Meso-American Polyhedral Cores and Prismatic Blades

The Polyhedral cores of Central America represent a distinct type of cylindrical core and their shape is the end result of the techniques used to remove prismatic blades vertically from the perimeter of the core. These cores reveal a technique and a degree of refinement different than any other core type and the cutting quality of the prismatic blades is unexcelled. In size, the cores range from an inch-and-a-half to eight inches in length and some are, no doubt, even smaller or larger. The prismatic blades are compatiable in size, lessening in length as the core grows progressively smaller. Although the core is an interesting study for archaeologists, it has never played a really important part in the tool industry other than some evidence that they were used as anvils, the midsection modified into ear plugs, and sometimes used as a reamer.

Interpreting the manufacturing techniques of these cores and blades has been a challenge to the writer for many years and has resulted in numerous experiments with various methods of manufacture. I do not feel that I have resolved all the problems which confronted the workers of the past, but I have succeeded in producing a core comparable to those made by the people of Meso-America. The observation of Torquamada of seeing the Early Americans use the crutch method to produce these prismatic blades has been invaluable to my experiments, however, he either failed to record the details that would be important to the stoneworker, or has been misquoted by his writers for, taken verbatum, I find it impossible to produce blades in the manner he purpotedly described. Translations of his observations were made by Sr. E.B. Taylor (1861)* and it is certainly possible and highly probable that they have lost something in the translation or that words like "bending" have been translated as "sitting", for I find it impossible, for me, and highly impractible

*Sir Edward Burnett Taylor - Anahuac or Mexico and the ancient + modern. London 1861 even for Ancient Man to remove prismatic blades in a sitting position and under the conditions described. I do, however, feel that the sitting position needs further study and experimentation for, if it can be proved workable, it would have certain advantages. For instance, the standing position allows the blades to fly [redacted] in the air and sometimes they are driven into the ground whereas the sitting position would place the core parallel with the ground and, therefore, the blades would hit the ground with less impact and decrease the breakage factor.

Unlike the other stone tools of the aboriginal, we are fortunate in having a recorded observation of this technique and it is well that we review and analyze the historical writings and observations of Torquemada, Sellers, Catlin, Joly and Hernandes.

According to the Spanish Franciscian Friar, Juan de Torquemada, (Monarquia Indiana, Seville, 1615): "They had, and still have, workmen who make knives of a certain black stone or flint, which it is a most wonderful and admirable thing to see them make out of the stone; and the ingenuity which invented this art is much to be praised. They are made and got out of the stone(if one can explain it) in this manner: One of these Indian workmen sits down upon the ground and takes a piece of this black stone, which is like jet, and hard as flint, and is a stone which might be called precious, more beautiful and brilliant than alabaster or jasper, so much so that of it are made tablets and mirrors. The piece they take is about eight inches long, or rather more, and as thick as one's leg or rather less, and cylindrical. They have a stick as large as the shaft of a lance, and three cubits, or rather more, in length, and at the end of it they fasten firmly another piece of wood eight inches long, to give more weight to this part, then pressing their naked feet together, they hold the stones as with a pair of pincers or the vise of a carpenter's bench. They take the stick(which is cut off smooth at the end) with both hands, and set well home against the edge of the front of the stone, which also is cut smooth in that part; and then they press it against their ~~brest~~ breast, and with the force of the pressure there flies off a knife, with its point and edge on each side, as neatly as if one were to make them of a turnip with a sharp knife, or of iron in the fire. Then they sharpen it on a stone, using a hone to give it a very fine edge; and in a very short time these workmen will make more than twenty knives in the aforesaid manner. They come out of the same shape as our barbers' lancets, except that they have a rib up the middle, and have a slight graceful curve toward the point. They will cut and shave the hair the first time they are used, at the first cut nearly as well as a steel razor, but they lose their edge at the second cut; and so to finish shaving one's beard or hair, one after another has to be used; though indeed they are cheap, and spoiling them is of no consequence. Many Spaniards, both regular and secular clergy, have been shaved with them, especially at the beginning of the colonization of these ~~re...~~ realms, when there was no such abundance as now of the necessary instruments and people who gain their livelihood by practicing this occupation. But I conclude by saying that it is an admirable thing to see them made, and no small argument for the capacity of the men who found out such an invention." (Holmes 1919) B.A.E Bulletin 60 pp 323-324

Certainly there are some inequities in this statement and, rather than conclude that Torquamada was a poor observer, I am inclined to believe that much of his meaning has been lost in the translation. For example:

(1) We now know that these blades are of obsidian whereas the translation observes that the black stone is as hard as "flint". This could be due to Torquamada's lack of knowledge of the properties of stone or his desire to be more descriptive, however, if we were to take this literally, it could be quite misleading regarding the lithic material.

(2) If the text is carefully studied, one notes that the observation of the "Indian sitting on the ground" does not actually relate to the removal of blades but, rather, I suspect, indicates core preparation. For we note that just previous to this statement he has been describing the stone and "They are made and got out of the stone in this manner: One of these Indian workmen sits down upon the ground and takes a piece of the black stone - about eight inches long, or rather more, and as thick as one's leg or rather less and cylindrical". Clearly he is talking of core preparation for the normal core is about eight inches long and about as thick as one's leg and is cylindrical and the sitting position is most normal for core preparation - establishing ridges, straightening ridges, grinding platforms, etc. The phrase "got out of the stone" I would interpret as meaning the worker was removing from a large block of obsidian a piece of stone large enough and properly shaped to serve as the core. There is no indication that Torquamada was referring to the sitting position for blade removal by pressure and my experiments have resolved, for me, that this position will simply not permit enough leverage to remove blades of this size and shape. When the worker is in a sitting position he can only apply pressure from the shoulders and this amount of force is insufficient to remove a blade. Also he is in an awkward position for seating his tool properly and as he lowers his chest for the thrust, his knees

would necessarily be lifted up which would lessen the hold of the naked feet on the core and, therefore, change its angle and lessen its stability. If the worker were seated with his back against an immovable object, such as a tree or large stone, he could exert great pressure by extending his arms, but the arms are also needed to provide the upward pressure and not just for pushing straight down or - in the sitting position - away from the worker. The sitting position also limits the amount of movement that can be expected by just flexing the shoulder muscles. Even if we consider the use of a clamp in conjunction with the sitting position we still cannot make this position feasable for the clamp would have to be secured to the ground to prevent its sliding and if the worker were in the sitting position he would - at the moment of thrust - just push the clamp away from him. Also any sort of holding device necessitates the repositioning of the core each time a new face is to be exposed which makes the sitting position awkward and highly impracticle.

(3) Torquemada's description of the holding method I also question for the translation states "they press their naked feet together, and they hold the stones as with a pair of pincers or the vise of a carpenter's bench." Suppose we change one word in this text and we have: "They press their naked feet together and they hold the stones as with a pair of pincers and the vise of a carpenters bench." This certainly concurs with my experiments and with Catlin's later description of the vise. I do use a crude holding device much resembling a carpenter's vise and I do press my feet together against the core such as "with a pair of pincers.". My experiments have definitely proven, for me, that it is impracticle, if not impossible, to sit on the ground and hold the core with the naked feet and remove prismatic blades by the pressure method. The outward force necessary

to remove a blade is so great that no degree of muscular development (even the, no doubt, superior muscles of the aboriginal) would suffice to immobilize the core sufficiently to accomplish removal. Any movement, however slight, will cause the blade to be ill-formed, (and all subsequent blades) or broken, before it has left the core; thereby making the core unfit for further use. Aboriginal cores are mute evidence of their immobility during manufacture for they are far too perfect and the flake scars show few undulations to have been held by the feet alone. Since the outward pressure is almost as great as the downward pressure, one must not only stand on the holding medium (for stability) but, if the core is extremely large, it must be further secured by the use of weights (heavy rocks or something similar) on the clamp. Further, I belive everyone is familiar with the sharpness of obsidian and even Torquamada attests to this in his description of the cutting edge. And a preformed polyhedral core must have established ridges which can be very sharp (covered in detail later in this text) which makes the naked feet holding method very dangerous. Picture, therefore, the aboriginal seated with this sharp-ridged core pressed firmly enough between his naked feet to hold it secure for the pressure removal of blades and what do you have - an aboriginal with badly cut, badly bleeding, feet. Even placing woven mats or some other substance between the feet and the core would not prohibit the cutting for obsidian will penetrate hide, skin, leather, mats and just about any material that could be used to assist in the holding. I believe the misconception of the seated position and the feet holding is the direct result of the first artist to depict this technique casually reading the text and then drawing the picture of the worker seated on the ground feet-holding the core. I have seen a very early drawing of this method in a German text* showing the worker seated flat on the ground with feet outstretched holding the core "pincer-like" between the feet

* The Paleolithic Finds from the Leine Valley near Hannover; Hildesheim, 1949 pp 133

and casually removing blades. Referring to Bulletin 60 (Page 323) we now find the worker seated on a boulder - in a semi-standing position - and with a shortened crutch, but still holding the core with the naked feet. But in "Flint-Working Techniques" (Ellis,1940) page 47 we now have a drawing of the worker standing but the text still contains the same old description of removing blades in a sitting position.

