece in a short time. Experiment has shown that when the worker use ~~with~~ a percusser of the proper weight & material ~~and weight~~, he can groove a basalt or granite maul in less than one hour. Pecking was a common technique in Neolithic times and implements ~~including~~ of flint-like materials were pecked in this manner before final smoothing and polishing. When pecking is used to ~~reduceing~~ reduce non-vitrious material the cones are often crushed; new ones are made and ~~they also~~ 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 morters, 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 tech require the force to be applied in two directions 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 principal but pressure is applied in two directions and the pressure tool may be held at different angles than 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 tangenetal to the direction of applied force. The pressure must be sufficient to prevent slipping. As outward pressure is gradually increased the inward pressure is maintained and 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 ~~undergoes a~~ shifts ~~in~~ 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 ajusted to the desired flake or blade termination. The fracture angle of the cone is used in pressure flakeing but only the uni-directional pressure scar can be measured by using the gage. See Fig. ____

Conclusions

An examination of the behavior of cones of force in isotropic materials is a ~~nessary~~ 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 canot be reconstructed, nor can functional flake scars ~~show how the the artifact performed a specific function~~ be interpreted to fit a specific use. A ~~realization~~ 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 when the mechanics of cone fracture are understood. The character of cone fracture is governed by a set of conditions. A replication of the conditions causing cone fracture will result in simular characteristics of flake and flake scars. The cone parts represent the developemental stages of artifact production from their workers intention, inception to the finished product, showing the diverse techniques and tools used.