(4) "Then they sharpen it on a stone, using a hone to give it a very fine edge". If we casually read the text, it would seem that Torquamada is stating that the aboriginal sharpened his prismatic blade. We know this cannot be true for this very intricate method of blade removal was invented by the aboriginal for the express purpose of giving a long, thin blade with an edge that is infinitesimal. Therefore, why hone it. Also, archaeological evidence reveals no abrasion of the edges of these blades that would indicate honeing. Analyzing the text, I conclude that he is either referring to the worker sharpening the tip of the crutch tool or that he is honeing the top of the core for the platform preparation. Personally, I believe the reference is to sharpening the tip of the crutch for this is a very necessary part of blade removal. Also, this reference is made in conjunction with the "stick" which would seem to indicate sharpening of the tool tip. "They take the stick with both hands, and set well home against the edge of the front of the stone, which also is cut smooth in that part; and then they press it against their brest; and with the force of the pressure there flies off a knife. - Then they sharpen it (tip of crutch) on a stone using a hone to give it a very fine edge; and in a very short time these workmen will make more than twenty knives in the aforesaid manner." Unfortunately, his description of the blade between these two explanations would lead one to attribute the honeing to the prismatic blade which certainly

would be unnecessary. It is unfortunate that he did not record the material used in the tip of the crutch, for just a sharpened woodened stick would not be sufficient to remove these blades." If the wood were hard enough, it could suffice, but for my experiments, our local hardwoods are much too soft to withstand this concentrated pressure. They merely crush and splinter and serve no purpose for blade removal. It is possible that the prehistoric workers used antler, bone or jade for this tip, but we have no documentation for this other than that the proximal ends of their blades indicate that less than one-eighth of an inch of surface was contacted by the distal end of the pressure tool, indicating a tip of material harder than wood.

(5) "They have a stick as large as the shaft of a lance, and three cubits, or rather more, in length, and at the end of it they fasten firmly another piece of wood eight inches long to give more weight to this part." It is a little hard to decipher the exact measurement of a "cubit" in 1615 for, even today, we have several meanings for a cubit. The Hebrew, Roman and English cubits all differ, being from eighteen to twenty-two inches in length. If we apply this measurement to the Aztec crutch we would have a length of 5'6" and when we add to this the cross-piece Torquamada refers to we would have a stick a total of about six feet long. Presently, we think of a cubit as being the length from the elbow to the tip of the middle finger. In my case this would be 19" per cubit and I would still end up with a crutch well over five feet, which is much too long for employing this pressure method. The ideal crutch for me is about thirty-two inches long but each worker will require a different measurement depending on his height, measuring the distance from the second joint of the first finger to the chest.

(6) "They will cut and shave the hair the first time they are used, at the first cut nearly as well as a steel razor, but they lose their edge at the second cut; and so to finish shaving one's beard or hair, one after the other has to be used." This is hardly consistent with the description and praise of their fine cutting edge unless we can assume that the barber was very careless with the tool and laid it down carelessly on some hard surface or permitted it to rub against another blade. For the only thing that will dull this fine edge is letting it rub against another blade or hard surface and if they are carefully handled and wrapped to protect the edge, they will retain a keen cutting surface almost indefinitely. I have shaved myself many times with the same blade and seen little or no use scars on the edge. Also, at the Arizona Archaeological Field School of the University of Arizona at the Grasshopper site this last Summer, Gene Seeley, Apache Cattle Manager, skinned a bear with one of these blades and, after the job was completed, we could see little or no dulling of the edge. It is conceivable, however, that these blades were so numerous that the barber cared little about ruining the edge and, therefore, used many of them for one hair cut to insure against offending the Spaniards by hair-pulling with a dull blade. Or perhaps when Torquamada said "but they lose their edge at the second cut" he was referring to the second time the hair or beard was cut.

Therefore, if we are to take the translated version of this Friar's observations verbatum we have: An Indian sitting flat on the ground, legs straight in front of him, holding a very sharp core between his naked feet and pressing off blades with a crutch that measures well over five feet. It simply will not work and I suggest the reader convince himself of this by trying this method personally. I rather think the standing position, with core in a holding device, and the worker pressing on a shorter crutch is the true picture.

I do not mean to infer that the sitting position and feet-holding methods are never used. I use this many times to produce other types of artifacts but not for pressure work. When I employ the use of my feet I am generally using the indirect percussion method. (see Indirect Percussion method, this paper)

Hernandez (1651)* made a little more detailed observation of this technique and added that the worker used a hard stone on the obsidian core before he applied the wood presser. He reasoned that they were removing angles from the edge and the platform before removing the blade. *(A Cabrol and L.Coutier, Bulletin de La Societe, Prehistorique Francaise, 1832) Coutier and Barnes,** quite correctly, deduced that the stone-worker scratched the platform of the core with a rough stone to abrade the surface and prevent the tip of the pressure tool from slipping. **(A.Barnes, Proceeding of the Prehistoric Society 1947)

G.E. Sellers recorded the observations of Catlin who lived with the North American Indians and observed their blade manufacture. "In some cases the stone operated on was secured between two pieces or strips of wood like the jaws of a vise, bound together by cords or thongs of rawhide; on these strips the operator would stand as he applied the pressure of his weight by impulse. The tool being used was a shaft or stick of between two and three inches diameter, varying in length from thirty inches to four feet, according to the manner of using them. These shafts were pointed with bone or buckhorn, inserted in the working end, bound with sinews or rawhide thongs to prevent splitting. For some kinds of work the bone or horn tips were scraped to a rather blunt point, others with a slightly rounded end of about one-half inch in diameter." Here we have a description of the vise and the crutch which both replicate the equipment I use in my manufacture.

N. Joly gives a description of polyhedral blade making in his book "Man Before Metals" (1883, page 212) His version is quite different from both Torquamada and Catlin. "M.Courtes, member of the French Scientific Commission of Mexico, and M.Chabot,maintain that the Aztecs, in making their obsidian razors, begin by shaping the rock near the quarry when it was taken. Then after having given to it the form of a prism terminated at one extremity by a blunt point, at the other a flat surface,the workman takes his prism in the left hand,and pressing it against some resisting surface,strikes it at first with light blows, gradually increasing them in force until at last he obtains splinters as sharp as razors and destined to serve the same purpose."

This method could very well serve to make sharp flakes but could not possibly produce a replica of the Polyhedral core of Meso-America. This description of manufacture would make little sense to any stoneworker for if it were at first struck with light blows this would crush the stone and destroy any platform preparation and increasing the velocity of the blows would remove a flake but it would have multiple undulations and concentric waves which are not present on the Polyhedral blades. The tiny platforms found on the polyhedral blades is testimony that they were removed by pressure and with repitition and accuracy and uniformity. A comparison of blades removed by percussion and pressure will quickly prove this point. Obsidian has very little resistance to end shock and is just not adaptable to removing long well defined blades by the percussion method.

All of these records are valuable contributions to the recording of this technique, but they do differ in some respects and I think one must analyze them and allow for translation discrepancies.

Dr. Robert Heizer's present investigation of the polyhedral site in Guatamela will probably contribute much information regarding what tools were used and the development and resolving of techniques of this particular blade industry. A surface collection from this site indicates methods of severing cores, core rejuvenation, use of exhausted cores as tools, aberrant core forms and those discarded in various stages of manufacture. But, at the present time, there has been very little study or research on the removal of prismatic blades from a Polyhedral core.

The actual removal of prismatic blades from the core is not a difficult technique. The problem lies in preforming the core in the proper shape with ridges to guide the blades and in the proper positioning of the tip of the crutch tool. Verification of this was manifest at the Lithic Technology Conference held in Les Eyzies in 1964 when every participant was able to detach a satisfactory blade. Further, the largest and most perfect blade was removed by Dr. Denise de Sonneville-Bordes whose weight is well under one hundred pounds, thus indicating that this technique also does not require tremendous strength. Each participant was given instructions and help in placing the tip of the pressure tool correctly on the platform, but the actual blade removal presented no problem for them.

Following is the record of my experiments with this technique which has produced a true replica of the Polyhedral core and blades.

Material:

Since my experiments have been an effort to reproduce the obsidian Mesoamerican Polyhedral cores, I have used, primarily, obsidian from Glass Butte, Oregon. It is found in many colors, textures and qualities and is an excellant working material. The best quality from this area is that with an absence of flow structure; that found in situ, and that with homogenity and glass-like qualities. However, I have also experimented with other materials such as cryptocrystalline varieties of quartz, flint and glass. Obsidian, or similar materials, must be homogeneous, fine-grained (or vitreous) uniform in composition and texture and free of internal stresses or strains. It must be devoid of inclusions, grain or undetected flaws, for the slightest imperfection will hing-off the blades and render the core useless for further blade removal. Fortunately for the men of prehistory, obsidian was found in abundance in certain areas of

Mexico and Guatamela and it appears that only that of supreme quality was selected for the Polyhedral industry.

All obsidian is not suitable for making polyhedral cores, yet can be excellant material for the manufacture of a variety of other tool forms. Some obsidians are excessively brittle as a result of self-contained internal forces which is characteristic of the volcanic glasses that are geologically old. Others have imperfections (amigdaloids of crystobolite) due to the obsidian reaching too great a temperature before it cooled. Many other factors are necessary for the formation of good obsidian. (Refer to Materials chapter) Color, or lack of color, appears to make little difference in workability of material, however, the presence of flow structure does cause differential resistance to applied pressure resulting in irregularities on both the core and the blades. Even a minute imperfection can cause the pressure platform to collapse or stop short the removal of the blade along the face of the core before it is removed in its entirety, thus creating either a step or hinge fracture. When this occurs, additional flakes or blades cannot be removed as too great a mass of material remains on the face of the core and, therefore, in most instances it must be abandoned.

Obsidian appears to have the properties of a solid yet behaves in the manner of a heavy liquid. In order to make blades or any other artifact, the maker must be able to control the wave mechanics of this most viscid material. The waves and undulations must be eliminated before a true blade may be removed from a core(See pressure work) A study of the wave patterns on cores and blades may reveal much regarding the techniques of manufacture. Considerable research and study is still necessary to compile and resolve the character of a heavy liquid and the behavior of solids subjected to force. My experiments have helped me resolve and permitted control of this phenomena which I call "wave motion." When making my blades and cores, I have used only body strength, but if these same fractures could be studied under laboratory conditions with the aid of a mechanized device, we could create exact conditions and resolve much of the statistics of this technique.

Crutch:

The tools used in Polyhedral blade manufacture are the chest crutch and the holding device. The crutch I use is about thirty-two inches long, however, the length will depend on the individual worker's stature. The length is determined by measuring the distance between the tip of the index finger and the chest. Place the shaft on the chest, bend over, and place the tip of the shaft on the platform of the core. The distance between the tip of the index finger and the chest will determine the correct length. It is important that the crutch be no longer, as the index finger must place and guide the tip of the pressure tool to the exact position on the edge of the core.

Shaft must be thick, but not so large as to be cumbersom and impare the line of sight between the worker and the top of the core. My crutch has been made from a heavy-duty shovel handle and has served the purpose very well. The wood must be semi-inflexible, for any quivering of the shaft will cause the blade to undulate as it tears loose from the face of the core. This will cause irregularities on both the blade and the core which cannot be overcome with subsequent blade removal.

A pointed piece of antler, ivory, bone, or metal is affixed at the end of the staff, secured by a ferrule, or serving to hold it tight. This immobalizes the tip of the pressure tool and also prevents the shaft from splitting. The tip is made flat on the side facing the worker and the opposite side is rounded to give it strength. The tip will resemble the point of a screwdriver with the outward side slightly rounded - much like a U with the top of the U facing the worker. This shape prevents the tip from dragging on the edge of the core which would cause the edge to crush. If the tip is rod-like with the point in the center, it will sometimes catch on the edge of the core and crush the platform. After use, the tip must be checked for contamination of particles of obsidian which will also cause the platform to crush. Using a copper tip eliminates the continual re-sharpening that is necessary with other materials.

The proximal end of the crutch is fitted with a short flat piece of wood shaped to the size and comfort of the worker, which will serve as a chest rest. Chest crutch now resembles a Capital T, the top part of the T being the part placed on the chest.

This type of crutch is not only useful for the removal of Polyhedral blades but is also usedto remove the channel flakes from points such as Folsom and Clovis and may be used for the final retouch on large bifacial artifacts. The crutch allows the workerto place the tip of the pressure tool on the platform with extreme accuracy and precision and permits him to apply controlled pressure in variable degrees.

If the crutch is employed to remove large blades by the combination of the pressure and percussion technique then a piece of hardwood about four inches long is affixed to the staff near the tip to serve as a striking medium for the worker to apply the blow when the first person applies the pressure. If one is fortunate enough to find a young sapling to serve this purpose, then he can saw off a limb near the tip of the staff to serve as the crotch for the striking medium. The striker, or percussion implement is a billet of hardwood, or a section of antler, about fourteen inches long. Downward and outward pressure is applied simultaneously with the blow delivered by the second person.

Vise.

The core must be affixed in some manner and I have experimented with every conceivable type of holding device including the modern carpenters vise, rack sticks, tounequits and even levers. None served as well as a homemade type similar to what prehistoric man could have devised. The most successful clamp, and the one most closely resembling the aboriginals, has been two poles, or two 2 x 4 pieces of lumber, tied loosely together at one end with nylon cord. This allows the core to be slid in either direction to provide a variable fulcrum. The core is placed between the two shafts near the tied section. The opposite ends are spread and a large cobble inserted between the poles and slid up toward the core-holding end until sufficient pressure is obtained to make the core immobile. This clamp can help further to secure the core by placing several large flat slabs of stone on the far end. The clamp now looks like a Capital A with the core at the apex of the A.

The holding device must be immobalized in order to remove blades repeatedly - for the angle of the core in the vise is so critical that any movement or change of position will result in the worker breaking the blade before it has been entirely removed from the core. When this happens, the core must usually be abandoned.

Using the feet alone to hold the Polyhedral core and at the same time press off blades is impossible because the feet would allow movement of the core and, to remove prismatic blades, it is essential that both the core and the vise be immobile. Polyhedral blade removal requires the worker to use the weight of the body and also assist with pressure from the knees. Therefore, with all this body movement, it would be most difficult to secure a core by the use of the feet alone. Also the holding device must exert a great amount of pressure to hold the core securely due to the amount of outward pressure exerted by the hands when detaching a blade. In fact, the core should be slightly imbedded into the wooden jaws of the clamp.

The feet do play a part in this technique, but only to stand on the holding device to give it added weight and insure against the clamp moving.

The beautiful prismatic blades removed from the Polyhedral core have parallel sides which feather out to an infintisemal edge, making them not only fine for a variety of cutting tools but also a formidable weapon. Freshly struck, they are unexcelled as cutting tools without modification or, to protect the users hand, they can be served or wrapped with magay fiber, sinew or thongs at one end in a manner similar to an authentic tool shown to me by Dr. Richard MacNeish. They will serve any cutting purpose, provided the nature of the material to be cut will not cause the edges to break, i.e. hard materials such as bone, stone, hardwoods etc. Cordage, fabrics, leather, textiles, flesh, hair and other pliable materials may be cut by little pressure and with much ease. They can be converted to a backed-blade by removing a series of small flakes on one edge to make it dull or abraded. Or they can be hafted in the manner of a Doctor's scalpel. Further, they can be worked into geometrics and inserted in various holding devices to suit the users needs. When these sections, or pieces, of sharp blades were inserted in the edges of wooden swords or lances, they were, indeed, a functional and superior weapon.

However, during manufacture, they tear away from the core with considerable velocity and if they strike against each other or hit any hard substance, they will break or lose their sharp edge. Therefore, during manufacture, a soft landing spot or catching device must be provided. For catching blades, I use a mat of polyethylene foam, sponge rubber, or a soft woven grass mat. For transporting or storing, they must be kept seperated, or wrapped individually. This necessary protection of edges may explain the wide distribution of utalized cores, for it would be much easier to transport a preformed core to the place of utalization rather than make several hundred blades at the source of material and then transport them to the occupation site.

Polyhedral blades have two types of transverse sections, those that are triangulate and, the more common, which is trapezoidal in section. The sides of the blades are characterized by their very acute angles. Blades that are triangulate in section have a longitudinal ridge that extends in a median line from the proximal to the distal end of the blade. On the dorsal side of the blade and on either side of the medial ridge there are remnants of the two previous flake scars which leaves a slightly concave surface, producing what is known in present-day cutlery as "hollow grinding." The ventral surface of the blade (the side next to the core) is slightly convex, which results in a blade with an extremely sharp edge. This feature is also present in a blade that is trapezoidal in section, however, trapezoidal blades - instead of having a single ridge - have two ridges to guide the flake, thereby making a flat surface with two beveled edges on the dorsal side. These ridges are the remnants of three previous flake scars. This type of blade is, by far, the most common perhaps because, functionally, it would make a deeper cut for the blade is flatter and does not have the obtuse angle of the triangulate blade. There are many aberrant forms of blades, depending much on the surface from which the blades are removed and also on the skill of the worker.

Polyhedral cores have numerous varients and do not have to be necessarily cylindridal in section. At the Museo de Anthropologia National in Mexico City, I saw much evidence of blades removed from just one side of an irregular piece, or pebble, of obsidian. Evidently the worker had found a piece of stone with natural ridges and had simply removed blades from one side of the stone. The final shape of the discarded core tells the story of the initial core preparation. It is not uncommon to find exhausted cores that still retain the original surface cortex on the base and one one or more sides, indicating the blades were removed from one or more faces of the preformed core but not around the entire perimeter. This suggests incomplete core preparation, or the use of naturally tabular pieces of obsidian.

Before a single blade can be removed from a core, a natural ridge of material must be found, or the worker must create such a ridge. If a round cobble of material is used, or just a large mass, then the worker most create this ridge by resorting to the percussion method and making his preform rectangular in shape. The ridge must be approximately at right angles to the platform face of the core and vertical between the long axis. If the percussion work has not established a ridge in this position then the worker must straighten this ridge by removing a series of alternating short flakes along the vertical length of the material. These scars differ from retouch in that the force is applied at the body of the material outward from the median line - whereas retouch is directed from the marginal edge inward. Therefore, the first blade removed from the core will bear these retouch scars and will have very little resemblance to the common lammelar blade. It is interesting to note, at this point, that Holmes (Bulletin 60, page 225, 1919) has identified these large flakes as "slightly specialized for undetermined uses" and as "Other interesting partially worked implements, the final shape of which could not be determined".
Photo page 225 Bulletin 60 (Holmes, 1919)
Clearly these are the first blades removed from the Polyhedral cores bearing the retouch scars. These first removed blades will be triangulate in section with multiple flake scars directed away from both sides of hhe median ridge and at right angles to the

longitudinal axis. And the blade will have the appearance of a triangulate drill unifacially flaked. However, the bulbs of force of these preparing flakes will start at the center of the long axis and will be intersected when the initial blade is removed.

Removal of the initial flake leaves two ridges on the core which are used by the worker to guide the next two flakes. At this stage of making ridges to guide subsequent blades, occasionally to make the blades slightly wider, another blade is taken off directly in back of the first. This is accomplished by removing the resulting overhang of the first blade removal and seating the pressure tool between the two previously established ridges. When this technique is used, the second blade will have the appearance of a functional tool for it bears the scars of the initial ridge preparing flakes and blades will have a fluted, or slightly concave surface on the dorsal side which is the scar left after removal of the first blade.

Platforms:

Platform surfaces are of five types:

1. Platforms with a flat flake surface.
2. Platforms left with a remnant of the bulb of a tiny flake which was designed and used to prevent the pressure tool from slipping.
3. Platforms with a flat flaked surface with scratches put there by the worker to prevent the pressure tool from slipping.
4. Platforms of the natural flat surface, using the roughness of the cortex to prevent slippage.
5. Platforms with the face of the core ground by abrasive to prevent slippage of the pressure tool.

The platforms of the prismatic blades are distinctive because they are normally at right angles to the longitudional axis of the blade and because of the very small contact surface between the pressure tool and the core. Platforms are ground as this allows the flake to be freed from the core more easily. The bulbs of force, which in this case is pressure, are normally diffused and quite flat. These bulbs are distinctive of pressure because of the absence of the erraller flake usually found in percussion struck flakes or blades. The curvature of the blades is somewhat variable because of the vector of angle in applying the pressure and the differences in the order of removal. Curvature increases as the core becomes progressively smaller for as the core is utalized, the resulting overhang from the bulbs of pressure must be removed before the next series of flakes can be detached.

Preparing the edges for removal of each series of blades decreases the area at the top of the core, making it slightly smaller than the midsection thereby making each successive series of removed blades slightly more curved. The exhausted core becomes tear-drop in shape with the pointed, or distal, end indicating in which direction pressure was applied. As the basal end of the core becomes more constricted, it is sometimes rejuvinated by removing the top with a single percussion blow that severs the core at right angles [illegible] ground by abrasive. Or when the platform surface was exhausted, it was simply abandoned.

Another type of Polyhedral core is made by changing the vector of angle of applied pressure to produce a straighter flake or blade. This type of core is prepared in a slightly different manner. Initially, the distal end of the core is made smaller than the proximal end on which pressure is applied. As the core gets progressively smaller from blade removal, the distal end will become conical. When the area of the apex or center, of the proximal end of the core becomes restricted, the distance between the proximal and distal ends lessens - the blades become shorter - and, therefore, the core is usually abandoned. Platforms on the blades will be slightly less than a right angle.

Upon abandonment, the core will still retain some of the top, or platform, face and will be tongue or bullet shaped.

Direct Percussion:

My first experiments in Polyhedral core making were by the use of simple direct hand-held percussion using a variety of percussion tools and the results were most discouraging. The use of direct hand-held percussion allowed me to remove blades with some regularity, but the characteristics of the blades, or flakes, in no way resembled thos of the Polyhedral because:

1. Blades detached by percussion were generally lacking in regularity of form.
2. They had too large a platform.
3. The bulb of percussion was much too large.
4. Multiple undulations on both core and blade resulted
5. The distal end of the blades terminated with the tip of the core adhering.
6. It was impossible to keep the edges of the blades parallel.
7. The platforms would collapse from impact.
8. The intensity of the blow could not be controlled with accuracy, causing many step and hinge fractures.
9. The use of percussion on this core type does not permit the worker to place the percussion tool with

the degree of accuracy necessary for blade removal.

10. The worker cannot simultaneously retain the same angle on the core and keep in relation to the guiding ridge, the angle of the blow.
11. The proximal end of the core is reduced faster than the distal end because the overlap left from the large bulbs of percussion must be removed before the next blade can be detached.
12. The platforms on a typical aboriginal blade are normally a sixteenth of an inch, or less, in width. This degree of accuracy cannot be obtained by using a direct percussion technique. Should there be any deviation in size of platform and if it exceeds the tolerance of one-sixteenth of an inch, the platform will collapse or the blade will be unduly thick, or it will terminate in a step or hinge fracture along the face of the core, making it worthless for further use.

Percussion is commonly used to remove blades from other types of cores but not from a Polyhedral and my experiments resulted in an exhausted core that in no way resembled the distinctive Meso-America types.

Indirect Percussion:

Another experiment involved the use of indirect percussion. Tools used for experiments in Indirect Free-hand Percussion have been of every conceivable type and material and I have tried this method both with and without the use of an anvil. I have used tools of both hard and soft hammerstone, wood, antler, horn, bone, shell, ivory billets and have even tried them hafted. Each percussion tool type leaves distinctive flake scars and some may be recognized and related to certain core and artifact types, yet none will replicate the Polyhedral blade or core. This method of blade detachment involves the use of an intermediate tool called a punch which is struck by a billet or a club.

The punch, or intermediate tool, may be an elongated pebble of varying degrees of hardness, texture and of different types of stone. The choice of stone depends on the type of material of the core. Hard wood has been used as a punch with little or no results. It splinters too easily, is much too resilient and will absorb the force of impact without removing a blade. A punch made of ivory, bone, antler or metal works much better for this type of experiment. The striking implement is selected from a variety of hammers, billets and clubs relative to the type of material being worked, the size of blades to be removed and compatiable with the amount of velocity needed to regulate the curvature, or flatness and termination of the blade. Velocity can be increased by using a longer handle or a longer billet. The weight of the percussor must correspond to the size of the blade desired.

Indirect percussion technique involves the need of a third hand, for the left hand holds the core and the blow is struck with the right hand, leaving no means of placing the intermediate tool. Since a second person was not available for these experiments, devices were improvised to hold the core so the left hand could place the punch. As a substitute, heels or feet may be used to hold the core, but the worker must be apt at holding with the feet and he must also have the assistance of an anvil to further immobalize the core. I have found that two poles flattened on the inside at the holding end and loosely tied with lashings to permit insertion of the core, makes an excellent holding device. When the core is placed between the flattened surfaces of the butts of the poles and then the opposite ends are spread until the desired amount of tension is obtained, the core will be held firmly and securely. This indirect percussion method will produce blades, but they will not have the characteristics of blades removed by pressure alone. The impact from the percussor causes excessive undulations and waves on both the core and blade; the dimensions of the blade cannot be controlled with regularity; the bulbs of force are much too large and the curve of the blade and termination of the ends cannot be controlled.

Because of the angle of impact, the resultant core form is not one with parallel sides, but will assume a conical shape. When this method is used if the material is flint, the blades have better form than those of obsidian for the wave mechanics of obsidian are more pronounced than those of flint.

An unconditional requisite of preforming polyhedral cores is to first establish corners (ridges) on the preformed core. Without these ridges there can be no polyhedral shape and no prismatic blades, for they are used to remove and guide the blades and they are the inception of the "faceted" shape of this core. If the percussion preforming has left these corners (or ridges) uneven - or not straight - then they must be straightened by careful retouch until they will produce a straight blade.

Preforms may have as few as one ridge, or as many as the worker can create. However, with just one ridge, it is unlikely that the finished core would assume the true polyhedral shape. The core is always percussion preformed to be rectangular in shape - with corners - which will be established as ridges either by percussion, indirect percussion, or pressure. It is of prime importance that the ridge be absolutely straight and vertical to the proximal and distal ends of the core, as any irregularity or deviation will cause the first and all subsequent blades to be malformed. This error cannot be overcome and all blades will be distorted. These variations of preforming will be covered under seperate preforming methods, i.e.

1. Core with one ridge
2. Core with two ridges
3. Core with three ridges
4. Core with four ridges
5. Core with more than four ridges.

Core with One Ridge:

1a The simplest form of core manufacture for prismatic blades is to establish a single ridge on the core to guide the first blade. A mass of obsidian is selected either a large cobble, or a lump with a natural flat face. Should the cobble be round and without a natural flat surface, it must be modified and this is done by percussion to sever the cobble in half. Each half of the cobble can then be used to prepare a core for pressing off blades. Half the severed cobble is held in the left hand and placed on the thigh of the left leg with the flat surface of the rock exposed. Strike a blow at right angles to the flat surface but near the edge to remove a single large flake the entire length of the cobble. This is to remove the cortex of the cobble and also to establish a corner perpendicular and at right angles to the top of the core.

Now rotate the cobble slightly and remove another flake in the same manner, positioning the blow so that the second flake scar will intersect the first flake scar and produce another corner - thereby establishing a ridge for removal of the first prismatic blade. If this large flake is removed properly, it should leave an angular projection (ridge) the full length of the cobble. If this ridge is irregular it must be straightened and this is done by percussion using a small hammerstone and removing small transverse flakes either unifacially or bifacially along the vertical line of the ridge its entire length until it is straight. This will, at the same time, remove the cortex or at least a part of the original surface of the cobble. If there is an overhang (lip), or bulbar scar, left at the top of the core (or ridge) at the point of percussion, it must be removed during the straightening process. This is done by turning the cobble and striking on the ridge - and at right angles to the ridge - just under the lip. This blow must be delivered just under the lip to prevent damaging the surface which will be the platform for seating the pressure tool for blade removal.

Now we must prepare the platform on the flat top of this ridge. This is done by roughing the surface (scratching or grinding) with a piece of silicous stone or a stone at least harder than obsidian. This is necessary to prevent the tip of the crutch from slipping.

The prepared half cobble is then secured in a suitable clamp with the ridge facing away from the clamp. The first pressure flake is then removed by the use of the chest crutch. The first blade will bear the scars of the ridge preparing flakes and will resemble a unifacially flaked tool. But it will differ in that these scars will show that force was applied from the median line out to the edge whereas a unifacially worked tool is just the reverse.

1b A varient of this single ridge method is to use a very large single tabular flake struck from a mass of obsidian by percussion. This is done by using a large hammerstone and striking off a cobble first one large flake to get a flat surface and then striking one blow directly behind to remove a thick flake with a flat surface. The first flake is discarded for it lacks conformity. The striking distance of blows in relation to the edge will determine the thickness of the large flake, which should be about two inches thick. For the platform, the top of the flake should be made flat by removing a large burin spall by percussion. Then the side of the flake is bifacially flaked to form a ridge which will be at right angles and vertical to the top - or the platform surface.

Removal of the first blade will establish two ridges to guide the next two blades and so on. As additional blades are removed, the core will assume the shape of a half-cylinder and, when exhausted, will not be polyhedral. The unworked portion, or back, of this core will retain the character of the original surface and only the worked portion will show the longitudinal scars left by the removal of blades. When blades are removed around the entire periphery, there is no indication of what the original core type was unless an assemblage of the blades can be associated with the core and the core reconstructed.

Cores with Two Ridges:

2a Prismatic blades may also be removed from a core having two ridges. This type is made in much the same manner as the core previously described under 1b. However, after the burin spall has been removed to create a flat surface at the top for the platform, another large burin type flake is removed at right angles and vertical to the first to establish the corners to guide the first two blades. Looking from the proximal end downward, the edge of the core should appear to be rectangular. If the ridges are irregular, they may need a slight amount of modification to make them perfectly straight and at right angles to the proximal end of the core. This core will normally still retain on one side the original surface.

2b A varient of the two ridge preform core is to make an object resembling the broken end of a large bifacial artifact. This type of preform core resembles a tongue with the lateral edges serving as the ridges to guide the initial blades. The proximal end of the core must be flat to provide a platform for the pressure tool. This flat surface is made by striking a percussion blow on one of the lateral ridges near the top. Removing this flake from the top of the core is most difficult.

for it is hard to prevent it terminating in a curve on the opposite side. If I prepare the platform after the bifacial ridge flaking is done, I turn the core and strike on one of the lateral edges (ridges) across the top of the core but directing the blow to remove a flake at right angles with the long axis of the core. This will terminate the flake on the opposite lateral edge of the top thereby confining the curve to a r estricted area. The surface character of a bifacial artifact accidentally broken will show a different break pattern, or lines of force, than this type of core. The lines of force of the broken artifact will not start at the lateral edge and the break will be at right angles to the long axis. Also, the curve of the broken artifact will extend from one edge to the other rendering that edge useless to seat a pressure tool. The biface core is made and designed on the previously prepared flat surface in order to have a perfect flat on the proximal end of the core.

The bifacial core is first shaped by percussion with a soft hammerstone and then using an antler billet it is made symmetrical. This is done in much the same manner as a large bifacial tool except that it will be left much thicker in section. Preforming includes establishing two ridges to guide the initial blades on the marginal edges. The first blade removed from each ridge of the bifacial core will be triangulate in section, the dorsal side of the blade bearing the bifacial flake scars of the first preparation. The ventral side of the blade will be smooth, but slightly convex in section - the curve extending from the point of pressure to the point of termination. The curve will be concave on the ventral side and will resemble an archers bow. A core of this type could be mistaken for a broken bifacial artifact if work was stopped at this point and no blades removed.

Core with Three Ridges:

Another experimental core is one with three ridges to guide the blades. Select a piece of obsidian with a natural flat surface and of the right thickness and length. Using a large hammerstone, remove two large flakes from either side of the center at right angles to the top of the core. After removal of these two flakes, the obsidian block should have the appearance of the forepart or prow of a boat.

Then, using the hammerstone, the block is struck on the top exactly in the center in line with the two previous flake scars. We have now removed the three sides of the original mass and are left with a large triangular piece of obsidian which is the core.

This triangular core requires little modification on the three ridges. One must remove the overhang left by the bulbs of percussion and, if necessary, straighten the ridges. This modification can be done either by very careful application of a small hammerstone, by using an indirect percussion tool, or by the use of pressure. Should one be working with a cobble, or a rounded mass of material, the core would be prepared in a similar manner as the rectangular core except that it would have three sides.

Core with Four Ridges:

When preforming a core with four ridges, it must be made cube-like. Then as the blades are removed, the core will assume the form of a regular polygon with as many facets as there are blades removed. The abandoned and exhausted cores of Mexico indicate that the rectangular type of core was, by far, the most common. A core 2 x 2 inches at the proximal end can yield as many as a hundred usuable blades provided the worker encounters no material or manufacturing difficulties. The making of the rectangular core is considerably more complicated than making a simple bifacial tool and represents a highly specialized industry.

Since the isotropic homogeneous qualities of obsidian make it devoid of clevage planes, preforming the core becomes a very exacting work. Using a simple hammerstone, the mass of obsidian is reduced into a rectangular shape with a perfectly flat surface to form the proximal end and the sides must be parallel, perpendicular, and at right angles to the proximal end. Primary flaking of the core is done with a flat surfaced hammerstone, for this flatness will diffuse the bulb of percussion. Flakes are then struck off the mass until the core is rectangular.

In order to shape the mass into a rectangular form, each flake must be evaluated and considered individually with an eye to the rectangular form before each flake is struck. It would serve little purpose and require far too much ddescription to describe the removing of each individual flake. It is sufficient that one know that the core is formed by percussion and must be rectangular in shape. After the core has been madw rectangular, the corners may be removed by striking percussion blows with a hammerstone or, if one is not adept at percussion, this can be accomplished by pressure with the aid of the chest crutch. After the corners are removed, the core will be

Octogon or rougly cylindrical in shape.

After the core has been made rectangular, ridges must be made by intersecting the two longitudinal flake scars by either unifacial or bifacial retouch. Either pressure or percussion may be used for this work, depending on the side of the core. Also using indirect percussion with punch to flake these ridges has proven most successful. If the punch is used, the ridge is straightened and made regular by alternating the flakes from right to left on either side of the proposed ridge, each bulbar flake scar providing the platform for the next flake. Flaking of this ridge is started at the distal end and continues alternately from right to left the entire length of the core. When flaking reaches the proximal end, extreme care must be used in flaking or the platform which will seat the tool to remove the blades will be damaged.

A ridge made in this fashion will have a sinuous appearance. This technique of establishing ridges has been used in my experiments and, I believe, by the aboriginal. However, I do not mean to imply that all cores are made in this manner. Further study at the actual sites will reveal much information and resolve the technique.

Sawn Cores:

Purely for the purpose of studying the consistent behavior of force in relation to isotropic material, I have at times used a rectangular shape of obsidian which has been cut by the diamond saw. Also, the sawing conserves material. But sawn material does have disadvantages. It causes scoring on both sides of the cut, leaving the material with the appearance of ground glass and it weakens the obsidian. The first blades removed from a sawn surface must be thicker than one would normally expect and until all of the sawn surface is removed, one must progress with caution, or the blades will break before they are detached from the core. Another disadvantage is the lack of curvature on the surface, making it difficult to remove the blades.

Platforms:

Preparing the top of the core to serve as a platform for the pressure tool is the next step before blades can be removed. My experiments have followed stages of changes and development that appear quite similar to the aboriginal phylogony.

Flaked Platform

Before I had an opportunity to study genuine cores, I prepared the platform by removing a small flake to seat the pressure tool which was, I later learned from ~~Scotty MacNeish~~ Dr. Richard MacNeish, much the same as the early cores of Mexico. He observed that some of the tops of the early cores had a flaked platform surface and some had a natural rough cortex. (Personal conversation) My first platform experiment was to remove by pressure a small flake directly above the ridge. The bulb of pressure left a depression in which I could place the tip of the pressure tool. This prevented the pressure tool from slipping when downward and outward pressure was applied. But this technique has one disadvantage. After the first series of blades has been removed from around the entire perimeter of the core, the top then has a convexity and this curve prohibits seating the pressure tool and, therefore, it is necessary to rejuvenate the core by removing the entire top. This rejuvenation is most difficult for the top of the core must be severed by removing a single flake with one blow and without leaving a rounded edge on the opposite side of the core top. I have never been satisfied with the termination of my rejuvenating flake but continue to experiment with this technique. Dr. Robert Heizer showed me some severed cores from Guatamela which appeared to have been broken by the use of heat and cold. He will, perhaps, have more information on this method when he returns from the site in Guatamela. This rejuvenation of the top of the core causes the core to be shortened each time a series of blades is removed from around the perephery of the core.

Scored Platforms:

My experiments have shown that grinding, or scoring, the platform surface prevents the pressure tool from slipping when downward and outward pressure is applied. This allows the worker to continue to remove blades until the complete core has been exhausted. The grinding technique is also useful to overcome the human factor of miscalculations of placing the pressure tool. If the tool is placedtoo close to the edge and there is not sufficient material to withstand the force, the platform will sometimes crush before the outward pressure can be exerted.

Should this happen, the core must either be abandoned, or it can be ground from the top toward the base until the damaged area has been removed. I have observed that the aboriginal also used this method of recovering their cores. A careful examination of the top of the core will reveal if the bulbs of pressure have been eliminated. If there are none, then, very possibly, the top of the core was rejuvenated by the severing or grinding techniques.

Blade Removal

Now, assuming that the obsidian has been properly preformed into a core with ridges, the platform ground until it has the appearance of frosted glass and is now immobalized in a clamp ready for blade removal. The pressure crutch has been made and we are now ready to remove the first blade.

But before we actually remove a blade, it is important to consider the actual removal of a prismatic blade from the core. A specialized flake - called a blade - with two parallel sharp cutting edges, long and thin, is desired. This type of blade has unlimited uses and accounts for the evolution of the obsidian prismatic blade - or Aztec razors. Indeed, it added much to the economy of many people prior to the use of metal. There is absolutely no resemblance or comparison between this elongated flake and the conchoidal fracture flake. The prismatic flake is not round or oval - it is either remobid or triangular in section and it does not have waves or undulations. The dorsal side is characterized by two or three facets left by scars from previous blade removal. These facets are the result of the ridges created by the worker to guide each blade removal. This is the marked difference between a chonchoidal fracture flake and a prismatic blade. The chonchoidal fracture flake is made on a flat surface with a hard hammer and there is no ridge, or mass, to control guide and prevent the spreading of the ~~blade~~ flake. Prismatic blades will be no straighter than the ridge left on one face of the core. Therefore, care should be given to the retouch of this ridge during straightening to see that it is left without a sinuous shape. The thickness of the flake is governed by the seating of the pressure tool on the platform.

If it is set close to the edge at the top of the core, a thin blade will result. If it is set far back, the blade will be thicker. (insert page 42-A) The width of the blade is also controlled by the steepness of the angle of the pre-established ridge. The more obtuse the angle, the narrower the blade. Removing these prismatic blades from the core by pressure involves problems that are not present when blades are removed by percussion. Each flake, or blade, is a part of a cone. In the case of the prismatic blades, the first blade is one quarter of the complete cone. The balance of the blades are still portions of cones, but at this time I cannot be certain what portion of the cone is detached with the balance.

The problem is to start removal of a cone part at the platform and then with downward and outward pressure to thrust the cone along the outward surface to the distal end. The downward and outward pressures change the angle of this cone. If only downward pressure is applied, the angle of the cone will veer inward into the body of the core - producing a true quarter of a cone but will terminate in a step-fracture before the blade has been detached at the distal end. If both downward and outward pressure is applied simultaneously then a quarter of a cone is produced, but the angle of the cone will change as the outward pressure is increased and it becomes parallel with the face of the core; thereby permitting the removal of a long narrow blade.

Removal of blade by percussion presents a different problem, for the worker must strike with the vector of angle, conforming with the angle of the cone, or he can alter the angle of the platform to conform with the angle of the blow.

(Insert on indicated spot on Page 42)

The thickness of the blade is controlled by the preparation of the longitudinal surface of the core. Should a thick blade be desired, the ridges from the top to the base must be isolated by blades removed from each side of the proposed thick blade. Repeated thick blades require the use of thin tabular cores. The seating of the pressure tool farther back from the edge of the top will also assist in taking off a thicker blade but usually results in the removal of the distal end of the core.

I have see Polyhedral cores that range in size from one and a half inches to as much as nine inches in length, the largest being from the State of Colima, Mexico and from Guatamela. These represent the size of the exhausted cores, but the size of the preformed core before the first blades were detached is unknown, and one wonders at the immense size of the first series of blades. I have been able to remove blades 7/8 inches in width by 7½ inches in length, but I prefer to use a block of stone approximately three and a half inches at the top by five and a half inches in length. However, the smaller the core, the more critical the placing of the tip of the pressure tool.

When we have placed the preformed core in the vise with the two corners exposed, we are ready to remove blades. These two corners bear the ridges which will guide the first two blades. The tip of the pressure tool is placed on the ground platform one eighth of an inch from the outward edge of the core. The chest crutch is then positioned on the chest with the top of the T portion of the crutch resting on the pectoral muscles of the chest. The chest rests on the crutch which is centered directly above and in line with the ridge that will guide the blade. The hands grasp the shaft firmly on a spot just below the slightly bent knees. By pressing with the knees against the hands, additional outward pressure may be obtained if the core is too large to detach blades by pressure from the hands alone. When very large blades are being detached from the core, the worker can help detachment by dropping the weight of the body on the crutch and simultaneously bending the knees and striking them against the hands and, at the same time coordinating the balance of downward and outward pressure to the tip of the crutch.

The platform of the core will usually support the entire weight of the body until outward pressure is applied.

The first flake or blade will be triangulate in section and will terminate with an expanding distal end and remove a portion of the distal end of the core. The distal end of this first blade will be more curved than will the balance of the blades. Slightly more downward pressure is required to remove the first blade than is needed for the balance of the blades. This is to assure its complete removal and to give the core a better form for removal of the balance of the blades and so that subsequent blades will have straighter ridges to follow and will n- not be malformed. If the core is rectangular, all four corners are removed in the same manner. After blades have been removed from the two corners, the flake scars left by their removal make four ridges to guide the next blades. In these experiments, I have used two methods to detach the next blades.

1. If I want the blades to be narrow, I place the tip of the pressure tool directly above and in line with the ridge and I repeat this placement on all four ridges. Like the first

detached blade, these blades will also be triangulate in section.

2. The second method involves trimming off the overhang left on the edge of the core by the bulb of pressure. If the platform is not prepared in this manner, it will crush when pressure is applied and thus ruin the core. This is required to free the platform and allow positioning the tip of the pressure tool on the edge of the core between the two ridges left by removal of the first blade.

Removing a blade by this method will result in a blade with the two ridges left after removal of the first blade and it will not be triangular in section but rather trapezoid. This type of prismatic blade is the more common, or the standard type, found in the Valley of Mexico. Its dorsal side is flat with both edges terminating in an acute angle to a very sharp edge. These two blade types are very familiar to the Archaeologist, but there are other aberrations having more than two ridges and other abortive forms which usually indicate poor judgement, or miscalculation, by the worker.

Blade types are governed by the manner in which the pressure tool is placed on the edge of the core. The triangular is made by directly following one ridge, and the trapezoid is made by positioning the tip of the pressure tool in line with, but between, two ridges.

The blades can now be removed in the same manner as the first, but before each is pressed off, the platforms must be prepared and freed. When all the corners of the preformed core have been eliminated by the removal of blades, the core will have the appearance of a polygon, or will be cylindrical in form. When blades have been detached from the exposed surface of the core, then it must be repositioned in the clamp to expose a new surface. It must be repositioned in the vise at the same angle as the previously worked surface, otherwise the blades will not be uniform. When the core has reached a cylindrical shape, all of the platforms over the ridges may be prepared at the same time. This enables the worker to remove blades without stopping to prepare the platform each time. By constant practice, rhythms and muscular motor habits are developed which aid in the uniformity of blade removal. Practice, good muscle control, and a knowledge of the amount of force required for removing blades of various sizes results in duplication of uniform blades.

Experience enables the worker to control the termination of the blades and he can even learn to stop the blade midway along the face of the core either in a feather edge or by a hinge or step fracture. The feathered edge is accomplished by increasing the amount of outward pressure and simultaneously reducing the amount of downward pressure. The step fracture is made by dissipating both the downward and outwardpressures and, at times, will leave the blade intact but still attached to the core. Rounding of the distal end of the blade is known as a hinge fracture. Hinging is accomplished by insufficient downward pressure and excess outward pressure.

Of course, in Polyhedral blade making, it is not desirable to hinge, step, or feather the blades, but this technique can be useful if a blade breaks before terminating at the distal end. Then the worker can recover the core by applying pressure at the distal end and removing a a blade up to and intersecting with the step or hinge fracture. Learning to control step and hinge fractures can also be useful in the channel flaking of a Folsom and Clovis point.

As the core becomes smaller, the curvature of the blades increase. This is because the bulbar portion of the blade is slightly thicker than the balance of the blade and the core must be trimmed at the top to compensate for the bulb of pressure. Each time the top of the core is trimmed, it becomes smaller until no platform surface remains. At this stage, the exhausted core has the appearance of a submarine, being a pointed ellipsoid. Some cores are originally designed wider at the top and as each series of blades is removed, the core becomes progressively shorter until it is abandoned, but it still retains some platform surface. This type of exhausted core has the appearance of a pointed paraboloid. The angles of the platform on a paraboloid core become slightly more obtuse as the blades are successively removed and the core becomes smaller.

Miscalculations and Recovery of Cores:

It is also well to consider here the miscalculations that remove the distal ends of the cores during blade detachment. As the core is reduced in size, the hazard of removing blades with the distal end of the core adhering increases. As the proximal end of the core becomes smaller, the platform areas become isolated. When this happens, it is very easy to position the tip of the pressure tool too far from the edge of the core causing the blade to be thickerthan normal. The thicker blade allows the force to spread and this will sever the core because of the reduced diameter of the core. To overcome this, the tip of the pressure tool is placed closer to the slightly abraded edge and the amount of outward pressure is increased. This samething can happen even when the core is not reduced in size if an excessive amount of downward pressure is applied.

The angles of the lateral edges of the parallel sided blade may be changed from acute to obtuse by using a thinner core. A core of thin tabular material can be used to make successive triangular blades. The flatter the surface of the core, the more obtuse the angle of the blade section and the flatter the blade.

The recovery and rejuvenation of cores is most important when there is a shortage of material or the time factor of preparing a new core is considered. There are many reasons why the worker can not remove a blade with each attempt. The tip of the pressure tool may become contaminated with small fragments of stone which allows it to slip thereby destroying the platform before a blade can be removed. The platform may collapse and be destroyed by placing the tip of the pressure tool too close to the edge which will not provide sufficient material to withstand the force. If the core is not properly secured in the clamp and it moves when outward pressure is applied, the pressure tool will slip and damage the edge of the core. When the platform is destroyed, the top of the core may be rejuvenated by removing a single flake across the entire top of the core or the core may be ground down until the damaged portions are eliminated. Or, occasionally, a new surface may be found beside the crushed portion and a blade can be removed without too much distortion of the blade and core.

The imperfections left by a step or hinge-fracture may sometimes be overcome by using the fracture of the step or hinge as a platform to place the tip of the pressure tool and then push off the balance of the blade. But any imperfection left on the core will disfigure the next series of blades. There is another method of recovering a core which has been spoiled by a blade hinge or step fracture during detachment. It is done by creating a platform on the distal end of the core directly in line with the blade broken from the top of the core. This is possible but most difficult. When such a platform can be made, then the broken blade is pressed from the distal end of the core to intersect the hinge or step fracture and, if successful, the worker recovers the core and can continue in the original manner of blade removal.

To date, I have not experimented too much with blades exceeding twelve inches in length, however, I have been successful in removing some of this size. Efforts to produce this size blade have been curtailed because of a lack of massive material and the absence of a co-worker. But I have made many attempts to remove large polyhedral blades by direct free-hand percussion. I have used obsidian but it hasn't the resistance to end shock found in flint-like materials and it is too brittle to withstand the impact. Blades can be removed from a large core, but breakage is excessive and it is unusual to remove a complete unbroken blade.

However, I have been successful when using a combination of pressure and percussion. One person applied the downward and outward pressure while the second person struck a projection on the shaft of the pressure crutch. I look forward to carrying out further experiments with this method when quantities of massive material is available.

Prismatic Blades Using a Short Hand-Held Staff:

I have recently suffessfully experimented with making polyhedral cores and blades with the aid of a short hand-held staff. Recently I visited Dr. Charles Borden at the University of British Columbia and reviewed much of his Pacific Northwest material. Among his collections were many micro cores and blades. They were shorter in relation to their diameter than the cores of Mexico, but the techniques appeared to be somewhat parallel. I noticed that the technique of Platform preparation and the technique of blade removal indicated different techniques were used and related to different materials. During a short demonstration to the students of stoneworking, an attempt was made to replicate this style of blade removal. Since I was not prepared for this demonstration and had not brought along my tool kit or chest crutch, I improvised by using just an antler tine and a hurridly made vise to remove the blades. The antler tine was approximately twelve inches long and pointed at the distal end. I improvised a clamp made of two tent stakes tied at one end with leather thongs. The core was inserted near the lashed portion and then spread at the opposite end and a small cobble inserted between these stakes and pushed forward toward the core until it was tight in the vise and secure. Then I knelt on the stakes and seated the tip of the antler tool on the extreme edge of the platform core between two ridges and with downward and outward pressure removed a series of bladlets.

When I returned home I made some experiments to employ this method in the use of making polyhedral prismatic blades. Using a hammer handle, I inserted a piece of bone at the tip to make a small pressure tool for removing these prismatic blades. The core wasimmobalized in the same manner I have described and the same working techniques were employed. I now find that blades up to four inches in length may be made by this method and with the use of this tool. Blades larger than four inches must still be removed by the use of the chest crutch.

This tool can be used either as a short staff for pressure removal of prismatic blades and micro blades or it can be used as a long-handled pressure tool.

When it is used as a staff, it is grasped at the top with the right hand and near the tip with the left hand and the tip placed on the preparedplatform. The right hand supplies the downward force while the left exerts the outward pressure thereby removing the blade. This short staff can be used for removing narrow blades but not for longer and wider blades. For the wider the blade, the greater becomes the amount of pressure required.

Relating Force to Stone Tool Manufacture:

My efforts to replicate the Mexican cores by pressure have revealed some interesting facts regarding forces. When one is cleaving, breaking, preforming or flaking lithic materials, he becomes aware of the differences in the amount of force necessary to cleve or remove flakes with the same surface area.

An example is the cutting of glass by the scoring method. A piece of plate glass three quarters of an inch thick and eight inches long, evenly secured to a solid work-bench, with an inch protruding from the edge will support several thousand pounds if it is unscored. After it has been scored by the wheel of a glass cutter, it may be broken quite easily with but a fraction of the pressure necessary in the unscored state. The area of glass broken can be compared to the area of obsidian removed from a core when detaching a blade by pressure. I have removed blades an inch wide and eight inches long by the use of the pressure crutch alone, yet my total weight is only 165 pounds. This makes it impossible for me to exceed this much downward pressure. The blade can be parted from the core by exerting outward pressure causing the blade to separate from the proximal end of the core, indicating that the blade is removed from the top of the core first then followed from the top to the distal end of the core. This is true of pressure flaking whether the worker is making cores or artifacts. It also occurs when one is fracturing by percussion for the percussion tool is describing an arc rather than descending in a straight line thus combining both downward and outward forces. This causes the flakes to be pulled from the artifact in much the same manner as blades are removed by pressure from a core. However, this technique is only applicable to certain types of percussion methods. These methods will be described in greater detail under the percussion method of "Cores".

Close inspection of both blades and cores has revealed a series of evenly spaced corresponding markings on both the blades and the cores that, as yet, I have been unable to analyze or explain. These markings fit and harmonize both the blade scar and the ventral surface of the blade. Both the blade and the core have identical markings. These minute stri'a, or fissures, are peculiar grooves, or channels, characteristic to isotropic materials but more pronounced in the vitreous obsidian and glass-like materials. These distinctive markings are extremely useful for both the typeologist and the student of technology for they are a key to positive identification of the sequence of flake and blade removal for they point accurately to the direction at which force was applied.

When examining a blade detached by pressure, either by eye or with the aid of a magnifying glass, one will observe that these fissures are at a forty-five degree angle to the lateral edges and they point in a gentle curve toward the direction of applied pressure and, occasionally, the longest fissure will become almost parallel with the lateral edge.

The spacing of these stri'a, or fissures, is remarkably regular, particularly on blades with parallel sides which have been removed by pressure. Blades removed by pressure have the stri'a on the marginal edges, while a blade or flake removed by percussion has a fissure radiating from the point of impact, or the bulb of percussion, to the distal end of the flake. The fissures are more prominent on the crests of the undulations which also characteri_e the percussion struck flake.

The spacing of these fissures can be from almost microscopic to more than an inch apart. But once the spacing pattern is set up then the entire group will be consistent. This spacing appears to be governed by the size of the flake - the larger the flake, the wider the space between the fissures. For example: Recently through the courtesy of Dr. Junius Bird, I received a large block of obsidian from Iceland (166 pounds). This block of obsidian had one broken face and on this face was a series of these fissures at least one inch apart. The break that caused these fissures appeared to be due to natural causes - such as settling or some diastrophism of the formation in which the obsidian was deposited. The magnitude of these fissures furnished me an opportunity to closely examine their structure. I noted that these fissures have a peculiar form in section. They appear to resemble steps with a very wide tread and a comparatively short riser with each step between the riser and the tread being rounded. There is also the phenomena of relatively microscopic strips of obsidian remaining between the tread and the riser and, at times, they were still attached to the riser, reminiscent of the crest of a wave. Some times, and particularly when percussion is used, the strip of obsidian is free, or nearly so, and it may be lifted off with a pointed instrument.

These strips seem to have a parallelism with the erraillure flakes found on the bulb of force for they, too, are neither firmly attached to the core or the bulb.

When this phenomena is studied and understood, it will, no doubt, provide a means of determining the difference between percussion and pressure flaking. However, a sufficient population of flakes should be studied and evaluated before any final conclusion are reached. The patterns of these markings can be related to various tool-making traditions and also should be useful for a more definitive technological aspect. But, at the present time, these peculiarities are not fully understood and need further investigation of materials with the properties of a heavy liquid even though they be solids.

Obsidian appears to be slightly less viscous than the varieties of cryptocrystalline materials and, therefore, it has a much better definition for study of this most interesting behavior of material. The frictional planes of molecular movement and wave motion create ripples and undulations on the surface of the stone and it would indeed add to our knowledge of the mechanics of stone flaking.

Some study has been done on this behavior of materials such as George McCurdy's paper on the blades of Mexico.(American Anthropologists,1900) which was sent to me by Dr. Jacques Tixier of the Natural History Museum in Paris.

Cutting Quality of Blades:

The cutting qualities of the obsidian polyhedral blades should be noted, for, to my knowledge, there is no ground or honed material or any metal tool sharper than the obsidian or glass blade replicas of Polyhedral prismatic blades. If the blades are removed properly from the core and are recovered without the edge striking another blade or a hard object, they will have a sharpness that is unexcelled. This sharp edge is the result of the blade leaving the core so quickly that the material is cleaved to the last particle of matter and the infinitesimal edge converges to zero. Such an edge produces a delicate and exacting cutting implement. However, such an edge must receive discriminate use and care or it will not sustain its sharp cutting quality.

Its sharpness was put to the test and made manifest at Grasshopper in July, 1966 when Mr. Gene Seeley used one of my freshly struck prismatic blades to skin a bear. The blade was used for the initial cut of the bear and both hair and hide parted with a minimum amount of pressure and there was little or no signs of wear on the blade edge. At a later date, Dr. William Longacre of the University of Arizana expect to publish a detailed account of the bear skinning with emphasis on the function and wear pattern of the stone tools.

My personal experience with the sharpness of an obsidian flake has resulted in much blood shed in conducting these experiments, for I have received many cuts when working this material. Fortunately, these unplanned incisions heal rapidly.

The obsidian is so sharp that it actually severs the cells without bruising and they unite rapidly and leave no scar. One accident removed a portion of the first joint of my finger just below the fingernail. The cut was deep and cut through some cartiladge and also the root of the nail with the flesh barely adhering to the finger by the cuticle. I attached the piece of flesh with a Bandaid and splinted the finger. In three days the skin graft was almost completely healed and in seven days the nerves were joined and full use of the finger had been regained. Cuts made by obsidian blades seldom leave a scar and my hands serve as mute testimony to this fact. I have received hundreds of cuts, but am unscarred. But this is not true when one receives a cut with materials that are less vitreous. Another testimony to the sharpness of obsidian blades is the use today of glass knives in the Medical Profession. An interesting comparison is the history of the Tepexpan Man dismembering an elephant with his prismatic blade and the modern scientist slicing an amobea with a modern glass knife. Apparently the aboriginal tool had considerable more refinement than that of modern man, for I doubt if the modern glass knife could do the job on an elephant.

Glass plate has proven to be the most satisfactory material for making the blades for a microtome. The glass plate is scored and broken in such a manner that the broken edge is used to section cells, tissue, etc. Several breaks are usually necessary before one eighth inch of good cutting surface is obtained whereas the aboriginal workmen were able to remove glades eight inches long with a total of sixteen inches of perfect cutting edge. Many types of microtome blades have been devised from diamond, sapphire, tungsten carbide and steel but when sharpened even with the finest abrasives, striations are present, causing the thin sections to be malformed.

From these experiments one can conclude that men of prehistory had tools which, if used with care, were comparable to modern cutlery. It might serve certain surgical needs if surgeons reverted to using stone scalpels where rapid healing is necessary on types of tissue that is viscid and resists clean incision and where little or no scarring is wanted. The surgeon that pioneers their use may be accused of reverting to Cave Man tactics, however.

<u>Experiments in Hi-Speed Photography</u>:

Dr. Earl Swanson, Director of Idaho State University Museum,with the assistance of Mr. Herbert Everett and Mr. Elmo Sackett of the Audio-Visual Department of the University,is conducting some experiments in High-speed photography on the removal of prismatic blades from the Polyhedral core. A high-speed Red Lakes camera is used which has a speed range of from five to forty-four thousand frames per second. These experiments are proving invaluable for the study of stoneworking and/the behavior of obsidian under pressure and will, no doubt, resolve many other questions when further films are made on the fracture of flint. Prior to viewing the hi-speed films of prismatic blade removal, I had thought that the blades left the core at a much slower rate of speed than the film indicated.

I have been experimenting with prismatic blade removal for many years and, during that time, have manufactured thousands of blades and have always believe that I could feel the blades bend ~~as they tore loose from the core and I was certaint~~

as they tore loose from the core and I was certain that I could control their behavior. During the pressure removal of the blade, the platform of the blade is first freed from the core by the downward and outward pressure and adhers to, or becomes a part of, the proximal end of the blade. Then the downward pressure releases the blade the vertical length of the core and terminates it at the distal end. The worker's control is, therefore, apparently a subconscious reaction comparable to the blinking of the eye.

When I am in good form and am familiar with the material, I am able to stop the blades at will and, occasionally, even leave them still adhering to the core. Yet, the many tests made with this hi-speed camera show that the blade is removed in the short interval of one frame - with the camera operating at 1/5000Ø ~~mf x~~ frames per second - or about 1/19000 of a second. It is puzzling but enlightening to discover that the blade is removed at such a high rate of speed. This paradox would seem to indicate that the blade removal is controlled by pre-programing the involuntary muscular behavior of the worker and not by consciously directing the reaction of the muscles during the blade manufacture. There is little doubt that the worker can control the bending of flakes or blades, for we have the surfave evidence proof on bifacially flaked artifacts that have been ripple-flaked over a curved surface from one lateral edge to the other.

It is possible that, because I am working in front of a high-speed camera and am fully aware of the time limitations, that I accellarate my blade removal as opposed to working under more relaxed conditions. For, knowing that I have a time interval of just 3/5 of a second to remove a prismatic blade, I tend to hurry the operation and believe that, under more normal circumstances the blade removal would be somewhat slower. It is difficult to synchronize the camera and speed of the worker, and, therefore, the work must be hurried. This necessary synchronization makes it most difficult to apply the outward pressure slowly enough to observe the bending of the blade and I have a tendency to thrust rather than press outward and downward slowly. Proper and normal blade removal requires considerable concentration in order to control the muscular behavior and this concentration is a little difficult under the hot lights of the camera and the attempt to beat the time interval. At this time there is need for continued camera experiments so that I can try to slow down the work of the blade removal or we might try increasing the speed of the camera. When the speed of the camera is increased, the time allotted for the experiment of blade removal will increase. Present calculations indicate that with the camera running at 5000 frames per second, the time interval between the parting of the blade from the proximal to the distal end of the core is 1/19000 of a second. This allows the worker only 1/5 of a second, or slightly less, to remove a blade.

To date, the film experiments have been most rewarding for they permit one to study the behavior of the material when subjected to pressure. It is interesting to note the action of the blade as it leaves the core, as well as the movement of the tip of the pressure tool. The path of the tip of the pressure tool moves at the same angle as the angle of the ideal cone, indicating the ratio of downward and outward forces is harmonious. The outward and downward path of the pressure tip is only about three eights of an inch away from the core while the distal end of the blade has departed from the base of the core at least an inch. Blades appear to compress in the form of a slight outward arc, and then, because of the elasticity of the material, assume their original shape and, in doing so, project themselves outward away from the core. The distal end of the blade moves faster and leaves the core before the proximal end. As the platform is torn loose from the core, fine particles of apparently crush obsidian are air-born in the vicinity of the pressure tool tip. Yet, upon examination of the platform, there is little evidence of any crushing on either the platform or the proximal end of the blade. Some photos reveal the tiny errailure flake in association with the fine particles. The errailure flake and flake scar is common to percussion work, yet is ordinarily not associated with pressure work. In these experiments, it seems to be related to the blades removed by a thrust rather than when slower downward and outward pressures are applied.

It is also interesting to note the angle of travel of the pressure tool tip, for it indicates when too much downward pressure is used. Should this be the case, the vector of angle of pressure tool travel will be closer to the core and usually results in a part of the distal end of the core being removed. But, if the vector of angle of this tool is away from the core, the blade will terminate before it has torn loose the full length of the core, and the distal end of the blade will be straight and feathered. When the downward pressure is too great, and the ridges guiding the blade have enough mass to contain the blade and prevent its spreading and removing the distal end of the core, the blade will flex to the point of breaking. If fracture of the blade does occur, it will break into three almost equal pieces even though it is removed entirely from the core. If and when the tip of the pressure tool and the downward and outward pressure is not directly in line with the two ridges that will guide the blade, the blade will be removed from the core but will break as it leaves the core with the broken pieces spiraling as they become airborn. This sort of miscalculation usually causes the core to be malformed and the successive blades removed from that area will also be malformed.

If the end of the shaft vibrates in a succession of waves, the blade will convulse and undulate and this peculiarity is usually associated with an excess of outward pressure. It may be possible to overcome this by the use of a thicker staff or by placing a weighting medium on the shaft of the pressure tool.

High-speed photography has permitted one to study the platform area contacted by the pressure tip which controls the thickness of the blades. It has also been useful in studying the muscular motor habits of the stoneworker. These habits and involuntary movements were undetected until photographed at high-speed. They are even more noticable in direct percussion work which will be more detailed when further experiments have been made with this technique.

By using close-up lenses, the camera has permitted one to observe all of the action and behavior of the material and to study this action either by motion or by single frame stills. The enlargements projected on a screen allow minute examination of details that may go undetected when just watching an actual demonstration. The film is also helpful to the stoneworker, for it allows him to observe many details that he cannot see during manufacture.. Should a platform crush, or a flake hinge or step-fracture, the cause and effect may be determined by closely observing what actually happened to set up this certain condition. This will allow the stoneworker to correct any miscalculations that are causing these truncations.

These films will also give invaluable aid to better understanding the fracture of materials with isotropic qualities. They show very clearly the behavior of the cone and its relation to the prismatic blade. We are all familiar with dropping a pebble into a pool and the resulting regularity of the waves which are the result of the force with which the pebble hit the water. These concentric waves may be compared to a solid with the same isotropic qualities. Dropping a pebble in water is much like a percussion blow, but when the pebble is slowly immersed in the water, no waves are evident and this slow movement is much the same as applying pressure. Blades removed by pressure have an absence of concentric rings (undulations). Should the pebble strike a piece of glass, which has much the same properties of a heavy liquid, waves will also result but they will be projected ahead of the pebble in the form of a truncated cone. And the truncation will be of the same size as the surface of the glass contacted by the pebble. But, should the pebble be pressed on the corner of a block of glass vertical to the flat plane, a quarter of a cone will be removed. This fourth of a cone will remove the corner but at the same time will travel back into the block of glass at the same angle as the cone removed from striking vertically into the flat surface. But the flake will resemble in no way a blade removed from a Polyhedral Core.

The high-speed camera shows that if the platform has been slightly freed, or isolated, by the removal of small flakes on each of its sides prior to blade removal, that when the blade is pressed off, the platform will act as the truncated part of a cone. The cone is then dislodged from the core by the application of outward pressure, and then the downward force pushes the mass of obsidian in the form of a blade the full length of the core. The greater mass has been confined by the two ridges previously established on the face of the core, forcing the blade to move in a line of least resistance thus creating a long trapezoid with parallel sides. The elasticity of the material permits some bending. The angles of the cone are converted by the outward pressure until the angle of the cone facing the core is made parallel to the side of the core bearing the two ridges which were established by previous blade removal.

The camera readily demonstrates how the angles of a cone can be converted by the application of the outward pressure. The vector of travel of the tip of the pressure tool after it leaves the core is the same as if one would use percussion instead of the downward and outward pressure. The main differences in the two methods - pressure and percussion - is that if one was able to strike repeatedly with the necessary accuracy the effect would be much the same as the splash of the pebble in water as mentioned before, making many concentric ripples, waves or undulations on both the blade and the core. The use of pressure is much slower and, again, may be compared to the immersion of the pebble which makes fewer rings or waves. The more vitreous materials have less viscosity than the more granular materials, therefore, the waves in the glassier rocks tend to be magnified. When making a decision or comparison of which technique was used - pressure or percussion - the material must also be considered. Considerably greater amount of force is required to remove a blade by pressure than by percussion which makes use of gravitational potential energy, and the intensity of the blow upon striking the core is converted to kinetic energy. The use of percussion also has an effect I am aware of but, at this time, unable to fully describe. It is that upon impact certain types of blows induce intense shock even though the blow is light and causes the blade to part from the core with much greater ease than those struck with less velocity. This pecularity is related to the elasticity of the material. I can think of only one example to illustrate this peculiarity andthat is to relate it to cany making. That is, breaking freshly made warm candy that is still plastic. It would be impossible to break this cany by bending but by giving it a sharp blow, it will easily shatter. This same principal appears to be related to the type of blow I am trying to describe. Also, once a flake is started, or a crack can be made appear on the core to break the molecular attraction, the balance of the flake or blade may be removed with x less force. This is, of course, characteristic of scoring glass before it is finally broken.

Conclusions:

My experiments in prismatic blade making have helped me reach some conclusions regarding the variable conditions that can be controlled by manual skill and the behavior and response of certain materials when subjected to stress. I have only admiration for the aboriginal's skill of making near-perfect calculations of angles and relating the dombinations of forces necessary to repeatedly remove blades from cores with such accuracy and precision. Their exhausted cores are evidence of the perfection and control of all of these factors. And attempt to replicate these blades and cores will make one appreciate the required skill and control necessary to duplicate the cores and blades of the aboriginal. No amount of theorizing by just examining a flake or blade scar will give a true picture of these techniques. Only by replicating can we change theory to fact. I am hopeful that the illustrati ns showing Ancient Man simply striking a block of obsidian with another piece of stone to remove a blade from a Polyhedral core will be reconsidered.

Before we can reach a final and definite conclusion on the manufacture techniques, the flake scars of both the core and blades must be studied in minute detail. Not just one - but many examples - and then every feature and characteristic of the aboriginal work must be duplicated. Only after years of experimenting, after thousands of blades were struck, and after analyzing the results of these experiments, did I reach the conclusion that true replicas could be made by the pressure technique. These experiments have shown that blades and cores made by the use of pressure do have every quality and characteristic of most cores and blades found in Mesoamerica. This conclusion is not only based on my experiments, but also on relating the aboriginal work to some of my pressure worked replicas.

It is not difficult to examine an artifact and see the approximate direction in which force was applied. But, determining how and by what technique, can and does involve actual working tests before final conclusions can be reached. Each technique characteristic to certain groups of men of prehistory may play an important part in their economy and, therefore, I recommend to each analysist the personal act of fracturing stone.

Flint Working Techniques of the American Indians: An Experimental Study. H. Holmes Ellis - Ohio State Archaeological & Historical Society Page 48 1940

B.A.E. Bulletin 60 Holmes 1919 ~~page~~ page 225

Prehistoric Technology S. A. Semenov 1964
Man Before Metals N. Joly, 1883